Ectocarpus- Structure and Life- cycle
(B.Sc. Botany Hons. Part-1, Paper-I)

Systematic Position:
Class: Phaeophyceae
Order: Ectocarpales
Family: Ectocarpaceae
Genus: Ectocarpus

Occurrence of Ectocarpus:
Ectocarpus is worldwide in distribution particularly in colder seas and Polar Regions. Ectocarpus is very common on seashore of Atlantic Ocean. Ectocarpus is found attached on sea rocks.

Some species of Ectocarpus are epiphytic e.g., *E. coniferus*, and *E. breviarticulatus* grow on larger algae like Fucus and Laminaria. *E. dermonematus* is endophytic species. *E. fasciculatus* is epizoic species growing on fins of faster. In India Ectocarpus is represented by about 100 species.

Thallus Structure:
The plant body is mostly typically heterotrichous and differentiated into

(a) creeping or prostrate system and

(b) projecting or erect system.

In some species one of the two systems may be reduced. In epiphytic forms the prostrate system is well developed, and the erect system is reduced.

In many species of Ectocarpus, the thallus is sparingly to profusely branched, the cells are uniseriate, joined end to end in a row. In some species, the older portions of the main branches are corticated by a layer of descending rhizoidal branches. In many species the terminal portion of a branch may end in a colourless hair with a basal meristem (Fig. 1A).

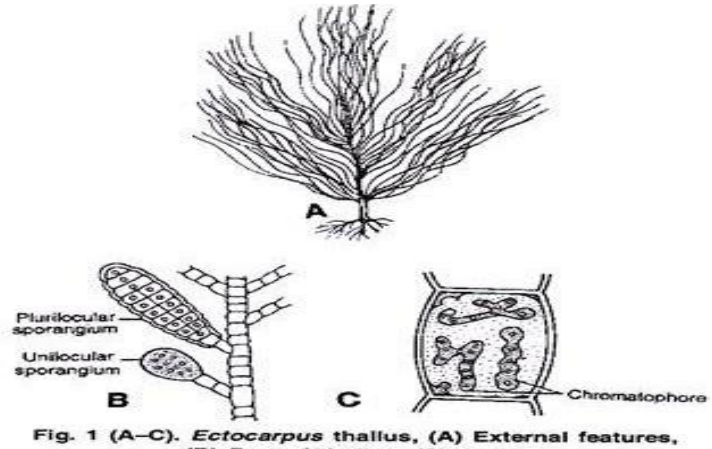

Fig. 1 (A–C). *Ectocarpus* thallus, (A) External features, (B) Part of thallus, (C) A cell

Structure of Cell:
The cells are generally rectangular, uninucleate and the nucleus is placed in the region of the central vacuole, suspended by protoplasmic threads. The cell contains a few parietal band shaped chromatophores with irregular branches (*E. siliculosus*) or many disc shaped chromatophores (*E.granulosus*) (Fig.1C). The chromatophores contain large amount of xanthophyll's in addition to chlorophyll.

Fucosan vesicles or granules are present in large number along with pyrenoid like bodies in the cell. The reserve food material is in form of **laminarin** and **mannitol.** The cell wall is differentiated into two layers, the inner firm layer is made of cellulose and the outer gelatinous layer contains alginic acid.

Growth of Ectocarpus:
The growth in the prostrate system is apical and in the erect system it is diffuse and intercalary. In intercalary or trichothallic growth meristem is located at the base of a hair (*E.irregularis* and *E. paradoxus*). The growth is apical in *E.lucifugus*.

Reproduction in Ectocarpus:
In Ectocarpus the reproduction takes place by asexual and sexual methods.

Asexual Reproduction in Ectocarpus:
The asexual reproduction takes places with the help of biflagellate zoospores. These zoospores are produced in unilocular and plurilocular sporangia (Fig. 1 B).

The sporophytic diploid plant forms two types of sporangia:

(a) Unilocular sporangia

(b) Plurilocular sporangia.

These two types of zoosporangia may be produced on the same plant or on different plants. The unilocular zoosporangia form haploid zoospores and the plurilocular sprogania form diploid zoospores.

Unilocular Sporangia:
The unilocular sporangia develop singly on tips of small branchlets. The terminal cell of the branchlet gradually increases in size and becomes ellipsoidal. This cell functions as sporangial initial (Fig. 2 A). The nucleus of sporangial cell first divides by meiotic division followed by many equational divisions. This results in formation of 32-64 haploid nuclei (Fig. 2 B, C).

