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Historical review of seaweed research in Malaysia before 2001

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Abstract — This historical account includes the seaweed researches made in Malaysia for the last 40 years. The studies are various and covers aspects from taxonomy, distribution, diversity, environmental background, utilization, aquaculture, and so on. The seaweed taxa recorded in Malaysia (including Singapore) until 2000 include 6 families, 14 genera, 20 species of Cyanophyta, 13 families, 25 genera, 85 species of Chlorophyta, 20 families, 49 genera, 87 species of Rhodophyta, and 8 families, 16 genera, 55 species of Phaeophyta. The other information concerning distribution, habitat condition, species composition, cover, zonation or cultivation, etc. is summarized and tabulated.

Key words: historical review, seaweed, research, flora, taxonomy, Malaysia

Introduction

Seaweeds and seagrasses with the phytoplankton forms the important primary producers of a shallow marine environment (e.g. mangroves, coral reef ecosystem, inter-tidal areas, lagoons, rocky shores). Similar to terrestrial plants, seaweeds absorb light energy in photosynthetic processes that chemically combine water and carbon dioxide to produce organic compounds. Through the process of photosynthesis, the aquatic environment is oxygenated. Nutrients are absorbed through incorporation into their cells constituting the plant body. Substances released by the plants in turn are consumed by heterotrophic bacteria (Wilkinson and Buddemeir 1994) and the plants themselves form the primary food for herbivores and are passed on through the food chains and webs to be utilized by various consumers of omnivores and carnivores. In Malaysia, along its 4800 km coastline, stretching along the Malay Peninsula, Sabah and Sarawak bounding much of the southern part of the South China Sea are environments with rocky shores, mangroves, lagoons, coral reefs, inter-tidal shores, sub-tidal areas which form habitats for marine plants (Johnson 1967, Sivalingam 1977, Crane 1981, Phang 1985, Japar Sidik et al. 1997, Phang 1998, Japar Sidik and Muta Harah 1999). Seaweeds also colonized mangrove mudflats, pneumataphores and tree trunks (Sarala and Sasekumar 1994).

This paper presents the available research information through various studies before 2001 on seaweeds in Malaysia. The information covers aspects from distribution, taxonomy, diversity and utilization.

Distribution, species composition and taxonomy

Ecological survey of seaweeds were conducted on different aspects covering distribution, zonation, substrate suitability, water quality, cover, frequency and floristic composition in areas from sandy beach, inter-tidal, rocky, degraded coral reefs to pristine coral reefs and sheltered zones in particular mangroves along the coastline and, off-shores islands of Malaysia where there are thriving places for seaweeds. The information pertaining to the above is summarized in Table 1. These studies also produced check lists of seaweed of Batu Ferringhi, an area between Tanjung Bungah and Muka Head, Penang (Sivalingam 1977, Crane 1981), Pulau Langkawi, Kedah (Ahmad and Hindun 1992), off-shore islands along the Kedah coast (Japar Sidik and Muta Harah 1999), Pulau Pangkor, Perak (Ahmad and Suzana 1992), Sementa, Selangor (Sarala and Sasekumar 1994), Port Dickson, Negri Sembilan (Goh and Sasekumar 1980, Phang 1985, 1989, 1995), Pulau Bidong Laut, Terengganu (Arumugam 1981), a number of areas along the east coast of Peninsular Malaysia (Tan 1984), Pulau Redang Archipelago, Terengganu (Green 1978, Ahmad and Hindun 1992, Japar Sidik et al. 1997), Pulau Tioman, Pahang (Ahmad and Hindun 1992), Pulau Sibu, Pulau Besar, Pulau Kapas, Johore (Ahmad and Suzana 1989) and other parts of Peninsular Malaysia (Chuang 1961) and West Sabah (Khew 1978). Most of these study sites are located in coral reef areas, and emphasis was less in mangroves (Sarala and Sasekumar 1994) and, rocky or inter-tidal areas (Johnson 1967, Sivalingam 1977, Crane 1981).

