One should also be aware that surf-exposed rocky outcrops along the SW-coast are not accessible during the SW-monsoon as a result of the continuous huge waves and swells (Figs 28A-F).

The big tsunami of 27 December 2004 locally uprooted part of the coastal mangroves but did not result in a noticeable change of the epilithic algal flora.

Fig. 28. Inaccessibility of the coast. A, B. During the SW-monsoon, most of the southern and western coastline is not accessible due to the surf; C-E. The spray caused by the huge surf during the SW-monsoon results in well developed seaweed vegetations in the upper tidal zones (*Ulva fasciata*, *Dermonema virens*, *Turbinaria ornata* var. *evesiculosa* respectively); F. Locally the waves result in huge fountains through the blow holes.

A real, severe threat to coastal areas is the use of lagoons as well as beaches as waste disposals, resulting in huge amounts of mainly plastic at high tide level and above (Figs 29B-G) or plastic bags or sheets wrapped around subtidal rocks and corals. In the neighbourhood of estuaries the beach can be covered by organic detritus (tree trunks, water hyacinth, …) mixed to plastic detritus (Fig. 29A).

Fig. 29. Pollution. A. In the neighbourhood of estuaries, mostly organic material drifts ashore (Wattale); B. Lagoons are frequently used as waste disposals, resulting in huge amounts of mainly plastic at high tide level and above (Chilaw lagoon); C. Close to the estuaries of the lagoons, rubbish is concentrated (Chilaw lagoon); D-G. Beaches are also frequently used as waste disposals (D, E: Chilaw; F: close to Mount Lavinia; G: close to Colombo).

An invisible threat to coastal habitats is the eutrophication of intertidal rockpools and lagoons by wastewater, mainly in touristic areas. The constant release of nutrient-rich effluents in these biotopes has a profound effect on the biodiversity. In a first phase the abundance and composition of algal assemblages changes drastically whereby fast growing foliose algae such as *Ulva* spp. become dominant (Fig. 30A), attracting opportunistic herbivores such as sea urchins. The effect of this herbivory is striking: in the haloes around the sea urchin's crevice all germinating seaweeds are grazed, only leaving a crust of coralline algae (Figs 30C, D). The resulting barrens habitat is much lower in biodiversity.

Fig. 30. Eutrophication. A. Eutrophication results in a first stage in the massive development of *Ulva* populations in the intertidal pools (Hikkaduwa); B. Some eutrophicated intertidal pools can be completely populated by sea urchins, grazing all germlings of soft algae. Only a crust of coralline algae remains on the bottom; C. Along the seaward side of the beachrock platform sea urchins can also become very abundant as a result of eutrophication (Beruwela); D. As a result of the continuous grazing by the sea urchins, the algal cover of the substratum is limited to coralline algae within their grazing area.

Man-made (anthropogenic) as well as natural pressures have contributed to the degradation of Sri Lanka's coral reefs. Some of the anthropogenic pressures are coral mining and dynamite fishing in areas as Kalpitiya. Blast fishing has a long-term dramatic effect on the ecosystems originally present as it completely destroys the original substratum. Even the presence of authorities such as Coast Conservation Department does not seem to be able to stop these destructive practices.

The main natural threats to Sri Lanka's reefs are predator plagues such as the spread of Crown of Thorns Starfish and coral bleaching - the death of corals due to the exceptional rise in surface sea temperature, as a result of an El Niño-effect which occurred in 1998.

The plans for dredging a deeper canal between N Sri Lanka and SE India (Palk Strait) to make the passage of large ocean boats possible, thus avoiding the circular trip around Sri Lanka, possibly will also have a huge impact on the ecology of the northern marine habitats.

7. History of phycological research in Sri Lanka

The first collections of seaweeds in Sri Lanka were carried out by the Dutch botanist Paul Hermann (1646-1695). His collection formed the basis of Linnaeus' Flora Zeylanica (1747). Linnaeus' son (Linnaeus fil., 1782) described *Fucus pinnatus* (*Caulerpa pinnata*) from the island. William Ferguson (1820-1887), a British civil servant and amateur botanist in Ceylon from 1839 until his death in Colombo, issued informal exsiccatae, Algae Ceylanicae, with specimens identified by Albert Grunow (1826-1914), an Austrian phycologist and diatomologist. The first set of these exsiccatae, which are deposited in the Natural History Museum, London (BM), were included in the list of Ceylon algae, compiled by G. Murray (1887), but some duplicates are present in the Herbarium of the Botanic Gardens in Peradeniya (PDA), Sri Lanka and the Nationaal Herbarium Nederland in Leiden.

By far the most celebrated collector in the Indian Ocean was the Irish botanist William Henry Harvey (1811-1866), who provided entertaining accounts of his adventures in letters to family and friends (Ducker, 1988). Harvey stopped in Ceylon on his way to Swan Colony (Western Australia), arriving on the 5th of September and leaving the 25th of December 1853. During this period he collected sufficient specimens in Trincomalee, Weligama and Galle, to be distributed as exsiccatae (Harvey, 1857). While in Australia, he published a paper (Harvey, 1854) describing three spectacular reticulate Delesseriaceae from Ceylon: *Claudea multifida*, *Martensia fragilis* and *Vanvoorstia spectabilis*, the latter representing a new genus named after John Van Voorst, the London publisher of some of his books (including Harvey, 1841; 1849). Harvey's eloquent dedication of *Vanvoorstia* goes as follows (Harvey, 1854: 143-144): "Among the marine algae, perhaps none are more curious and few more beautiful than those net-like or lacework Florideae of which several genera, as *Claudea*, *Dictyurus*, *Martensia*, *Hanowia*, *Haloplegma*, *Thuretia* etc., have been discovered in the warmer seas… I have now the pleasure to introduce to botanists, from the south coast of Ceylon, not only a new species of *Claudea* and of *Martensia*, but also add to this interesting group a new genus, which yields to none of its associates in beauty and delicacy of structure. This genus I wish to dedicate to John Van Voorst, Esq., F.L.S., the well-known Natural History publisher, who, though not himself a working naturalist, is a notable instigator of work in others, and, as originator of a noble series of Monographs illustrating the Natural History of Great Britain, deserves the respect and thanks of his countrymen. The crest of the Van Voorst's (a family of no mean standing in Holland) is a mermaid from whose toilet the exquisitely delicate lacework now to be described may have been stolen; and I have peculiar pleasure in associating with so charming a sea-plant the name of a friend for whom, personally, I have a cordial regard and esteem". Most of Harvey's Ceylon collections, however, were treated by Kützing (1807-1893) and J. Agardh (1813-1901), as Harvey was busy pursuing other projects. His collection is deposited at the Trinity College in Dublin. Duplicate specimens, deposited in the National Herbarium of New South Wales (NSW), in Sydney can be seen online on: http://www.aussiealgae.org/HarveyColl/ceylon.php

Martens (1868) reported seven species from Galle, on the south coast of Ceylon, on the basis of material collected during the Prussian Expedition to eastern Asia.

Zanardini (1872) recorded eight species and Piccone (1886; 1889) listed a few species from Ceylon obtained during the round-the-world cruise of the corvette Pisani from 1882 to 1885. G. Murray (1887) provided the first extensive catalogue of Ceylon algae, based largely on collections made by Ferguson and Harvey. Barton (1903) reported 18 taxa on the basis of material collected by Herdman. Svedelius (1906a, b; 1945) published on the seasonality of the seaweeds of Ceylon and on Ceylon species of *Caulerpa* and *Galaxaura* respectively.

Børgesen, like Svedelius and others, collected algae at Galle and gave (1936) an extensive list of species obtained by him and others at this classical locality and a few other places in Ceylon.

Finally, there are the extremely valuable papers by Durairatnam (1961; 1962; 1963) on the marine algae of Ceylon, in which he treats all the species previously reported as well as some new species, that had not been reported before, totalling 174 taxa belonging to the Chloro-, Phaeo- and Rhodophyceae.

In recent times no algal diversity studies have been carried out anymore. Coppejans collected extensively along the SW coast since 1997 on a yearly basis. The specimens are deposited in the herbarium of Ghent University (Belgium) (GENT) and are currently under study. De Silva (1995) and De Silva & Mallikarachchi (2002) recently published on the effects of some environmental factors on the distribution pattern of algae on the south coast of Sri Lanka. Finally Mallikarachchi wrote his MPh thesis (2004) on anthropogenic effects on the distribution patterns of algae along the SW coast of Sri Lanka. His work includes 125 macroalgal taxa of which 44 Chlorophyta, 10 Phaeophyceae and 71 Rhodophyta. Some of these are new records for Sri Lanka. Voucher specimens of this study are deposited in the herbarium of the University of Ruhuna (Matara) and the National Herbarium in Peradeniya (PDA), Sri Lanka.

8. Marine plants and seaweeds

Marine plants are photosynthetic organisms in different evolutionary lineages (only macroscopic ones are included here): they are represented by the seaweeds, the seagrasses and the mangroves. Only the seaweeds are treated in the present book. Marine micro-algae, prokaryotic blue-greens (Cyanobacteria), seagrasses and mangroves are not included in this guide. For more information we refer to the more general work on Marine Botany by Dawes (1998) and more specialized, recent books such as Graham and Wilcox (2000) on seaweeds, Larkum *et al*. (1989; 2006) on seagrasses and Tomlinson (1986), De Lasserda (2002) on mangroves. The website http://www.seaweed.ie/ offers a concise but highly informative introduction on seaweeds and their uses.

8.1. Seaweeds - What are they?

Seaweeds are marine macroscopic (mostly visible with the naked eye), photosynthetic (carrying out oxygen-producing photosynthesis) eukaryotic organisms. They are non-vascular, which means no vascular bundles present as in higher plants, the uptake of nutrients from the surrounding seawater succeeding through diffusion through the whole plant surface.

Their primitive plant body, called a thallus, is not composed of roots, stems and leaves (like in terrestrial plants and seagrasses), although some structures can look like them (Fig. 31A). They do not produce flowers nor seeds but reproduce by spores (Figs 31B-E).

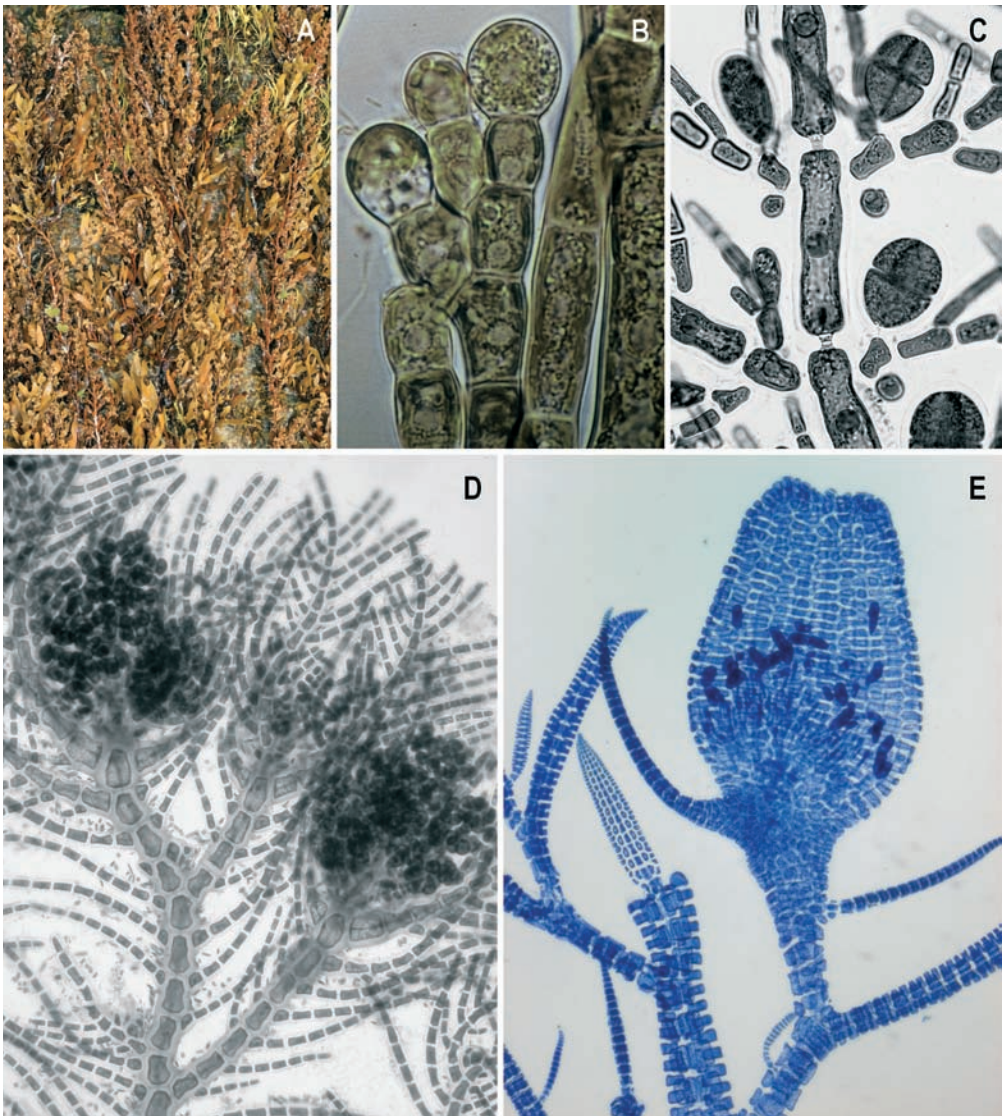


Fig. 31. General characters of seaweeds. A. Some seaweeds look similar to higher plants, with 'stems' (stipes), 'leaves' (blades) and inflorescences (receptacles) (*Sargassum* sp.); B. Monosporangia in the red alga *Acrochaetium* sp.; C. Tetrasporangia in the red alga *Balliella crouanioides*; D. Carpospores in the gonimoblast of *Skeletonella nelsoniae*; E. Carpospores in the cystocarp of *Platysiphonia delicata*.

The Chlorophyta (green algae), Phaeophyceae (brown algae) and Rhodophyta (red algae) originated separately, spaced in time. The seaweeds therefore are not a natural group as they have different ancestors: evolutionary they are polyphyletic. This is also reflected in the different pigments, cell wall components and storage products of the three groups of seaweeds. The Chlorophyta are more closely related to the land plants than to the other two groups of seaweeds (they also contain chlorophyll a and b, their main cell wall component is also cellulose and their storage product is also starch). 'Seaweeds' therefore refers to an ecological grouping of organisms which look similar because these forms occur in the same environment, and have similar roles in the ecosystem (equivalent to groupings as 'herbs', 'shrubs', 'trees' or 'succulents' on land).

8.2. Seaweed colour and classification

Although seaweeds are classified in green, brown and red algae, it is not always easy to determine in the field to which of these groups a certain specimen belongs. They all contain chlorophyll a (the primary photosynthetic pigment) and therefore can all be green(ish) if this pigment is dominant. Brown algae contain additional brown coloured compounds (accessory pigments) which are called xanthophylls. Depending on the amount of xanthophylls, brown algae can vary from yellowish orange to blackish brown. Red algae have accessory pigments belonging to the phycobilins. The most important ones are phycoerythrin (red) and phycocyanin (blue). Depending on the balance of the chlorophyll and the various phycobilins, red algae vary from pink to purplish red. In specimens growing in sun-lit sites, chlorophyll can become dominant and the red alga then can become greenish (Fig. 32A). Looking at the specimen in transparency (holding it against the sunlight) sometimes more clearly reveals the real colour of the seaweed.

Some seaweeds show the phenomenon of iridescence. As a result of layered cell walls or cell inclusions, some of the light reaching these algae is diffracted, certainly when they are submerged (or wet). These specimens then iridesce, either completely or only the branch tips, or in a banded or spotted pattern, in shiny greenish as in *Bryopsis* (Fig. 32B), bluish as in *Canistrocarpus magneanus* (Fig. 32C), *Dictyota* sp. (Fig. 32D), *Cottoniella amamiensis* (Fig. 32E), *Hypnea pannosa* (Fig. 32F), green-pinkish as in *Hypnea* sp. (Fig. 32G), blue-pinkish as in *Laurencia* sp. (Fig. 32H), brownish-yellowish as in some *Dictyota* species (Figs 33A-C), pinkish as in *Laurencia natalensis* (Fig. 33D), creamy as in *Chondracanthus acicularis* (Fig. 33E) or even golden shades in *Champia ceylanica* (Fig. 33F). Iridescence generally disappears as soon as the specimen is out of the water or dries out. It definitely cannot be observed on herbarium specimens and it therefore is important to mention this iridescence and even the original colour of the seaweed on the herbarium label, as this can dramatically change upon drying: some bright green *Microdictyon* species *in situ* become black (Fig. 34A), but also many brown and red algae change colour (mostly become darker) upon drying. If species are spotted (*Euryomma platycarpa*, Fig. 37F), they can keep this design even after drying.

