In 2004 the National Species Conservation Action Group organised a series of seminars at which presentations by invited authors were made on selected topics. Fernando, de Silva and Mallikarachchi made a presentation on marine algal studies, past and present; the paper reproduced here was prepared for publication based on that presentation. However, the intended publication of the proceedings of that seminar on lower plants never materialised. It is reproduced here as sent for publication in late 2005. The bibliography and checklist mentioned in the text are not included.

Unpublished Paper: Current Taxonomic Status of Marine Algae in Sri Lanka

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Introduction

Marine algae have not been studied intensively in Sri Lanka in recent years. However, early botanical explorers included algae among the groups they studied: many type locations are in this country. Sri Lankan workers have been few in recent years, their work being hampered by lack of facilities. The National Herbarium at Peradeniya contains the collections of early workers, but these have been of little use in identifying recent collections for a number of reasons. There is renewed interest in this group of plants in Sri Lanka: environment and biodiversity assessments of coastal and marine sites are increasing, and with that the need for identification of algae has become necessary. This paper is broken up into sections that deal with early studies, recent work, current taxonomy and issues pertaining to identification. A select, but fairly comprehensive, bibliography is included. Three classes of macroalgae alone are discussed—Chlorophyceae, Phaeophyceae and Rhodophyceae.

Early studies of Sri Lanka's marine algae

Paul Hermann (1646-1695) was a physician who worked in the Dutch hospital in Colombo from 1672 to 1679. His main interest was botany and during his time in the country collected plants and sent collections – the first from the country – back to Leiden, in Holland. While in Sri Lanka he was offered the chair in botany at Leiden that he took up in 1780 (Uragoda, 1987). Hermann's herbarium was sent to Linnaeus in 1747 and he excitedly began to examine the specimens – the first extensive collection of tropical plants that he had seen. Later that year he published Flora Zeylanica based on Hermann's collections and frequently quoted this work in his Species Plantarum (Blunt, 1971).

In Species Plantarum Linnaeus described 56 species of marine algae; but only in two was there a hint of an Indian Ocean provenance. In the protologue to *Fucus natans* (*Sargassum natans* (Linnaeus) Gaillon) Linnaeus cited a reference in Flora Zeylanica. This would suggest that Paul Hermann had collected this alga in Sri Lanka and therefore he becomes the first of a number of Europeans who collected or described marine algae from the country (Silva et al., 1996). Johann Gerhard König (1728-1785), one of Linnaeus's students, collected algae in Sri Lanka while stationed in Madras. Many of his collections were described by Retzius (1791) including *F. zeylanicus* of unknown identity. Linnaeus's son (Linnaeus fil., 1782) described two species from Sri Lanka, *Fucus flavus*, which is probably a sponge, and *Fucus pinnatus* (*Caulerpa pinnata* C. Agardh).

William Ferguson (1820-1887), a British civil servant in Sri Lanka from 1839 until his death in Colombo made collections and issued an informal exsiccata, Algae ceylanicae, with the specimens determined by Albert Grunow (1826-1914). A set of this collection is in the British Museum, with duplicates in the National Herbarium at Peradeniya.

William Harvey (1811-1886), a celebrated collector in the Indian Ocean, broke journey in Sri Lanka from September to December 1853 on his way to Australia. He collected algae in Trincomalee, Weligama and Galle and distributed these as an exsiccata in 1857. Most of these specimens were described by Kützing and J. Agardh. While in Australia he published a paper describing three spectacular reticulate Delesseriaceae from Sri Lanka: *Claudea multifida*, *Martensia fragilis*, and *Vanvoorstia*

spectabilis. In 1887 George Murray compiled a Catalogue of Ceylon algae in the Herbarium of the British Museum based on the Ferguson and Harvey collections. This work listed 223 species of which 15 belong to the Cyanophyceae and freshwater algae.

Many expeditions in the nineteenth century collected off the coasts of Africa and Australia, a few in Sri Lanka. A. Grunow (1867) described collections by Anton Jelinek, the naturalist on the voyage of the Novara (1857-1859). G. Zanardini (1872) described collections by Odoardo Beccari (1843-1920). A. Piccone (1886) described those from the voyage of the Vettor Pisani (1882-1885) collected by Cesare Marcacci. F.R. Kjellman, who joined the Vega expedition, visited Sri Lanka on his way back to Europe and made some algal collections. Some of his specimens are found in the exsiccatae of Wittrock and Nordstedt (1880 & 1884).