Teo and Wee (1983) provided the first taxonomic account of seaweeds of Singapore, which also included sea-

Table 1. Summary of major research conducted on seaweeds pertaining to habitats, diversity at various locations in Malaysia.

Author	Location	Description
Japar Sidik and Muta Harah (1999)	West Coast Peninsular Malaysia Pulau Bidan, Pulau Songsang, Pulau Telor, Pulau Bunting and Tukun Terendek Degraded coral reef and rocky areas	—The survey of seaweed distribution (habitats: e.g. associated with live corals, dead corals, coral rubbles, sandy bottom and even boulders), species diversity, their forms as epiphytic, epilithic, rhizophytic and drift and their status in a particular stations. —11–12 species with a total of 16 species were recorded. The Chlorophyta (green seaweed) dominated other seaweed. The survey revealed that the seaweed diversity is low relative to other areas in the west coast. Environments have turbid waters and extremely poor visibility. Despite the poor water condition, e.g. *Caulerpa serrulata*, *Halimeda opuntia*, *Pocockiella variegata* and the filamentous (*Cladophora* spp.) and tuft forms (*Chaetomorpha* spp.) are able to colonize and establish in such areas. Even then their colonization and establishment were only observed in shallow, at most from 0.3 m to 2 m depth. The brown seaweed (Phaeophyta) e.g. *Padina* sp. and *Hypnea* sp. which are known to inhabit deeper waters are also found to occur at similar shallow depth.
Phang (1998)	East Coast Peninsular Malaysia West Coast peninsular Malaysia Sabah Sarawak Singapore	—The seaweed flora of Malaysia with the updated species records added to those listed in Phang (1984, 1994), Phang and Wee (1991), Teo and Wee (1983). The number of taxa recorded from Malaysia (including Singapore); 6 families, 14 genera, 13 species of Cynophyta; 13 families, 25 genera, 85 species of Chlorophyta; 20 families, 49 genera, 87 species of Rhodophyta; 8 families, 16 genera, 55 species of Phaeophyta. —The economic seaweeds and their methods of cultivation e.g. *Eucheuma* (in Semporna, east coast of Sabah), *Gracilaria* (at Ban Merbok, Perak), Peninsular Malaysia. —Cultivation experiments on *Gracilaria changii* by Fisheries Research Institute at Batu Maung, Penang.
Japar Sidik et al. (1997)	East Coast Peninsular Malaysia Pulau Redang Archipelago Pulau Redang, Pulau Pinang, Pulau Ekor Tebu, Pulau Kerengga and Pulau Lima Coral reef areas	—Seaweed species list with a total of 63 of the five islands; Chlorophyta (25 species), Phaeophyta (9 species) and Rhodophyta (29 species). The seaweed depending on species utilized a variety of substrates, sandy bottom, mostly dead corals and live corals. Low light condition due to sedimentation (resulting in poor visibility), live coral and sandy bottom are less favorable for seaweed colonization and growth. —Comparison of yearly seaweed distribution, 1995 vs. 1996. —Also documented the presence of seagrasses *Halophila minor*, *H. decipiens*, *Halodule pinifolia* only around Pulau Redang and they form the first records for Pulau Redang.
Phang (1994)	West Coast Peninsular Malaysia Pulau Langkawi, Port Dickson, Kuala Selangor, Pulau Besar East Coast Peninsular Malaysia Pulau Tioman, Pulai Tulai, Pulau Perhentian, Pulau Tenggol Singapore Pulau Labrador, Pulau Sentosa	—Nineteen new records of seaweeds from the various locations. The new records of Cyanophyta (2 species), Chlorophyta (4 species), Rhodophyta (10 species) and Phaeophyta (3 species) reported. —Listed an additional 7 taxa of Chlorophyta, 18 taxa of Rhodophyta and 5 taxa of Phaeophyta. This included the species mentioned from Pulau Redang (Green 1978), Pulau Pinang (Abbott et al. 1991, Xia and Abbott 1987) and Pulau Sibu (Ahmad and Suzana 1989). —Description of plants, their habitats, distribution and uses as food.
Phang and Wee (1991)	West Coast Peninsular Malaysia Pulau Pinang (Teluk Bahang, Batu Ferringhi, Sungei Dua, Batu Maung), Selangor (Sementa, Morib), Negeri Sembilan (Cape Rachado, Port Dickson,	—A brief historical review on studies of seaweed in Malaysia including Singapore. —The seaweed flora of Malaysia including Singapore from 50 collection sites. A total of 212 taxa recorded include 5 families, 13 genera and 12 species of Cyanophyta; 13 families, 24 genera and 74

