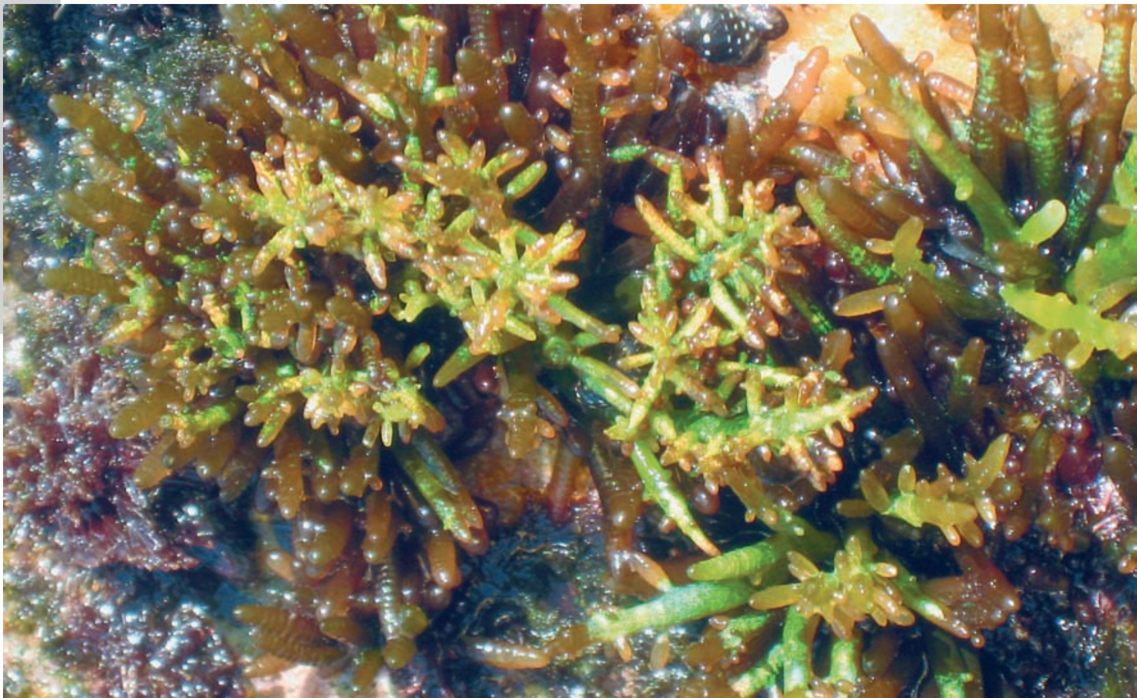
Abc Taxa

Sri Lankan Seaweeds
Methodologies and field guide to the dominant species

Eric Coppejans
Frederik Leliaert
Olivier Dargent
Rasanga Gunasekara
Olivier De Clerck



Volume 6 (2009)

Abc Taxa

a Series of Manuals Dedicated to Capacity Building in Taxonomy and Collection Management

Produced with the Financial Support of the Directorate-General for Development Cooperation

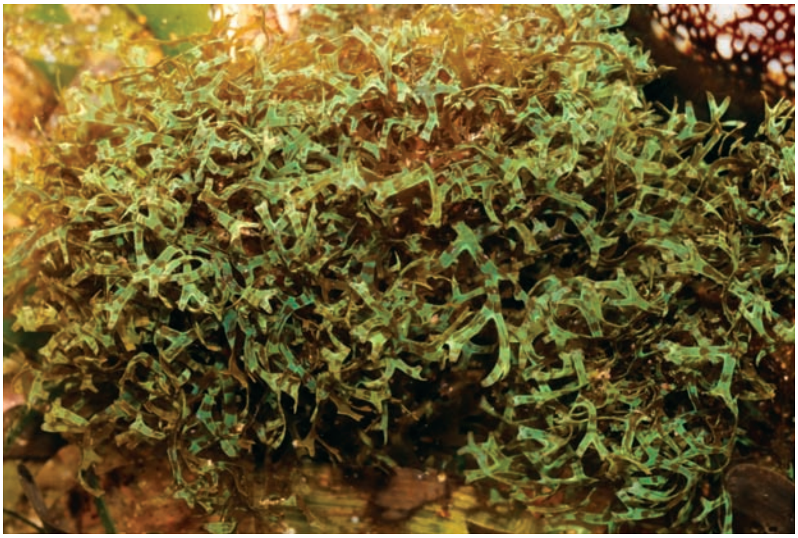
Belgian Development Cooperation .be

Instructions to authors

http://www.abctaxa.be

ISSN 1784-1283 (hard copy)
ISSN 1784-1291 (on-line pdf)
D/2009/0339/5

Sri Lankan Seaweeds
Methodologies and field guide to the dominant species



by

Eric Coppejans

Ghent University, Phycology Research Group
Krijgslaan, 281 (S8), B-9000 Gent, België
Email: eric.coppejans@ugent.be

Frederik Leliaert

Ghent University, Phycology Research Group
Krijgslaan, 281 (S8), B-9000 Gent, België
Email: frederik.leliaert@ugent.be

Olivier Dargent

Email: olivier.dargent@free.fr

Rasanga Gunasekara

University of Ruhuna, Department of Botany
Matara, Sri Lanka
Email: rda@bot.ruh.ac.lk

Olivier De Clerck

Ghent University, Phycology Research Group
Krijgslaan, 281 (S8), B-9000 Gent, België
Email: olivier.declerck@ugent.be
http://www.phycology.ugent.be

Cover illustration: Iridescent *Champia ceylanica*. This page, *Dictyota ceylanica* with banded iridescence.

Preface

The 2008 Olympic Games held in China had been prepared with an unprecedented sense to perfection. However, a couple of months before the start, marine algae belonging to the genus *Ulva*, were at the point to obstruct the games' sailing events.

A gigantic bloom that struck Qingdao bay in late June marked its presence. Some 130,000 people and more than 1,000 boats were mobilised to clear an astounding 13,000 km^2 slick of algae. At the end, more than one million tons of sea lettuce was removed and buried.

Such an algal bloom can happen anywhere and anytime if the conditions are right: excess of nutrients (particularly phosphorus ran-off from fertilised agricultural land), warm coastal water, and plenty of sunlight. Some algal blooms can be very harmful when excreted toxins contaminate the water. In such cases, mussels and other edible bivalves turn detrimental induced by their filtering mode of life.

Algae have an important and direct impact on our daily life for many reasons. In Asian countries, they form a direct food source for millions of people. In western societies, cell wall extracts, better known as carrageenans, agar and alginates, are widely used in cosmometics, food and pharmaceutical industries, where they are used as emulgators, stabilisers and gelling agents.

Professor Eric Coppejans of Ghent University has studied marine algae for more than 40 years. His collecting trips encompass virtually all seas, with a special focus on the Indian and West Pacific ocean. Eric Coppejans is not only a renowned scholar; he also has that invaluable quality to disseminate his state of the art knowledge with zeal towards fellow scientists and students, especially those from developing countries.

All authors combine a thorough knowledge of the field with an exquisite taxonomic experience including molecular systematics. It thus comes as no surprise that one of them, Dr Frederik Leliaert, was key to the identification of the Qingdao bay algae. As for the algal reference collections of Ghent University, they are so rich in taxa and so well managed that they act as a world-class showcase towards the value of a taxonomic collection.

Abc Taxa offers an excellent opportunity to present the authors summary of field and laboratory techniques for the study of seaweeds, complemented with a detailed taxonomic overview of the dominant marine algal species living along Sri Lanka's 1,600 km coastline.

This sixth volume of *Abc Taxa* offers students and researchers a practical and comprehensive guide to a diversity rich group of marine organisms of utmost importance as primary producers and biological indicators, but often neglected due to lack of accessible and pertinent literature. The numerous excellent illustrations, mainly by Olivier Dargent, make this volume attractive even to the layman.

Dr Jackie L. Van Goethem

Honorary Head of Department at RBINS

ප්‍රස්තාවනාව

වර්ෂ 2008 දී චීනයේ පැවති ඔලිම්පික් තරංග පෙර විරු නොවූ උත්කර්ශවත් අන්දමින් පැවැත්වීමට කටයුතු සූදානම් කරන ලදී. කෙසේ නමුදු එම උළෙල ආරම්භ කිරීමට මාස දෙකකට පමණ ප්‍රථම උල්වා ඝනයට අයත් කරදිය ඇල්ගාවක් ඔරු පැදීමේ තරංග ඉසව්වලට බාධා කරන තත්ත්වයට පත්විණ.

තරංග පැවැත්වීමට නියමිතව පැවති කුයින්ඩාඕ බොක්ක අවහිර වන පරිදි මෙම ඇල්ගාව අති විශාල ලෙස වර්ධනය වීම ඊට හේතුවයි. වර්ග කිලෝමීටර් 13000 ක වපසරියක් ගත් මෙම විශ්මය ජනක ඇල්ගාව ඉවත් කිරීමට මිනිසුන් 130000 ක් හා බෝට්ටු 1000 ක් යෙදවීමට සිදුවිය. අවසානයේදී ඇල්ගේ ටොන් මිලියනයකට වඩා ඉවත් කොට වලලා දමන ලදී.

අතිරික්ත පෝෂ්‍ය ද්‍රව්‍ය (විශේෂයෙන්ම පොහොර යෙදු වගාබිම්වලින් සේදී එන පොස්පරස්), වෙරළාසන්න උණුසුම් ජලය, සහ ඕනෑතරම් හිරු එළිය, ඇතුළු අවශ්‍ය තත්ත්වයන් නිසි පරිදි ඇතිවිට මෙබඳු ඇල්ගී අධිවර්ධනයන් ඕනෑ තැනක ඕනෑම කාලයක ඇතිවිය හැක. ජලයට විෂ ද්‍රව්‍ය මුදා හරින ඇතැම් ඇල්ගීවල මෙබඳු අධිවර්ධනයන් ඉතා හානිකර වීමට පුළුවන. එබඳු අවස්ථාවල බෙල්ලන් සහ ආහාරයට ගතහැකි වෙනත් ද්වි කපාටිකයින් ඔවුන්ගේ පෙරා බුදින චර්යාව හේතුකොට ගෙන ආහාරටය නුසුදුසු හානිකර තත්ත්වයට පත්වේ.

කරුණු රාශියක් හේතුකොටගෙන ඇල්ගී අපගේ දෛනික ජීවිතයට වැදගත්වන සෘජු බලපෑම් ඇති කරයි. ආසියාතික රටවල මිලියන සංඛ්‍යාත ජනතාවකට එය සෘජු ආහාර ප්‍රභවයක් වේ. බටහිර සමාජය කැරජිනේස්, ඒගාර්, හා ඇල්ජිනේට්, ආදී වශයෙන් දන්නා සෛල බිත්ති නිස්සාරකයන් ඇල්ගීවලින් ලබාගෙන බහුල වශයෙන්ම සුවඳ විලවුන්, ආහාර, සහ ඖෂධ කර්මාන්තයන්හිදී තෙලෝදකරණය, ස්ථිරකරණය හා ජෙල තැනීම ආදී අරමුණු සඳහා යොදා ගනී.

ගෙන්ට් විශ්වවිද්‍යාලයේ මහාචාර්ය එරික් කොපජෙන්ස් වසර 40කට වඩා වැඩි කාලයක් ඇල්ගී සම්බන්ධව අධ්‍යයන කටයුතු සිදු කොට ඇත. ඔහු ඉන්දියානු හා බටහිර පැසිපික් සාගර කෙරෙහි විශේෂ අවධානයක් සහිතව සත්‍ය වශයෙන් ලෝකයේ සියළුම සාගරවල ඇල්ගී නිදර්ශක එකතු කිරීමේ චාරිකාවල නියැලී ඇත. මහාචාර්ය එරික් කොපජෙන්ස් හුදෙක් කීර්තිධර විද්‍යාර්ථයෙකු පමණක් නොව තම සුවිශේෂී දැනුම විශේෂයෙන්ම සංවර්ධනය වන රටවල සමකාලීන විද්‍යාඥයින් හා ශිෂ්‍යයින් අතර බෙදා හැරීමේ අමිල ගුණයෙන් ද යුක්ත මහත්මයෙකි.

මෙම ග්‍රන්ථයෙහි සියළුම කතුවරයන් අණුක වර්ගීකරණය ඇතුළු වර්ගීකරණයන්හි අත් දැකීම් සහිතව මෙම ක්ෂේත්‍රයේ හසල දැනුමක් ඇති විශේෂඥයෝ වෙති. එය පුදුමයට කරුණක් නොවන්නේ චීනයේ කුයින්ඩාඕ බොක්කෙහි ඇල්ගාව හඳුනාගත් ආචාර්ය ෆෙඩ්රික් ලෙලියට්ද ඔවුන් අතරෙන් එක් අයෙකු වීම නිසාය. ගෙන්ට් විශ්ව විද්‍යාලය සතු ඇල්ගී තක්සෝන රාශියකින් පොහොසත් මනාව පවත්වාගෙන යන නිදර්ශක එකතුව ලොව විශිෂ්ට වටිනාකමකින් යුතු ඇල්ගී වර්ගීකරණ එකතුවක් ලෙස සැලකිය හැක.

ශ්‍රී ලංකාව වටා වර්ග කිලෝමීටර් 1600 ක් වූ සමුද්‍ර තීරයේ පවතින ඇල්ගී විශේෂවල වර්ගීකරණය සම්බන්ධව දල විශ්ලේෂණයක් ක්ෂේත්‍රයේදී හා පරීක්ෂණාගාරයේදී ඒවා අධ්‍යයනය කරන ආකාරය සම්බන්ධ කරුණු සාරාංශ ගත කොට ඉදිරිපත් කිරීමට ලැබීම ඒබීසී ටැක්සා (*Abc Taxa*) ලද අනර්ඝ අවස්ථාවක් ලෙස සලකනු ලබයි.

ශ්‍රී ලංකාවේ කිලෝමීටර් 1600 ක දිගින් යුත් වෙරළ තීරයේ ප්‍රමුඛ ඇල්ගී විශේෂවල සාගරවල විස්තරාත්මක තක්සෝන විද්‍යාත්මක විවරණයකින් ද සම්පූර්ණ වූ මුහුදු ඇල්ගී අධ්‍යනයට යොදා ගනු ලබන ක්ෂේත්‍ර හා විද්‍යාගාර තාක්ෂණයන් පිළිබඳව සාරාංශයක් ඉදිරිපත් කිරීමට ඒබීසී ටැක්සා (*Abc Taxa*) මගින් කතුවරයන්ට මහඟු අවස්ථාවක් ලබාදී ඇත .