W. A. Herdman made many collections, including algae, in 1902 as part of the studies on the Pearl Oyster Fishery in the Gulf of Mannar. These were identified and listed by Ethel S. Barton (1903). Nils Svedelius stayed in Sri Lanka from November 1902 to August 1903 and visited Galle, Matara, Weligama, Gintota, Dondra and Tangalle on the south coast, Ambalangoda, Kosgoda, Bentota, Beruwela, Colombo and Negombo on the west coast, Jaffna in the north and Trincomalee in the East. He published two papers in 1906: one in English on the ecology and systematics of the Ceylon species of *Caulerpa* and the other in German on the algal vegetation of the coral reefs at Galle.

In 1907 A. D. Cotton described and named *Euptilota fergusonii* from one of Ferguson's collections (Ferguson no. 20, from Panadura). In 1912 E. Zeh published "New species of the genus *Liagora*" and in 1915-1916 A. Grunow published "Additamenta ad cognitionem Sargassorum". F. Børgesen visited India in 1927/28, making a short trip to Sri Lanka. He examined the coral reefs at Galle and collected algae from that area. The results of his study were published in 1936. This paper listed 68 species: 21 Chlorophyceae, 8 Phaeophyceae and 39 Rhodophyceae. His list contained 27 species that were not included in Murray's list.

This period of pioneering algal studies was followed by a gap of many years until a second phase commenced, driven by Sri Lankans. But these were largely sporadic studies. In 1952 M. Durairatnam commenced surveying the marine algal beds and marine algal resources of the Sri Lanka coast on behalf of the Government. His studies were divided into systematic identification, algal distribution and identification of commercially important algae. He published 9 papers on macroalgae (and others on phytoplankton) between 1961 and 1979. His major publication was in 1961 – Contribution to the study of the marine algae of Ceylon – wherein he described 171 species of marine algae including 54 species new to Sri Lanka: 10 Chlorophyceae, 11 Phaeophyceae and 33 Rhodophyceae. In a subsequent paper in 1962 – Some marine algae from Ceylon - 1 – he described an additional 14 species of which 3 were new to science. These were deposited in the National Herbarium at Peradeniya, but not all have survived the ravages of time. In 1963 he published a paper describing the Laurencias of the island – Some marine algae from Ceylon – 2. *Laurencia* Lamouroux. The 1961 publication included a checklist of Sri Lanka marine algae: a total of 315 species divided between Chlorophyceae (84), Phaeophyceae (65) and Rhodophyceae (166).

In 1979 S. Balasubramaniam published a checklist of the marine algae of Jaffna in the Peradeniya University botanical journal Phyta. He listed 110 species, one (Asparagopsis taxiformis) being a new record. He had also listed *Chlorodesmis hildebrandtii* with a query as a possible new record needing confirmation. R. A. S Ranatunga and M. W. R. N. de Silva published a new alga (*Caulerpa filicoides* Yamada) in 1986 (Abstract). This was earlier (1965) reported (Abstract) as an unidentified new *Caulerpa* by M. S. Tambiah and M. W. R. N. de Silva. The same two authors, at the same sessions of the Sri Lanka Association for the Advancement of Science (SLAAS), reported on a preliminary survey of the marine algae in a restricted area in Hikkaduwa.

Other workers reported on aspects of culture, regeneration and extraction of agar. A number of papers were published on the chemistry of marine algae in the nineteen eighties and nineties. These papers are of significance from a taxonomic perspective as they listed algae hitherto unrecorded from Sri Lanka (see below). However, no authorities are cited in the papers to support identification of species.

A milestone in the taxonomic study of the algae of the Indian Ocean was the publication in 1996 of a Catalogue of the Benthic Marine Algae of the Indian Ocean by Silva, Basson & Moe. This compilation listed Indian Ocean records together with

a comprehensive synonymy and their distribution. The lists were made from publications of marine algae available to the authors, whether from taxonomic, ecological or analytical works. Thus, there are no citations from Balasubramaniam's checklist of the Jaffna algae that was published in a University journal, nor from Ranatunga and de Silva's abstract from the SLAAS Proceedings, but the chemical analytical papers of Mahendran & Sirisena et al. (1980), Bandara et al. (1988), Dantaranarayana et al. (1981), Mageswaran & Sivasubramaniam (1984a & b), Mageswaran et al. (1985), Jayasekera (1994) and Ratnasooriya et al. (1994) are cited. Citations from this catalogue have been summarised by the present authors to compile a new checklist of marine algae for Sri Lanka (Appendix I). This checklist contains 385 species and infra-specific taxa (Chlorophyceae [84], Phaeophyceae [93] and Rhodophyceae [208]) and includes 12 new records collected by the authors (see Table 3).