Table 1. (Continued).

Author	Location	Description
Phang and Wee (1991)	Pasir Panjang), Melaka (Pulau Undan, Pulau Nangka, Pulau Besar, Pulau Upeh) East Coast Peninsular Malaysia Terengganu (Pulau Bidong Laut) Sabah Pulau Labuan, Kota Kinabalu, Pulau Balambangan, Kudat, Pantai Likas, Pantai Lok Kawi, Pantai Bak-Bak, Pantai Labuan, Usukan, Kota Belud, Pulau Tiga, Kuala Abai Singapore Kranji, Sembawang, Punggol, Pulau Ubin, Pulau Ketam, Pasir Ris, Pulau Sekudu, Pulau Tekong, Changi, Telok Paku, East coast Park, Pandan, Tuas, Tanjong Gul, Labrador, Sentosa, Pulau Hantu, Pulau Salu, Pulau Sakeng, St. Johns, Pulau Saturn, Pulau Biola and Tanjong Teritip	species of Chlorophyta; 19 families, 39 genera and 59 species of Rhodophyta; and 8 families, 13 genera and 46 species of Phaeophyta —Threats and strategy to conservation of marine algae.
Sarala and Sasekumar (1994)	West Coast Peninsular Malaysia Sementa, Selangor Mangrove forest area	—Seaweed communities associated with pneumatophores, basal area of tree trunks and sediment surface in a mangrove area. —A list of nine species, *Colpomenia*, *Gracilaria blodgettii*, *G. crassa*, *Dictyota dichotoma*, *Catenella nipae*, *Rhizoclonium* sp., *Bostrichia radicans* and *Caloglossa lepreurii*. —Quantitative data on percentage cover, frequency of occurrence and biomass in relation to the substrates.
Ahmad and Hindun (1992)	West Coast Peninsular Malaysia Pulau Pangkor, Perak, Pulau Langkawi, Kedah East Coast Peninsular Malaysia Pulau Redang, Terengganu Pulau Tioman, Pahang Pulau Besar, Pulau Kapas and Pulau Sibu, Johore Coral reef area, exposed during low tides, shallow and deep water of 3 m	—A total of eight species of *Caulerpa*; *C. cupressoides*, *C. peltata* and *C. racemosa* was represented by five varieties, var. racemosa, var. clavifera, var. macrophysa, var. microphysa and var. turbinata —Keys for identification, illustration on the morphology and local distribution of the eight species.
Ahmad and Suzana (1989)	East Coast Peninsular Malaysia Pulau Sibu, Johore Area of 150–200 m from the beach and coral reefs	—A total of fifteen species of marine algae of the division Chlorophyta were identified. —Keys for identification, illustration on the morphology and local distribution of the fifteen species.
Phang (1985)	West Coast Peninsular Malaysia Cape Rachado, Port Dickson, Negeri Sembilan West Coast Peninsular Malaysia Coral reef flat areas	—The general classification of seaweeds and their reproduction. —Types of seaweed and their adapted strategies inhabiting the coral reef flat of Cape Rachado. —The description of common seaweeds in the area e.g. *Sargassum*, *Gracilaria*, *Avrainvillea*, 6 species of *Caulerpa*, *Acanthophora*, *Laurencia*, *Carollina* and *Amphiroa*.
Crane (1981)	West Coast Peninsular Malaysia North coast of Penang between Tanjong Bungah and Muka Head Inter-tidal areas	—A list of 20 species of Chlorophyceae and 9 species of Phaeophyceae. —Keys for identification, illustration on the morphology, description of plants and local distribution of the seaweed species. —Factors contributing to the low diversity of seaweed species around the island are the relatively large tidal amplitude, seasonal variation and

Table 1. (Continued).