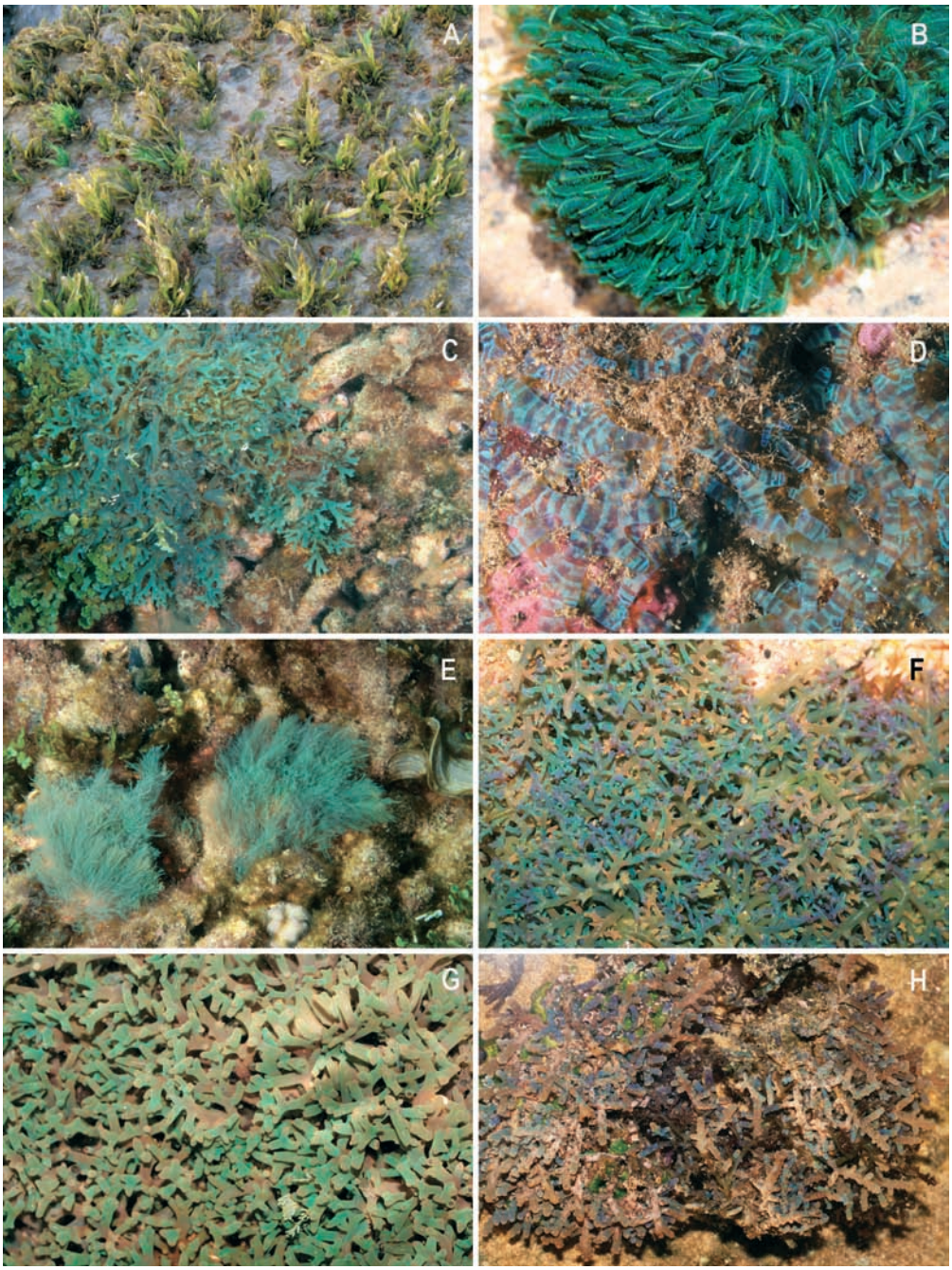


Fig. 32. Seaweed colours. A. Red algae, exposed to strong sunlight can become greenish because of the dominance of chlorophyll, rather than purplish red as a result of the phycobilines; B. Green iridescence in *Bryopsis pennata*; C. Blue iridescence of the whole thallus of *Canistrocarpus magneanus*; D. Banded blue iridescence in *Dictyota* sp.; E. Bluish iridescent *Cottoniella amamiensis*; F. A plant of *Hypnea pannosa* with blue iridescent tips; G. A plant of *Hypnea* sp. with green-pinkish iridescence; H. Partly iridescent *Laurencia* sp. in the infralittoral fringe, air-exposed at extreme low water (Hikkaduwa).

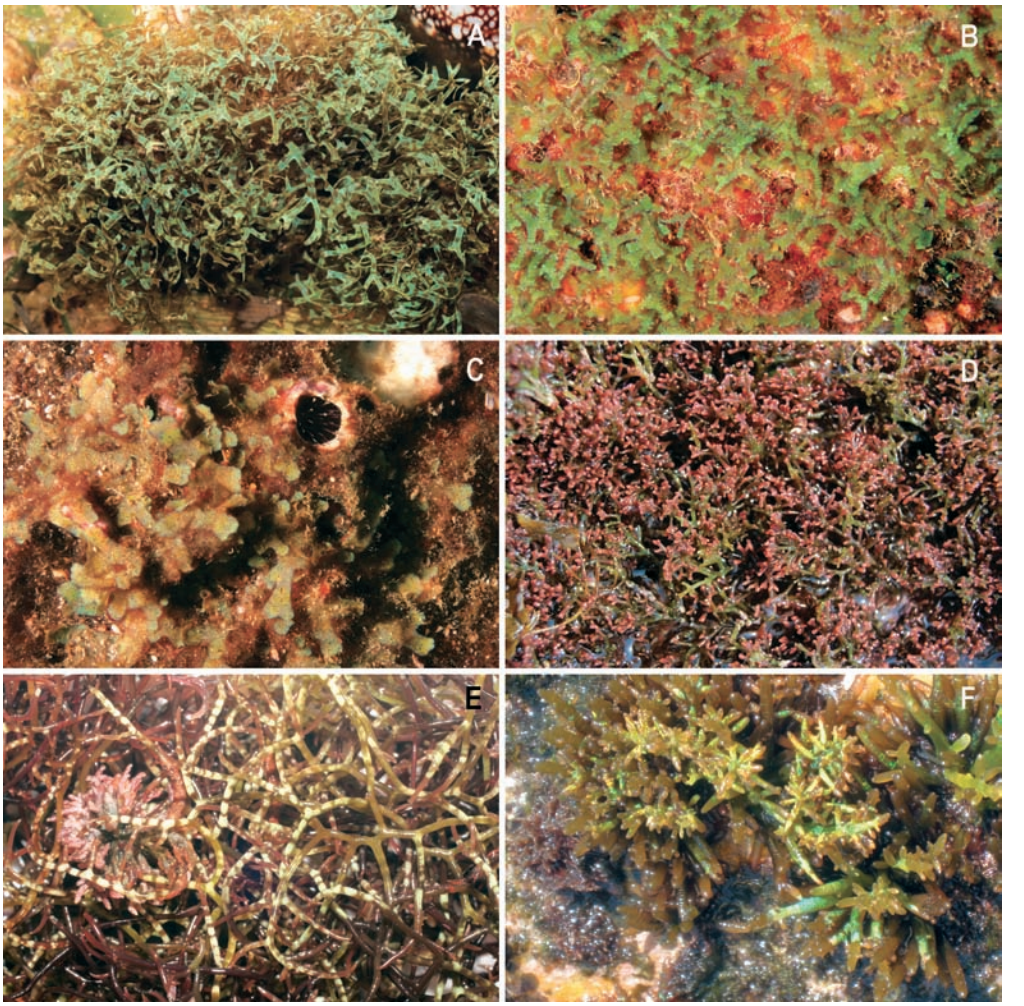


Fig. 33. Seaweeds colours. A. Brown and blue-greenish banded iridescent *Dictyota ceylanica*; B. Marginally banded iridescent *Dictyota* sp.; C. Spotted iridescent *Dictyota* sp.; D. *Laurencia natalensis* with pinkish iridescent tips; E. *Chondracanthus acicularis* with banded creamy-coloured iridescence; F. *Champia ceylanica* with golden iridescence.

Some green algae (e.g. *Acetabularia*, *Neomeris*, *Halimeda*) can be completely or partly (towards the basis) white (Fig. 34B) as a result of intracellular calcification. The brown alga *Padina* (Fig. 34C) can also be whitish, mostly on the upper surface by extracellular calcification. *Liagora* (Fig. 32D), *Dichotomaria*, *Tricleocarpa* and *Galaxaura* species are pinkish white depending on the degree of calcification. Articulated corallines (red algae) such as *Amphiroa* spp. (Fig. 34E), *Jania* spp. as well as crustose corallines (Fig. 34F) also become whitish by calcification, especially when they get older and grow in sun-lit biotopes.

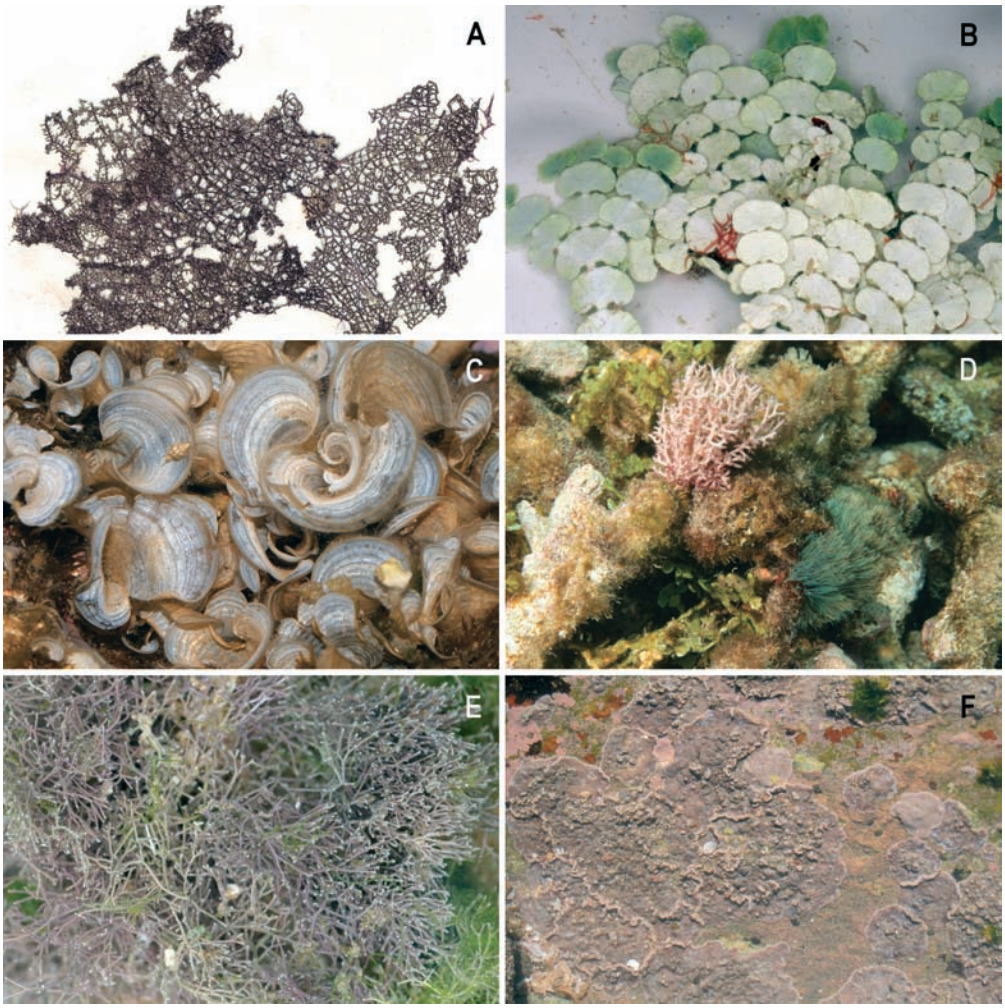


Fig. 34. Seaweed colours. A. Some *Microdictyon* species (e.g. *M. okamurae*), being green *in situ* become black upon drying; B. Whitish segments of the green alga *Halimeda* as a result of intracellular calcification; C. Whitish upper surface of the blades of the brown alga *Padina*, as a result of calcification on the upper surface; D. The thallus of the slippery red alga *Liagora* is whitish because of slight calcification; E. The brittle thallus of the coralline red alga *Amphiroa* is greyish white as a result of heavy calcification; F. Crustose coralline red algae are also greyish pink because of the heavy calcification.

Some brown algae, such as species of *Dictyopteris* or *Spatoglossum*, can become (partly) bluish after collecting as a result of chemical reactions of the plants themselves. Again, this effect disappears after drying. In some cases even the paper on which the specimens are drying may colour bluish.

8.3. Morphology

The form of seaweeds is extremely diverse: from filamentous and only a few mm high to complex fronds of up to more than 60 m long in colder water (in the tropics they rarely reach 1 m). They can be supple, stiff to even brittle or stone-like.

Filamentous algae are mostly composed of a single row of cells (= uniseriate). They can be unbranched (*Chaetomorpha* spp., Fig. 35A) or branched (species of *Cladophora*, *Valoniopsis*, *Acrochaetium*, Fig. 35B). In some species, several filaments get intertwined and form "rope-like" structures (*Asteronema breviarticulatum*, Figs 35C, D) because of the presence of hook-like side branchlets. In other species the filaments become stiff, intertwined and creeping over the substratum, resulting in crispy, spongy cushions (*Cladophoropsis* spp., *Valoniopsis pachynema*, Fig. 35E). Sometimes the branches anastomose and form a two- or threedimensional reticulum (*Microdictyon* sp., *Phyllodictyon* sp., Fig. 35F, *Boodlea composita*, Fig. 35G, *Tolypiocladia calodictyon*, Fig. 190C, *Dictyurus purpurascens*, Fig. 174) or blades (*Anadyomene wrightii*, Fig. 35H). The branching of these filamentous representatives can be very diverse: from irregular over dichotomous (*Ceramium* spp., Fig. 36A, *Chlorodesmis* spp., Fig. 36B, *Centroceras clavulatum*), sympodial (*Ceramium* sp., Fig. 36C), unilateral (*Euptilota fergusonii*, Fig. 36D), alternate (*Euptilota fergusonii*, Fig. 36E), spiralized (*Murrayella periclados*, Fig. 36F), opposite (*Phyllodictyon* sp., Fig. 35F, *Boodlea* sp., Fig. 35G, *Bryopsis* sp., Fig. 36G, *Callithamnion* sp., Fig. 31C), to whorled (= verticillate, *Caulerpa verticillata*, Fig. 36H). In some taxa, the filaments can be covered by a rhizoidal cortex (*Euptilota fergusonii*, Fig. 36J). Sometimes the filamentous species are composed of unicellular, siphonal, coenocytic structures (*Bryopsis* spp., Fig. 36G). More rarely, filamentous thalli are composed of a few cell rows (some elegant, tubular *Ulva* species, Fig. 36I, *Polysiphonia* sp., …).

Blade-like species can be very thin, membranous and supple (*Porphyra* spp., Fig. 37A and some Delesseriaceae: a single cell layer , Fig. 37D, *Ulva* spp.: 2 cell layers, Fig. 37B, *Padina*: 3 to several cell layers depending on the species, Fig. 37C). Others are somewhat thicker, becoming fleshy, cartilaginous (*Lobophora variegata*, Fig. 37E, *Euryomma platycarpa*, Fig. 37F), composed of an inner medulla and an outer cortex, gelatinous or spongy in texture. Some are entire (some *Porphyra* spp.), others lobed (*Nitophyllum marginale*, *Euryomma platycarpa, Peyssonnelia* spp., Fig. 37G) or branched and being composed of compressed to flattened axes (*Ulva fasciata*, Fig. 38A; *Polyopes ligulatus*, Fig. 38B, *Halymenia durvillei*, Fig. 38C; *Dictyota* spp., Fig. 38D; *Stoechospermum polypodioides*, Fig. 38E, *Gracilaria* spp., Fig. 38F). Their branching type can be as diversified as in the filamentous type. The flattened axes can also anastomose and form a two-dimensional reticulum (*Claudea multifida*, Fig. 39A; *Martensia fragilis*, Fig. 39B). Some blades are somewhat (*Ulva pertusa*) or (locally) profusely perforated (*Ulva reticulata*, Fig. 39C). They can be smooth or show smaller or larger surface proliferations (*Halymenia durvillei*, Fig. 39D). The fronds may have a marked, thickened central portion (= midrib) as in the genus *Dictyopteris* (Fig. 39E).

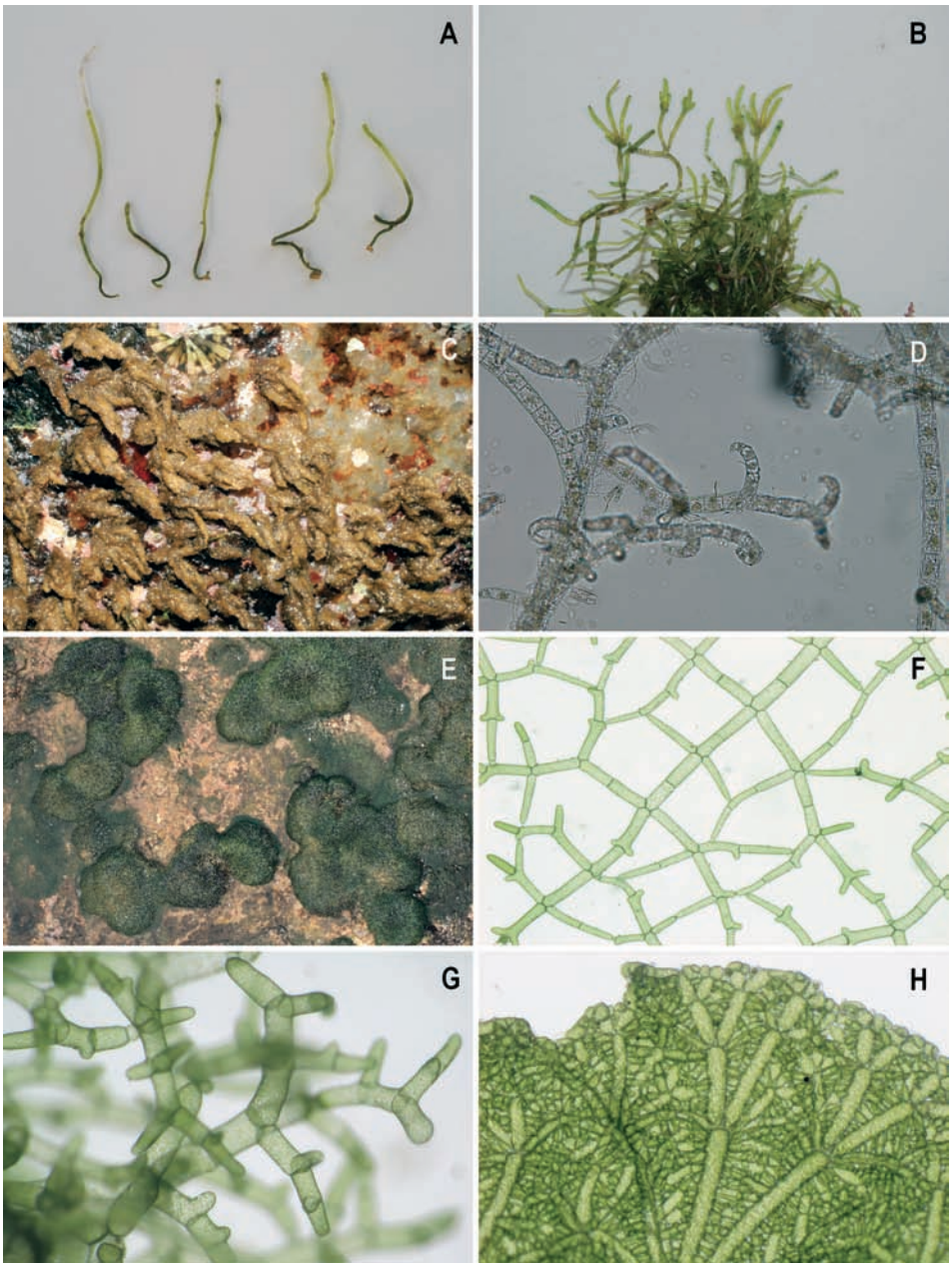


Fig. 35. Seaweed morphology: filaments. A. Unbranched filaments in *Chaetomorpha spiralis*; B. Branched filaments in *Valoniopsis pachynema*; C. 'Rope-like structures' in *Asteronema breviarticulata* as a result of the longitudinal intertwining of filaments and mutual attachment by hook-like branchlets; D. Detail of the hook-like branchlets in *Asteronema breviarticulata*; E. Stiff, intertwined, branched filaments creeping over the substratum, resulting in crispy, spongy cushion-like structures (*Valoniopsis pachynema*); F. Branches anastomosing and forming a reticulum in a single plane (*Boodlea montagnei*); G. Branches anastomosing and forming a three-dimensional reticulum (*Boodlea composita*); H. Branches anastomosing and forming blades (*Anadyomene*).