The nuclear divisions are not followed by wall formation and the sporangium remains unilocular (Fig. 2). Each nucleus of the sporangium gets surrounded by protoplast segment and ultimately transforms into 32-64 zoospores (Fig. 2 D). Each zoospore is pyriform, uninucleate with two laterally inserted unequal flagella.

The anterior flagellum is longer, pantonematic (Tinsel) and directed forward while the posterior is shorter, acronematic and directed backward (Fig. 2 E).

The zoospores discharge en-masse in gelatinous matrix through a terminal pore in sporangium. The zoospores after being discharged remain in spherical mass at the apex of sporangium. The zoospores remain inactive for 30-60 seconds then become free and swim in water. They remain motile for about 30 minutes.

These zoospores are haploid, they withdraw flagella and attach to the substratum by their anterior ends. The zoospores germinate within 2-3 hours to produce a new Ectocarpus plant which is similar to sporophytic plant in structure (Fig. 2F-I). These plants are called gametophytic plants as on maturity they bear plurilocular gametangia.

According to Knight (1929), Schussing and Kothbaouer (1934), rarely the zoospores released from unilocular sporangia, show pairing and fusion but the fate of such zygotes is not known.

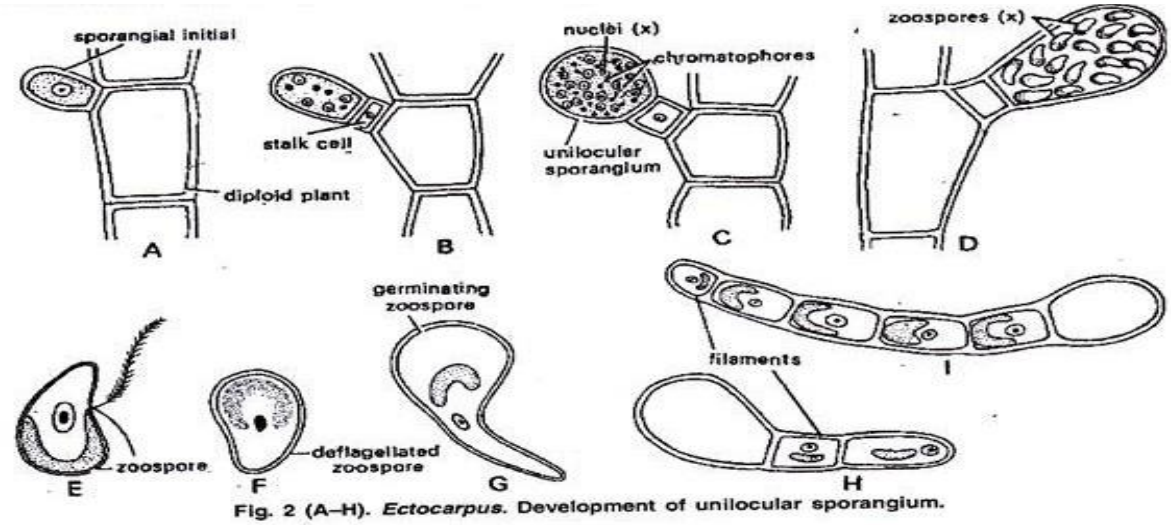

Fig. 2 (A–H). *Ectocarpus*. Development of unilocular sporangium.

Plurilocular or Neutral Sporangia:
Like unilocular sporangia, the plurilocular sporangia also develop from the terminal cells of the branchlets of diploid sporophytic plant. The cell which functions as sporangial initial (Fig. 3A) enlarges in size and becomes spherical or elongated structure. It repeatedly undergoes transverse divisions to form a row of 5-12 cells (Fig. 3A, B). Then vertical divisions start in all the cells starting with the median cells of the row.

Many transverse and vertical divisions result in formation of cubical cells arranged in 20-40 transverse tiers (Fig. 3C). The cells are arranged in regular rows. This multicellular structure is called plurilocular sporangium.

The protoplast of each diploid uninucleate cell of the sporangium is transformed into a single biflagellate zoospore (Fig. 3D-F). The zoospores of plurilocular and unilocular sporangia are identical in structure but zoospores of plurilocular sporangia are diploid and zoospores of unilocular sporangia are haploid.