Recent Studies

Two groups have been studying marine algae in recent years. At the Ruhuna University two of the authors (MPdeS & MUM) have been engaged in a study of the ecological and anthropogenic impacts on littoral algal diversity and abundance in addition to a taxonomic survey along the southern coast funded by a grant from the National Science Foundation of Sri Lanka (De Silva and Mallikarachchi, 2002). The study is restricted to 4 reef sites along the southern coast of Sri Lanka and a large proportion of algal communities remain unexplored. Within a distance of less than 36 km, they have identified 11 new species of algae, suggesting that much of our marine algal flora remains unknown.

The work of the other author has been largely casual collections of algae from a variety of littoral and sublittoral sites on the west, south and east coasts. The selection of sites and the work of collection have been determined by the activity of the Sri Lanka Sub-Aqua Club (SLSAC). In recent years algae have been recorded as part of the reef-monitoring program of the National Aquatic Resources and Research Agency. Eight new species have been identified: five new species are common to the Ruhuna survey and the SLSAC study. Preference was given to collecting green and brown algae as the available literature (and state of knowledge) enabled them to be identified at least to genus level; large numbers of red algae, though present, were often uncollected unless of a familiar genus. A considerable number of specimens from both collections remain undetermined and more new records are likely. See Table 1. (Ruhuna = MP de Silva & MU Mallikarachchi; SLSAC = Malik Fernando)

Table 1: Numbers of species and infra specific taxa recorded in the Ruhuna and SLSAC studies

	RUHUNA		SLSAC	
	Genera	**Species/taxa**	**Genera**	**Species/taxa**
Rhodophyceae	46	71	33 [16][1]	67 [47][3]
Phaeophyceae	5	10	12	24 [12]
Chlorophyceae	14	44	19	60 [18]
TOTAL	**65**	**125**[2]	**44 [16]**	**152 [77]**

Note: Figures within square backets indicate numbers of specimens either undetermined or in need of confirmation.

[1]In addition to these 16 members of CORALLINALES of unknown genera, the collection contains many specimens that remain undetermined even to genus level and are not counted for this table.
[2]Many species remain to be determined.
[3]Numbers undetermined to species level within square brackets.

The current taxonomy of marine algae in Sri Lanka

The taxonomy of algae commenced with the 57 species described by Linnaeus in his Species Plantarum in 1753. He assigned them to three genera: *Fucus* (cartilaginous thalli), *Ulva* (membranous thalli) and *Conferva* (filamentous thalli). Later workers divided the three genera into numerous others; this trend continues, as circumscription of genera becomes more finely defined. The inherent variability among the marine algae, in response to ecological conditions and other factors, led to the naming of many species and infra-specific taxa. Later workers have recognized this and have reduced many of these names to synonyms.

The catalogue of Silva et al. has brought together the currently accepted (as at 1996) names of Indian Ocean algae, their synonyms, bibliography and distribution. However continuing research, often based on culture studies, continues to change the picture by proposing that more species be reduced to synonyms and proposing new species. Molecular biological studies (using DNA analysis) are likely to change the picture further by revealing hitherto unsuspected relationships.

Figure 2 shows the numbers of algae listed in the Indian Ocean Catalogue recorded from Sri Lanka, compared with the Indian Ocean totals. The algae so listed is reproduced in Appendix I as a Sri Lanka Checklist, together with new records from the recent studies.

Table 2: Marine algae in the Indian Ocean and Sri Lanka
Note: "Species" include infra specific taxa.

	INDIAN OCEAN		SRI LANKA	
	Genera	**Species/taxa**	**Genera**	**Species/taxa**
Rhodophyceae	390	1810	96+5[1]	203+7[2]
Phaeophyceae	96	596[3]	22	92+1[4]
Chlorophyceae	77	585[5]	27+1[6]	78+6[7,8]
TOTAL	**563**	**2991**	**151**	**387**

Source: Summarised from Silva et al. (1996). Additions to the list recorded by the authors are prefixed by (+).