Author	Location	Description
Crane (1981)		differences in habitats. The low spring tides create an extremely harsh environment for plants due to desiccation and intense solar radiation.
Arumugam (1981)	East Coast Peninsular Malaysia Pulau Bidong Laut, Terengganu Coral reef area	—Seaweed communities of 20 species identified during the study comprising Cyanophyta (4 species), Chlorophyta (6 species), Phaeophyta (3 species) and Rhodophyta (7 species). —Distribution of seaweed in different regions of the reef. —Three distinct communities of macroalgae; a blue-green algae (*Anabaena* spp.) dominated the sandy beach, a high diversity mixed community in the reef flat, rim, front and slope areas and a blue-green algae dominated in the sandy bottom beyond the reef slope.
Sivalingam (1977)	West Coast Peninsular Malaysia Batu Ferringhi, Penang Island Inter-tidal and rocky areas	—Seaweed zonation pattern investigation on the seaward side of Penang Island. The seaweed lists provided was only given to genera level and their biomass in terms of wet weight. —The pattern was based on density distribution of various seaweeds and their plotted zonation pattern. Distribution of seaweed in the various zones e.g. Lower Tidal Zone (LTZ), Intermediate Tidal Zone (ITZ) and Higher Tidal Zone (HTZ) were also given.
Green (1978)	East Coast Peninsular Malaysia Pulau Redang Coral reef areas	—Information on seaweed species listings in Pulau Redang Archipelago.
Johnson (1967)	Inter-tidal zones, beaches, rocky areas, coral reefs	—Information on the seaweed species and the regions of the beach, supra-littoral belt, supra-littoral fringe, mid-littoral belt, sub-littoral fringe and sub-littoral belt. —Seaweeds associated with rocky areas and coral reefs. —Anatomy of Malayan seaweed and the illustrations on green, brown and red seaweeds found in Malaya (Peninsular Malaysia). —Information adaptation to environment and reproductive strategies —Information on economic uses of seaweeds, *Eucheuma*.

weeds in Malaysia. The publication by Phang and Wee (1991) provided a comphrensive list of taxonomic identity of seaweeds in both Penininsular Malaysia, East Malaysia (Sabah only) and Singapore. This list was updated with the incorporation of new records of seaweed from various locations with additional description on habitats, distribution and function including uses as food (Phang 1994). The list was further expanded to include the taxonomic identification and re-evaluation of seaweed species to include locations in Sarawak (East Malaysia). The taxa recorded from Malaysia (including Singapore) include 6 families, 14 genera, 20 species of Cynophyta, 13 families, 25 genera, 85 species of Chlorophyta, 20 families, 49 genera, 87 species of Rhodophyta, and 8 families, 16 genera, 55 species of Phaeophyta.

Several publications are devoted to include illustrations complemented with description of the plants and the anatomy of the different divisions of seaweed (Johnson 1967), keys for identification and illustration on morphology of Chlorophyceae and Phaeophyceae from Penang Islands (Crane 1981), pictorial guide and description mentioning the adaptation of seaweeds (Phang 1985), illustrations on morphlogy and keys for identification of species specific on the division Chlorophyta (Ahmad and Suzana 1989), and illustration on morphology and keys for identification of genus *Caulerpa* (Ahmad and Hindun 1992). The seaweed species description and their pictorial illustrations for Malaysia were written by Ahmad (1995). The seaweed list for Sarawak from different divisions is available from records of Fisheries Research Centre Sarawak (2000). All these publications are important as they can serve as references and guides to the seaweed species, locality and occurence in Malaysia.