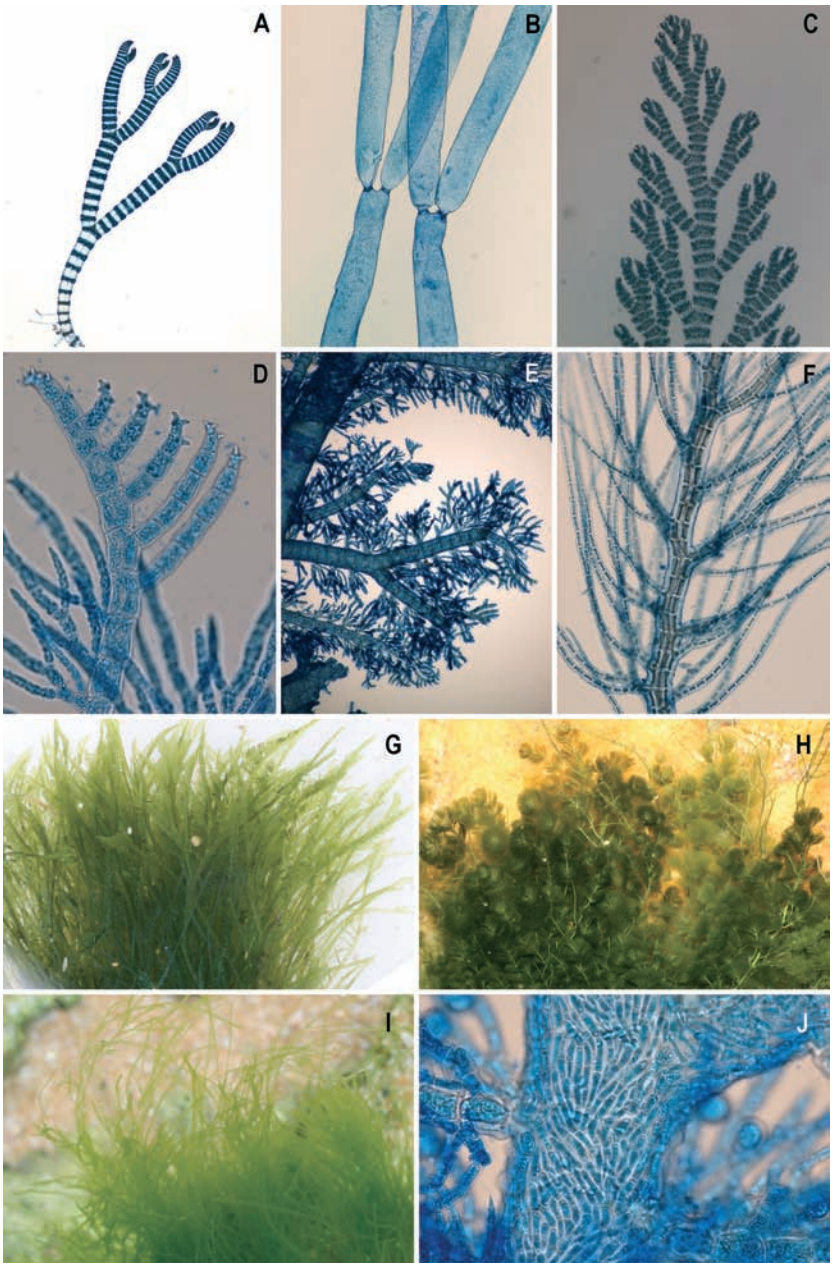


Fig. 36. Seaweed morphology: branching pattern; cortication. A. Dichotomous branching in *Ceramium* sp.; B. Dichotomous branching of the coenocytic filaments of *Chlorodesmis*; C. Sympodial branching in *Ceramium* sp.; D. Unilateral branching in terminal branches of *Euptilota fergusonii*; E. Alternate branching in subterminal branches of *Euptilota fergusonii*; F. Spiralized branching in *Murrayella periclados*; G. *Bryopsis* sp.: thallus composed of coenocytic, unicellular, pinnately branched structures; H. Whorled (verticillate) branching in *Caulerpa verticillata*; I. Irregularly branching tubular *Ulva*: branches composed of a few cell rows surrounding a central cavity; J. In some taxa (*Euptilota fergusonii*) the main axes can be covered by a rhizoidal cortex.

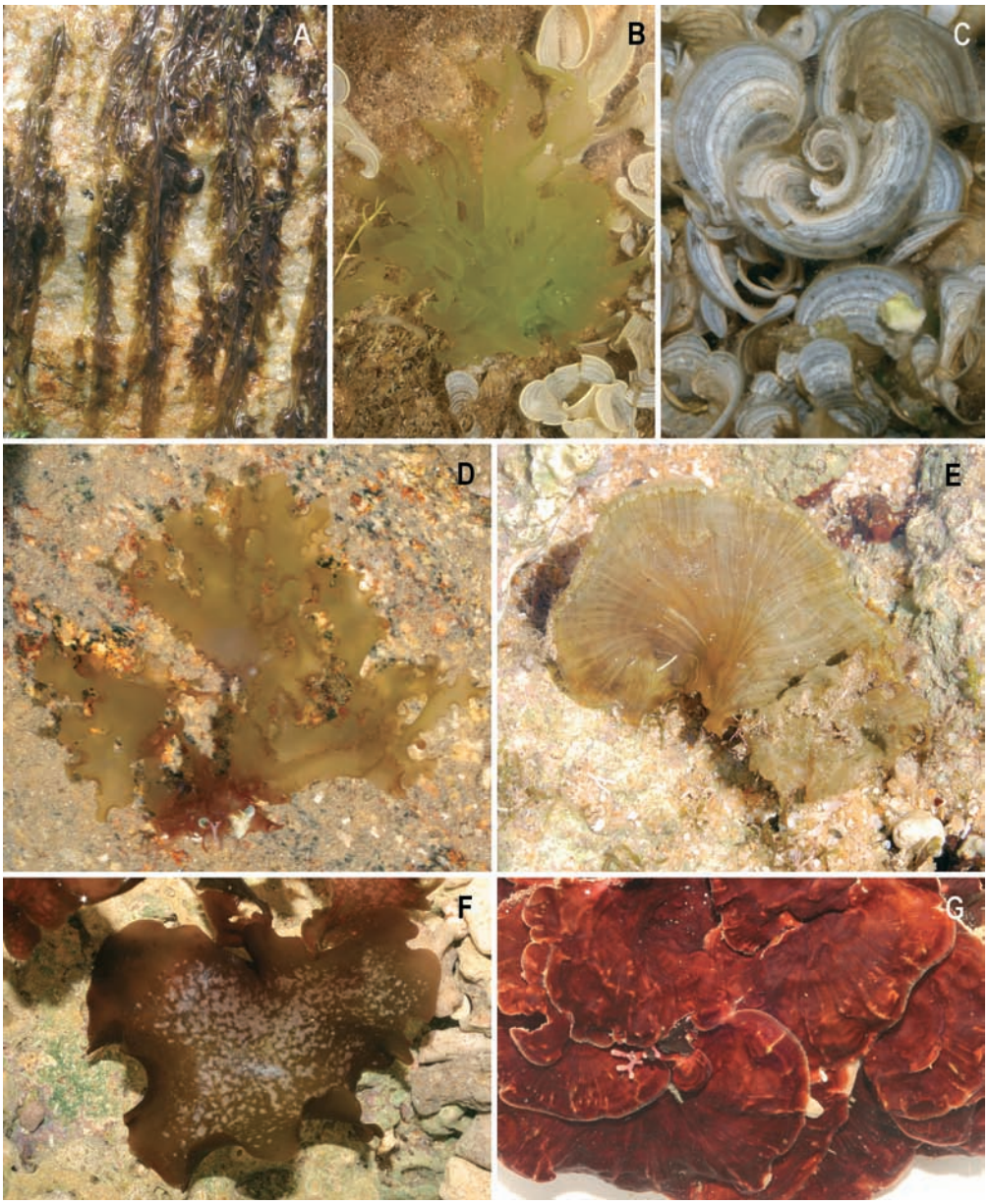


Fig. 37. Seaweed morphology: blades. A, B. Blade-like species can be very thin and membranous, a single cell-layer thick: A. *Porphyra*; B. A blade-like *Ulva*, two cell layers thick, surrounded by blades of *Padina*, 3 to 4 cell layers thick; C. Funnel-shaped blades of *Padina*, 3 to 4 cell layers thick; D. *Nitophyllum marginatum*; E, F. Cartilaginous blades are composed of an internal medulla and an outer cortex: E. *Lobophora variegata*; F. *Euryomma platycarpa* with spotted blades; G. Lobed blades of *Peyssonnelia*.

Fig. 38. Seaweed morphology: strap-like blades. A. *Ulva fasciata*; B. *Polyopes ligulatus*; C. *Halymenia durvillei*; D. *Dictyota ceylanica*; E. *Stoechospermum polypodioides*; F. *Gracilaria* sp.

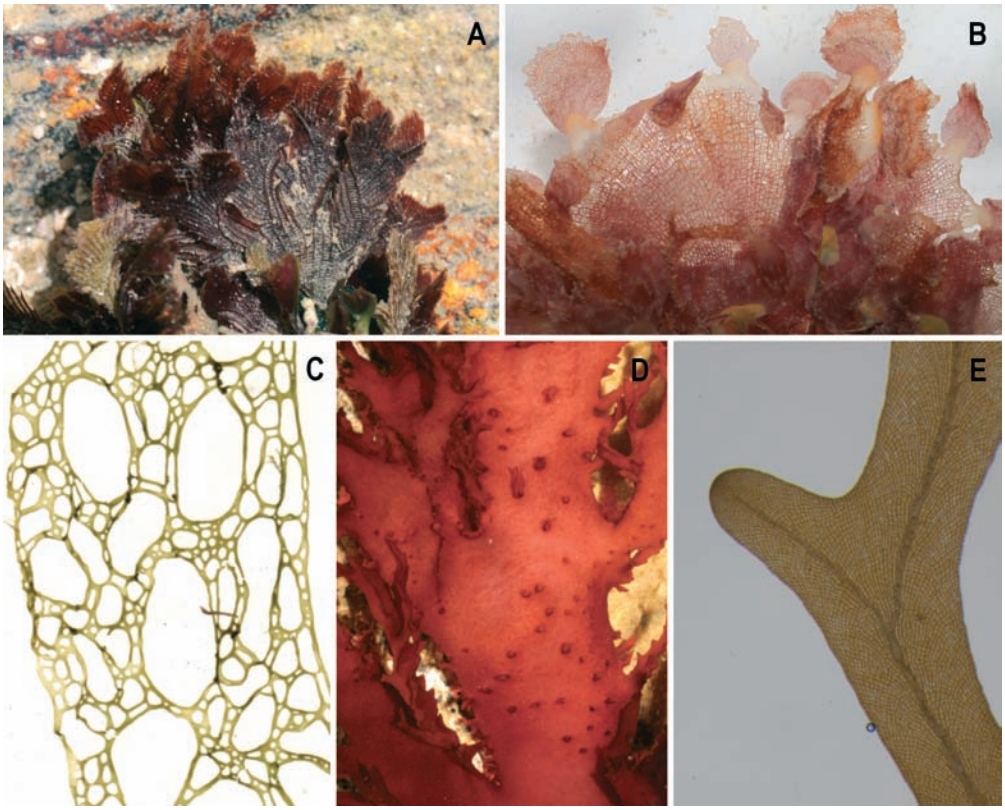


Fig. 39. Seaweed morphology: anastomosing blades; perforations; proliferations; midvein. A, B. The straps can anastomose and form a two-dimensional reticulum (A: *Claudea multifida*, B: *Martensia fragilis*); C. The blades can be (regularly) perforated (*Ulva reticulata*); D. The blades can present surface proliferations (*Halymenia durvillei*); E. Strap-like thallus with midvein (*Dictyopteris delicatula*).

Some seaweeds look like brains (cerebriform): *Colpomenia sinuosa*, Fig. 40A; *Dictyosphaeria cavernosa* (young specimens, Fig. 40B), *Hydroclathrus clathratus* (which is profusely perforated). Others again are composed by large, inflated cells (*Boergesenia forbesii*, Fig. 68; *Valonia* spp., Fig. 40C) or are crustose (like crusts) (*Ralfsia*, Fig. 40D; crustose reds, Figs 40E-G).

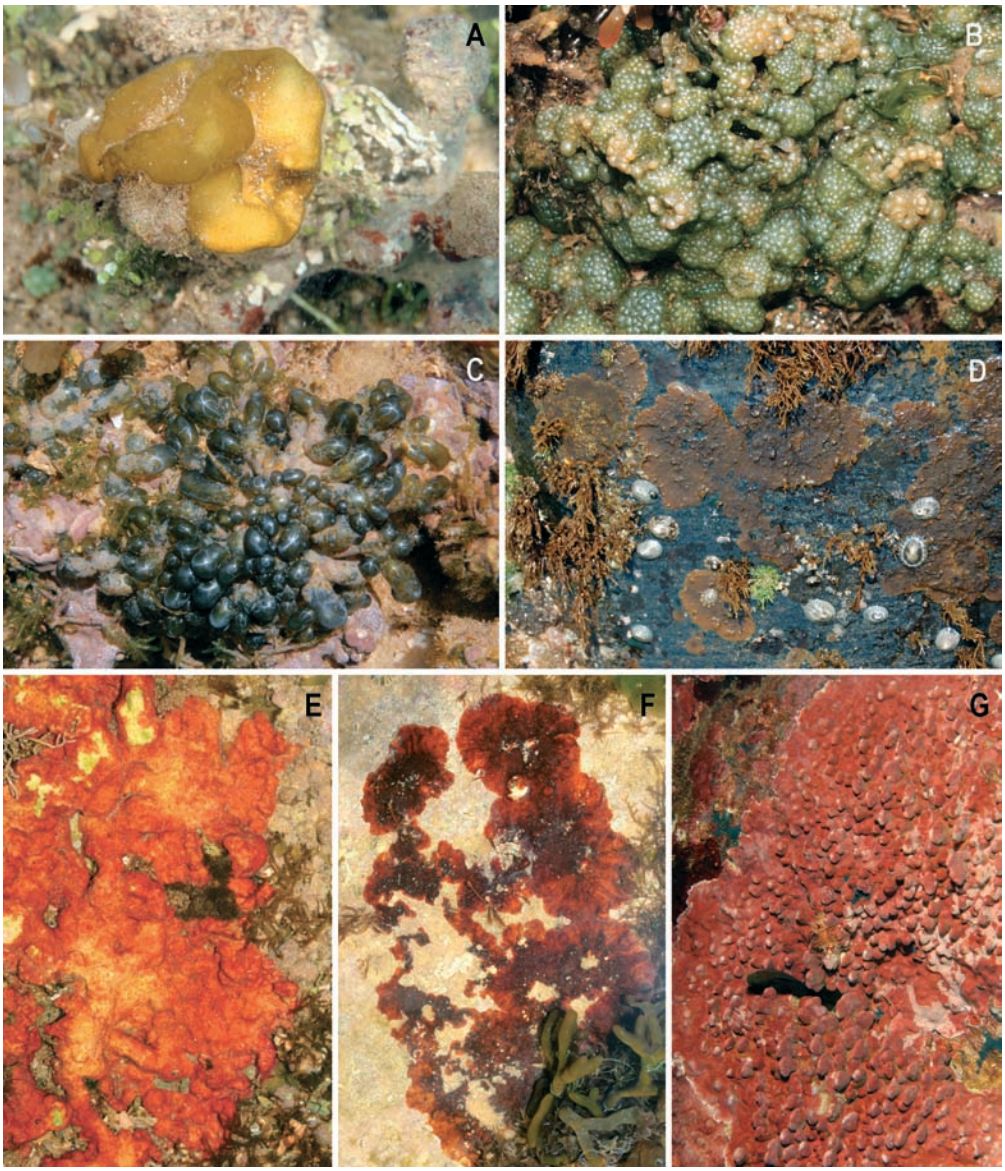


Fig. 40. Seaweed morphology: inflated and crustose. A. Some seaweeds look like brains (cerebriform): *Colpomenia sinuosa*; B. Cerebriform thalli of young *Dictyosphaeria cavernosa*; C. Thalli composed of large inflated cells: *Valonia utricularis*; D-G. Crustose algae: D. *Ralfsia ceylanica* (between *Chnoospora minima*); E-G. Crustose red algae.