ඒබීසී ටැක්සා හි මෙම හයවන වෙළුම පර්යේෂකයන් හා ශිෂ්‍යයින් හට ජෛව නිදර්ශක හා ප්‍රාථමික නිෂ්පාදකයින් ලෙස පරම වැදගත්කමක් සහිත කරදිය ජීව කාණ්ඩයක් පිළිබඳව සවිස්තරාත්මක මග පෙන්වීමක් කරනු ලබයි. ප්‍රධාන වශයෙන් Olivier Dargent විසින් ඉදිරිපත් කර ඇති අනර්ඝ ඡායාරූප හා රූප සටහන් විශාල සංඛ්‍යාවකින් ද සමන්විත මෙම වෙළුම ආධුනිකයන්ට පවා ආකර්ශනීය වනු ඇත .

ආචාර්ය ජැකී එල් වැන් ගොතම්,
RBINS හි සම්මාන අංශ ප්‍රධාන

முகவுரை :–

2008 ம் ஆண்டு சீனாவில் நடைபெற்ற ஒலிம்பிக் போட்டு எப்போதாவது ஏற்பாடு செய்யாதவாறு மிக ஒபர்வான மட்டத்தில் நடைபெற்றது. எனினும் போட்டி சடைபெற இரு மாதங்களுக்கு முன்னர் உல்வா வர்க்கத்துக்குறிய கடற்பாசி, படகுப் போட்டி நிகழ்ச்சிக்கு இடையூராகிவிட்டது.

போட்டி நிகழ்ச்சி நடைபெற நியமிக்கப்பட்ட குயின்டாஒ பொக்கையில் கடற்பாசி அடர்த்தியாய் கடர்ங்குந்தமை இத்தடைக்கு காரணமாயிற்று 13,000 கி மி^{2} அடர்ந்த இப்பாசிற் தட்டை அகந்ந 130000 பேர்களையும்1000 படகுகளையும் ஈடுபடுத்தலாயின. எற்றில் ஒரு தொன் மிலியனுக்கும் அதிகளவு பாசி நீக்கப்பட்டு புதைக்கப்பட்டன.

மிகுந்த போஷாக்குகள் (குறிப்பாக உரமிடப்பட்ட விதைநிலங்கள் குழுவுண்டு வரும் பொசுபரஸ்) கரையோர வெப்பநீர், அதிக சூரிய ஒளி ஆகியன போதியளவு பெறப்படும் போது இவ்வாறான பாசிகள் படர்ந்து வளரும். சிலவகை கடற்பாசி நச்சுத் திரவத்தை வெளியிடும் போது அது நீரில் கலந்து பல ஆபத்துக்களை வினைவிக்கும். இவ்வேளைகளில் சிப்பிகள் உற்கொள்ளக்கூடிய இருகவாடங்களுடையன வடித்து உண்ணும் முறையினால் உண்ணும் போது தீய விளைவுகள் ஏற்படும்.

பல காரணங்களை முன்னிட்டு கடற்பாசி எம் அன்றாட வாழ்வில் நேரடியான தாக்கங்களை உண்டாக்கும். ஆசியான் கண்டத்தைச் சார்ந்த நாட்டு பல்லாயிரக் கணக்கான மக்களுக்கு அது உணவு உற்பத்தி ஸ்தானமாகிறது. மேற்கதிய நாட்டவர்கள் கரஜீனன்ஸ், ஏகார், ஆல்ஜினேட்ஸ் போன்ற மருந்து தொழிற்சாலைகளில் அவற்றை திரவமாக்கல், ஸ்திரப்படுத்தல் போன்றவிற்றுக்குப் ரிரயோகிப்பர்.

கென்ட பல்கலைக்கலகப் பேராசிரியர் எரிக் கொபர்ஜீன்ஸ் 40 வருடங்களுக்கும் அதிகமாக கடற்பாசி கம்பந்தமாக ஆராய்ந்துள்ளார். அவர் எல்லாக் கடல்களிலும், இந்து, பசுபிக் சமுத்திரங்களில் விஷேடகவனத்துடன் கடல் பாசி சூழ்வதை ஆராயும் பயனத்தை மேற்கொண்டார். இவர் பிரபல்யம் வாயிந்த ஒரு விஞ்ஞானி மட்டுமல்லாது தனது நுன்னறிவை விஷேடமாக வளர்ச்சியடையும் நாடுகளிலுள்ள சமகால விஞ்ஞானிகளுக்கும் மாணவர்களுக்கும் புகட்டக் கூடிய நற்குணசீளாராகவும் விளங்கிளர்.

இந்நூயின் எல்லா ஆசிரியர்களும் அனுமூலக்கூறுகளை இனங்காணுதல் சம்பந்தமாக நேர்த்தியான அனுபவத்தைப் பெற்றவர்களாவர். சீனாவில் குயின்டாஒ பொக்கை பாசியை கண்டு பிடித்தவர் ஆசிரியர் ப்ரெட்ரிக் லேலியட் என்பவர் என்பதால் இது அதிசயமல்லவே.
கென்ட் பல்பலைக்கலகத்துக்குரிய மிகுந்த கடற்பாசிப் பரிசீலனைத் தொகுப்பு உலக அதி உன்னத இனங்காணல் தொடுப்பாபப் பருதப்படும்.

இவங்கையைச் சூழ வர்க கி. மி. 1600 சமுத்திரஅருகிலுள்ள பாசி வர்க்கத்தை இணங்காணுதல் தொடர்பாக ஆய்வுகூடங்களில் மேற்கொள்ளப்பட்ட ஆய்வுகளின் சாராம்சத்தை முன்வைக்க ஏபீசீ டாக்சா மூலம் ஆசிரியர் குலாமுக்கு பெரும் சந்தர்பம் கிட்டியது.

ஏபீசீ டாக்சாவின் ஆறாம் பகுதி ஆராய்ச்சியாளர்களையும் மாணவர்களைளும் அக்கஜீவி வேற்றுமையின் ஆரம்ப சிட்டிக்காட்டிகளாள, அதன் முக்கி வழிகாட்டியளாக கருதுகின்றது. எனினும், பொருத்தமான போதனைகளின் பற்றாக்குறையும் சிலவேளைகளில் தென்பட்டன. ஒலீவியர் டாகன்ட் மூலம் வெளியிடப்பட்ட உன்னதமான எண்ணற்ற விளக்கப்படங்கள் பயிற்றுனருக்கும் பாமாருக்கும் மிக்க கவர்ச்சிகரமானவை.

ஆசிரியர் ஜாகீ எல் வான் கோதமி
RBINS இலாகா தலைவர்

Table of contents

1. Purpose of this book

In the first place, this book is meant to provide a summary of field and laboratory techniques in phycology (the study of algae), and their ecosystems. It also gives a glance to the dominant species of marine algae present along the coast of Sri Lanka. In addition, it should, therefore, be clear that the species described and illustrated here are only part of the marine flora of Sri Lanka, not at all a comprehensive Flora. It is an easy-to-use guide to the identification of the most frequent seaweeds, intended to be used by biologists, students, amateur naturalists, and others interested in the marine life of this island.

The taxonomic part covers the different groups of marine macroalgae (Chlorophyta or green algae, Phaeophyceae or brown algae and Rhodophyta or red algae). Numerous smaller seaweeds (mostly epiphytic ones) and turf algae (low, dense mats of grazed algae) are omitted although they can locally be a very important component of tropical and subtropical marine ecosystems, especially in heavily grazed areas. Encrusting coralline algae are not included as they are not well studied in the region and are mostly not easily identified by simple observation and descriptions. The prokaryotic blue-green algae (= Cyanophyta or Cyanobacteria) are not covered either.

Although the Sri Lankan seaweed flora has only been sporadically studied, it seems to be relatively rich, with about 440 taxa, belonging to 148 genera currently recorded along a coastline of 1585 km (Baldwin *ed*., 1991; Silva *et al*., electronic version).
The correct identification of seaweeds mostly requires the study of microscopic structures (see chapter 8.7). Therefore this guide represents a compromise between ease of use and technical detail. The photographs of the macroalgae in their natural environment, sometimes combined with herbarium and/or microscope pictures as well as the relatively detailed descriptions should enable anybody to identify these most frequent seaweeds in the field.

We do hope that this book may lead to an increased interest of local scientists and enhance the study of these beautiful and intriguing marine organisms. Although they generally go unnoticed, they are extremely important as primary producers along the shores as well as providing food, shelter, spawning areas and living biotopes for numerous animals.

2. Sri Lanka

2.1. Introduction (after Wright, 1994; Höfer, 1995; Perera, 2006)

According to the *Mahavamsa*, the modern history of Sri Lanka starts in the fifth century AC, with the arrival of Prince Vijaya together with 700 followers in Mannar. They called the island 'Thambapanni' (copper-coloured sand). These Buddhist Simhalese (originally from N India) are the ancestors of the actual Sinhalese majority of the population of the island who replaced the prior inhabitants, the Veddahs. The Greek sailors could not pronounce 'Thambapanni' and called the island 'Taprobane'. The seafarers of old Arabia called her 'Serendib', a word that has since evolved into the soothing state of mind known as serendipity (the faculty of making happy and unexpected discoveries by accident). Latter-day adventurers came up with the nickname 'Pearl of the Orient'. Another romantic, descriptive name for the island is 'The teardrop of India'. Marco

Polo called it ‘the finest island of its size in the world’. In the 8^{th} and 9^{th} centuries the Moors had achieved a dominant commercial position but remained unobtrusive.

The first permanent Tamil settlements (coming from the Indian mainland) occurred in the 10^{th} century AD, but mostly in the 12^{th} century, without dislodgement of the original Sinhalese population. In the 13^{th} century more violent invasions took place with the help of Tamil and Kerala mercenaries, resulting in the permanent dislodgement of the Sinhalese power from N Sri Lanka and the confiscation of lands and properties. These factors lead to the foundation of a Tamil Kingdom in that part of the island, next to several other Kingdoms, with a deliberate policy of peaceful migration of more Tamils.

The island was later called ‘Ceilao’, a corruption of ‘Sinhala-dvipa’ by the Portuguese, who ruled the coastal provinces during less than 60 years in the early 16^{th} century; they introduced Roman Catholicism. The Dutch drove the last Portuguese from the island in 1658. They called the island ‘Ceylan’ and introduced Dutch Calvinism. In 1796 the British supplanted the Dutch in the coastal areas. They managed to control the Kingdom of Kandy in the Highlands in 1815, becoming the first European power to rule the whole island, now called ‘Ceylon’. They introduced English calvinism. The British were unable to persuade the Sinhalese to work cheaply and willingly on the plantations, so they imported large number of Tamil labourers.

In February 1948 the island celebrated the return to its independence from foreign domination in a smooth and peaceful way. In May 1972 the country’s name was finally changed to ‘Sri Lanka’ (officially the Democratic Socialist Republic of Sri Lanka), meaning ‘Island of Happiness’. Its capital is Sri Jayawardenepura Kotte, the commercial capital being Colombo where the international airport and major marine harbour are situated. The population was about 20 million people in 2005. The languages are Sinhala, Tamil and English, each with their own alphabet. The religions are mostly Buddhist, but also Hindu, Christian and Muslim. The time zone is GMT + 5 ½ hours.

2.2. Location

Sri Lanka is located in the Bay of Bengal, in the northern Indian Ocean (Fig. 1), sharing the same continental shelf as India. The northernmost point of the island is Point Pedro. Talaimannar (at the tip of Mannar peninsula) is only 48 km apart (SE) from Dhanushkodi in India, separated from it by the Palk Strait in which numerous sandbanks and small limestone shoals form ‘Adam’s Bridge’. According to temple records, this natural causeway was formerly complete, but was breached by a violent storm in 1480. The island is situated between 5° 55’ and 9° 50’ N latitude and 79° 42’ and 81° 52’ E longitude. The drop-like island is 435 km long and 225 km at its widest part, totaling a surface of 65 610 km^2 and a coastline of 1585 km. Dambulla, famous for its ancient cave temple, marks the geographical centre of the island. The old harbour town of Dondra represents the island’s southernmost tip. Beyond the lighthouse of Dondra Head there is not a single speck of land before the ice of Antarctica.

2.3. Geography and geology

The northernmost half of Sri Lanka is composed of a huge plain. The central part of the island is dominated by hills and mountains, culminating to 2524 m (Pidurutalagala, close to Nuwara Eliya). In some parts of the south, hills almost reach the coastline.

Fig. 1. General position and map of Sri Lanka with indication of sampling sites (red dots). Modified from map Base 802514 6-00, Library of Congress, Geography and Map Division, Washington, D.C.: Central Intelligence Agency, 2000 (digital id: http://hdl.loc.gov/loc.gmd/g7750.ct001762).

More than 90 percent of Sri Lanka's surface lies on Precambrian strata, some of it dating back 2 billion years. The metamorphic rock surface was created by the transformation of ancient sediments under intense heat and pressure during mountain-building processes. The theory of plate tectonics suggests that these and related rocks forming most of south India were part of a single southern landmass called Gondwanaland. Beginning about 200 million years ago, forces within the earth's mantle began to separate the lands of the Southern Hemisphere, and a crustal plate supporting both India and Sri Lanka moved toward the northeast. About 45 million years ago, the Indian plate collided with the Asian landmass, raising the Himalayas in northern India, and continuing to advance slowly to the present time. Sri Lanka experiences few earthquakes or major volcanic events because it rides on the center of the plate.

Actually, the rock floor of Sri Lanka is composed of gneisses and schists topped with a layer of graphite, crystalline limestone and quartzites. Several places are rich in gems (rubies, sapphire, amethyst, zircons, tourmalines, topaz, …) resulting in numerous gem pits in the middle of paddy fields (e.g. in the Ratnapura area).

The substratum of the sandy beaches (Fig. 2A) and lagoon bottoms can either be fine grained and of geological origin (erosion of rocks, Fig. 2B), coarser coral sand (Fig. 2C) or be composed of large calcified segments of decayed *Halimeda*, a green seaweed, the so-called *Halimeda*-sand (Figs 2D, E). The pore diameter increases relative to the amount of each sand-type, resulting in a different interstitial fauna.