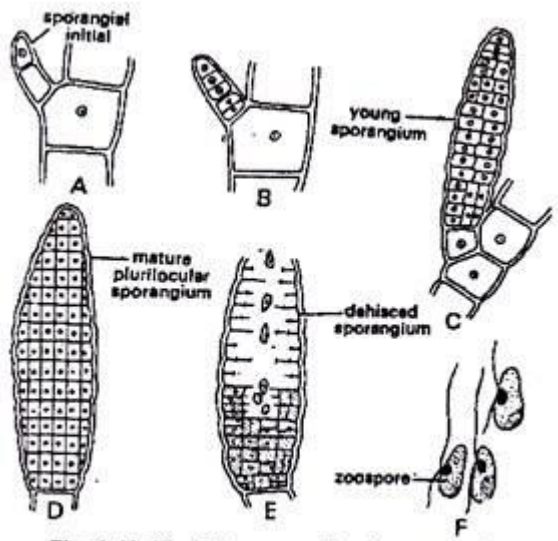

Fig. 3 (A–H). *Ectocarpus.* Development of Plurilocular Sporangia

The mature zoospores are liberated from the sporangium through apical or lateral pores. The zoospores remain motile for 4-5 hours and then germinate into diploid thallus which later on bears unilocular and plurilocular sporangia.
These diploid zoospores multiply only sporophytic plants and they do not play any role in alternation of generation. The formation of unilocular and plurilocular sporangia is affected by environmental conditions like temperature and salinity of water. E. siliculosus produces unilocular sporangia at 13°C, plurilocular at 19°C and both unilocular and plurilocular at 16°C.

Sexual Reproduction in Ectocarpus:
The sexual reproduction may be isogamous, anisogamous or oogamous. Most of the Ectocarpus species are anisogamous. The gametes are biflagellate, motile and are produced in plurilocular gametangia borne on haploid or unisexual plants.

The plurilocular gametangia and plurilocular sporangia are similar in structure and development. The plurilocular gametangia are either sessile or stalked and vary in shape from ovate to siliquose. The plurilocular gametangia develop singly from the terminal cell of the lateral branchlets.

The gametangial initial divides transversely to form a row of 6-12 cells. Further divisions are transverse and vertical in these cells to make hundreds of cubical cells arranged in 20-40 transverse layers. The protoplast of each cubical cell in gametangium metamorphosis into single biflagellate pyriform gamete. The gametes are liberated in water through terminal or lateral pore in gametangium.

In E. siliculosus the gametes are morphologically similar (Fig. 4A). Hence the reproduction is isogamous but physiologically anisogamous. The fertilization occurs between gametes from separate plants. These gametes are morphologically identical, but one is less active, becomes passive after a short period and behaves as female gamete. The more active gametes are considered male.

The active male gametes cluster around female gamete and cling themselves by their anterior flagellum. It is known as clump formation. In this clump formation (Fig. 4B) one male gamete is able to fuse with female gamete. The gametes fuse to form a diploid zygote. In other species of Ectocarpus gametes from same plant can fuse to form a zygote showing isogamous reproduction.

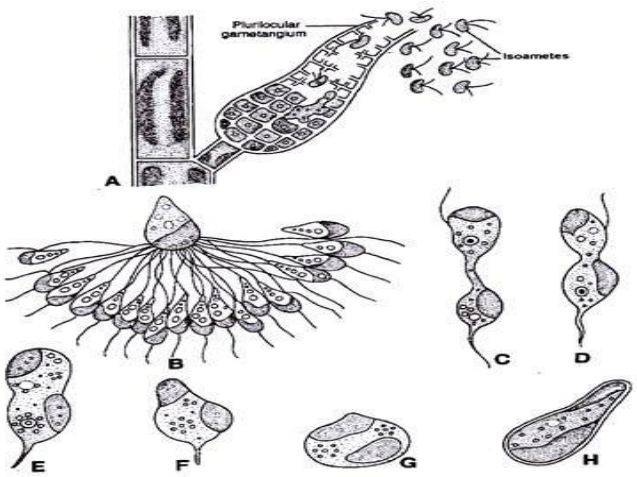

Fig. 4 (A–H). *Ectocarpus*. A. Plurilocular gametangium, B. Clump formation, C–H. Fusion stages and zygote.

In E. secundus, the sexual reproduction is anisogamous, the gametes are different in size. The smaller gametes are produced in micro-gametangia and the larger are produced in bigger mega-gametangia. The micro-and macrogametes after liberation fuse and form zygote, (Fig. 5A-E).