The most complex seaweeds are composed by holdfast(s), stipe(s) and frond(s). A typical example of this morphology is the genus *Sargassum* (Fig. 41A). The function of the holdfast is solely attachment (as opposed to roots in higher plants which also play a role in extracting water and nutrients from the soil). It can be rhizoids (thin filamentous structures: *Caulerpa* spp., Fig. 41B). In *Avrainvillea erecta* (Fig. 41C) and *Halimeda macroloba*, these filamentous structures get intricated and hold large amounts of sand, resulting in a 'bulbous holdfast' which is completely sunken in the soft substratum. Attachment can also be performed by a disc (most *Sargassum* spp., most red algae, Fig. 41D). The stem-like portion (stipe) of the thallus can be cylindrical or compressed, unbranched or branched, supple or rigid. It bears one or several blades (the genus *Sargassum*, Fig. 41G) which are wider than the stipe and are the main photosynthetic part of the seaweed. At the basis of the stipe, horizontally spread branches can be present (stolons or rhizomes, Figs 19D, 41E, F), spreading across the substratum, possibly attaching to the substratum again and giving rise to new uprights. In some species (*Sargassum*) the uprights bear air bladders (Fig. 41H) as 'floaters', to keep the plant upright and optimalize the surface for photosynthesis.

Fig. 41. Seaweed morphology: holdfasts, leaf-like structures, air bladders. A. *Sargassum* sp.: a thallus with holdfasts, stipes and blades; B. *Caulerpa sertularioides* with prostrate rhizomes attached by numerous rhizoids; C. *Avrainvillea amadelpha* with a bulbous holdfast composed of intertwined filaments; D. *Halymenia durvillei*: discoid holdfast; E. *Turbinaria* sp. with stolons; F. *Gracilaria corticata*, with basal stolons; G. *Sargassum crassifolium* with leaf-like blades on the stipes; H. *Sargassum crassifolium* with air bladders (aerocysts).

The growth direction of seaweeds can vary: most are erect (*Dermonema virens*, Fig. 42A), at least when they are submerged. Others grow horizontally and mostly have numerous attachment points to the substratum (*Dictyota* sp., Fig. 42B): they are prostrate. Some are horizontally spread in the basal portion, but upwardly curved towards their apices (*Halimeda gracilis*, Fig. 42C): they are ascending, or downwardly curved: they are arcuate (*Valoniopsis pachynema*, Fig. 42D). Others again are horizontally spread from a vertical wall (*Peyssonnelia* spp., some *Halimeda* spp. Fig. 42E): they are resupinate. Finally some seaweeds hang down from vertical or overhanging walls (some *Halimeda* spp., Fig. 42F): they are pendulous.

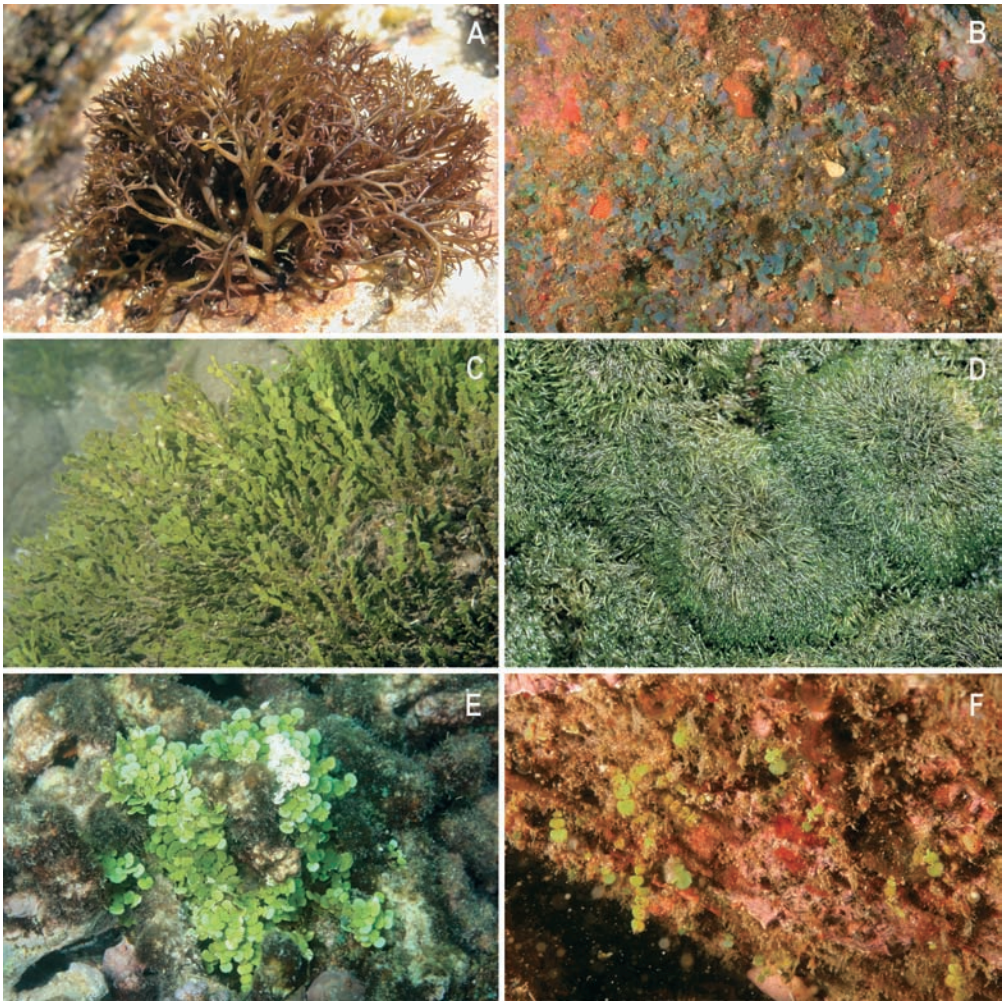


Fig. 42. Growth forms. A. Erect: *Dermonema virens*; B. Prostrate: *Dictyota*; C. Ascending: *Halimeda gracilis*; D. Arched branches of *Valoniopsis pachynema*; E. Resupinate: *Halimeda* sp.; F. Pendulous: *Halimeda* sp. hanging down from an overhang.

Another vegetative character that can be used in some groups of seaweeds is the way of cell division. In most cases, the apical cell undergoes a transverse division, the daughter cells grow longitudinally, elongating the main axes. A successive inclined division at the apical pole results in a lateral branch. If this cell division process is repeated, the result is an acropetal organization of the thallus: the side branches are progressively longer from the apex to the basis (Fig. 43A). In other taxa, intercalary cell divisions occur: older cells undergo cell divisions. This results in a non acropetal organization of the thallus: longer side branches alternate with shorter ones (Fig. 43B). In other green algae, the formation of a transverse wall at the basis of the side branch is delayed (*Cladophoropsis sundanensis*, Fig. 43C). In some green algae (the genera *Siphonocladus*, *Struvea*, *Dictyosphaeria*) a special kind of cell division occurs, called segregative cell division. A multinucleate protoplast divides into several, rounded daughter protoplasts within the mother cell (Figs 43D, E), which subsequently become surrounded by a wall (Fig. 43F). The newly formed cells are either released after rupture of the mother cell (*Valonia ventricosa*), remain *in situ* and form parenchymatic thalli (*Dictyosphaeria* spp.), or rupture old parental walls and form branches (*Struvea* spp., *Siphonocladus* spp., Figs 43G-H). In the genera *Ernodesmis* (Fig. 43I) and *Valonia*, small, lens-like cells are formed at the apex of the mature cells, growing out to new cells.

A major problem in describing or identifying seaweeds is their morphological plasticity. Depending on the ecological conditions, the same species can become larger (in a sheltered lagoon) or smaller (on the seaward, surf-exposed rock wall), less or more densely branched, plane or spirally twisted, without or with hook-like branches. An extreme example is the *Caulerpa racemosa*-complex, where on the same stolon (thus the same individual) the erect branches can have a different morphology from the proximal to the distal part of that stolon. Sometimes the side branchlets of a single upright can be different from the basis to the tip, being cylindrical at the basis, club-shaped higher up, becoming turbinate or even peltate at the tip. As the morphology of these side branchlets has been used in the past to describe taxa (species, varieties or forms), the presence of a mixture of morphologies creates major identification problems. Other seaweeds change their morphology by ageing or show sexual dimorphism (the genus *Sargassum*, *Boodlea composita-Phyllodictyon anastomosans* complex).

On the other hand, molecular systematics frequently points out to ‘cryptic diversity’: seaweeds with a similar morphology appear to belong to different taxa, based on the DNA-information. As a result, new species will have to be described, preferably with (at least) a distinguishing morphological or anatomical character or a different geographical distribution (the different taxa being present in different oceans).

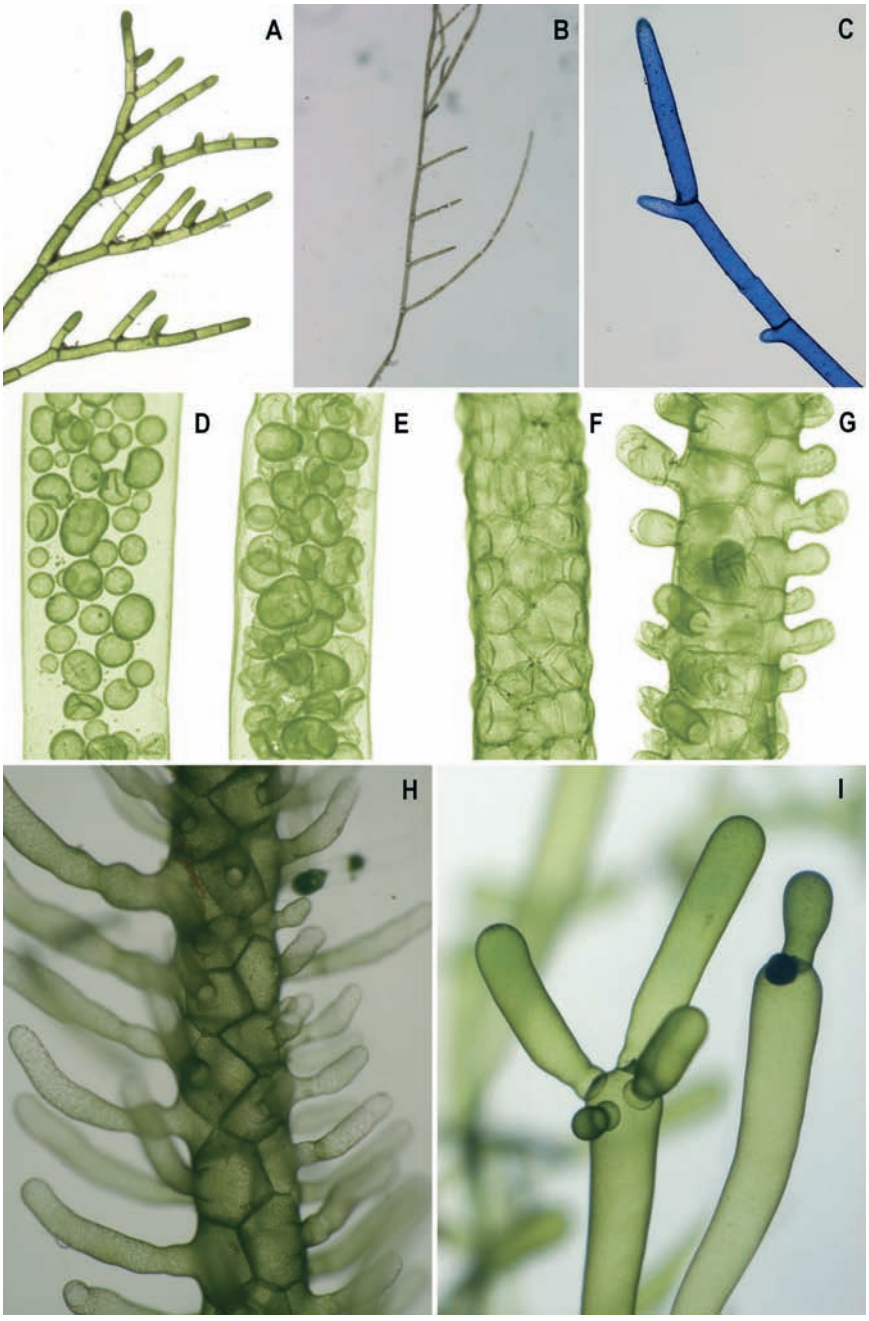


Fig. 43. Cell division. A. Acropetal organization: the branchlets gradually become more developed proximally; B. Non acropetal organization, with short branchlets alternating with longer ones (*Cladophora sericea*); C. Postponed transverse cell wall formation after the formation of a lateral branch (*Cladophoropsis sundanensis*); D-G. Segregative cell division in *Siphonocladus* sp.; H. Final stage of segregative cell division: numerous side branchlets growing out of the parental cell; I. Formation of apical lenticular cells from where new cells grow out (*Ernodesmis* sp.).

8.4. Life histories and reproduction

Life histories in seaweeds are complex; moreover they vary among and even within groups. Therefore only a general scheme can be given here, although characters of the reproductive structures can be critical for the identification on species or even on genus level. In most green and brown algae there is an alternation of two generations: the haploid gametophytes and the diploid sporophytes. The gametophytes produce gametes in gametangia, specialized structures which, in general, can only be observed by microscope. In several brown algae however, where reproductive structures are often grouped in sori (*Dictyota* sp., Figs 44A-D) or in receptacles with gametangia in *Sargassum* sp. (Fig. 44E) and *Turbinaria* sp. (Fig. 44F) which can be observed with the naked eye. The male and female gametangia are mostly produced on different plants, but in some cases they are both present on the same plant. The gametes will fuse and produce a diploid zygote which germinates into a diploid sporophyte. On the sporophyte, meiosis takes place and haploid spores are produced (*Dictyota* spp., Figs 44G, H), developing into new gametophytes. In some rare cases (*Codium* spp., *Caulerpa* spp.), the life cycle is reduced to a single diplont generation, the only haploid stages being the gametes. Moreover, in the genera *Halimeda, Caulerpa* and other green algae, the whole cytoplasmic content of the thallus is being transformed to gametes (= holocarpy, Fig. 44I).

In red algae, the life history is even more complex by the addition of a third generation: fertilisation of the female gamete (carpogonium) attached on a carpogonial branch, is performed by a male gamete (spermatium), produced in a spermatangium (Fig. 45A); spermatangia can be grouped in sori (Fig. 45B). The diploid zygote remains attached to the haploid female gametophyte and develops in a diploid carposporophyte. This part of the life history (a generation) usually has only small dimensions, but generally visible with the naked eye, as globular structures, called gonimoblasts (Fig. 45C) or as lateral, ball-like structures, called cystocarps (Figs 45D-F). In some cases, the cystocarps are embedded in the thallus and therefore more difficult to see in the field. The carposporophytes produce diploid carpospores which germinate after liberation into tetrasporophytes in which meiosis takes place with the production of haploid tetraspores (Fig. 45G) which in some cases can be grouped in stichidia (Fig. 45H) or in sori (Fig. 45I). The tetraspores germinate into haploid gametophytes. In most of the red algae, the life cycle thus consists of three generations, of which the gametophyte and the tetrasporophyte are often (almost) identical. In some cases (*Asparagopsis taxiformis*), the tetrasporophyte (*Falkenbergia hildenbrandii*) is markedly different from the gametophyte (Fig. 45J). In the past, both generations of that seaweed have been described as different algae, placed in different genera, as phycologists then were unaware of the fact that they represent two phases of the same seaweed. It is only after culture experiments in aquaria that this was discovered. In some brown (*Sargassum*) and red algal genera (*Liagora*) one of the phases can be microscopic or crustose.

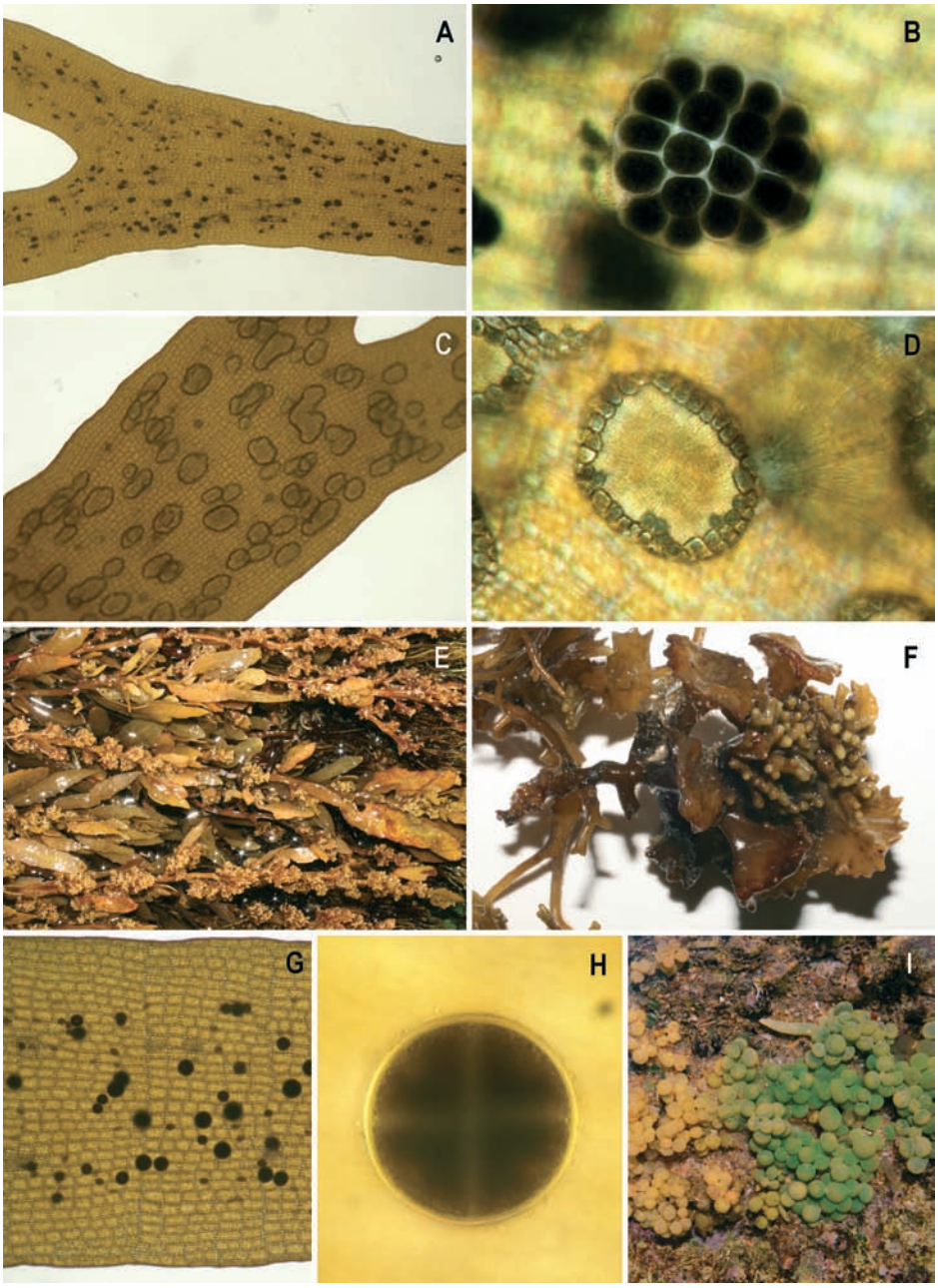


Fig. 44. Reproduction structures in brown and green algae. A. Sori of female gametangia (oogonia) on the haploid gametophyte of a *Dictyota*; B. Detail of a sorus of oogonia of a *Dictyota*; C. Sori of male gametangia (spermatangia) on the haploid gametophyte of a *Dictyota*; D. Detail of a sorus of spermatangia of a *Dictyota*; E. Receptacles of a *Sargassum*, containing the gametangia; F. Receptacles of a *Turbinaria*, containing the gametangia; G. Tetrasporangia on the diploid sporophyte of a *Dictyota*; H. Detail of a cruciately divided tetrasporangium of a *Dictyota*; I. A *Caulerpa*-plant in which the formation of gametes is taking place (the yellowish part of the thallus).