Fig. 2. Sandy beach and soft substrates. A. Sandy beach (Kalutara); B. Colourfull, fine-grained sand of geological origin (Batheegama); C. Coarse coral sand, partly covered with some drift *Halimeda gracilis* plants and *Halimeda* sand (Weligama); D. Pure *Halimeda*-sand (Weligama); E. Seagrasses (*Cymodocea rotundata*) growing in *Halimeda* sand in a lagoon (Weligama).

2.4. The coastline

The major part of the West coast N of Colombo as well as of the E coast is composed of extensive sandy beaches (Fig. 3A), lagoons (Fig. 3D) and estuaries (Figs 3E, F). Along the sandy beaches, interrupted beachrock platforms can be present over long stretches, mostly parallel to the beach and close to low water mark (Fig. 4A). The landward margin of the visible part of these beachrock platforms is frequently covered by a thin layer of sand, evolving in a mostly rather steep beach (Fig. 4B). Some of the beachrock platforms are provided with numerous rock pools (Figs 4C, D). Locally a narrow, shallow lagoon can be present between the platform and the beach (Figs 4E-H). The seaward side of the platforms, generally abruptly ends with small vertical cliffs (0.5-2 m high), split up by crevices (Figs 5A, B). They are exposed to severe surf, forming a habitat with surf-resistant species (Fig. 5C).

Fig. 3. Coast types. A. Sandy beach and a few rock outcrops in the sea (Hambantota); B. A wide bay (Dickwella); C. An enclosed bay (Nilwella); D. Chilaw lagoon; E. An estuary; F. Estuary, sandy beach and small dunes (Hambantota).

Fig. 4. Beachrock platforms. A. Extended beachrock platforms at about low tide level (Chilaw); B. Extended beachrock platforms breaking down, at the foot of a steep beach (Chilaw); C. Intertidal pools on the beachrock platform (Chilaw); D. Intertidal pools on the beachrock platform and lagoon (on the right hand side; Beruwela); E, F. Broken-up beachrock platform and small lagoon (next to Dickwella Resort peninsula); G. Beachrock platform and narrow lagoon (Koggala); H. Beachrock platform and broad lagoon (Beruwela).

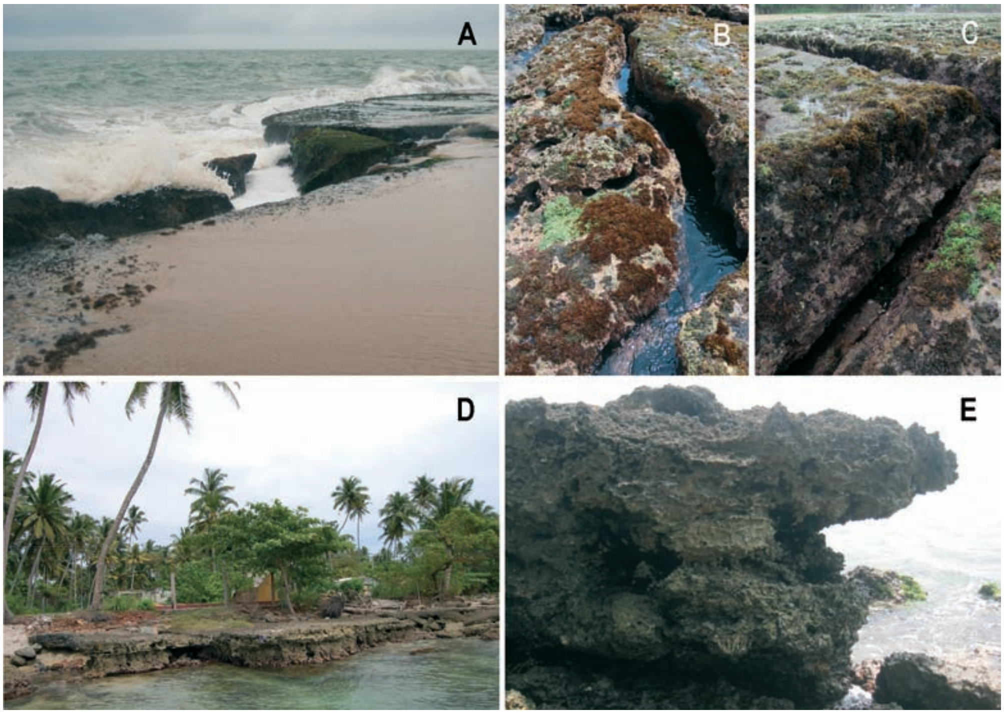


Fig. 5. Coast types. A-C. Broken-up beachrock platform with vertical walls covered by a typical surf-resistant seaweed vegetation (A, B. Chilaw; C. Hikkaduwa); D. Small cliff wall as the result of the erosion of a fossil reef (Polhena Beach, Matara); remark: the effects of the 2004 tsunami are still visible on land; E. Detail of a small eroded cliff wall of a fossil reef (Polhena Beach, Matara).

The southern coastline is characterized by the alternation of rocky coasts (Fig. 6A), rocky peninsulas (Fig. 6B), rock boulder areas (Fig. 6C) and wide or narrow sandy bays (Figs 3B, C; 6D, E). Some coast stretches are composed of small cliffs of eroded fossil coral (Figs 5D, E). A few places (Weligama, Hambantota/Usangoda) are characterized by short but high cliff walls (Figs 6F, G). Coastal dunes are rare, but if present they can be well-developed as in parts of Yala Park (Fig. 6H). Small islands (Figs 7A, B) or protruding rock boulders (Figs 7C, D) are scattered along the coast.

Submarine rock reefs and isolated submerged rocks are present all around the island. Real coral reefs are rather rare (e.g. Bar Reef at Kalpitiya (Fig. 7E), the lagoon reefs of Galle, Weligama, …). The once famous Coral Gardens in Hikkaduwa almost completely died off after the 1998 El Niño. In general, the sublittoral coastline drops gradually.

Fig. 6. Coast types. A. Rocky coast during the SW-monsoon (Dickwella); B. Surf-exposed peninsula (Tangalle); C. Rock boulders with a dense seaweed vegetation and marked zonation (Nilwella); D, E. Rocky peninsulas alternating with sandy bays fringed by beachrock platforms (Tangalle); F. Cliffs at Weligama; G. Cliffs alternating with sandy beaches (Usangoda protected area, Hambantota); H. Dunes alternating with beachrock and intertidal rocks (Yala).

Fig. 7. Coast types. A. Coastal islands (Beruwela); B, D. Large rocky outcrops in the sea and coastal beachrock platform (B. Koggala; D. Beruwela); C. Coastal island in Weligama Bay; E. Healthy coral reef close to Kalpitiya (Bar Reef).

2.5. Climate and seasons

Sri Lanka's climate is tropical. In the north-western parts of the island, there are some extremely hot areas, where temperatures occasionally climb above 38°C. Frost can occur on the highest mountain peaks, and snow has only rarely been observed. The coastal areas are subject to an almost continuous seabreeze, limiting the temperature to 30°C in daytime most of the year (up to 33°C in April) and 27°C at night (with a rare 22°C occurring occasionally). At Kandy (altitude 450 m) mean temperature drops to 20°C, whereas Nuwara Eliya (altitude 1890 m) can be as cool as 16°C. The 'seasons' are defined by the monsoons. They are seasonal winds that carry rain with them. These 'trade winds' were already used by the Greeks (1st century A.D.) for sailing.

The SW-monsoon brings heavy and prolonged rains from the Indian Ocean along the SW-coast between mid (to late) May and September. It enters the island in an area between Chilaw (N of Colombo) and Hambantota (in the south). The clouds hit the central highlands where they cause huge rains (locally up to 5000 mm per year) resulting in turbid coastal water (Figs 8A, 7B). On the other side of the mountain crest there is a rainshadow resulting in a dry season along the East coast. The second season (the Convectional Cyclonic Period or intermonsoonal months) occurs in October and November. Even then, sudden afternoon showers and thunderstorms can be abundant (Figs 8B, C), resulting in inundations, landslides and more turbid coastal water. Inversely, the NE-monsoon brings agriculturally significant rainfall from the Bay of Bengal to the northern and eastern parts of the country between December and March. The West coast is mostly dry in that period, but even then, late afternoon or night showers can periodically be frequent. During the convectional convergence period (mid April to late May) the island comes under the influence of the Inter Tropical Convergence zone. This is a constant daily weather sequence with bright clear mornings that induce convectional activities leading to the formation of rain clouds by early afternoon and thunderstorms in the late afternoon. The pre-monsoonal period (mid April to late May) has transitional weather patterns. During this time Convectional weather is gradually suppressed by the surges of the South West monsoon.

The coastal region East of Hambantota is much drier, resulting in a different, 'savanna-like' coastal vegetation.

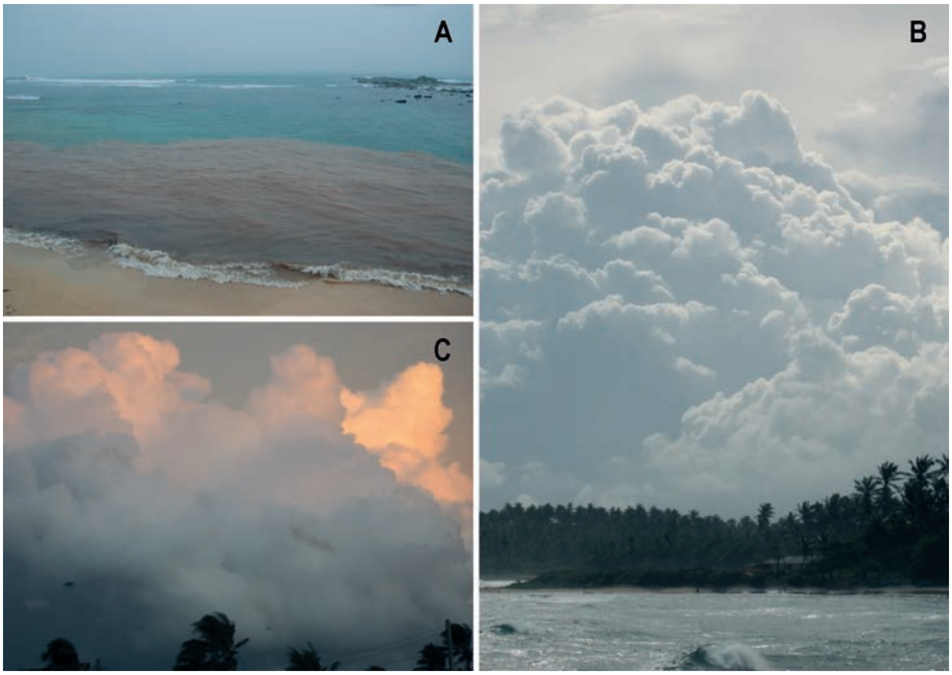


Fig. 8. Thunderstorms and effect on coastal water turbidity. A. Turbid coastal water after heavy rains (Unawatuna); B, C. Late afternoon thunderstorms arriving during the SW-monsoon (Dickwella).

2.6. Currents, seawater temperature, salinity, tides and wave action

Indian Ocean surface currents are mainly controlled by the monsoon. Two large circular currents, one in the northern hemisphere flowing clockwise and one south of the equator moving anticlockwise, constitute the dominant flow pattern. During the winter monsoon, however, currents in the north are reversed.

Satellite images show that the average seawater surface temperature around Sri Lanka is between 26 and 28°C, being somewhat higher along the northern coast. It has been shown that individual seaweed species distributions over a biogeographic scale are overwhelmingly limited by seawater temperature regimes. Several tropical species are present in the Jaffna area but have not been observed south of Kalpitiya.

The maximum tidal range for the Sri Lankan coast is about 70 cm (Dayananda, 1992). There are two tidal cycles per day.

Along the southwest coast, both the swell and the waves are highest between May and September, this is during the SW-monsoon. The direction of the swell is very constant all over the year, approaching from the south, being 2.5 to 3.0 m high and with a frequence of about 16 seconds. The direction of the short waves is strongly influenced by the monsoons. During the SW-monsoon they vary from SW to W. Their height increases from April onward, reaching a peak in June-August and decreasing again to November (Scheffer *et al*., 1994).

Best underwater visibility is from March to April.

2.7. Biodiversity – General

As a result of the early edicts of the country's Buddhist leaders, Sri Lanka can boast the world's first wildlife sanctuary, created by King Devanampiya Tissa in the 3rd century BC. Up to the colonial period large areas were put aside as Forbidden Forests: wilderness areas and watersheds. Deforestation started with the onset of the colonial era when the rulers were more bent on exploiting rather than conserving the natural resources. Under British rule large surfaces were cleared for their coffee, tea and rubber plantations and the slaughter of 'big game'. Also in the post-colonial era, the rate of deforestation remained alarming with the total forest cover being reduced to 50% over the last 4 decennia.

Nevertheless, biodiversity in Sri Lanka is still very high, as a result of an impressive habitat diversity caused by differences in temperature and rainfall according to altitude. Most groups of organisms include a large number of endemics. The vegetation supports over 3368 species of flowering plants (of which 26 per cent are endemic) and 314 species of ferns and fern allies (of which 57 species are endemic). Similarly, the country supports a high faunal diversity due to the varied climatic and topographic conditions prevailing in the island.

Within the territorial waters of the country, there are 38 species of marine mammals, including the sperm whale, the blue whale and a rare species of dugong. When compared to the extent of its shoreline Sri Lanka has limited true coral reefs. It is estimated that only 2% of the coastline has fringing coral reefs. There are widespread areas of patch reefs, but the extent of these has not been determined in detail. Most fringing reefs are found on the South-western, southern (e.g. Hikkaduwa, Unawatuna, Weligama) and eastern coasts (e.g. Pigeon Islands, Trincomalee). Well-developed offshore coral reefs occur in the Gulf of Mannar and west of the Kalpitiya Peninsula (Bar Reef). Coral reefs around the Jaffna Peninsula are less well developed, and occur mainly around the coastal islands. At present, only two coral reef areas have been afforded legal protection as Marine Protected Areas (MPA's) in Sri Lanka, namely the Hikkaduwa National Park in the south and Bar Reef Marine Sanctuary in the north west of the country. In addition, the area around the Great Basses and Little Basses reefs has been designated a Fisheries Protected Area. The coral reefs include 193 species of coral, over 300 species of fish and over 200 species of crabs. Five out of the eight existing marine turtle species (worldwide) regularly visit the sandy beaches of Sri Lanka to nest.