Despite the numerous studies conducted, the coverage on standing biomass and productivity of natural populations are only documented by Sivalingam (1977) and Sarala and Sasekumar (1994).

Environmental characteristics and seaweed flora

Habitats possess their uniqueness and variations in environmental conditions. Seaweeds present in a particular habi-

Table 2. Utilization of various seaweeds in Malaysia.

No.	Division/Species	Category of utilization				Notes	Author
		Food	Medicine	Feed	Fertilizer		
1.	DIVISION CHLOROPHYTA						
	Acetabularia major		+			Treatment of gall stone, stone in bladder. This use was by the people of north coast of Java and not by the Malays	Burkill 1935
	Caulerpa fergusoni	+				—	Phang 1987
	C. racemosa	+				Consumed by the people in East Malaysia	Burkill 1935
						Salad	Ismail 1987
	C. serrulata					Salad	Ismail 1987
	C. sertularioides					Salad	Ismail 1987
	Chaetomorpha antennina	+				—	Phang 1987
	C. crassa	+				Salad	Ismail 1987
	C. javanica	+				Dried and boiled	Ismail 1987
	Ulva (*Enteromorpha*) *intestinalis*	+				Salad	Ismail 1987
				+		—	Phang 1987
	U. (*E.*) *prolifera*	+				Salad	Ismail 1987
	U. lactuca	+				Salad	Ismail 1987
		+	+	+	+	Antimicrobial	Phang 1987
	U. latissima	+			+	Flourished in polluted waters. Eaten in soup, as salad and an ingredient for garnishing The Chinese use it for feeding pigs. Seaweed possessed 50% carbohydrate and 15% protein after the water is reduced to 19%	Burkill 1935
	U. pertusa		+			Antihelminthic, antipretic	Phang 1987
	U. reticulata		+			—	Phang 1987
2.	DIVISION PHAEOPHYTA						
	Dictyota apiculata	+				Occurred along the coast of Malaysia and is edible	Burkill 1935
		+				—	Phang 1987
	D. linearis	+				Salad	
	Padina australis	+				Salad and vegetable	Ismail 1987
	P. tetrastromatica	+			+	—	Phang 1987
	Sargassum		+			The Chinese pharmacies in the Straits stored dried plants. *Sargassum* was recognized as Chinese drug. For iodine production	Burkill 1935
			+			Chinese medicine	Phang 1987
	S. tennerinum				+	Source of alginic acid	Phang 1987
	S. vulgare					Salad and vegetable	Ismail 1987
	S. wrightii				+	Source of alginic acid	Phang 1987
	Turbinaria conoides	+				Occurred throughout Malaysia. Consumed raw, described as having pleasant taste. They are made into pickle in East Malaysia	Burkill 1935
		+				—	Phang 1987

Table 2. (Continued).

No.	Division/Species	Category of utilization				Notes	Author
		Food	Medicine	Feed	Fertilizer		
2.	DIVISION PHAEOPHYTA						
	T. ornata	+				Occurred throughout Malaysia. Consumed raw, described as having pleasant taste. They are made into pickle in East Malaysia	Burkill 1935
						Salad	Ismail 1987
3.	DIVISION RHODOPHYTA						
	Acanthophora specifera					Found along the coast of Peninsular Malaysia. No record regarding the uses	Burkill 1935
	Chondria armata		+			Antibiotic	Phang 1987
	Corallina		+			Antihelminthic, Vermifuge	Phang 1987
	E. gelatinosa	+				Agar	Ismail 1987
	E. horridum	+				Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	E. muricatum	+				Agar	Ismail 1987
		+				Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	E. spinosum	+				Consumed as food and for containing elements such as cough.	Burkill 1935
	Gelidium amansii	+				Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	G. latifolium	+				Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	G. rigidum (*Gelidiopsis rigida*)	+				Present along the coast of Malaysia. Seaweed collected for agar.	Burkill 1935
	Gigartina pistillata	+				Agar	Ismail 1987
	Gracilaria		+			The Malay administer the seaweed boiled in vinegar for cough and consumption	Burkill 1935
	Gracilaria confervoides	+		+		Agar	Ismail 1987
		+				Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	G. crassa	+				Agar	Ismail 1987
	G. lichenoides	+			+	Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	G. taenioides	+				Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	Halymenia formosa	+				Eaten in the Philippines Islands. Probably brought to Malaysia from Philippines	Burkill 1935
	Hypnea cenomyce	+				For making agar. Edible species in the Philippines	Burkill 1935
	H. cervicornis	+				For making agar. Edible species in the Philippines	Burkill 1935
	Laminaria		+			Mentioned as absent from Malayan waters. The Chinese import a preparation of *L. saccharina* for treating goiter bronchocele for disorder deficient in iodine	Burkill 1935
	Laurencia botryoides					Reported only present in Singapore and not consumed	Burkill 1935
		+				Consumed as unextracted and extracted forms (phycocolloids)	Phang 1987
	L. obtusa	+				Agar and jelly	Ismail 1987
	L. papillosa	+				Agar and jelly	Ismail 1987