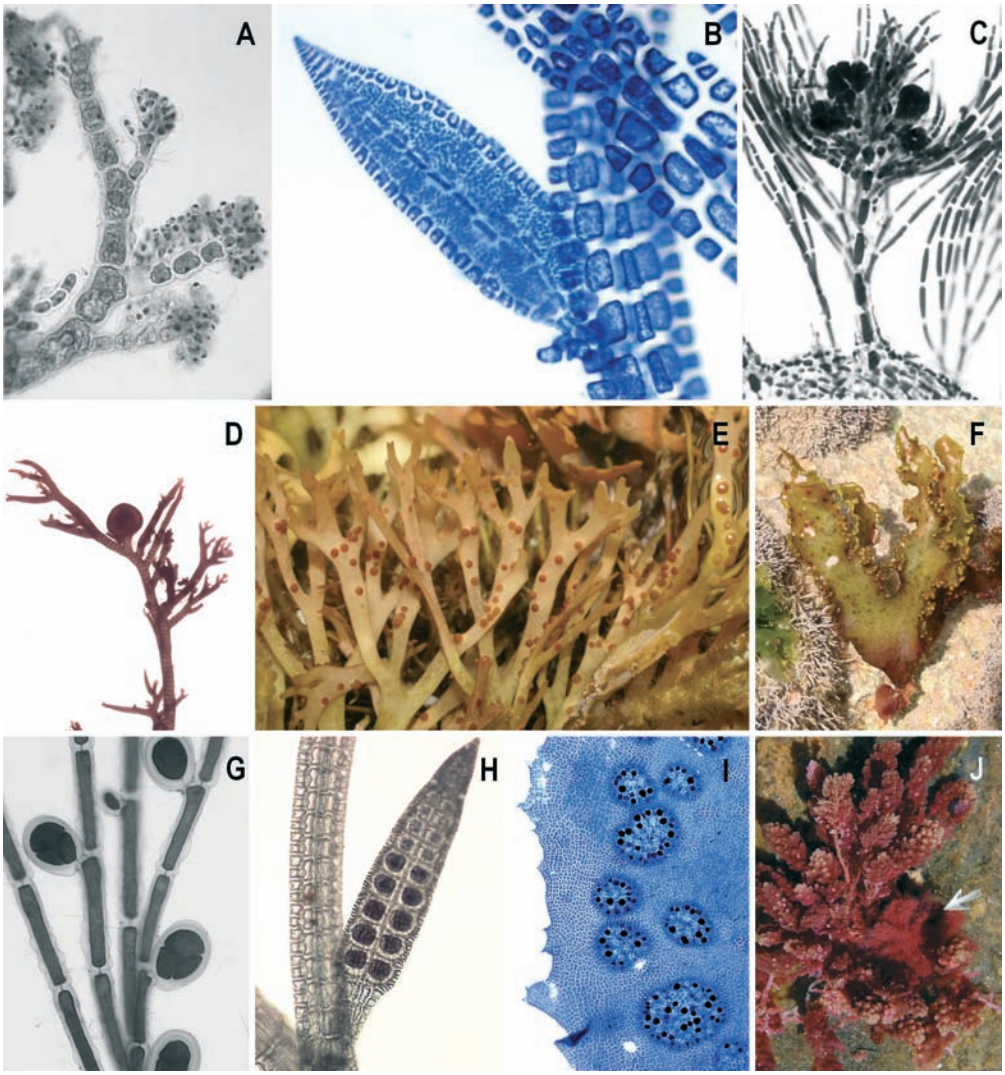


Fig. 45. Reproduction structures in red algae (mainly shown by African examples). A. Spermatangia in *Sciurothamnion stegengae*; B. A sorus of spermatangia in *Platysiphonia delicata*; C. Gonimoblasts (groups of diploid carpospores) in *Sciurothamnion stegengae*; D. A cystocarp on *Rhodomelopsis africana*; E. Cystocarps as wart-like protrusions on *Gracilaria corticata*; F. Cystocarps (mainly) on the margin of the female blade of *Sarcodia montagneana*; G. Tetraspores in *Sciurothamnion stegengae*, produced after meiosis in tetrasorangia on the diploid sporophyte; H. Tetrasporangia in a stichidium of *Platysiphonia delicata*; I. Sori of tetrasporangia in *Augophyllum marginifructum*; J. *Asparagopsis taxiformis*: the large gametophyte with cystocarps and the filamentous tetrasporophyte (*Falkenbergia hildenbrandii*) in the centre (arrow).

Reproductive structures, or even the presence of a particular life history phase, are generally seasonal. It is therefore imperative to carry out collecting in different seasons as reproductive characters are mostly needed for correct identification (as flowers are in higher plants).

Many seaweeds also reproduce asexually (without formation of gametes), by the production of asexual spores. Some even multiply vegetatively, by fragmentation (some branches break off, stay alive, attach to the substratum and go on growing to new plants) or by production of propagules (*Sphacelaria* spp.: branchlets with a special morphology, detaching from the mother plant and each of them producing a new juvenile; Fig. 104). Others again, growing in soft substratum, can produce underground, horizontally growing bundles of rhizoids from which new erect plants develop (genera like *Udotea*, *Halimeda*, …).

8.5. Biodiversity of seaweeds

In most biodiversity studies the algae are omitted, probably because they are 'invisible' as a result of their submersed habitat. The total number of species of algae is difficult to assess: the important environmentally induced morphological plasticity and variability results in major identification problems: some entities are classified on different taxonomic levels, depending on the author (species, variety, form). The total number of Algae [including (freshwater) microalgae] would be approximately 350 000 spp. (Brodie & Lewis, 2007).

Some areas in the world are more species rich than others. In the Pacific Ocean, species-rich areas are the Philippines and Japan; in the Atlantic Ocean: Europe (N-Spain, France, United Kingdom), the Caribbean Sea. The Red Sea and the Indian Ocean are still understudied, but South Africa and southern Australia seem to have a high seaweed diversity. In South Africa this could be the result of the presence of different climate zones.

Maximum seaweed endemism is present in Antarctica, southern Australia and New Zealand.

Based on data from the literature, Silva *et al*. (1996) mention 455 taxa belonging to 410 species and 161 genera for Sri Lanka. However, as already mentioned in the chapter on the history of seaweed research in Sri Lanka, this island is absolutely understudied. Historical collections from sublittoral biotopes are sporadic, and recent ones are still under study. A study by Mallikarachchi (2004) shows that a large percentage of the known seaweed flora of the island is present along a limited SW-shoreline. This conclusion is partly biased as this part of Sri Lanka has been most frequently visited by phycologists, whereas collections from the N and East coast are scarce and therefore even more fragmentary.

Smaller species (such as turf-forming algae and epiphytes) are more numerous, adding to the species diversity, but they are not readily observable/identifiable and therefore most of these are not included in this Field Guide.

8.6. Nomenclature, taxonomy and classification of seaweeds

The nomenclature of algae (giving scientific names to organisms and groups to which they belong), similarly to higher plants, follows the International Code of Botanical Nomenclature (ICBN, 2006). Macroscopic seaweeds belong to 4 Divisions (or Phyla) if the blue-greens are included: Cyanophyta (Cyanobacteria) - Blue-green algae (prokaryotic), Chlorophyta - Green algae, Phaeophyceae - Brown algae, Rhodophyta - Red algae. The divisions are subdivided in classes, which names end on -phyceae (exclusively for Algae). The classes contain orders, ending on -ales, subdivided in

families, ending on -aceae. The nomenclature in botany (including flowering plants, ferns, mosses, algae and fungi) is binomial, meaning that the name is composed of two words: the genus name (e.g. *Rhodymenia*), with a capital initial followed by the species epithet (e.g. *Rhodymenia tripinnata*) written in lower case. The genus and species names are usually written in italics. They are followed by the name of the author who described the species (e.g. *Rhodymenia tripinnata* Hering). Sometimes, further research shows that the original author placed the species in a wrong genus. In this case, the name of the first author is placed between brackets and the name of the author who makes the new combination (putting the species in the correct genus) is added (e.g. *Portieria tripinnata* (Hering) De Clerck). In some species, subentities (infraspecific taxa) are distinguished which are called varieties (var.) or forms (f.), the names of which are again usually written in italics.

When proposing a new species, a type specimen is designated after which the species is described. For seaweeds this is generally a herbarium specimen, which is then deposited in a registered herbarium. Quite frequently isotype specimens are deposited in other important herbaria. These isotype specimens were collected at the same type locality (place where the type specimen is coming from), on the same day as the type specimen and were regarded as 'duplicates' by the original author (= form part of a single collection). Type specimens are extremely important for subsequent studies of the species (checking for new characters, for DNA-analysis, …). Preferably, several specimens should be mounted on a 'type sheet', with the indication of the real type specimen, the holotype, as to show the morphological variation of the species (sometimes gametophytes and sporophytes are (slightly) different, or different ecological situations induce a morphological change).

The description of a new species of seaweed has to include the reference to the type specimen as well as a diagnosis in Latin (what are the characters of this species, distinguishing it from other species of the same genus). Illustrations also have to be added.

Subsequent analysis sometimes indicate that two 'species', each with their own name, described from different areas (even from different oceans) are identical. Only a single name can be applied for that species, and the name from the oldest description has to be chosen; the other name then becoming a synonym. Opposite to this, molecular analysis sometimes proves that a species, present in different oceans (with a similar morphology at the different locations), belongs to different species according to the locality (cryptic species). The specimens from the type locality then keep the original name, whereas the other ones have to be described as new species. A thorough study of morphological and anatomical characters then 'hopefully' leads to discriminating characters for each species. All this means that names of seaweeds change in time and that the same taxon can have different names in different books, depending on the time of publication. If one is compiling a species list from a region, he should be aware of these synonymies for not including the same species several times under different names.

As a result of ongoing molecular research, the higher rank classification of seaweeds also changes on a regular basis. We here follow the Index Nominum Algarum (http://ucjeps.berkeley.edu/INA.html) and Guiry & Guiry (2009; www.algaebase.org) which are both excellent sources for keeping up with recent taxonomic revisions as they are

continuously updated (see remark at introduction of Rhodophyta). Silva *et al*. (1996, http://ucjeps.berkeley.edu/rlmoe/tioc/ioctoc.html) is also an excellent basis to find synonymies, taxonomic remarks, and a systematic classification of the seaweeds of the Indian Ocean. Be aware, however, that since 1996 a surprisingly large number of names have changed already.

As opposed to terrestrial plants, seaweeds rarely have common (vernacular) names. Moreover, they sometimes induce confusion, such as 'Ceylon Moss' which is not a moss at all, but a red alga, *Hydropuntia edulis* (not included in the present book).

8.7. Identification of seaweeds

If possible, one should start by following a training course where specialists can introduce you to the most common genera and species of the area. If this is not possible, Field Guides on the area (such as this book) or from the same ocean or from an adjacent tropical region should be used. They are becoming more numerous nowadays. Useful recent guides for Sri Lanka are: Huisman (2000) on Marine Plants of Australia, Littler & Littler (2003) on South Pacific reef plants, De Clerck *et al.* (2005a) on the seaweeds of Kwazulu-Natal, Oliveira *et al*. (2005) on Marine Plants of Tanzania, Huisman *et al*. (2007) on Hawaiian Reef Plants, Ohba *et al*. (2007) on Marine Plants of Palau, Skelton & South (2007) on Samoan Benthic Marine Algae. For the identification of red turf algae, Price & Scott (1992) is very useful. Anyway, one should remain cautious with identifying organisms solely based on field guides: as opposed to a real 'Flora' they only contain the dominant species! The possibility that a different, closely related species was collected cannot be excluded. Therefore, the next step is the use of (preferably recent) monographs of a group (e.g. De Clerck, 2003 on the genus *Dictyota* in the Indian Ocean, or Leliaert & Coppejans, 2006 on the genus *Cladophoropsis*) or detailed regional publications (e.g. Van den Heede & Coppejans, 1995 on the genus *Codium* from Kenya, Tanzania and the Seychelles; Kraft, 2007 on the marine green algae of the Lord Howe Island area), as well as comparison with specimens from existing herbaria with trustworthy identifications.

Anyway, for the identification of macroalgae on species-level, morphological and anatomical characters are needed (e.g. in the genus *Codium*, measurements of utricles have to be made; in *Ulva* spp., the number of pyrenoids per cell have to be counted, …). In brown and red algae, quite often the analysis of reproductive structures is important for identification on genus and/or species level (just like flowers in higher plants!). The analysis of these characters can only be carried out in a laboratory, with the use of a microscope with a calibration plate. Sterile specimens therefore frequently remain unidentified because critical characters for species (or even genus) distinction are absent.

8.8. Seaweed resources from Sri Lanka

Natural populations of the red alga Ceylon Moss (*Hydropuntia edulis* (S.G. Gmelin) Gurgel et Fredericq) were harvested in the past for extraction of agar from its cell walls. This seaweed is quite abundant in Puttalam lagoon, but it is not collected anymore and not included in this guide.

9. Survey methods for seaweeds

For this chapter we also refer to Leliaert & Coppejans (2004); http://www.persga.org/.

9.1. Qualitative assessment of the macroalgal flora of an area

Qualitative assessment of the marine flora of a coastal area implies general collecting in a specific area, resulting in a more or less complete list of species. Depending on the study, the coastal area can vary from a small area (e.g. a coastal strip of 10 m, a rock outcrop, etc.) to a large area (e.g. one to several km of coastline, a small offshore island, etc.). When comparing species numbers or biodiversity indices of different coastal areas, these areas should be of comparable size. The resulting species list is important for calculating biodiversity indices of an area. A major disadvantage of qualitative collection data is that species abundance is not taken into account. This can partially be corrected by making the sampling method semi-quantitative. This implies that each species is ranked based on its abundance, evaluated by visual observations. An example of such a ranking is the Tansley scale (Table 1 in Appendix). The growth form (sociability) of the seaweeds can also be taken into account; here the Braun-Blanquet's sociability scale can be used for each species (Table 2 in Appendix). As a matter of fact, Braun-Blanquet's cover-abundance scale is most used (Table 3 in Appendix). These data can be added on the herbarium labels.

9.1.1. Getting ready for fieldwork

It is evident that adapted clothing (protection against the sun/rain) is needed. In this respect good footwear is extremely important. The use of booties (tight, ankle-high, rubber boots with a thick sole and a zipper) is advisable, as well on rocky as on sandy or even muddy substratum, because they completely protect the feet against sharp obstacles (barnacles, oysters, coral fragments, …). If snorkeling is planned, a (thin) rubber wetsuit is useful for protection against sharp walls or irritating animals (jelly fishes, siphonophores, …), or at least knee pads. The availability of a towel also comes out handy.

The value of a report/publication on the biodiversity of an area largely depends on the presence of reference (voucher) specimens which allow ulterior control of the identifications. On its turn, the value of these specimens depends on the field data which are added to them. Therefore, a notebook (intertidal work) or a white plexiglass plate (in the subtidal and in intertidal pools) and a pencil are indispensable (Fig. 46A). Collecting gear includes a bucket, plastic vials, plastic bags, prenumbered labels on hard paper. Many algae and some seagrasses can be removed by hand, but a scraper or a stout knife may be handy or even necessary. Some thick encrusting algae can be removed with a knife, but many (especially the crustose coralline algae) must be collected along with the substratum. This can only be done by use of a heavy instrument such as a hammer and a chisel.

Fig. 46. Field work. A. Using a plexiglass plate and a pencil for taking notes in the water; B. Collecting by wading at low tide; C. Even with a seemingly smooth sea, a sudden big wave can emerge; D. Fully equipped for SCUBA-diving and underwater photography; E. Putting specimens in zip-lock bags during SCUBA-diving; F, G. Sorting out specimens on the field.

If available, a camera, a map, and a Global Positioning System (GPS) can be extremely useful. Be careful in this wet environment: put them in a watertight camerabox or (ziplock) bags!

Intertidal habitats can be sampled by wading (Fig. 46B) during (extreme) low tide or by snorkeling at high tide. Therefore, check the time of low tide as to get organized for the sampling. If snorkeling is planned (deep intertidal pools or subtidal) mask, snorkel, fins, mesh bag, plastic collecting bags and labels shouldn't be forgotten. For

extensive collecting or observation in the subtidal, SCUBA diving is advisable. Next to the snorkeling gear, a rubber suit, a belt, weights, the full air-cylinder, regulator, diving watch, depth gauge, inflatable backpack (= BCD, buoyancy control device), and a buoy should be brought or hired at a diving center (Figs 46D, E). These generally check the diving license, so don't forget to bring it.