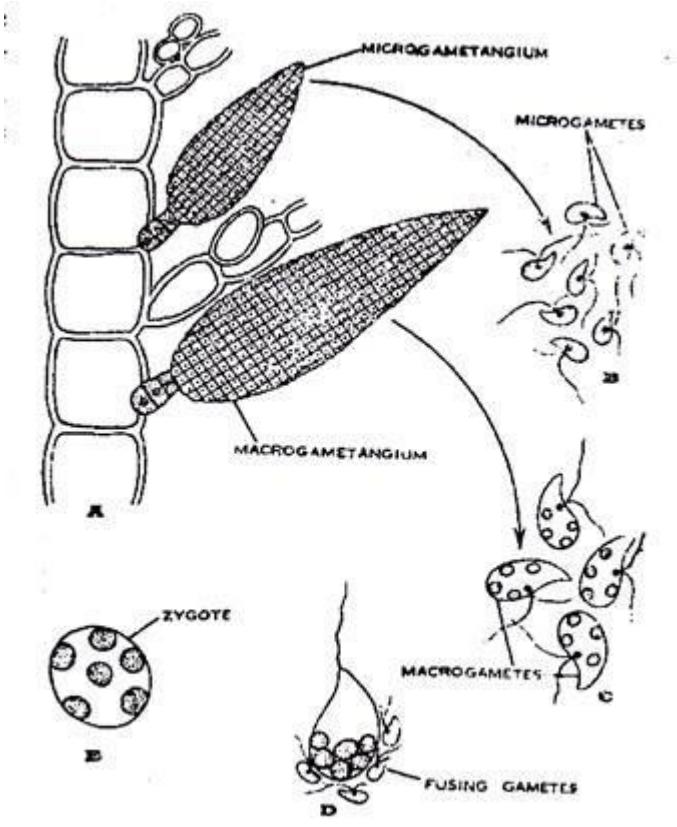

Fig. 5 (A–E). *Ectocarpus*. Anisogamous sexual reproduction

In E. padinae three distinct types of plurilocular gametangia are formed. The largest mega-gametangia represent oogonia and the smallest micro-gametangia represent antheridia (Fig. 6A, B).
The egg and antherozoids produced by the mature mega-gametangia and micro-gametangia fuse to form zygospore. The medium sized meso-gametangia give rise to medium size gametes. They do not fuse but develop new plant parthenogenetically.

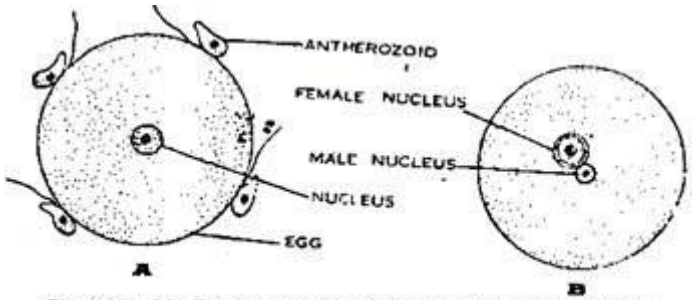

Fig. 6 (A, B). *Ectocarpus.* Oogamous sexual reproduction

Fertilization in Ectocarpus:

In isogamous species the fusing gametes are morphologically and physiologically similar. The two gametes of same gametangium or from two different gametangium of same thallus fuse to from zygospore. In physiologically anisogamous species, gametes from two filaments of different strains fuse. The female gamete after liberation secretes a volatile sexual attractant sirenine.

A large number of male gametes are attracted and cluster around female gamete to make clump formation (Fig. 4B). After sometimes one male gamete fuses egg to make zygospore and other gametes detach themselves from female gamete. The zygospore germinates after 2-3 days. Its diploid nucleus divides mitotically to make diploid Ectocarpus plant.

Life Cycle of Ectocarpus:
The sexual thalli of Ectocarpus are haploid. The haploid plants bear plurilocular gametangia. The isogametes or anisogametes fuse to form diploid zygospore. The diploid nucleus of zygospore divides mitotically during germination. This forms diploid, sporophytic plants. The diploid plants bear both unilocular and plurilocular sporangia.

The zoospores formed in plurilocular sporangia are diploid and give rise to diploid sporophytic plants on germination. The zoospores formed in unilocular sporangia are haploid and on germination form haploid gametophytic thalli. In Ectocarpus the sporophytic and gametophytic plants are morphologically similar hence there is **isomorphic alternation of generation** (Figs. 7 & 8).