tat reflect those that can adapt or have adapted to the environmental conditions. Variability in environmental conditions either natural or subjected to human induced activities has caused variation in seaweed species composition and diversity. Several of these studies suggest that such events as associated with human activities produced impact to seaweed communities. Phang (1988) reported that the ecosystem along the west coast of Peninsular Malaysia was especially vulnerable to pollution from land-based and sea-based sources and silts resulting from land-based activities. A change of maximum TSS (total suspended solid) level from 150 mg l^{-1} to 1503 mg l^{-1} at the coral reefs at Cape Rachado resulted in a decrease in biomass of the seaweed and loss of some fragile species. Short tuft forms and encrusting species are especially vulnerable to sedimentation. Large, flexible, branched species like *Sargassum* and *Padina* are less susceptible and are able to avoid smothering by silt. A survey on five islands (Pulau Bidan, Pulau Songsang, Pulau Telor, Pulau Bunting and Tukun Terendek) off the coast of Kedah (Japar Sidik and Muta Harah 1999) revealed that seaweed diversity (11–12 species) was low relative to other areas in the west coast (80 species, Phang and Wee 1991) and other similar coral reef areas such as Pulau Bidong Laut (20 species, Arumugam 1981), Pulau Sibu (15 species, Ahmad and Suzana 1989), Redang Island archipelago, Terengganu (63 species, Japar Sidik et al. 1997), Pulau Ekor Tebu (19 species), Pulau Lima (27 species), and Pulau Kerengga (11 species). There were abundant boulders, rocks, coral rubbles and dead corals that form favourable substrates for colonization and establishment of seaweed and yet their diversity is relatively low. Reduced light transmission caused by turbidity (as confirmed by turbid water and extremely poor visibility) in the water column creates unfavourable condition for many seaweeds to thrive. Despite the poor water condition, several seaweed species e.g. *Caulerpa serrulata*, *Halimeda opuntia*, *Pocockiella variegate* (*Lobophora variegata)*, the filamentous forms (*Cladophora* spp.), and the tuft forms (*Chaetomorpha* spp.) are able to colonize and establish in such areas, even if their colonization and establishment were only observed in the shallow places at most from 0.3 to 2 m in depth. *Padina* sp. and *Hypnea* sp. known to inhabit deeper waters were also found to occur at similar shallow areas. Other factors causing the low diversity of seaweeds, e.g. in Penang, are the relatively large tidal amplitude and seasonal variation and differences in habitats (Crane 1981). In these areas, the low spring tides could create an extremely harsh environment for plants due to desiccation and intense solar radiation.