Freshly collected specimens should be processed as soon as possible to minimize decay. If the way back to the laboratory is long, the specimens might decay under way. It then is preferable to prepare the collected specimens in the field (Figs 46F, G) or to store them in a cool box. If specimens are sorted at the collecting site, bring sorting and preparation trays, a floater, herbarium paper, a plant press with straps, card board, newspaper and fleeces, jars (Eppendorfs) and silicagel, formalin, zip-lock bags and hermetically closed jars (e.g. ice cream boxes).

9.1.2. Arriving in the field

Note the date, the locality (name of the closest town or village + eventually local name of the collecting site). If you have a GPS-system: add the GPS and longitude-latitude coordinates.

Make a general description of the site: is it a peninsula (Fig. 6B), a straight coastline, eventually with a beachrock platform (Fig. 4), a wide bay (Fig. 3B), an enclosed bay (Fig. 3C), isolated rocky outcrops (Figs 7C, D), an island (Figs 7B, C), a lagoon (Fig. 3D)? Describe the substratum: solid rock (Fig. 6A), boulders (Fig. 6C), sand, mud. Rate the general coast inclination: overhanging, vertical, sloping, subhorizontal. Give a general description of the biotope(s): seaweed vegetation (Fig. 6C), seagrasses (Figs 12A, B), mangrove (Figs 13A-C), coral reef (Fig. 7E).

Eventually add pictures.

9.1.3. Field collecting

Extensive and well-prepared collections are the basis of diversity based studies of (marine) organisms. The importance of good collections for taxonomic studies is evident, but it is equally important that representative collections - often referred to as voucher specimens - be kept of each species recorded in ecological surveys. Without such specimens, there is little or no possibility of later checking on the basis of names used in publications. Such specimens should be numbered, labeled and be deposited in a recognized herbarium (Womersley, 1984).

Take the time of low tide into account, certainly if you want to collect by wading. If it is already low tide upon arrival, go to the lowermost part first and come up with the tide. Take care not to get encircled by water. If the tide is still going down, go down with the tide and do the uppermost parts on your way back.

Collecting can be done by species (a single species and label per bag: numerous bags will be needed, but sorting out will be much easier); note the field identification of each number. Sometimes preference is given to collecting by biotope (a pool, a rock wall, a phorophyte: several species in a single bag, but with a single label). In species-rich areas or time shortage the latter method is being used. Always add ample seawater in the bags as to avoid decay by temperature rise or desiccation. Also add a label, which corresponds with a number in your note book (plexiglass plate) where you add: the detailed ecology of the collecting site (air-exposed/submerged at low tide;

pool: vertical/overhanging/sloping wall/(sand-covered) bottom; epilithic/epiphytic (on what?); the level relative to the tides (above high tide level (supralittoral); between high and low tide (intertidal (high -, mid -, low -)); under low water mark (subtidal)). Make notes on morphological characters which will be lost after processing the specimens, such as growth form (isolated plants, individual tufts, gregarious, forming intricated cushions); growth direction (erect, ascendant, prostrate, pendulous); *in situ* colour: some seaweeds are iridescent when alive; some seaweeds change colour upon drying; consistency: membranous, gelatinous, cartilaginous, stiff, brittle; eventually, presence of reproductive structures.

ALWAYS collect several specimens as to illustrate morphological variability and to be able to look for fertile specimens. ALWAYS collect complete specimens, including the holdfast as this might be a character needed for identification: presence of a disc, haptera, rhizoids, a bulbous structure.

While collecting, be aware of possible danger: even with a seemingly smooth sea, a sudden big wave can emerge (Fig. 46C).

9.1.4. Coming back from the field

If the laboratory is far from the sea and not provided with seawater, collect a (plastic) drum with seawater for sorting out the specimens, or … sort out in the field! (Figs 46F, G).

9.1.5. Sorting out the specimens

If the species have been collected individually, put them in separate trays (vials) and add the field number. If the collecting was made by collecting site, put the collection of one bag and its label in a large tray and sort out the different species in smaller trays (vials) giving them each a subnumber (e.g. collection from site 3: species 3a, 3b, 3c, 3d) (Fig. 47A).

9.1.6. Finally numbering and labelling the species

Copy the data from your field notebook or from the plexiglass plate on the computer or in the final notebook: date, place, general description of the site.
Each species gets a final serial number, preferably preceded by the collector's initials (e.g. HEC = Herbarium Eric Coppejans). Start with 0001 and go on all of your life: e.g. day 1: HEC 0001-0024, day 2 HEC 0025 – 0056 and so on). Add the detailed ecological data from the field as well as the morphological data (eventually add observations carried out in the laboratory). A HERBARIUM SPECIMEN WITHOUT A (complete) LABEL IS SCIENTIFICALLY (almost) USELESS!

Individual labels are printed out and added to the herbarium specimens. All these label data are introduced in a database. This way data can be retrieved by: collector, place, period, genus or species level (over different regions, oceans); herbarium, formalin preserved, silicagel, culture specimens.

The final label

Number: HEC 16128 (eventually +F, +S, +L; see further)
Name: *Caulerpa racemosa* (Forsskål) J. Agardh
Locality: Sri Lanka, Galle, in front of the lighthouse
Collection date: 15 August 2008
Ecology: on the sand-covered bottom of a low intertidal pool
Morphology: thallus fleshy, dark green, with starlike, slightly iridescent light green stripes; well attached to the substratum by numerous rhizoids; stolons prostrate, intricated; uprights with short rachis and densely set vesicular branchlets, resulting in a grape-like appearance
Collector: Eric Coppejans
Identification: W.F. Prud'homme van Reine (+ date of identification)

9.1.7. Preparation of a herbarium specimen

- Take a tray and fill it with clean SEAwater;

- Put a (cork)floater in the water (or an inclined smooth surface; Fig. 47B);
take a bristol card (or strong drawing paper) of the size adapted to that of the specimen that you want to prepare;

- Write the serial number IN PENCIL in the right down corner;

- Put the bristol paper and the seaweed in the tray, on the floater (Fig. 47C);

- Choose (a) nice, complete specimen(s) (with holdfast; eventually fertile);

- Arrange the specimen(s) in an optimal way, by pushing the floater under water (Figs 47D, E); filamentous, supple specimens can be spread by a small brush;

- Take the floater, bristol card and specimen slightly inclined out of the water and let the surplus of water run off (Fig. 47F);

- Put the bristol card + specimen on a newspaper on a horizontal surface and let it air-dry somewhat (Fig. 47G); don't leave it in the sun and don't wait too long: the specimens should not shrivel!

- Put the air-dried specimens between newspapers, covered by a fleece (Figs 48A-E), preferably regularly alternated by corrugated cardboard (for aeration);

- Close the plantpress with belts or put weights on them (Fig. 48F);

- Keeping the plant press in the sun or adding a ventilator directed on the press increases the drying speed, avoiding molding of the specimens; NEVER put the plant press in an oven (unless it is a drying oven with ventilation)!

- Change the newspapers (not the flieces) daily until the specimens are dry;

- Mount the herbarium specimen on standard dimension sheets (eventually stick the loose plants with glued paper strips, never directly with glue; certainly don't plastify them!!!) together with the label (Figs 49A, G);

- Store in a dry room, sheltered from direct sunlight (Figs 49B-F).

Fig. 47. Preparing herbarium specimens. A. Sorting out specimens in trays filled with seawater; B. The cork floater in the tray filled with seawater; C. The numbered bristol card on the floater; D. Arranging the specimens of the bristol card; E. Specimens arranged on the bristol card, on the floater, still in the tray with seawater; F. Taking the floater and the bristol card with specimens out of the water, letting drip off most of the water; G. The bristol card with specimens is (shortly) air dried.

Fig. 48. Preparing herbarium specimens. A. In the plant press a corrugated cardboard and dry newspaper is placed; B. Placing the bristol card with specimens on the newspaper; C. Putting a fleece on the specimens; D. Adding a newspaper on the fleece; E. Adding a corrugated cardboard on top; F. Closing the plant press.

Fig. 49. Storing specimens. A. Example of a seaweed herbarium specimen (*Grateloupia lithophila*) and label in the ring binder at the GENT herbarium; B. The National Herbarium of Sri Lanka in Peradeniya; C. The inside of the National Herbarium of Sri Lanka; D. The cupboards where the specimens are kept in the National Herbarium of Sri Lanka; E. Cupboard with the large herbarium specimens at the GENT herbarium; F. Cupboard with smaller herbarium specimens classified in ring binders at the GENT herbarium; G. A mounted specimen of *Acrosorium ciliolatum* (Harvey) Kylin, with field identification on the full label and final identification on the 'Determinavit-label'.

9.1.8. Formalin-preserved specimens

Most herbarium specimens can be resoaked for anatomical analysis, but most of the time cells remain shrivelled and cytological details (e.g. plasts) difficult to observe. Therefore it is better to keep (part of) a specimen in 4% formaldehyde (pure formalin = 40%, so 1 part of formalin + 9 parts of SEAwater; the concentration is not critical and even half the above will usually give good preservation). Add the same label (number) as the serial number of the herbarium specimen and add '+F' on the herbarium label and in your data set as to indicate that there is a formalin-preserved specimen.

Formalin is a strong irritant and carcinogenic and therefore should be handled with care, avoiding inhalation or direct contact with the skin. Store the formalin preserved specimens in hermetically closed vials, out of the light, in a (preferably cool) room with ventilation and NEVER in a room where persons are working on a regular basis (separate store room)!!!

9.1.9. Silica-preserved specimens

Fragments of most herbarium specimens can be used for molecular analysis (in as far as they have not been previously stored in formalin), but most of the time results are (much) better when fragments are immediately dried in silicagel. Therefore, Eppendorfs are being used, (almost) filled with fine-grained silicagel. The Eppendorfs should be kept closed at all times, otherwise the silicagel would attract air humidity. Only a small fragment (a few mm only) of an apical part of the specimen should be cut off and cleaned and dried with a paper tissue. The young apices are less epiphytized but still have to be cleaned as to remove the eventual single-celled epiphytes (e.g. diatoms). The fragment is put in the Eppendorf and a tiny label with the same serial number as the herbarium specimen is added (Fig. 50A). The Eppendorf should be closed immediately (Fig. 50B) and somewhat shaked, as to completely surround the fragment by silicagel: the quicker the drying process, the better the molecular extraction will proceed. Some scientists prefer to dry two fragments for the case that the DNA-extraction on the first fragment didn't succeed. It is useful to indicate on the top of the Eppendorf that it has been used (Fig. 50C). On the herbarium label and in the data set '+S' should be added as to indicate that there is a silicagel-preserved portion. Of course this should be deleted from the data set as soon as the fragment(s) have been used.

Fig. 50. Silicagel dried specimens. A. Putting a specimen in a labeled Eppendorf; B. Closing the Eppendorf; C. Indicating that the Eppendorf has been used.

Molecular techniques are outside the scope of this field guide. For details we refer to Hillis & Moritz (1996).

9.1.10. Living specimens

Sometimes, research is carried out on living specimens. They are put into culture for the study of life cycles, cell division, morphological variation in response to temperature, light, salinity, eutrophication, ... Therefore, small fragments (e.g. an apical branch) are isolated, delicately cleaned (to take away most of the epiphytes) and put in a large amount of seawater (+ same serial number as the herbarium specimen). In the laboratory, the fragments are brought in special vials (depending on the size of the seaweed), with enriched seawater. Depending on the research to be carried out they are brought into culture rooms with controlled light intensity, light cycle, temperature, … This is a very intensive and time-consuming work as contamination by Bacteria or microalgae has to be checked continuously. On the herbarium label and in the data set '+L' should be added as to indicate that there is a living portion in culture. Of course this should be deleted from the data set as soon as the fragment died or is not kept in culture anymore. For further information on algal cultures, we refer to Andersen (2005).

9.1.11. Important remark

Although seaweeds are not included on the CITES-list of protected organisms, most countries require official authorisations for the export of specimens. The administration of an export permit can take up to several months. Furthermore, one should pay attention to import regulations specific to certain countries which may prohibit bringing living as well as dead plant material into the country (e.g. Australia, New Zealand). Therefore, inform yourself well and take care of starting up the necessary procedures well in advance.

9.2. Quantitative assessment of the macroalgal and seagrass flora of an area

For this chapter we refer to Leliaert & Coppejans (2004).

10. Divisions of Algae from Sri Lanka and general remarks

Voucher specimens of the taxa included in this Field Guide, collected by Eric Coppejans have been deposited in the herbarium of the Ghent University, Belgium (GENT); many more specimens, of taxa not included in this book, are also deposited in GENT. Specimens collected by Upali Mallikarachchi are deposited in the herbarium of the Botanical Garden of Peradeniya (PDA) and at the University of Ruhuna (Matara).

We do not provide identification keys as they may give the false impression that all taxa occurring along the Sri Lankan coast are included. This is definitely not the case: only the dominant species are presented.

Several genera are under monographic study in different research institutes all over the world. Molecular data indicate that the actual species concept in some of these genera (*Sargassum*, *Laurencia* / *Chondrophycus*, *Portieria*, *Gelidium, Jania,* …) have been superseded. In those cases we include some species without final identification but eventually with indication of their 'traditionally used' names.

10.1. Chlorophyta, Ulvophyceae - Green algae

Taxonomic overview of the species included in this guide. Taxa indicated with an asterisk have their type locality in Sri Lanka.

Ulva compressa Linnaeus
1753: 1163 Fig. 51

REFERENCES: Tseng (1984: 254, pl. 126, fig. 1, as *Enteromorpha*), Huisman (2000: 230, + figs, as *Enteromorpha*), Abbott & Huisman (2004: 48, fig. 5D, as *Enteromorpha*), Huisman *et al*. (2007: 162, + figs), Kraft (2007: 35, fig. 13).

TYPE LOCALITY: Probably Bognor, Sussex, England according to Hayden *et al*. (2003: 289).

Description - Plants gregarious, mostly in extensive (frequently monospecific) populations; thallus tubular to slightly compressed towards the apices, erect, 2-3 (-5) cm long, with some side branches or at least smaller proliferations at the (extreme) basis, generally unbranched in the upper part, monostromatic, light green to almost transparent (bleached); in surface view, the polygonal cells with rounded corners are not systematically arranged in longitudinal rows; they are about 10-15 µm in diameter; 1 (-2) pyrenoid(s) per cell.

Ecology - Epilithic on the bottom of shallow intertidal pools.

Distribution - Reported to occur globally.

Notes - *Ulva* was circumscribed to consist of green seaweeds with distromatic blades, and *Enteromorpha* was established for tubular forms. The taxonomy of both genera in Europe has been studied by Bliding (1963, 1969) and more recently by Maggs *et al*. (2007). Molecular phylogenetic studies have demonstrated that *Ulva* and *Enteromorpha* are not distinct evolutionary entities and therefore a single genus, *Ulva*, is presently recognized (Hayden *et al*. 2003).
Numerous tubular *Ulva* species have been collected in Sri Lanka, especially in lagoons. Only some are included here.

Fig. 51. *Ulva compressa*.

Ulva fasciata Delile
1813: 297, pl. 58: fig. 5 Figs 9A; 17C; 38A; 52

REFERENCES: Jaasund (1976: 5, fig. 9), Tseng (1984: 256, pl. 127, fig. 4), Trono (1997: 10, fig. 3), Abbott & Huisman (2004: 55, figs 10A-D), Coppejans *et al*. (2005: 42, fig. 9), Oliveira *et al*. (2005: 190, fig. p. 191), Huisman *et al*. (2007: 164, + fig.).

TYPE LOCALITY: Alexandria, Egypt.

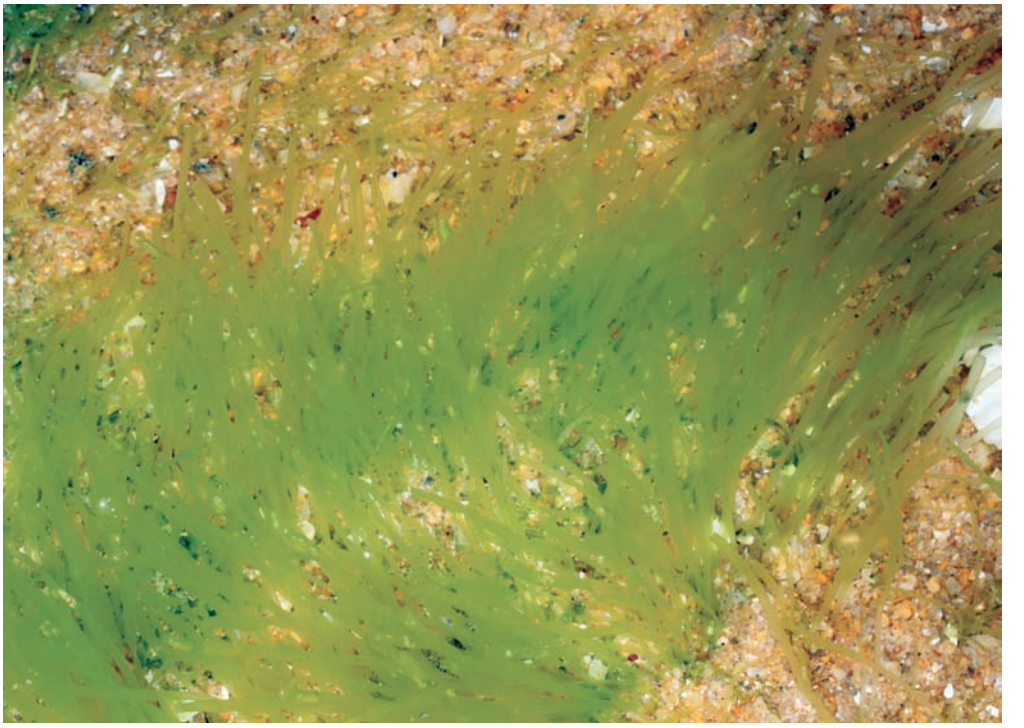
Description - Plants mostly gregarious, composed of rather tough blades, irregularly divided in long (up to 30 cm) strap-like divisions, 1-3 cm broad, gradually tapering towards their apices, undulated, especially at the margins (more rarely completely flat) and sometimes longitudinally contorted, bright green. Cells, in cross section, in two adhering layers, isodiametric or broader (parallel with the surface) than long; one (occasionally two) pyrenoid(s) per cell. Young specimens as well as plants growing in their upper ecological range, have rounded lobes and form pompon-like structures.

Ecology - Epilithic in the high intertidal zone, as well in pools as air-exposed and continuously wave-swept, frequently hanging down from vertical walls.