3. Main communities containing seaweeds

Seaweeds occur in three major marine communities: seaweed vegetations s.s., seagrass beds and mangrove forests.

Seaweed vegetations sensu stricto. They are best developed on rocky substratum; most benthic marine macroalgae are thus epilithic. Here they occur in the intertidal zone as well as above (in the spray zone) and under it (in the subtidal, on submerged reefs and rock boulders). Their development depends on the season and the surf (see chapters 4 and 5). Monospecific vegetations can occur, e.g. *Ulva fasciata* (Fig. 9A), *Sargassum* sp. (Fig. 9B), *Gracilaria corticata* (Fig. 9C), *Chaetomorpha antennina* (Fig. 9D) or *Dermonema virens* (Fig. 9E), but mostly tufts of different species are mixed or contiguous (Figs 10A-C), or different genera/species can really be intricated (Figs 10D-F). Mid and low intertidal rock pools generally contain a rich, continuously submerged seaweed flora which is different from the air-exposed substratum at low tide. High intertidal pools warm up too much and mostly contain coloured water (blooms of specific phytoplankters) with an elevated salinity (as a result of evaporation).

Fig. 9. Monospecific vegetations. A. Monospecific vegetation of *Ulva fasciata* (Dickwella); B. Monospecific vegetation of *Sargassum* sp. (Beruwela); C. Monospecific vegetation of *Gracilaria corticata* (Chilaw); D. Monospecific vegetation of *Chaetomorpha antennina* (Unawatuna); E. Monospecific vegetation of *Dermonema virens* (Nilwella).

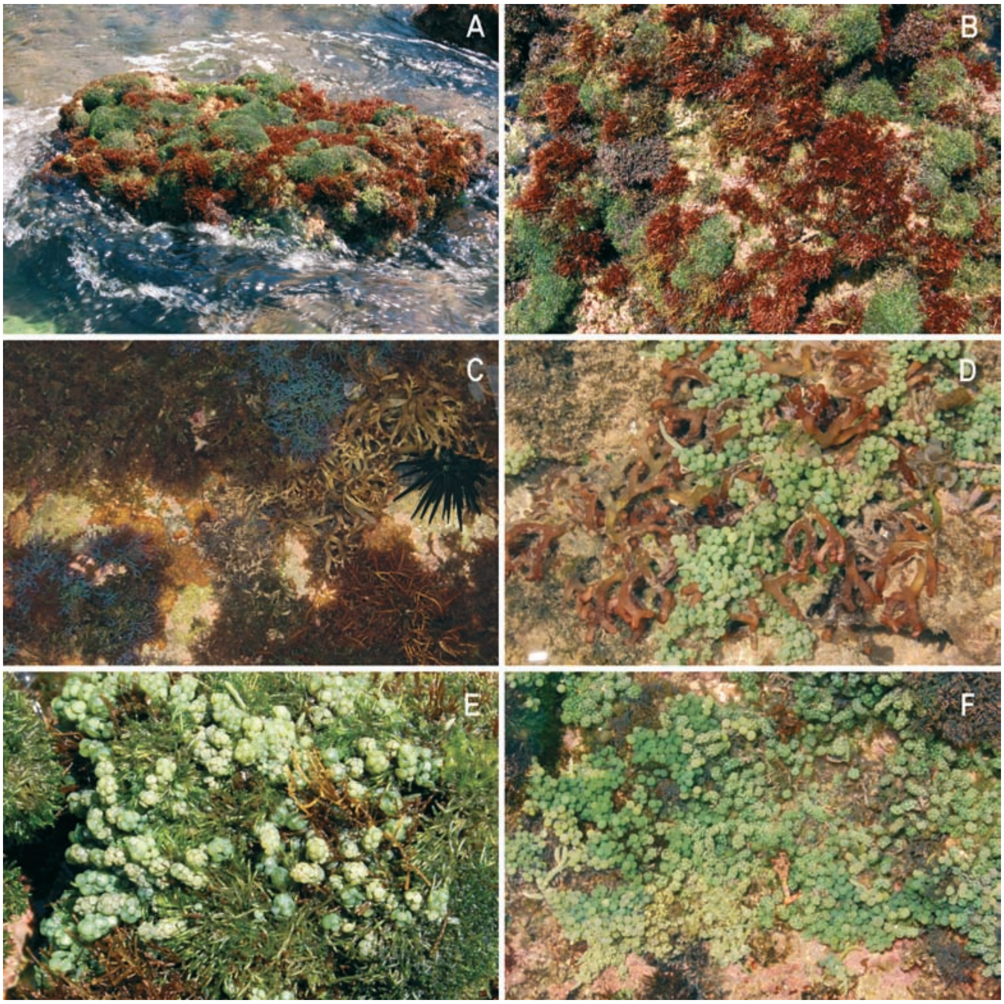


Fig. 10. Mixed vegetations and intricated seaweeds. A. Mixed vegetation of contiguous tufts of *Valoniopsis pachynema* (green bumps) and *Pterocladiella caerulescens* (Hikkaduwa); B. Detail of a mixed vegetation of *Valoniopsis pachynema*, *Pterocladiella caerulescens*, *Hypnea pannosa*, *Gracilaria corticata* and *Gelidiella acerosa* (Hikkaduwa); C. Detail of a mixed vegetation of *Hypnea pannosa*, *Polyopes ligulatus*, *Gelidiella acerosa, Laurencia* sp., *Laurencia natalensis* and others (Hikkaduwa); D. The green alga *Caulerpa racemosa* intricated to the red alga *Gracilaria crassa*; E. Intricated seaweeds: *Valoniopsis pachynema*, *Caulerpa imbricata*, *Gelidiella acerosa*, *Pterocladiella caerulescens*, *Ulva* sp.; F. Intricated seaweeds: *Caulerpa racemosa*, *C. imbricata*, *Chondria armata*, *Hypnea pannosa*.

In sheltered areas with sandy substratum, seaweed growth is limited due to erosion by shifting sands, but some seaweed genera can grow in this subtidal habitat (*Ulva*, *Padina*, *Acanthophora*, *Hypnea*, *Centroceras*, …), being attached to shell or coral fragments.

Fig. 11. Epiphytism. A. *Asteronema breviarticulata* forming epiphytic tufts on *Chnoospora minima*; B. Crustose Corallinaceae epiphytic on *Sargassum*; C. *Ceramium* cf. *taylori* epiphytic on *Caulerpa peltata* var.; D. *Laurencia* sp. epiphytic on *Sargassum*.

Many small algae (e.g. *Ceramium* spp., *Laurencia* spp., crustose Corallines) grow as epiphytes on different other seaweeds (Figs 11A-D).

Fig. 12. Seagrass meadows and associated seaweeds. A, B. Seagrass meadows becoming air-exposed at extreme low water (Nilwella); C. *Halimeda gracilis* growing between the submerged seagrasses in the lagoon (Weligama); D. *Caulerpa racemosa* partly growing between the seagrass *Thalassia hemprichii*, air-exposed at extreme low tide (Nilwella); E, F. Leaves of the seagrass *Cymodocea serrulata* covered by crustose Corallinaceae.

Seagrass ecosystems develop in surf-sheltered, subtidal biotopes. They thrive best in shallow lagoons (e.g. Puttalam Bay, Chilaw and Weligama lagoon) and protected bays. Some seagrass meadows become air-exposed at extreme low water (Figs 12A, B). Larger seaweeds (e.g. some species of *Chaetomorpha*, *Avrainvillea*, *Halimeda*, *Caulerpa*, *Codium, Tolypiocladia*) grow between the seagrass plants (Figs 12C, D) or on their stolons (e.g. *Hypnea* spp.); smaller ones grow as epiphytes on the seagrass stipes and leaves (e.g. species of *Dictyota*, *Laurencia*, *Ceramium*, *Polysiphonia*, small encrusting corallines, Figs 12E, F).

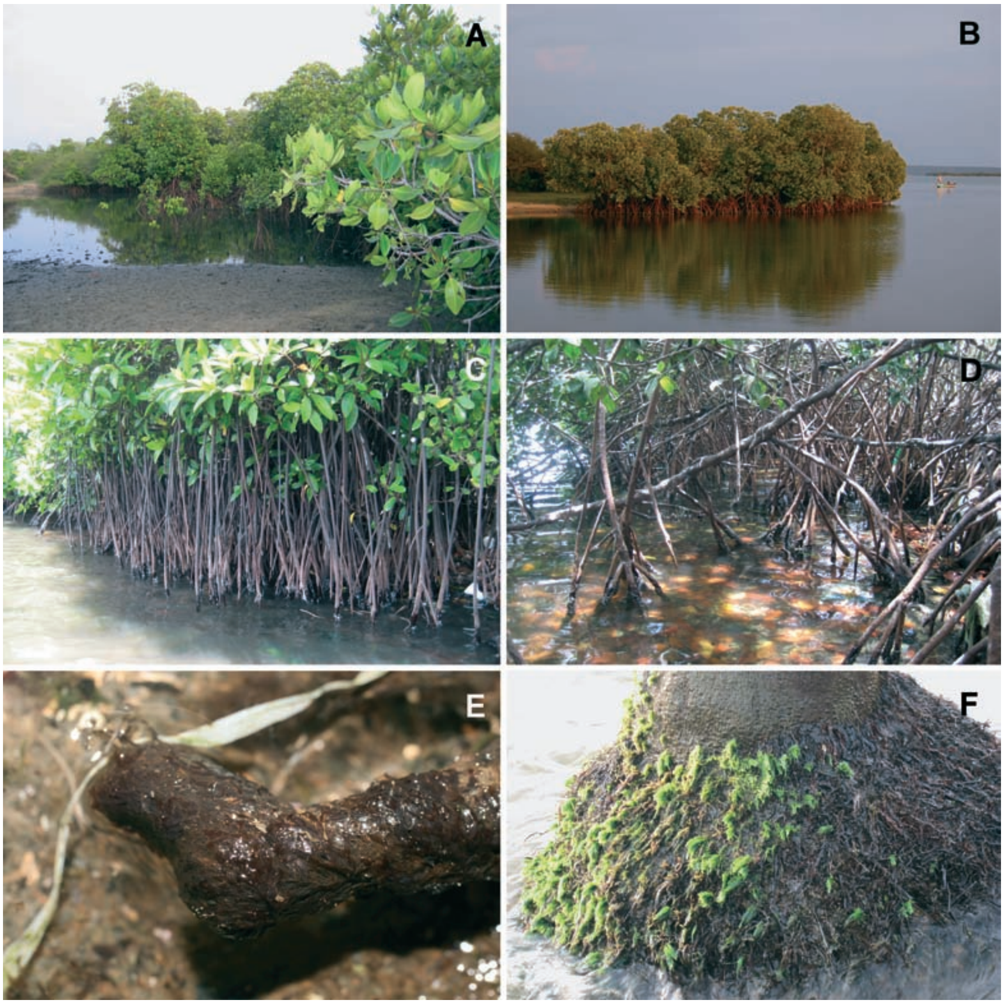


Fig. 13. Mangrove and associated seaweeds. A, B. *Rhizophora* mangrove (Kalpitiya); C, D. Rhizophores of *Rhizophora* sp. on which epiphytic algae develop (Chilaw lagoon); E. Detail of a rhizophore covered by *Caloglossa leprieurii* and *Polysiphonia* sp. (Chilaw lagoon); F. Basal part of a palm tree standing in the sea after coastal erosion and covered by seaweeds (Wattale).

Mangrove forests (Figs 13A, B) are best developed in sheltered, high intertidal to supralittoral zones. They occur mainly around lagoons and in estuaries. Some macroalgae develop in the mangrove tide channels (e.g. *Caulerpa* spp.), others in the silty pools in the mangrove vegetation (e.g. filamentous *Chaetomorpha* spp., tubular and blade-like *Ulva* species), others again on the aerial roots (rhizophores (Figs 13C, D) and pneumatophores) and the basis of the tree trunks (e.g. species of *Laurencia*, *Caloglossa*, *Catenella*, *Murrayella* and *Bostrychia*, Fig. 13E). As these algae are rather small and largely covered by sediments, they often go unnoticed. Even basal parts of palm trees standing in the sea after coastal erosion can be covered by seaweeds (Fig. 13F).

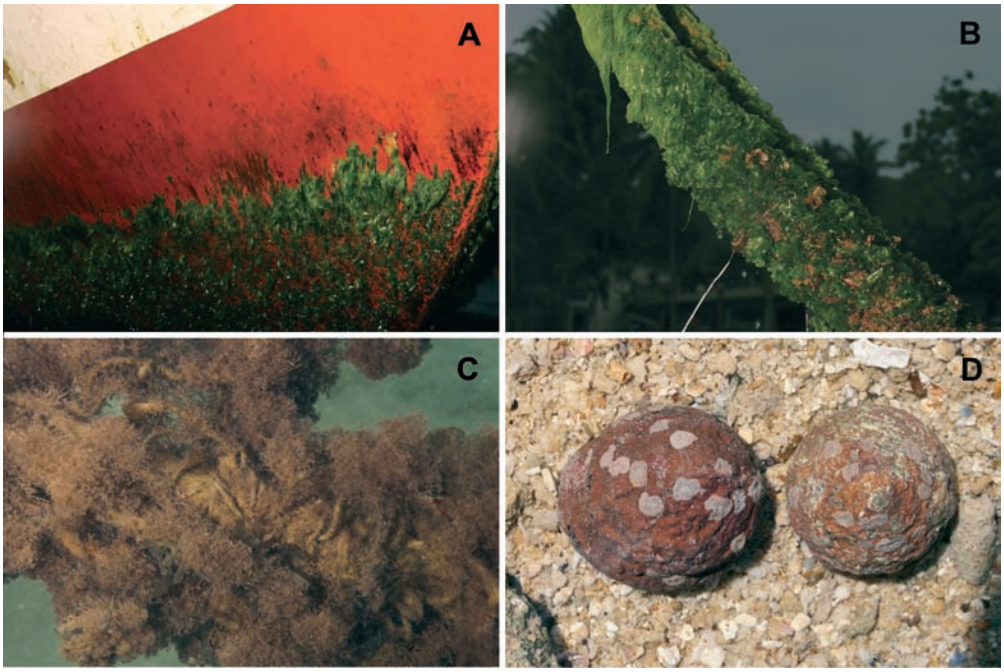


Fig. 14. Fouling and epizoic algae. A. Fouling on a boat: tubular and blade-like *Ulva* spp. (Beruwela); B. Fouling on a rope: tubular and blade-like *Ulva* spp. and *Padina* sp. (Beruwela); C. Fouling on a rope: dense vegetation of *Jania* (Weligama); D. A shell of a Gastropod covered by crustose coralline algae.