The economic and edible seaweed

Several seaweed species have been used for foods, processed products, and medicinal usage by the local ethnic, and their availability locally and abroad were described in detail by Burkill (1935). Additional utilization was included and added to the Burkill's (1935) list by Ismail (1978) and Phang (1987). The economic and consumable seaweed in Malaysia were: *Acetabularia major*, *Ulva latissima* (green seaweeds), *Dictyota apiculata*, *Sargassum* spp., *Turbinaria ornate*, *T. conoides* (brown seaweeds), *Acanthophora*, *Eucheuma spinosum*, *E. horridum*, *E. serra*, *Gracilaria* sp., *Gelidium rigidum* (*Gelidiopsis rigida*), *Laurencia botryoides* (red seaweeds). The category of utilization and notes on their usage and preparations is summarized in Table 2.

The cultivation of seaweed

The importance of seaweeds as a marine resource has been emphasized due to the increasing demand for them as food and raw materials in the production of industrial colloids, e.g. agars, carrageenan and alginates of varied usage and application in industries. To supply the demand for the industrial applications, gel-producing seaweeds, e.g. *Euchema denticulatum* particularly in the Philippines are farmed as an alternative to harvesting the wild crop (Doty 1973, Glen and Doty 1990). Since then the selected and farmed varieties have been introduced to numerous parts of the world for the purpose of research or the development of commercial cultivation including Sabah, East Malaysia. Seaweed farming was developed in Semporna, Sabah, in 1986 with the support of the Fisheries Department personnel and fishermen. It was aimed to produce a source of seed stock of *Eucheuma* and to attract the fishermen to be involved in farming in order to increase their income. An estimate of about 1.5 ha of suitable site was farmed with *E. striatum* or the initial seedlings of 30,000 plants with an average weight of 250–300 grams per plant. The farmers were able to farm 4 ha in October 1987. There were six families who started the *Eucheuma* farming. In 1988, 10 families of fishermen were involved covering an area of 10 ha. The production of *Eucheuma* in 1987 amounted to 400 Mt wet weight. Some were consumed as food and others were exported as dried material (Arman Shah 1988). In Semporna, the environmental and oceanographic conditions are favorable for seaweed farming of *E. spinosum*. In addition to favorable environment, the alternative livelihood for the coastal dwellers and the present internal and external demands for carrageenan have given the impetus for seaweed farms to expand in the area. Significant portion of *Euchuema* produced from farms are sold in an unprocessed sun-dried forms to a local company involved in the seaweed trading with the carrageenan factory in Cebu, Philippines. The seaweed production through farming is recognized as a very supportive alternative source of livelihood and employment for the local inhabitants. *Gracilaria changii,* a good source of high quality agar and agarose (Shaharuddin et al. 1994), has also been experimentally cultivated in shrimp ponds at Ban Merbok, Perak, Peninsular Malaysia by the Fisheries Research Institute, Batu Maung, Penang, and in mangrove ponds and irrigation canals, resulting in daily

growth rates of 3.6, 3.3 and 8.4% per day respectively (Phang 1998). The different methods of cultivation for the two species is documented by Phang (1998). Compared to *Eucheuma*, *Gracilaria* farming was lagging behind due to absent of supporting agar factories in the neighbouring countries. The high demand for tropical seaweeds in the international market either as raw materials in the manufacture of commercial products such as agars, carrageenan and alginates or refined, is primary factor influencing the expansion and development of farming technology for some seaweeds e.g. *Eucheuma* in Sabah, East Malaysia. This also led to searching for alternative sources of alginates in other seaweeds such as *Sargassum hornchuchi* and *S. Vulgare* (Omar et al. 1985), *Sargassum* spp., *Dictyota* sp., *Cystoseira* sp., *Padina* sp. and *Turbinaria* sp. (Mariam and Fasihuddin 1992), where all species occurring in coastal waters of Sabah, East Malaysia. Their alginic acid content varied with species, 30-38.4% (*Sargassum*), 32% (*Cystoseira*), 22% (*Dictyota*), 20% (*Turbinaria*) and 16% (*Padina* sp.). Alginic acid content of some species are comparable to 30% content obtained from the temparate *Laminaria* (Chapman and Chapman 1980).

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