Distribution - Widespread in tropical to warm-temperate regions.

Note - Taxonomic details of *U. fasciata* are provided by Aguilar-Rosas (2005).

Fig. 52. *Ulva fasciata*.



Ulva intestinalis Linnaeus
1753: 1163 Figs 26B; 53

REFERENCES: Tseng (1984: 254, pl. 126, fig. 3, as *Enteromorpha*), Trono (1997: 8, fig. 2, as *Enteromorpha*), Abbott & Huisman (2004: 49, figs 7A-C, as *Enteromorpha*), Coppejans *et al.* (2005: 42), Skelton & South (2007: 231, figs 636-640).

TYPE LOCALITY: 'in Mari omni'.

Description - Plants gregarious, mostly in extensive (monospecific) vegetations, unbranched, but small proliferations can be present; thin cylindrical at the basis, becoming inflated to irregularly bullose and constricted higher up, monostromatic; in sheltered lagoons, specimens become up to 30 cm long, the lumen being inflated with air bubbles, making the upper parts of the thallus floating on the water surface; bright green when young, bleached and yellowish green in older specimens. Cells in surface view irregularly arranged, 1-2 pyrenoids per cell.

Ecology - Epilithic in sheltered intertidal pools but best developed in sheltered lagoons where it can grow in huge quantities and seem loose-lying.

Distribution - Widespread globally.

Fig. 53. *Ulva intestinalis*.

Ulva lactuca Linnaeus
1753: 1163, pl. 2 Fig. 54

REFERENCES: Trono (1997: 12, fig. 4), Payri *et al.* (2000: 64, figs p. 65), Oliveira *et al.* (2005: 190, fig. p. 191), Kraft (2007: 46, fig. 18).

TYPE LOCALITY: Sweden.

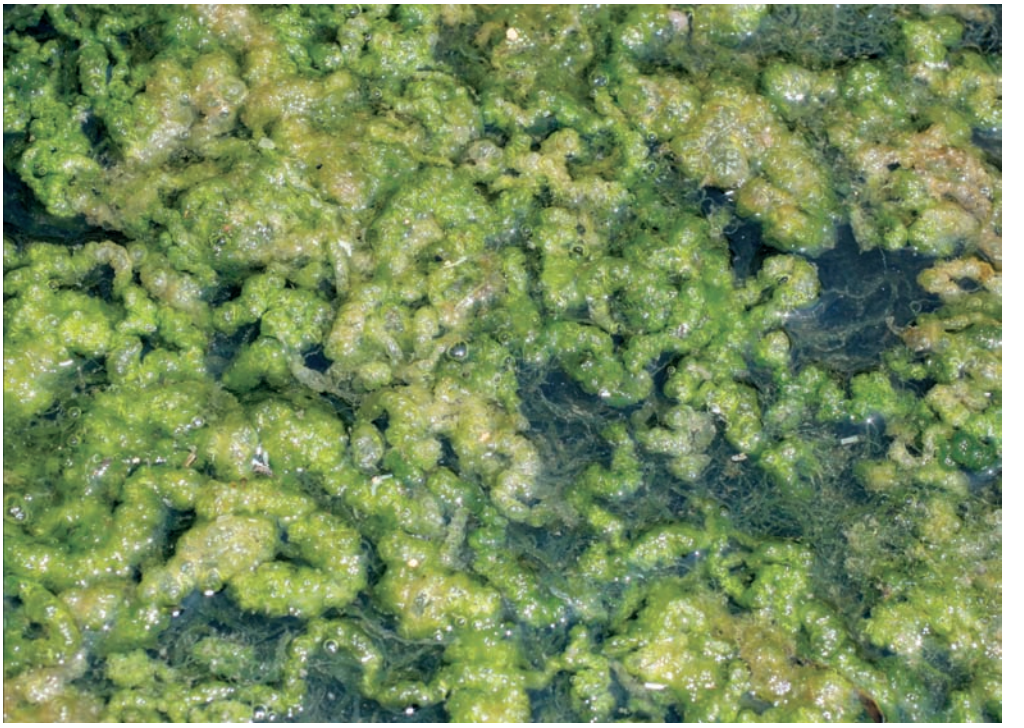
Description - Plants forming large, supple, orbicular to lobed, shortly stipitate blades, up to 20 cm long, markedly undulated all over, bright green; round perforations can be present; cells in surface view angular, mostly containing a single (but up to 2) pyrenoid(s); in transverse section the blade is 50-60 µm thick in the median part, up to 80-100 µm in the basal part where rhizoid-producing cells are abundant; cells isodiametric to slightly elongated, perpendicular to the blade surface.

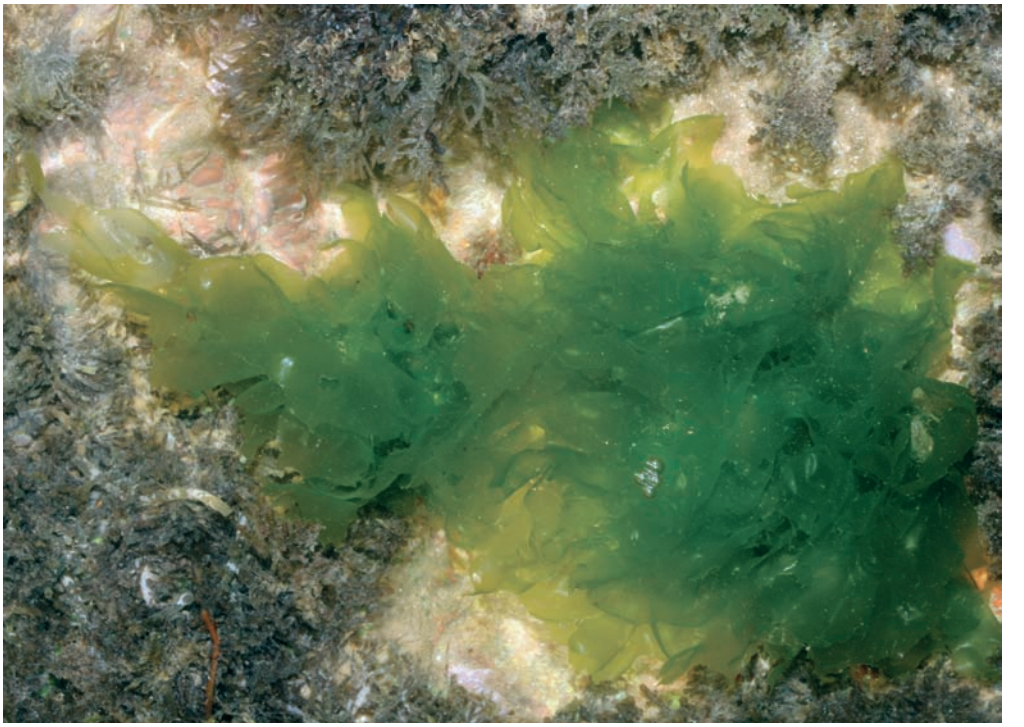
Ecology - Epilithic in shallow intertidal pools.

Distribution - Reported globally.

Note - Extremely abundant in pools along the beach as a result of eutrophication, at sites with numerous hotels.

Fig. 54. *Ulva lactuca*.





Ulva pertusa Kjellman
1897b: 4-7, pl. 1, pl. 3: figs 1-8 Fig. 55

References: Jaasund (1976: 3, fig. 7), Tseng (1984: 258, pl. 128, fig. 2), Trono (1997: 13, fig. 5).

Syntype localities: Various in Japan.

Description - Thallus blade-like, rather thick and stiff, especially at the basis, thinner upwards, oval, suborbicular to irregularly lobed and lacerated, 10-15 cm long, undulated and wrinkled at the basis and at the margin, irregularly perforated with smaller and larger holes with smooth margin, light green when fully grown. Basis of the blade up to 500 µm thick as a result of the numerous rhizoids being formed between the two adhering cell layers, median parts about 100 µm, without internal rhizoids; on transverse section, cells elongated, perpendicular to the blade surface, about two to three times as long as wide resulting in a palisade-like appearance; chloroplasts 'cap-like' in surface view, those of cell pairs away from each other resulting in almost transparent lines where cells are arranged in short rows; 1-2 (-3) pyrenoids per cell.

Ecology - Epilithic in the intertidal and on coral debris on sand about mean low tide.

Distribution - Mentioned from several localities in the Indian Ocean, but also from the Pacific and Atlantic Ocean (California, Europe).

Notes - The morphology and distribution of *U. pertusa* is specified in López *et al*. (2007).
Typical for this species are the irregularly placed, isolated, small perforations of different sizes, with a smooth margin. Durairatnam (1961: 17, pl. 1: fig. 2, pl. 21, fig. 1) mentions *U. fenestrata* Postels et Ruprecht from Sri Lanka, a species described from Siberia. The perforations in the blades of the latter species are crenulate. *Ulva lactuca* Linnaeus, morphologically similar to *U. pertusa*, has only a single pyrenoid per cell (only rarely 2).

Fig. 55. *Ulva pertusa*.

Ulva prolifera O.F. Müller
1778: 7, pl. DCCLXIII(1) Fig. 56

References: Tseng (1984: 256, pl. 127, fig. 1, as *Enteromorpha*), Abbott & Huisman (2004: 52, fig. 8D, as *Enteromorpha*).

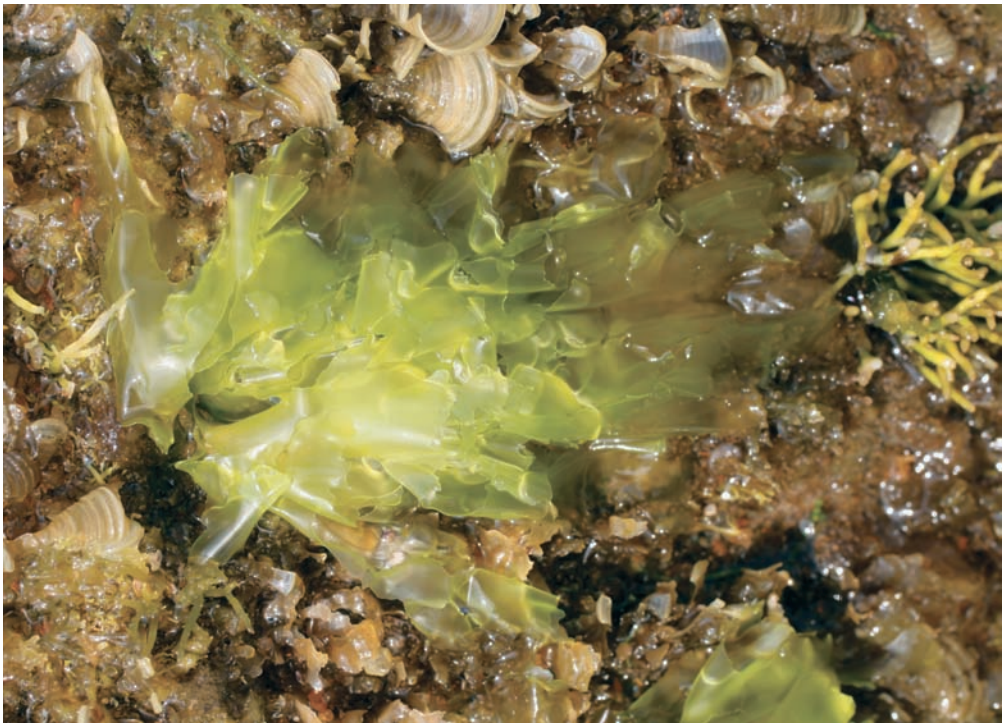
Type locality: Denmark.

Description - Plants growing in densely intricated masses, where individual specimens are difficult to separate, up to 10 cm long, light green; thalli regularly tubular (not contricted nor compressed), all axes extremely thin, slender and supple, with rather similar diameter (1 mm or less), the main axis richly, radially branched, the side branchlets not branched again; cells small, rectangular (about 9-12 x 8-9 µm) to square, markedly arranged in longitudinal rows and partly also in transverse rows; one (rarely two) pyrenoid(s) per cell.

Ecology - On shell fragments on the shallow, silty-sandy bottom at the margin of a sheltered lagoon.

Distribution - Reported worldwide.

Fig. 56. *Ulva prolifera*.



Ulva reticulata Forsskål
1775: 187 Figs 39C; 57

REFERENCES: Jaasund (1976: 3, fig. 5), Magruder & Hunt (1979: 33, fig. 2, p. 32), Moorjani & Simpson (1988: 16, pl. 29c), Calumpong & Meñez (1997: 101, + fig.), Trono (1997: 15, fig. 6), Abbott & Huisman (2004: 57, figs 11A-B), Oliveira *et al*. (2005: 190, fig. p. 191), Huisman *et al*. (2007: 163, + figs).

SYNTYPE LOCALITIES: «Gomfodae» (Al-Qunfudhah), Saudi Arabia, Mokha, Yemen.

Description - Thallus without recognizable holdfast, mostly strap-shaped, less frequently irregularly lobed, exceeding 30 cm in diameter, completely perforated, with larger and smaller holes side by side, up to the blade margin, resulting in a bright green net-like structure, the hole area exceeding the blade network; straps 3-10 mm wide; blade 40-80 µm thick, composed of two adhering layers of rectangular cells, perpendicular to the blade surface, resulting in a palisade-like appearance.

Ecology - Entangled to other algae in the whole intertidal zone and shallow subtidal.

Distribution - Reported from all over the Indian Ocean as well as from the western Pacific Ocean and South America (Chile and Venezuela).

Fig. 57. *Ulva reticulata*.

Ulva rigida C. Agardh
1823: 410-411 Fig. 58

REFERENCES: Jaasund (1976: 3, fig. 8), Littler & Littler (2000: 306, fig. p. 307), Abbott & Huisman (2004: 57, figs 12A-D), Coppejans *et al.* (2005: 44, fig. 11), Oliveira *et al*. (2005: 190, fig. p. 191), Kraft (2007: 46, fig. 19).

LECTOTYPE LOCALITY: Cádiz, Spain.

Description - Plants mostly gregarious, forming small rosettes of relatively stiff bladelets 2-3 cm in diameter at air- and surf-exposed sites, becoming up to 10 cm in more sheltered pools; bladelets orbicular, undulated, lobed, with smooth surface and small, pluricellular, marginal teeth; dark green. Cells, in cross section in two adhering layers, broader (parallel with the surface) than long to isodiametric close to the blade margins, to narrower than long towards the central part of the blades, then resulting in a palisade-like appearance. Two to five pyrenoids per cell.

Ecology - Epilithic, along surf-exposed coasts, mostly in the upper intertidal.

Distribution - Reported worldwide.

Fig. 58. *Ulva rigida*.

Chaetomorpha antennina (Bory de Saint-Vincent) Kützing
1847: 166. Figs 9D; 13F; 17A; 59

REFERENCES: Tseng (1984: 262, pl. 130, fig. 1), Lewmanomont & Ogawa (1995: 41, + fig.), Cribb (1996: 21, bottom fig. p. 20), Payri *et al*. (2000: 68, top fig. p. 69), Abbott & Huisman (2004: 66, figs 18A-D), Coppejans *et al*. (2005: 46, fig. 14), Huisman *et al*. (2007: 170, + figs), Kraft (2007: 51, figs 21A-D).

TYPE LOCALITY: Réunion.

Description - Plants forming 1-10 cm high, erect, isolated, characteristic brush-like tufts, composed of rigid, unbranched, septate filaments, dark to bright green. Attachment to the substratum by rhizoids sprouting from the base of the basal cells, resulting in a profusely branched, stoloniferous rhizoidal system. Basal holdfast cells elongated, thick walled, with proximal, annular constrictions, 400-700 µm in diameter at the distal end, up to 7.5 mm long. Other cells of the filaments subcylindrical, 400-750 µm in diameter, 700-1000 µm long, gradually becoming broader and barrel-shaped upwards. Filaments of reproductive specimens with white tips that erode easily, resulting in a gradual diminishing size of the plants.

Ecology - Epilithic in high intertidal, best developed on the seaward side of rocks along surf-exposed coasts.

Distribution - Widespread in tropical and subtropical seas.

Notes - Ten *Chaetomorpha* species have been recorded for Sri Lanka (Silva *et al*. 1996). *Chaetomorpha antennina* can be easily distinguished from other attached *Chaetomorpha* species in the region (e.g. *C. aerea*, *C. indica*) by the characteristic brush-like tufts and basal cell with annular constrictions. Some common *Chaetomorpha* species occurring in the Indian Ocean are discussed by Sartoni (1992).
Some tufts of *Chaetomorpha antennina* are pinkish as a result of numerous tiny red algal epiphytes (*Acrochaetium*).

Fig. 59. *Chaetomorpha antennina*.

Chaetomorpha crassa (C. Agardh) Kützing
1845: 204 Figs 21A; 60

REFERENCES: Jaasund (1976: 5, fig. 10), Lawson & John (1987: 66), Moorjani & Simpson (1988: 14, pl. 19), Littler *et al.* (1989: 32, fig. 2, p. 33), Sartoni (1992: 299, fig. 4E), Lewmanomont & Ogawa (1995: 42, + fig.), Calumpong & Meñez (1997: 110, fig. p. 111), Trono (1997: 18, fig. 8), Oliveira *et al*. (2005: 194, figs p. 194).

SYNTYPE LOCALITIES: Trieste and Venezia, Italy; England.