Fouling. Some seaweeds grow very well on floating hard substrata which are submerged or at least continuously wave-swept, such as boats and ropes (Figs 14A-C).

Seaweeds can also develop on animals (they are then called epizoic), such as shells of Gastropods (Fig. 14D).

4. Seasonality

As a result of the seasonal monsoons, the macroalgae of the intertidal and supralittoral zones show a well-marked seasonality. From June to November these parts of surf-exposed rock outcrops show a very dense seaweed cover (*Porphyra* spp., *Dermonema virens*, *Chnoospora minima*, *Asteronema breviarticulata*, *Chaetomorpha antennina*, *Ulva fasciata*, *Jania intermedia*, *Champia ceylanica*, …) (Fig. 15A). In the dry season (November onwards) these species ‘disappear’ due to overheating and desiccation. As a matter of fact, most of them are still there, but reduced to their crustose basis or present as a short algal turf. Some small specimens can still be found under rock overhangs, in crevices or in shaded intertidal pools. The mid to low intertidal pools on the sheltered, landward side of the rock outcrops also show a very different aspect over the seasons. In the cooler rain season, with huge surf, they are regularly flushed by seawater, stabilizing temperature as well as salinity. They then contain dense vegetations of tubular *Ulva* spp. which disappear in the dry season, when these pools heat up and salinity rises too much due to evaporation.

The first observations of the algal seasonality in Sri Lanka were formulated by Svedelius (1906b). Gunasekara (in prep.) carried out a study on seasonality of seaweed vegetations on rocky outcrops (mainly a beachrock platform in Dickwella) in the framework of his MSc-thesis at the University of Ruhuna (Matara).

Because of this pronounced seasonality of seaweed development, it is absolutely necessary to visit study sites in different seasons to get a complete view of the alpha-diversity of the area.

The seaweeds from the low intertidal and subtidal biotopes are less sensitive to seasonality as they are submerged (or at least continuously wave-swept) most of the time and the seawater temperature does not vary as much as the air temperature. On the other hand, presence of reproductive structures (frequently needed for identification) is mostly seasonal, even in these lower zones.

The seasonality of seagrasses and mangroves is limited to the discrete flowering seasons and the more pronounced loss of leaves in some periods of the year.

5. Zonation

The marine environment can be subdivided in two fundamentally different ecosystems: the intertidal that undergoes the tides twice a day and the subtidal that is continuously submerged.

The seaweeds occurring in the intertidal are subject to variable periods of emersion and submersion from high tide to low tide level. As a result, there is a strong variation of ecophysiological factors such as temperature, salinity, surf, light and desiccation depending on the level in the intertidal. Moreover, competition between different organisms (both plants and animals) also influences the distribution of algae along a shore.

The combination of all these factors results in the presence of superposed zones, mostly parallel to the height of the shore, each with a characteristic species composition of seaweeds and animals. The species from the upper zones are more tolerant to variation of the ecophysiological factors (they are eurytherm, euryhaline and euryionic). Those from the lower zones are less tolerant (they are stenotherm, stenohaline and stenoionic). It is clear that along wave-swept coasts the spray- and splash-zones will be much higher than along sheltered coasts, proving that zonation is not exclusively dictated by tidal levels. So for example, along a harbour wall, the same species will be present in a higher zone along the surf-exposed seaward side, than on the sheltered, harbour side.

In the subtidal and circalittoral zones light, hydrodynamics and siltation are the main factors defining the presence and the distribution of marine organisms.

In the description of the ecological distribution of the taxa included in this book the following zonation terminology is used:

- The **supralittoral**, corresponding with the <u>spray-zone</u>, is dominated by crustose lichens and some blue-greens (Figs 15B, C); it is never submerged by seawater, even at extreme high tide.

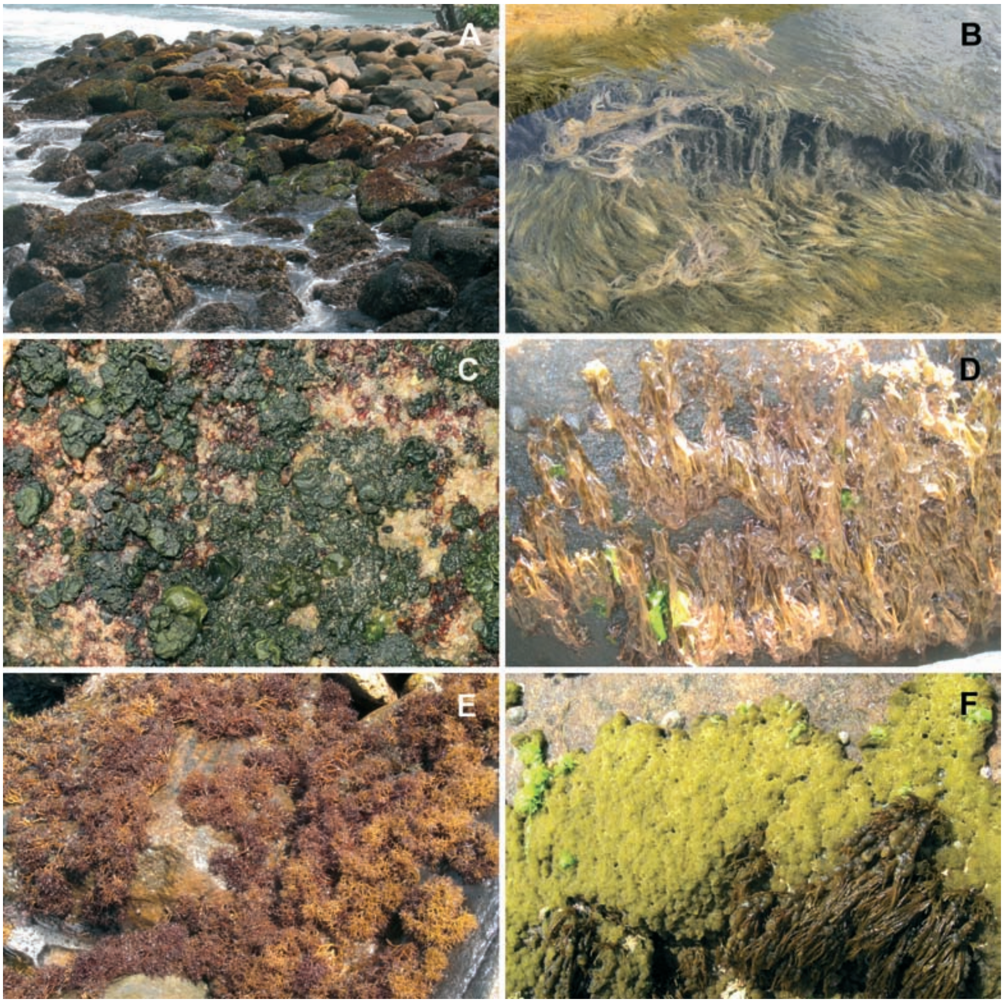


Fig. 15. Seaweed vegetations in the upper intertidal. A. Surf-exposed rocks with dense seaweed cover during the SW-monsoon (Nilwella); B. High intertidal rockpool covered by filamentous blue-greens (Dickwella Resort peninsula); C. The blue-green *Brachytrichia quoyi* on high intertidal rocks (Beruwela); D. *Porphyra* sp. in the supralittoral fringe of surf-exposed coasts during the SW-monsoon season (Dickwella); E. *Dermonema virens* in the supralittoral fringe of surf-exposed coasts during the SW-monsoon season (Nilwella); F. A zone of bleached, short tufts of *Centroceras clavulatum* on top of *Chnoospora minima* in the supralittoral fringe of surf-exposed coasts during the SW-monsoon season (Dickwella Resort peninsula).

- The **supralittoral fringe** (the lowermost part of the supralittoral), corresponding with the splash-zone is a relatively arid zone transitional between land and sea; it is only submerged at spring high tides. Relatively few species occupy this zone (and only during the SW monsoon with rough seas, as they completely dry out once the sea is getting calmer). Typical seaweeds in this zone are: *Porphyra* spp. (Fig 15D), *Dermonema virens* (Fig. 15E), *Centroceras clavulatum* (Fig. 15F), *Chnoospora minima*

(Figs 16A, C), *Asteronema breviarticulata* (Fig. 16B), *Ralfsia ceylanica* (Fig. 16C). On the shaded, overhanging walls of the eroded fossil beachrock cliffs, *Rhizoclonium africanum* (Fig. 16D), *Bostrychia tenella* (Fig. 16E) and *Murrayella periclados* (Fig. 16F) form extensive coverings in marked superposed zones.

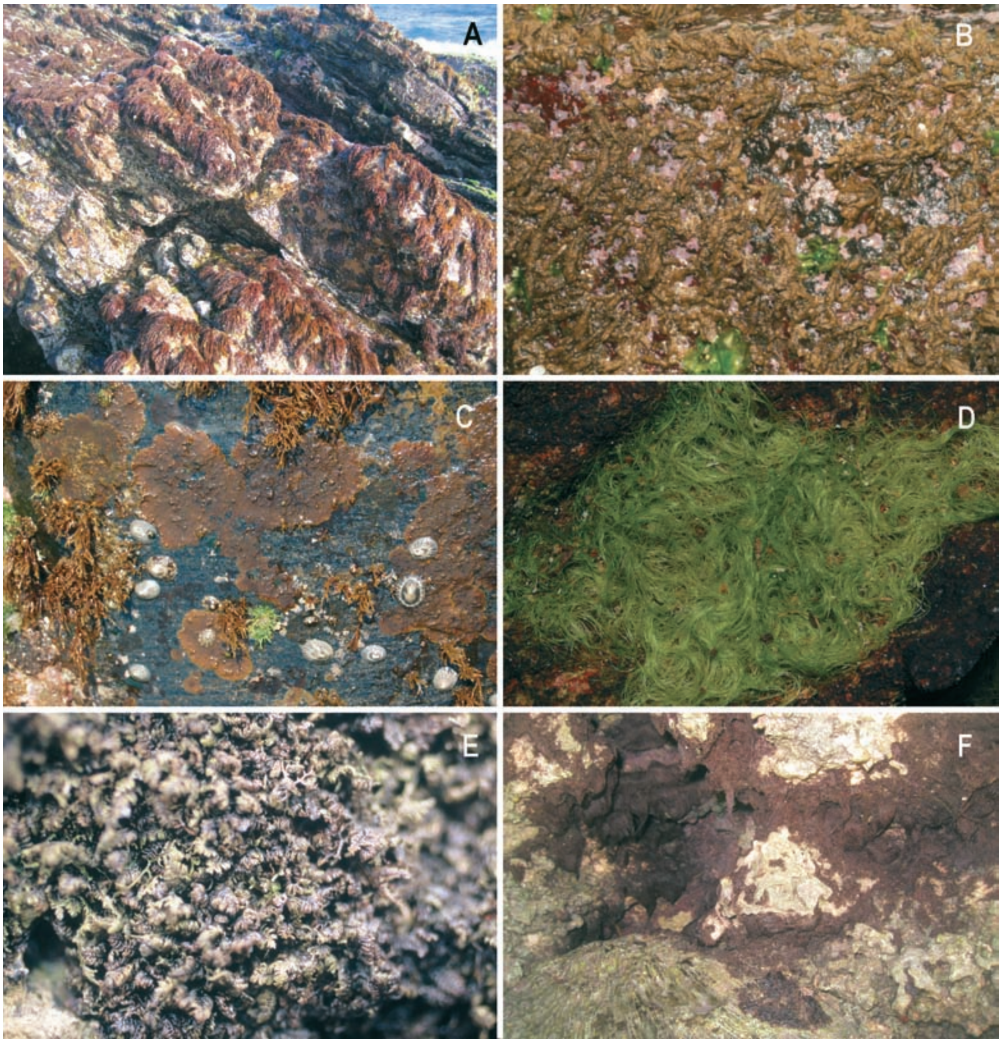


Fig. 16. Seaweed vegetations in the upper intertidal. A. Extensive vegetations of *Chnoospora minima* in the supralittoral fringe of surf-exposed coasts during the SW-monsoon season (Dickwella Resort peninsula); B. The zone of *Asteronema breviarticula* in the supralittoral fringe of surf-exposed coasts during the SW-monsoon season (Unawatuna); C. Brown crusts of *Ralfsia ceylanica*, between *Chnoospora minima* in the supralittoral fringe of surf-exposed coasts (Dickwella Resort peninsula); D. *Rhizoclonium africanum* in the supralittoral fringe of surf-exposed coasts (Unawatuna); E. *Bostrychia tenella* forming dense vegetations on shaded (mostly vertical) rock walls in the supralittoral fringe (Unawatuna); F. *Murrayella periclados* (and other filamentous red algae) forming dense vegetations on shaded (mostly vertical) rock walls in the supralittoral fringe (Matara, Polhena Beach).

Fig. 17. Seaweed vegetations in the upper and mid intertidal. A. *Chaetomorpha antennina* in the upper intertidal of surf-exposed coasts (Unawatuna); B. *Cladophora sericea* in the upper intertidal of the landward side of surf-exposed rocks (Wattale); C. *Ulva fasciata* in the upper intertidal of the landward side of surf-exposed rocks (Dickwella); D. *Jania intermedia* forming extensive vegetations in the middle intertidal along surf-exposed coasts (Dickwella); E. *Champia ceylanica* and *Laurencia natalensis* on crustose *Ralfsia* and Corallinaceae in the middle intertidal along surf-exposed coasts (Nilwella); F. Cascades between low intertidal rock pools (Dickwella); G. Densely intricate, low tufts of *Caulerpa sertularioides* and *C. racemosa* in the cascades between the rock pools (Dickwella); H. Detail of a densely intricated tuft of *C. sertularioides* from a low intertidal cascade (Dickwella).