Notes:
[1]Five new genera – *Asparagopsis, Nemastoma, Cottoniella, Wrangelia & Microcladia*
[2]Seven new species (2 *Nemastoma* as yet undetermined, not included in checklist)
[3]Includes 239 in *Sargassum*
[4]Includes 43 in *Sargassum*; 1 new species (*Dictyota*)
[5]Includes 131 in *Caulerpa*
[6]One new genus – *Ventricaria*
[7]Includes 35 in *Caulerpa*
[8]Six new species (in *Avrainvillea, Cladophora, Chaetomorpha, Cladophoropsis, Dictyosphaeria & Ventricaria*)

Table 3: New species and infra specific taxa collected by the authors

	Name	Location	Habitat
Chlorophyceae	*Avrainvillea amadelpha*	Talpe	Littoral
		Trincomalee: Erakkandy, Pigeon Islands	Sublittoral, 2 m
	Caulerpa racemosa var. *occidentalis*	Akurala	Littoral
	Chaetomorpha spiralis	Hikkaduwa, Dadalla, Talpe	Littoral
	Cladophora laetevirens	Dadalla	Littoral
	Cladophoropsis sundanensis	Hikkaduwa, Dadalla, Talpe, Beruwela: Barberyn Reef	Littoral
	Dictyosphaeria versluysii	Talpe	Littoral
		Trincomalee: Erakkandy, Dutch Bay	Sublittoral, 2-3 m
	Ventricaria ventricosa	Trincomalee: Pigeon Islands, Erakkandy, Dutch Bay	Sublittoral, 2-3 m
Phaeophyceae	*Dictyota dumosa*	Talpe	Littoral
Rhodophyceae	*Asparagopsis taxiformis*[1]	Dadalla	Littoral
		Colombo (Wellawatte); Galle: Unawatuna; Kalpitiya Bar Reef	Sublittoral, 1-7 m
	Cottoniella filamentosa	Dadalla	Littoral
		Boossa	Sublittoral, 20 m
	Microcladia glorie-sepi	Hikkaduwa, Talpe	Littoral
	Wrangelia penicillata	Dadalla	Littoral

Note: [1]S. Balasubramaniam had previously reported this in his checklist of the marine algae of Jaffna (1979); this record had been overlooked in the Indian Ocean catalogue of Silva et al.

Issues pertaining to identification of marine algae in Sri Lanka

Identification of marine algae requires access to laboratory facilities with at least a good microscope and the necessary literature. Current literature is also necessary as algal taxonomy advances rapidly. Access to expert knowledge in major phycological centres is essential in a field like this where local expertise is totally lacking. The Ruhuna group has forged collaborative international links on algal research with experts at the University of Ghent, in Belgium and the University of Pune, in India. By these means they have been able to obtain relevant literature, gain practical know how and have specimens identified. A special training program in techniques in phycology has been proposed, to be held at the University of Ghent as early as possible to fill the gap of lack of specialized personnel in Sri Lanka.

The non-availability of an algal herbarium in Sri Lanka reflecting current nomenclature is a constraint for algal research. The marine algae in the Classical Collection at the National Herbarium at Peradeniya are of limited use. The old names are confusing for someone without knowledge of the synonymy. Most labels are incomplete as regards collection data. Table 4 gives a list of collectors and the dates (year) of their contribution to the herbarium (Chlorophyceae and Phaeophyceae only). The table (as 4a) also lists phycologists who have determined many of the specimens. Another factor that limits use for identification of contemporary material is the lack of descriptions of species characters. Steps are underway to augment the Classical Collection of the National Herbarium with a Contemporary Collection and to establish an algal herbarium at the University of Ruhuna. Herbarium sheets prepared by the Ruhuna University workers have been deposited. These consist of collections from the littoral zone. Another set of sheets consisting of littoral as well as sublittoral algae from various localities in the south, west and east resulting from the SLSAC study are being prepared for depositing. It is proposed to ensure that there is concordance in nomenclature between the two sets. Notes will also be available regarding characters used in determining species, especially to differentiate similar species.

Table 4: National Herbarium (Peradeniya) Classical Collection (marine algae)
Names of collectors and date(s), Chlorophyceae & Phaeophyceae Table 4a.

Name	Dates		Determinations by
George Gardner	1844, 1846		"Kew"
William Harvey	(1853) No date on labels		Dickie
No name	1869, 1870, 1871, 1872, 1873, 1881, 1882, and 1889		Greville
William Ferguson	1881, 1886, 1887		Grunow
Henry Trimen	1882		Murray
Titus (Ferguson's servant)	188?		Nils Svedelius
H. Neville	1887		S. O. Gray
Weber-van Bosse (Siboga Expedition; foreign Caulerpas)	1899		Weber-van Bosse
A. H. G. Alston	1926, 1927, 1928		
Sorel Kalenberg & E. C. T. Holsinger	1928		
M. Durairatnam	1957, 1958, 1962		

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