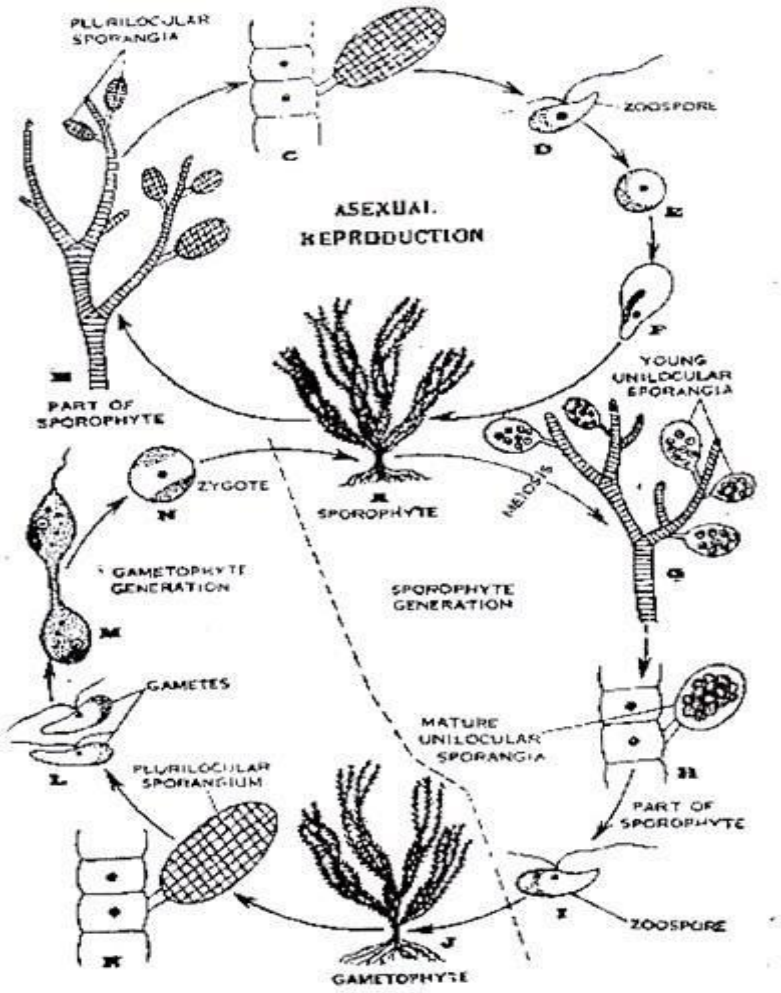

Fig. 7. *Ectocarpus.* Diagrammatic life cycle

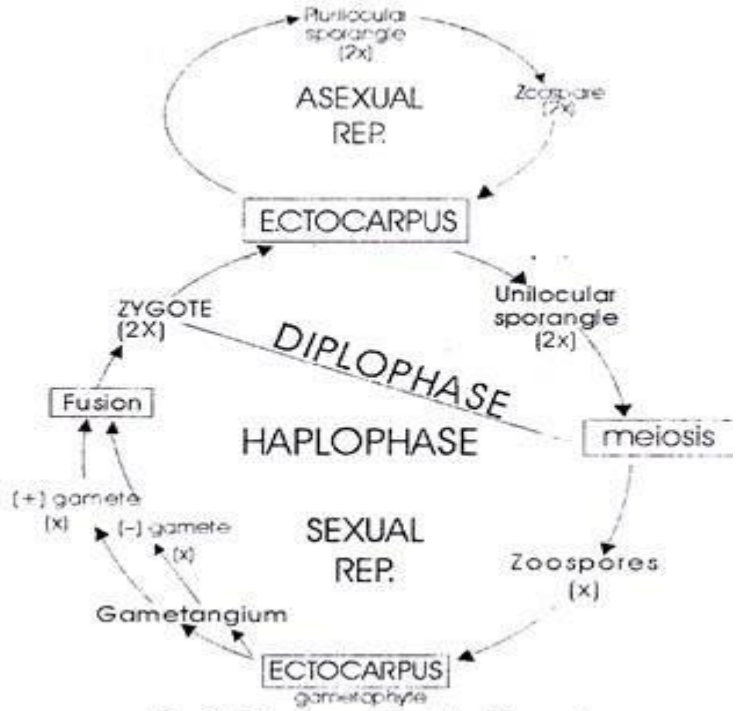

Fig. 8. *Ectocarpus.* Graphic life cycle

Reference:

1. Algae by B.R.Vashishta

2.Biology Discussion