- The **intertidal**, frequently called eulittoral in anglosaxon literature, roughly corresponds with the zone between mean high water and mean low water levels. On surf-exposed rock outcrops the intertidal is densely covered by macroalgae during the SW monsoon: in the upper intertidal, *Chaetomorpha antennina* (Fig. 17A) is extremely well developed along the seaward, surf-exposed side of rocky shores, whereas *Cladophora sericea* (Fig. 17B) and *Ulva fasciata* (Fig. 17C) are abundant on the landward, more sheltered but still continuously wave-swept side. The middle intertidal is characterized by extensive vegetations of the articulated coralline *Jania intermedia* (Fig. 17D) at sites exposed to extreme surf. Along medium exposed sites, *Laurencia* spp. and *Champia ceylanica* (Fig. 17E) are abundant. In the cascading overflows between intertidal pools, *Caulerpa sertularioides* and *C. racemosa* locally grow in densely intricated, low tufts (Figs 17F-H). In the lower intertidal, large barnacles can be abundant (quite often covered by *Gelidium* sp., Fig. 18A), together with some *Pterocladiella caerulescens* (Fig. 18B), *Ahnfeltiopsis* spp., *Jania cultrata*, … Vertical and overhanging (mostly shaded) walls can be covered by *Botryocladia skottsbergii* (Fig. 18C), and *Codium arabicum* (Fig. 18D).

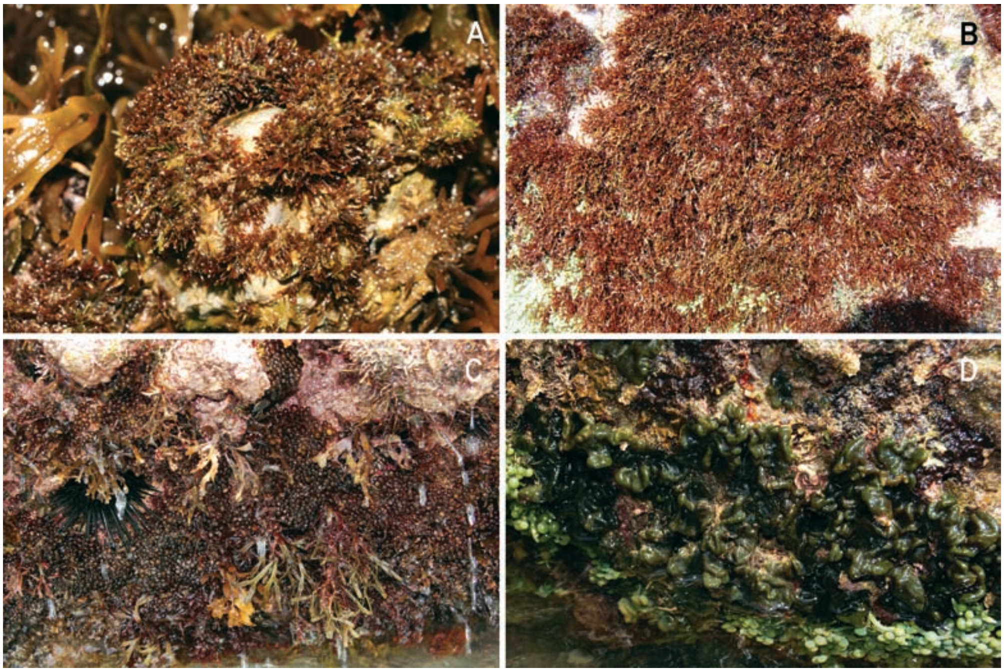


Fig. 18. Seaweed vegetations in the low intertidal. A. A large barnacle covered by a small *Gelidium* sp. and surrounded by *Gracilaria corticata*; B. *Pterocladiella caerulescens* growing in extensive vegetations in the lower intertidal along surf-exposed coasts (Unawatuna); C. *Botryocladia skottsbergii* growing in extensive vegetations on vertical walls in the lower intertidal along surf-exposed coasts (Unawatuna); D. *Codium arabicum* on a vertical wall in the lower intertidal along surf-exposed coasts (Galle).

At about low tide level, continuously wave-swept sloping to horizontal rock surfaces are covered by vegetations of different composition from the seaward to the landward side (Fig. 19A). On the extremely wave-swept seaward side, *Dictyosphaeria versluysii* (Fig. 19B) can be abundant, whereas *Turbinaria ornata* f. *evesiculosa* develops on seaward horizontal surfaces (Figs 19C, D), followed by a zone of *Sargassum turbinatifolium* (Fig. 19E). The middle part is covered by mixed seaweed vegetations where some species can be dominant, e.g. *Sargassum* sp. (Fig. 19F),

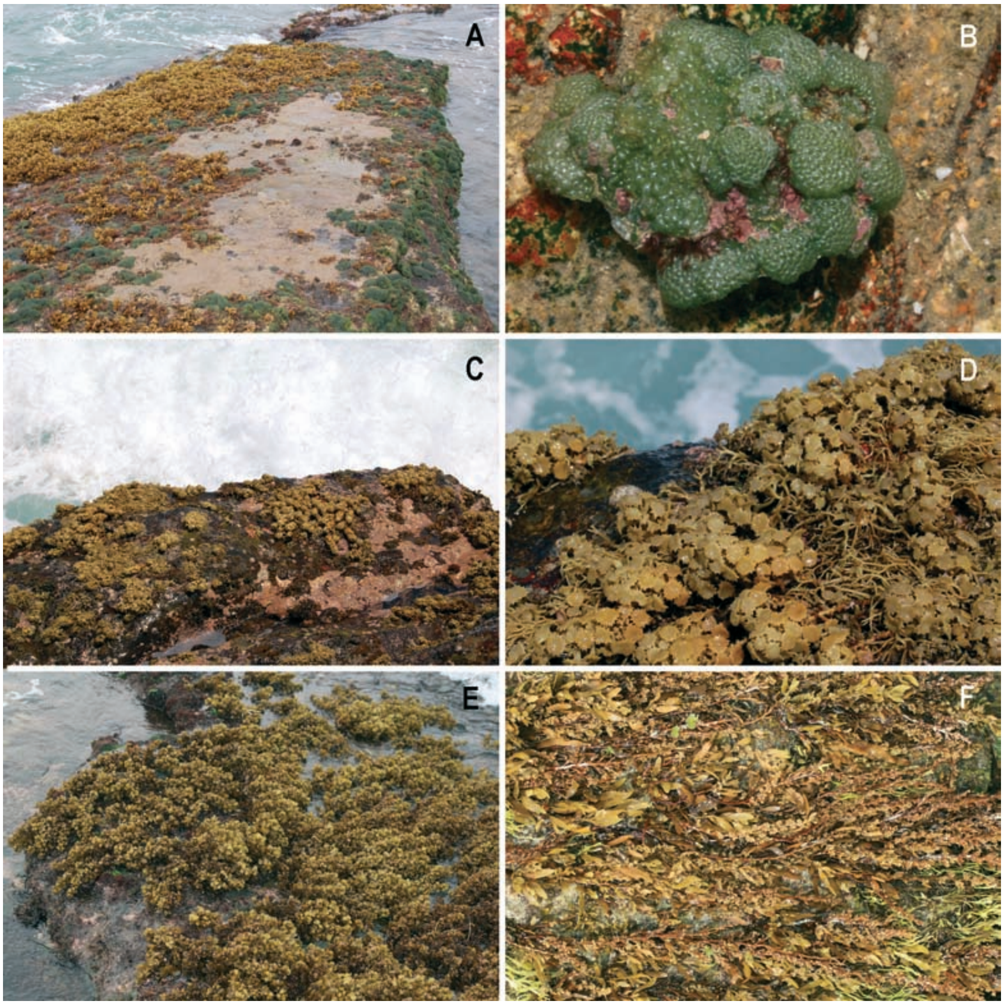


Fig. 19. Seaweed vegetations at about low tide level. A. Lower intertidal of a beachrock platform with *Sargassum turbinatifolium* on the seaward (surf-exposed) side and *Valoniopsis pachynema* on the landward (more surf-sheltered) side (Beruwela); B. *Dictyosphaeria versluysii* in the lower intertidal on the surf-exposed, seaward side of the beachrock platform (Beruwela); C, D. *Turbinaria ornata* f. *evesiculosa* at low tide level along extremely surf-exposed rocky coasts; E. *Sargassum turbinatifolium* at low tide tide level along surf-exposed rocky coasts; F. *Sargassum* sp.-vegetations in the middle part of beachrock platforms at about low tide level.

Hypnea pannosa (Fig. 20A), *Pterocladiella caerulescens*, *Caulerpa racemosa* f. *macrophysa* (Fig. 20B), *C. imbricata* (Fig. 20C) or combined with numerous species such as *Polyopes ligulatus*, *Gracilaria corticata*, *G. salicornia*, *Laurencia* spp., *Caulerpa sertularioides*, *Dictyopteris delicatula*, *Bryopsis pennata*, *Chlorodesmis caespitosa*, *Gelidiella acerosa, Spyridia hypnoides*, … On the more sheltered, landward side, *Valoniopsis pachynema* is a common green alga forming extensive cushions (Fig. 20D) next to *Dictyosphaeria cavernosa* (Fig. 20E). On vertical walls, *Portieria tripinnata* develops on the seaward side, whereas *Caulerpa lentillifera* (Fig. 20F) and *Dictyurus purpurascens* grow on the more sheltered, landward walls.

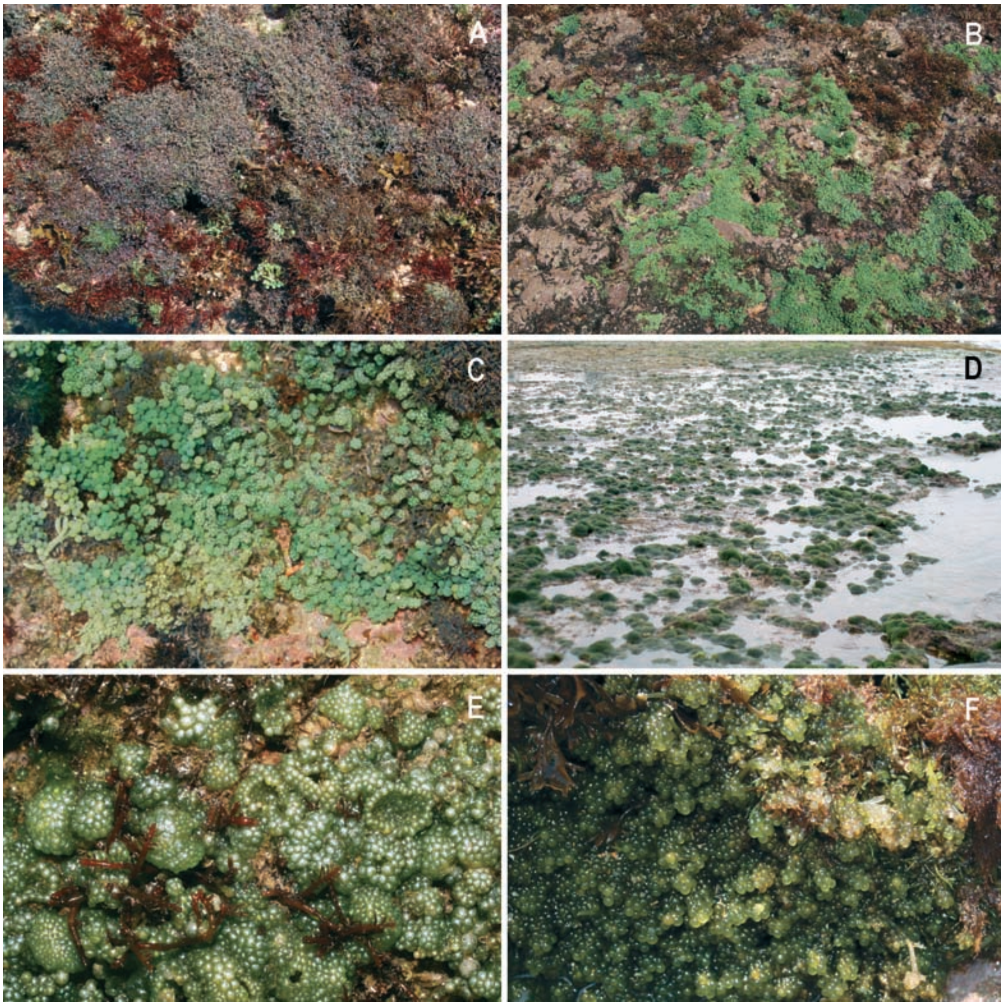


Fig. 20. Seaweed vegetations at about low tide level. A. Mixed seaweed vegetation with dominance of *Hypnea pannosa* and *Pterocladiella caerulescens* in the lower part of beachrock platforms at about low tide level; B. Mixed seaweed vegetation with dominance of *Caulerpa racemosa* and *Polyopes ligulatus* in the lower part of beachrock platforms at about low tide level; C. Mixed vegetation of *Caulerpa racemosa* and *C. imbricata* in the lower part of beachrock platforms at about low tide level; D. Numerous hemispherical cushions of *Valoniopsis pachynema* at about low tide level; E. *Dictyosphaeria cavernosa* (mixed with some *Gelidiella acerosa*) at about low tide level along more sheltered coasts (Beruwela); F. *Caulerpa lentillifera* on sheltered, landward vertical walls of the beachrock platform (Dickwella).