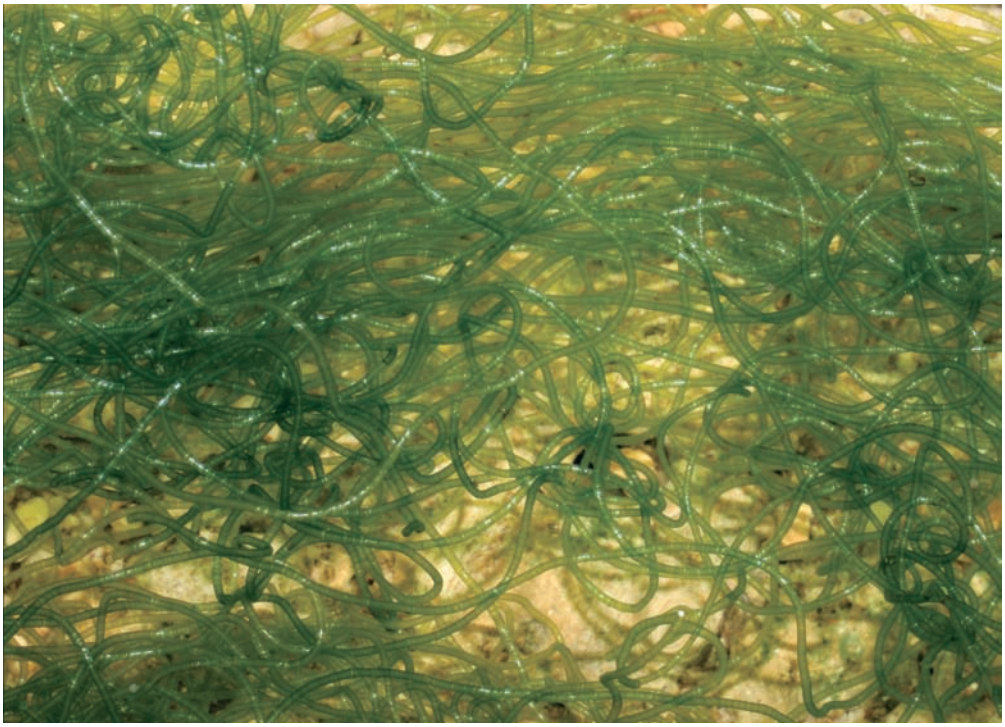
Description - Plants forming loose-lying clumps or entangled tufts with other algae of intricated, thick, tough, curly, unbranched, mostly dark green filaments (sometimes with a bluish hue). Cells visible with the naked eye, (395-) 450-650 (-685) µm in diameter, mostly as long as broad, but up to twice as long (just before cell division even sometimes up to 1 mm long). Some specimens with marked constrictions at the transverse walls (resulting in barrel-shaped cells), others more cylindrical.

Ecology - Present in the whole intertidal zone, most frequent in low to middle intertidal pools, entangled with other algae.

Distribution - Pantropical.

Note - DNA sequence data has shown that *C. crassa* from Europe is conspecific with *C. linum* and that the tropical species, referred to as *C. crassa* constitutes a new species (Leliaert & Boedeker 2007). The latter can be easily distinguished from other unattached *Chaetomorpha* species by the coarse filaments.

Fig. 60. *Chaetomorpha crassa*.



Chaetomorpha spiralis Okamura
1903: 131-132, pl. XCV — Figs 35A; 61

REFERENCES: Tseng (1984: 262, pl. 130, fig. 3), Sartoni (1992: 299, fig. 5A), Coppejans *et al*. (2000: 62, fig. 24), Abbott & Huisman (2004: 70, fig. 19B).

TYPE LOCALITY: Nemoto, Boshu Province (Chiba Prefecture), Japan.

Description - Some plants gregarious, others solitary, 5-20 (-30) cm long, growing in open populations between other algae; basal parts of the stiff, unbranched filaments coiled or at least markedly sinuous, dark green; upper parts straight or slightly sinuous, light green; diameter in the basal parts 500-750 µm, where the cells are cylindrical and isodiametric, gradually becoming beadlike and reaching a diameter of 1 mm at the filament apices.

Ecology - In shallow, low intertidal rock pools with sandy bottom; continuously wave-swept.

Distribution - Tropical and temperate Indian and Pacific Ocean.

Fig. 61. *Chaetomorpha spiralis*.

Cladophora herpestica (Montagne) Kützing
1849: 415 — Fig. 62

REFERENCES: Huisman (2000: 239, + figs), Coppejans *et al*. (2005: 54, fig. 22, as *Cladophoropsis herpestica*), Kraft (2007: 85-89, fig. 36), Skelton & South (2007: 245, figs 676-677).

TYPE LOCALITY: Bay of Islands, New Zealand.

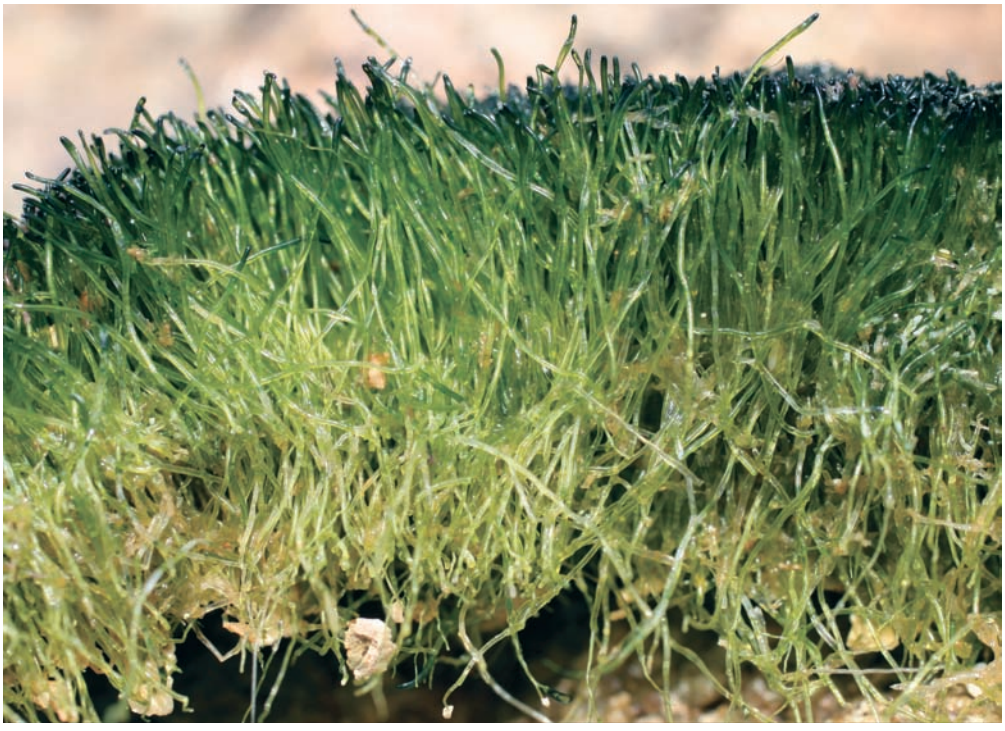
Description - Plants forming compact, rigid, hemispherical to horizontally spread cushions, firmly attached to the substratum, about 2 cm thick, composed of densely set, rather stiff, straight, erect, radially arranged, strongly entangled branchlets; upper part light green, inner part dark green; attachment to the substratum by basal hapteroid rhizoids and by rhizoids sprouting from the proximal pole of cells in any part of the thallus; rhizoids in upper parts of the cushions horizontally directed and hereby consolidating the structure. Cells of the filaments generally each producing a single lateral at their apical pole, mostly unilaterally placed; at increasing distance from the apex a cell may give off a second branch; cross wall formation at the base of the laterals markedly delayed; older laterals eventually displacing the main axes, which then appear as lateral appendages. Filaments generally branching to the 1st or 2nd order. Apical cells and cells of the terminal branch systems subcylindrical, generally curved or sinuous, 120-450 µm in diameter, up to 10 mm long. Cell walls up to 90 µm thick in the basal cells, coarsely striated longitudinally. Tetrahedral protein crystals present in most cells.

Ecology - Epilithic, just above low water mark, air-exposed at low tide but continuously wave-swept; surf exposed coasts.

Distribution - Widely distributed in the tropical to subtropical Indo-Pacific.

Notes - This species has been placed in *Cladophoropsis* based on the typical branching pattern but is returned to its original genus by Leliaert *et al*. (2007) based on DNA sequence data.
Cladophora is a large and common green algal genus with a worldwide distribution in marine as well as freshwater habitats. The taxonomy of the genus has been studied by van den Hoek (1963, 1982), van den Hoek & Chihara (2000), Leliaert & Coppejans (2003) and Leliaert & Boedeker (2007). Molecular phylogenetic studies have demonstrated that the genus is polyphyletic (Leliaert *et al*. 2003, 2007).
This is a new species for Sri Lanka.

Fig. 62. *Cladophora herpestica*.



Cladophora prolifera (Roth) Kützing
1843: 271 Fig. 63

REFERENCES: Lawson & John (1987: 75, pl. 4, fig. 5); Moorjani & Simpson (1988: 14, pl. 22); Lewmanomont & Ogawa (1993: 44, + fig.); Leliaert & Coppejans (2003: 32-33, figs 6A-C), Oliveira *et al*. (2005: 195, fig. p. 195); Leliaert & Boedeker (2007: 166-167, figs 78, 79).

TYPE LOCALITY: "in mare Corsicam".

Description - Plants erect, coarse, growing as stiff tufts, 2-4 cm high, locally in extensive populations; thallus composed of densely branched, fastigiated filaments, dark green (blackish when dried); old cells in the basal and middle part of the thallus each giving off one rhizoid with annular constrictions at their basal poles; these rhizoids growing down along the cell or cells below, where they entangle and form a conspicuous stipe attaching to the substratum; growth by apical cell division, later combined with intercalary growth; each subapical cell forming a lateral, often immediately after being cut off from the apical cell: lower down a second or even a third lateral can be formed; apical cells cylindrical with rounded tip, 90-130 µm in diameter, length/width ratio 2,5-5,5; cells of the terminal branch systems cylindrical, 150-200 µm in diameter, l/w ratio 2,5-8, increasing towards the base of the thallus; cells of the main axes and basal cells elongated and club-shaped, up to 200 µm in diameter, l/w ratio 7-10; basal parts often with annular constrictions; rhizoids 40-100 µm in diameter.

Ecology - Epilithic in surf channels just under low water mark or in the wave-exposed lower intertidal.

Distribution - Widespread in tropical to warm temperate seas. Also recorded from the British Isles.

Fig. 63. *Cladophora prolifera*.

Cladophora sericea (Hudson) Kützing
1843: 264 Figs 17B; 64

REFERENCES: van den Hoek (1963: 77-92, pls 17-21), Abbott & Huisman (2004: 77, fig. 22E), Leliaert & Boedeker (2007: 172-174, fig. 84).

TYPE LOCALITY: Sheerness, Kent, Great Britain.

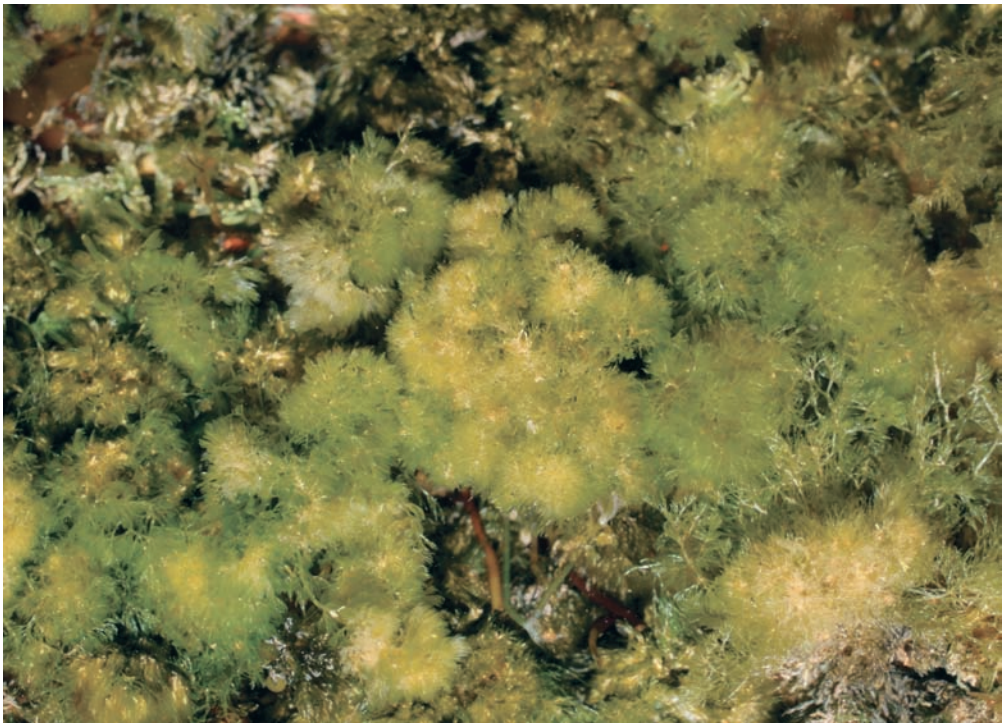
Description - Plants light green, forming lax tufts or threads, to 7 cm tall, frequently in dense populations covering large areas of rocks; thallus composed of pseudodichotomously branching main axes, densely set with branches of various lengths; attachment to the substratum by branching rhizoids developing from the basal cells; growth mainly by intercalary cell division, many new cells each producing a branch at their apical pole, thus giving rise to rows of branches that are similar in age, or young (shorter) ones intercalated between older (longer) ones. Cells generally producing a single branch, but older cells may produce a second or sometimes a third branch. Apical cells cylindrical to slightly tapering, diameter (22-) 25-35 (-38) µm; cells of the main axes cylindrical, up to 100 µm in diameter.

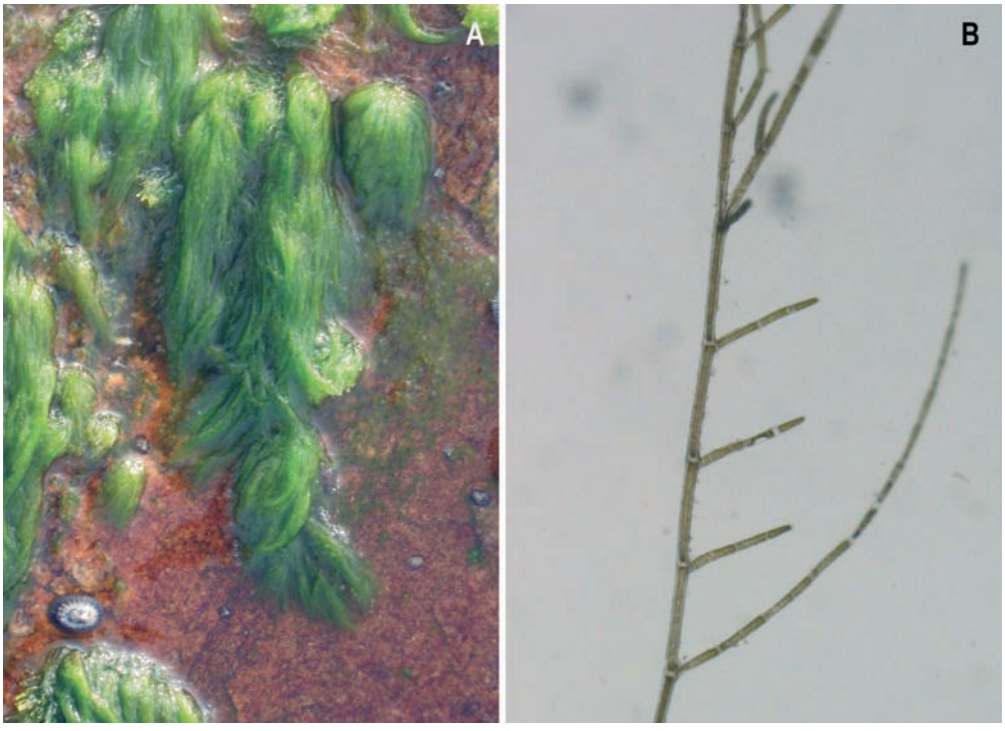
Ecology - Epilithic in the high intertidal, on the landward side of rock boulders along surf-exposed coasts; continuously wave-swept, but rarely really inundated.

Distribution - Reported worldwide; in the Indian Ocean this species has until now only been reported from Réunion, Singapore and South Africa.

Note - *Cladophora sericea* is part of a closely related species complex, also including *C. albida, C. capensis, C. flexuosa* and *C. opaca* (Bakker *et al.* 1995).

Fig. 64. *Cladophora sericea***.** A. A population *in situ***;** B. Detail of non-acropetal growth.




A
B

Cladophora socialis Kützing
1849: 416 Fig. 65

REFERENCES: Leliaert & Coppejans (2003: 51, fig. 3), Abbott & Huisman (2004: 78, figs 23A-C), Oliveira *et al*. (2005: 196, + fig.).

TYPE LOCALITY: Tahiti.

Description - Plants forming a dense, supple filamentous cover on the phorophyte, dark green; filaments densely branched, interwoven, well attached by uni- and multicellular rhizoids arising from the proximal poles of the short basal cells; upright branch systems 1-1.5 cm high, branching at wide angles (45-90°); mostly a single lateral per cell; newly formed laterals often without cross-walls at their base; in older laterals cross-walls are steeply inclined to the parent cell; apical cells cylindrical with rounded tip, 23-27 µm in diameter, l/w ratio 10-25; basal cells cylindrical, 60-120 µm in diameter.

Ecology - Epiphytic on *Galaxaura filamentosa*, in a rock pool in the low intertidal, continuously wave-swept.

Distribution - Widespread in tropical and subtropical waters.

Notes - *C. socialis* closely resembles *C. coelothrix* Kützing from which it differs by its smaller cell diameter. The latter is more frequent along the Sri Lankan shores.
A new species for Sri Lanka.

Fig. 65. *Cladophora socialis*.

Cladophora vagabunda (Linnaeus) van den Hoek
1963: 144 Figs 21B; 66

REFERENCES: Sartoni (1992: 304; figs 6C-E), Trono (1997: 20, fig. 9), Coppejans *et al.* (2005: 50, fig. 19), Abbott & Huisman (2004: 79, figs 24A-D), Oliveira *et al*. (2005: 196, fig. p. 196), Kraft (2007: 80, fig. 33).

LECTOTYPE LOCALITY: Selsey, Sussex, England.

Description - Plants forming lax tufts, 1 to 3 cm tall, frequently in extensive populations; thallus composed of pseudodichotomously branching main axes, typically ending in densely branched fasciculate terminal branch systems, light green; attached to the substratum by branching rhizoids developing from the basal cells; terminal branch systems distinctly acropetally organized, (refracto-) falcate. Cells producing one to three (sometimes four) branches. Apical cells cylindrical, with rounded tips or slightly tapering, diameter (35-) 45-55 µm; cells of the main axes cylindrical, 180-210 µm in diameter.

Ecology - Epilithic or epiphytic (on *Gracilaria corticata*) in shallow, low intertidal pools.

Distribution - Reported worldwide.

Fig. 66. *Cladophora vagabunda* (herbarium specimens).