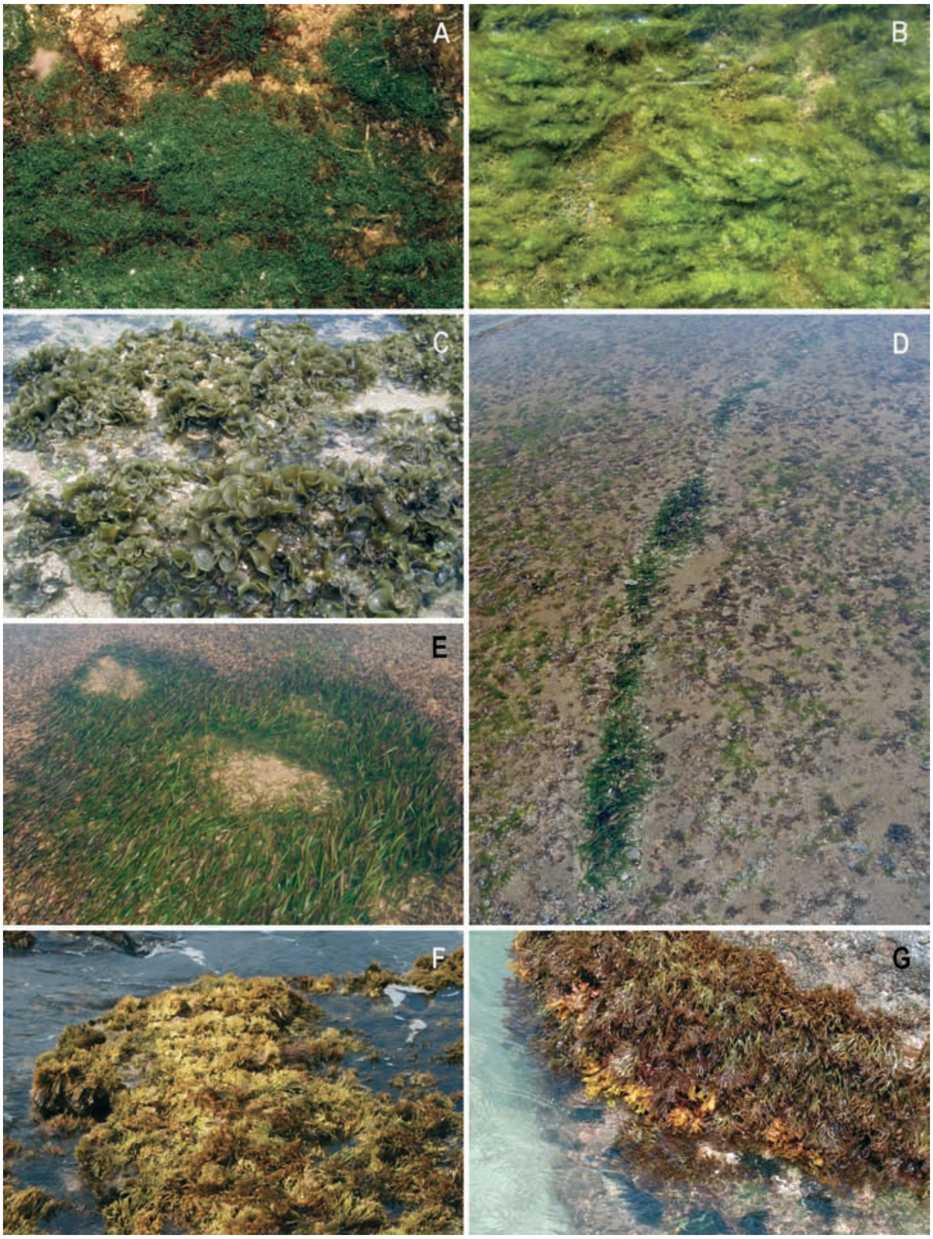


Fig. 21. Seaweed vegetations at about low tide level. A. *Chaetomorpha crassa* intertwined to *Gelidiella acerosa* in shallow pools at about low tide level (Beruwela); B. *Cladophora vagabunda* populations in shallow, rather sheltered but regularly wave-swept low intertidal pools (Beruwela); C. *Padina boergesenii* populations in shallow, rather sheltered low intertidal pools; D. A sand-filled crevice of the beachrock platform at about low tide with development of seagrasses (Beruwela); E. A low intertidal rock pool with sandy bottom covered by seagrasses (Beruwela); F. Subhorizontal surface of the beachrock platform at low water level, covered by extensive vegetations of *Gracilaria corticata* and *Sargassum* (Chilaw); G. A vertical wall at low water level, covered by a vegetation of *Gracilaria corticata* and some *Sarcodia montagneana* plants (Unawatuna).

In places, low intertidal pools contain large amounts of *Chaetomorpha crassa* (Fig. 21A) intertwined to *Sargassum* spp. and *Gelidiella acerosa*. Other low intertidal pools are covered by *Cladophora vagabunda* (Fig. 21B) or *Padina* spp. (Fig. 21C). In sand-filled crevices and pools with a sandy bottom seagrasses can develop (Figs 21D, E). In other areas, the subhorizontal surface of the beachrock platform at low water level is covered by extensive vegetations of *Gracilaria corticata* (Figs 21F, G).

- The **infralittoral fringe** is air-exposed only during spring tides when the sea is smooth, but generally this zone is continuously wave-swept, even at low tide. Subtidal species survive in rock pools and surge channels close to extreme low water level. *Amphiroa foliacea* (Fig. 22A), *Halimeda discoidea* (Fig. 22B), *Valonia fastigiata* (Fig. 22C), *Caulerpa verticillata* (Fig. 22D), *C. taxifolia* (Fig. 22E), *Halimeda opuntia* (Fig. 22F), *Polyopes ligulatus* (Fig. 22G), *Sarcodia montagneana*, *Carpopeltis maillardii*, *Chondria armata* (Fig. 22H), *Jania cultrata, Laurencia* spp. (Fig. 22I) are among the numerous air-exposed algae between waves at low water. *Dictyota ceylanica* (Fig. 23A), *Asparagopsis taxiformis* (Fig. 23B) and *Spyridia hypnoides* (Fig. 23C) can be frequent algae forming isolated tufts, mainly in pools. In surge channels, *Gracilaria canaliculata* can be well developed (Fig. 23D). On sand-covered rock substratum, a typical seaweed vegetation can be observed, composed of *Bryocladia thwaitesii* (Fig. 23E), *Grateloupia lithophila* (Fig. 23F), *Ulva fasciata*.

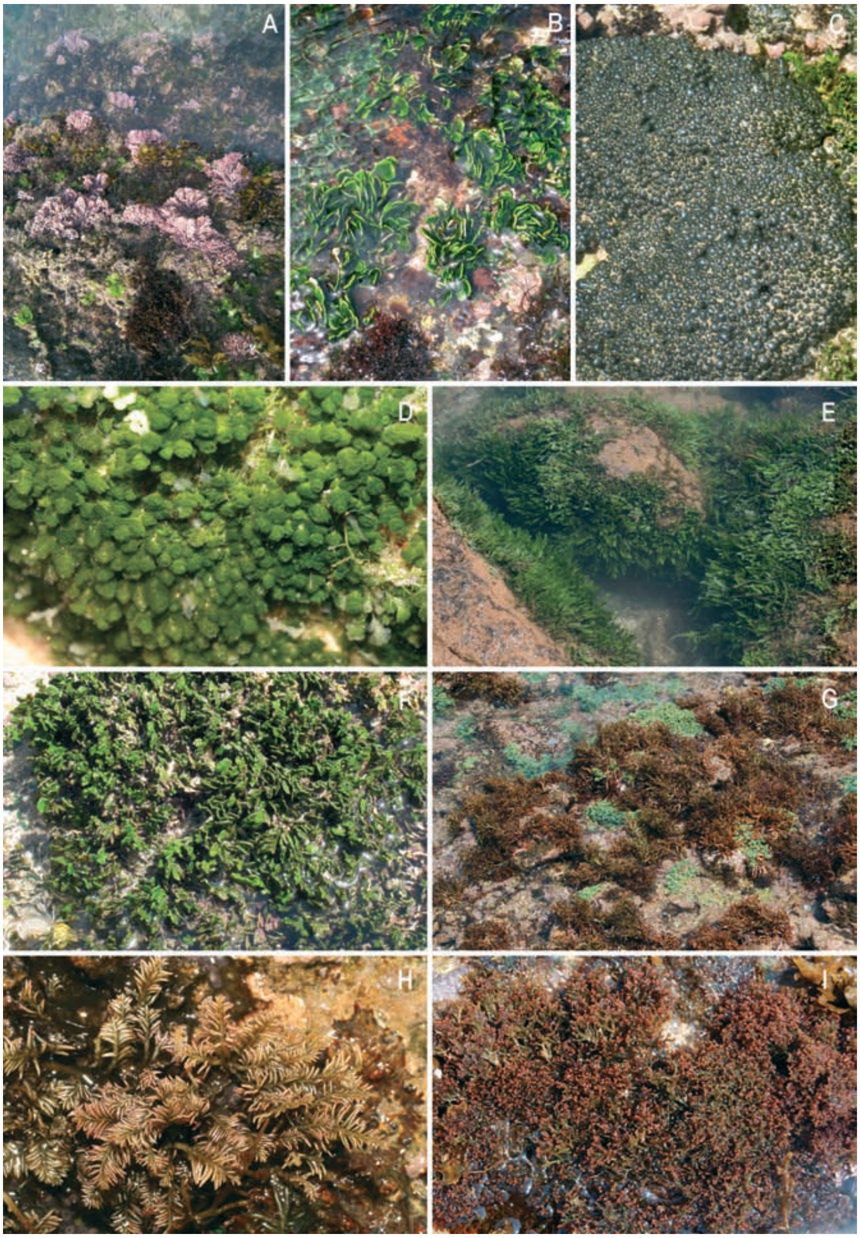


Fig. 22. Seaweed vegetations at and just under low tide level. A. *Amphiroa foliacea* just under low water level in surge channels; B. *Halimeda discoidea* in the infralittoral fringe (Nilwella); C. *Valonia fastigiata* in the infralittoral fringe (Nilwella); D. *Caulerpa verticillata* on sheltered, landward vertical walls of the beachrock platform (Dickwella); E. *Caulerpa taxifolia* mainly on vertical walls just under low water level (Weligama); F. *Halimeda opuntia* in the infralittoral fringe, partly air-exposed at extreme low water (Nilwella); G. *Polyopes ligulatus* (mixed to *Caulerpa racemosa* and *Gracilaria* crassa) in the infralittoral fringe, partly air-exposed at extreme low water (Galle); H. *Chondria armata* in the infralittoral fringe, air-exposed at extreme low water; I. *Laurencia natalensis* in the infralittoral fringe, partly air-exposed at extreme low water (Batheegama).

Fig. 23. Seaweed vegetations at and just under low tide level. A. Cushions of *Dictyota ceylanica* in the infralittoral fringe (Hikkaduwa); B. *Asparagopsis taxiformis* in a rock pool at about low water level (Nilwella); C. Populations of *Spyridia hypnoides* in the infralittoral fringe (Nilwella); D. *Gracilaria crassa* (together with *Polyopes* ligulatus) in surge channels in the infralittoral fringe (Galle); E. Monospecific vegetations of *Bryocladia thwaitesii* on partly sand-covered rocks in the infralittoral fringe of sheltered bays (Dickwella); F. Monospecific vegetations of *Grateloupia lithophila* on partly sand-covered rocks in the infralittoral fringe of sheltered bays (Dickwella).

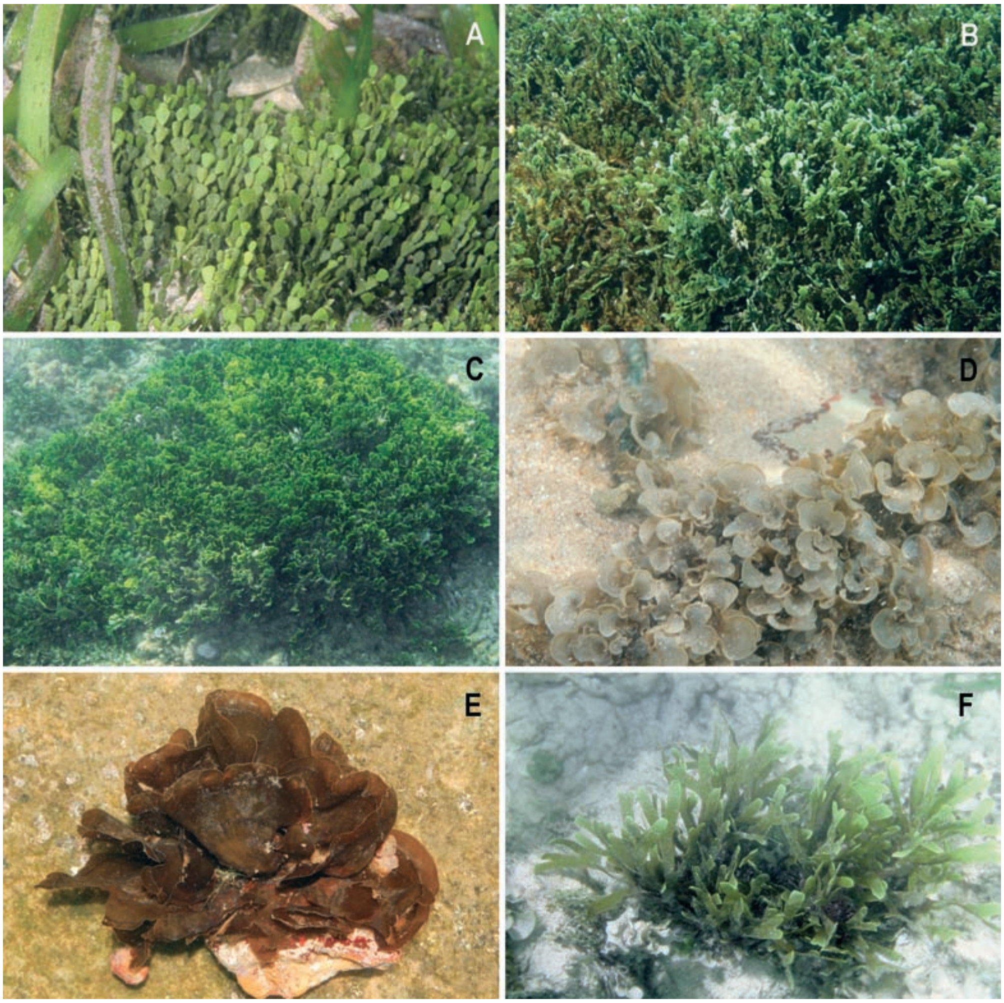


Fig. 24. Seaweed vegetations in the shallow subtidal. A. *Halimeda gracilis* populations mixed to seagrasses in the subtidal (Weligama); B. Dense *Halimeda gracilis* vegetations on coral rubble (Kalpitiya); C. Dense *Halimeda discoidea* vegetations on coral rubble (Kalpitiya); D. *Padina boergesenii* on coral debris in the subtidal of a lagoon (Weligama); E. A large, erect plant of *Lobophora variegata* on a dead coral fragment on the bottom of a lagoon (Beruwela); F. *Stoechospermum polypodioides* on dead coral in the lagoon (Weligama).

- The **infralittoral** or **subtidal** is continuously covered by seawater. On sand-covered rocky substratum *Caulerpa racemosa* var. *cylindracea* f. *laxa* can locally form nice populations.

In lagoons with sandy substratum, seagrass meadows develop, with the associated macro-algae on the sand (mainly *Halimeda gracilis*, Fig. 24A) or epiphytic on the seagrasses. When coral rubble is present on the lagoon bottom *Halimeda gracilis* and *H. discoidea* can grow in extensive vegetations (Figs 24B, C); tufts of *Padina* spp. (Fig. 24D),

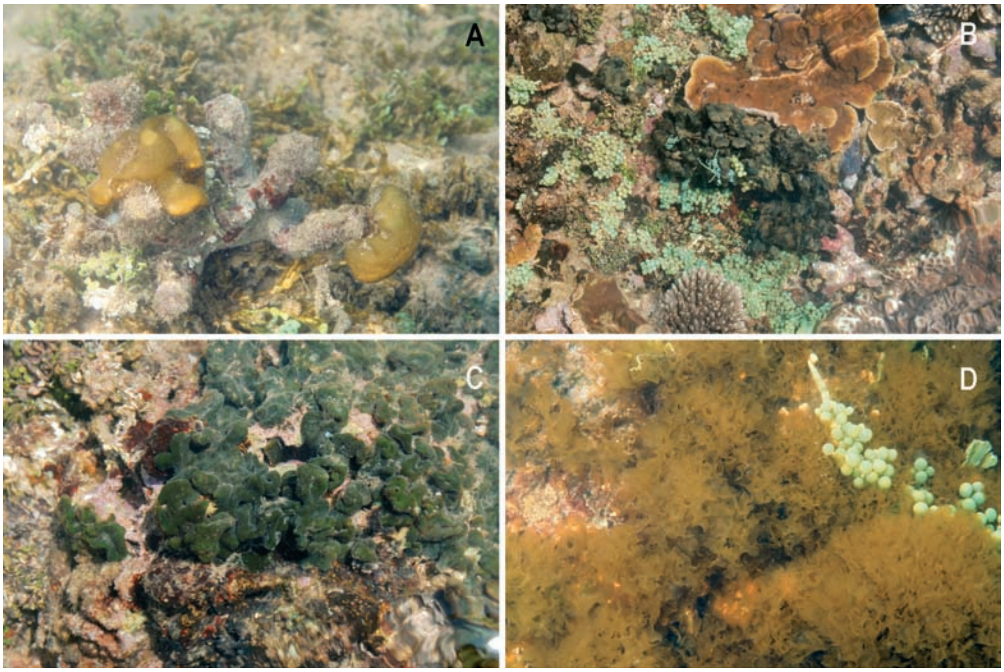


Fig. 25. Seaweed vegetations in the shallow subtidal. A. *Colpomenia sinuosa* on dead coral in the lagoon (Weligama); B. *Avrainvillea amadelpha* next to *Caulerpa racemosa* and *Halimeda opuntia* on hard substrate in the shallow subtidal (Galle); C. Extensive vegetations of *Codium arabicum* on hard substrate in the shallow subtidal (Galle); D. A dense cover of *Nitophyllum marginatum* on hard substrate in the shallow subtidal (Galle).

Lobophora variegata (Fig. 24E) and *Dictyota* spp. can also develop. Locally, extensive populations of *Stoechospermum polypodioides* (Fig. 24F) are present and *Colpomenia sinuosa* can be abundant (Fig. 25A).

In lagoons with hard substratum (Galle), corals develop, together with *Halimeda opuntia*, *Avrainvillea amadelpha* (Fig. 25B), and locally populations of *Caulerpa sertularioides*, *C. racemosa*, *C. imbricata*, *Codium arabicum* (Fig. 25C), *C. geppiorum, Dictyota ceylanica*, *Nitophyllum marginale* (Fig. 25D), *Claudea multifida*.

In rather isolated, shallow lagoons with soft substrate (Chilaw), seagrasses can be abundant. Close to the estuaries, where the salinity is still about the same as seawater, *Acanthophora spicifera* locally grows in large loose-lying ball-like tufts (Fig. 26A). More land-inward, where salinity is lower and the water temperature higher, *Ulva intestinalis* (Fig. 26B), *Chaetomorpha linum* (Fig. 26C) become abundant, together with cylindrical *Gracilaria* spp. (Fig. 26D). In the most isolated pools, mats of blue-greens develop on the silty substratum, drifting at mid-day (Fig. 26E) as a result of the numerous oxygen bubbles being produced by photosynthesis (Fig. 26F).

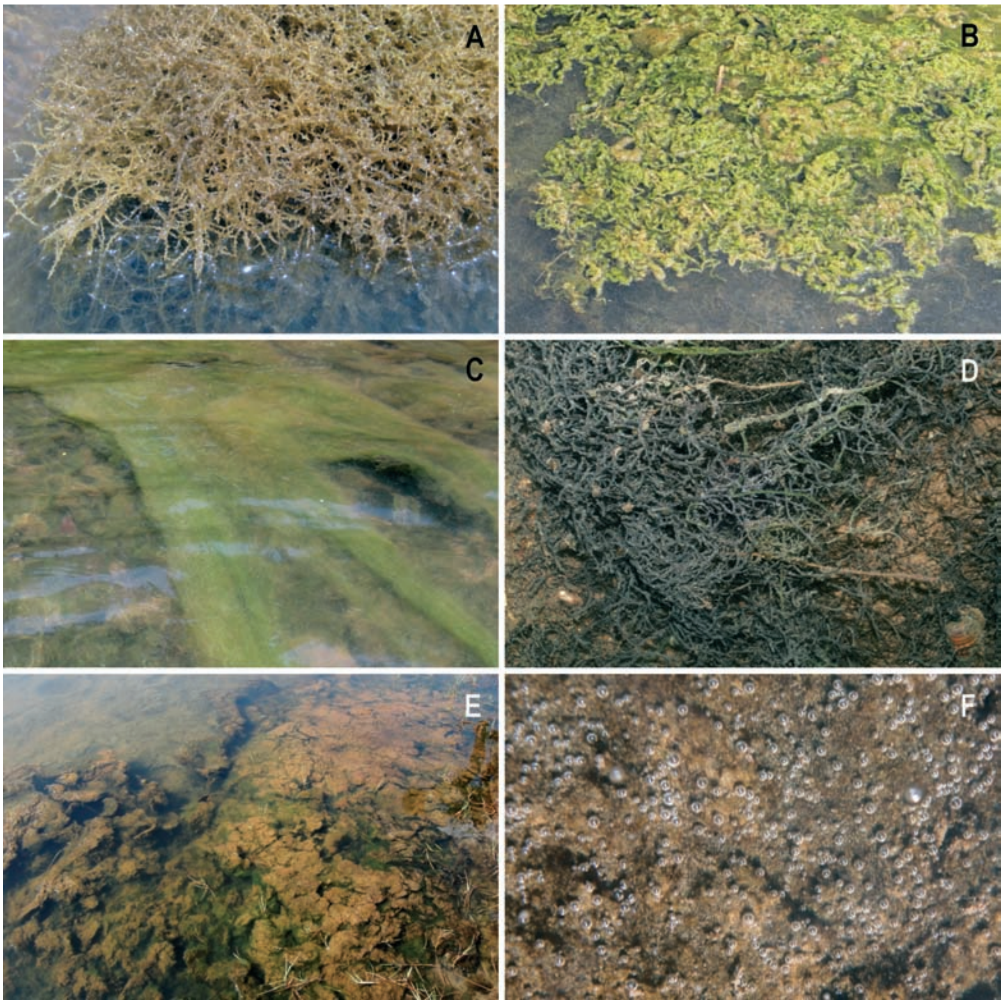


Fig. 26. Algae in shallow, isolated lagoons. Large tufts of *Acanthophora spicifera* close to the estuary; B. *Ulva intestinalis* in more sheltered, inward sites; C. Entangled *Chaetomorpha linum*-strands; D. Entangled *Gracilaria*; E. Mats of blue-greens in the most isolated parts, partly floating; F. Oxygen bubbles produced by photosynthesis of the mats of blue-greens.

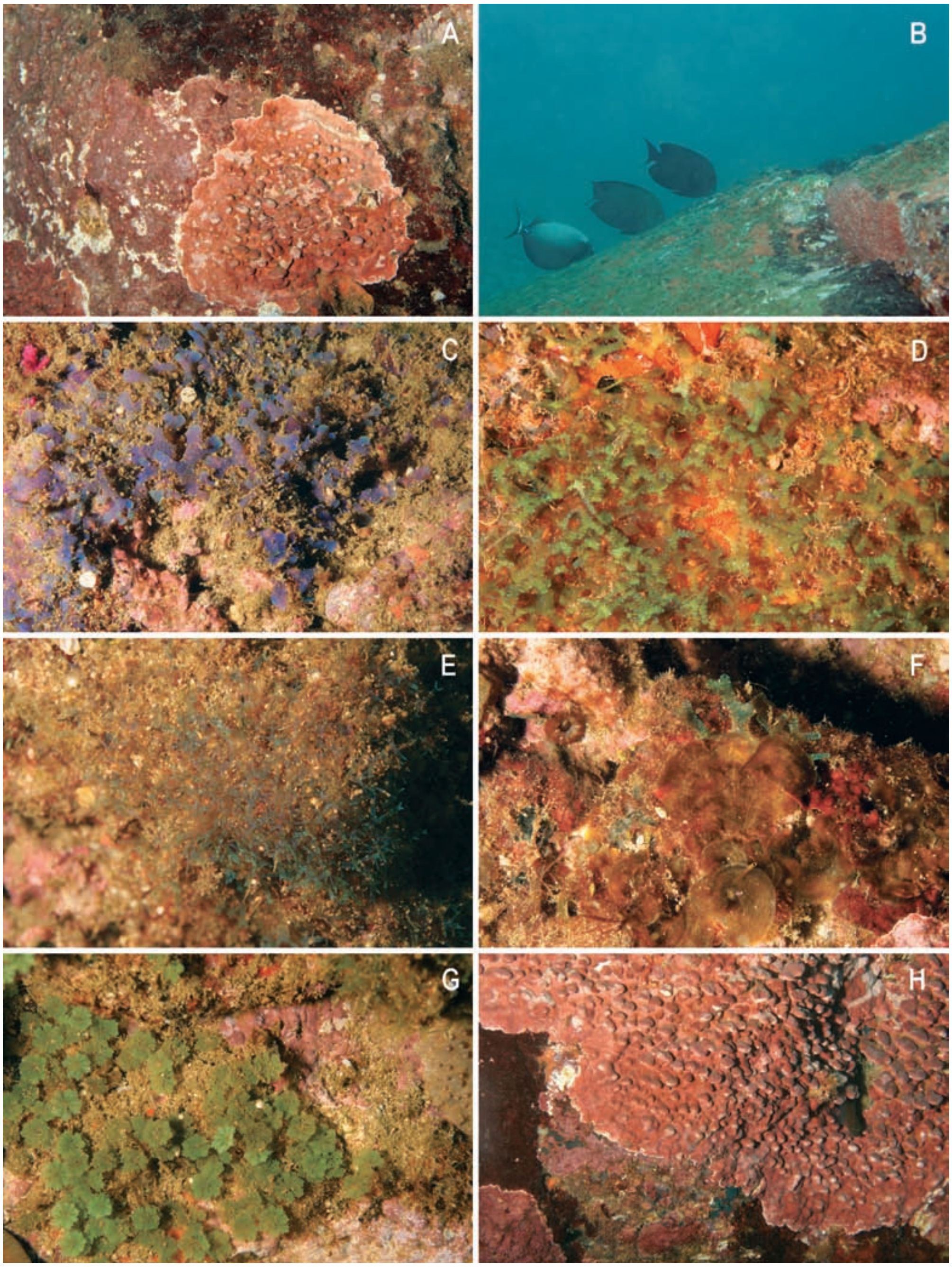


Fig. 27. Seaweeds on deepwater boulders (-25 m). A. In areas with high grazing pressure by herbivorous fish, only crustose corallines survive (Beruwela); B. In some areas, grazing fish limit the development of soft, erect algae (Beruwela); C-E. Representatives of *Dictyota* seem to be resistant to herbivory; F. The prostrate growth form of *Lobophora variegata* also escapes herbivory; G. *Caulerpa filicoides* is the most frequent uncalcified seaweed on and around rock boulders between 20 and 25 m depth; H. Crustose corallines locally cover almost 100% of the rock substrate on the boulders between 20 and 25 m depth.

On rocky substratum on the seaward side of the beach rock platform, healthy coral reefs can develop, but they are rare (Bar Reef in the Kalpitiya area). Mostly, the rocks are covered by seaweed vegetations. These can be species poor: exclusively composed of encrusting corallines (Fig. 27A) in places with numerous herbivores (Fig. 27B) or *Portieria hornemannii*-*Asparagopsis taxiformis* dominated vegetations.

Other areas again show a very diversified seaweed vegetation.

The isolated rock boulders in deeper parts of the subtidal (15-30 m depth) are intensively grazed by herbivorous fish. The dominant algae which seem to be resistant to this herbivory are several species of *Dictyota* (Figs 27C-E), *Lobophora variegata* (the prostrate growth form, Fig. 27F) and *Caulerpa filicoides* (Fig. 27G), next to encrusting corallines (Fig. 27H).

6. Accessibility and threats

As a result of the unstable geopolitical situation, large areas of Sri Lanka were, while preparing the present guide, not accessible for visitors. Along the West coast, the area north of Puttalam, including Jaffna, was closed down. Collecting in the Kalpitiya area was almost excluded and visiting the East coast was also strongly discouraged. As a result, the marine plants included in this book are mainly coming from the southwest and south coast of the island. Some larger, typically tropical species, reported by previous phycologists from the Jaffna area, have not been collected south of Kalpitiya (e.g. *Anadyomene wrightii, Caulerpa cupressoides*, *C. scalpelliformis*, *Udotea flabellum*, *Cystoseira trinodis*, *Hormophysa cuneiformis*, *Dictyopteris polypodioides*, *Neurymenia fraxinifolia*).