Taiwania, **44**(2): 271-298, 1999

Floristic Studies on the Benthic Marine Algae of Northeastern Taiwan

Su-fang Huang[1, 2]

(Manuscript received 3 April, 1999; accepted 9 May, 1999)

ABSTRACT: The composition, distribution, seasonal succession and phytogeographic affinities of the benthic marine algae in the northeastern Taiwan were studied. A total of 50 families, 105 genera and 179 species of marine algae were identified, including 3 species of Cyanophyta, 42 species of Chlorophyta, 27 species of Phaeophyta and 107 species of Rhodophyta. Among them, 9 species are new records in Taiwan. There are 42 families and 52 species of algae appeared in all sampling stations, which are representatives of the major algal community of northeastern Taiwan. The Jaccard's similarities of composition were over 40% between the sampling stations. Based on the analysis with UPGMA-method, it can be divided into 2 clusters, with station I (Nan-ya) as a separate cluster and stations II to VI as a joint one. With respect to vertical distribution, 8 species of the marine algae grow along the supralittoral fringe, 25 species on the upper and middle littoral zone, 85 species on the lower littoral zone and 143 species in the sublittoral zone. Most of species are seasonal and more abundant in winter and spring than in summer and autumn. The seasonal succession occurs twice between December-January and August-September. According to the phytogeographic study, it was found that the algal flora of northeastern Taiwan is mainly tropical, together with a number of temperate species. Their distributions are closely related to the meeting of the warm Kuroshio Current and the cold China Coastal Current.

KEY WORDS: Taiwan, Northeastern Taiwan, Marine algal flora, Community ecology, Phytogeography, New records.

INTRODUCTION

The study on the marine algae of Taiwan began in a German's report in 1894 (Heydrich, 1894). More than 500 species of seaweeds have been recorded since then (Okamura, 1931, 1936; Yamada, 1950; Shen and Fan, 1950; Chiang, 1960, 1962a, 1962b, 1972, 1973a, 1973b, 1992a, 1992b, 1993; Wang and Chiang, 1977; Chiang and Chou, 1980; Wang and Chen, 1980; Chen and Chiang, 1981a, 1981b, 1982; Chou and Chiang, 1981; Yang, 1981; Chiang and Chen, 1982, 1983; Yang and Chiang, 1982; Chiang and Wang, 1987; Lewis and Norris, 1987; Chen, 1991; Huang, 1990, 1991; Wang *et al.*, 1993; Wang and Chiang, 1993, 1994; Yang *et al.*, 1994; Huang, 1997, 1998). However, the majority of previous work is focused on algal classification; only minor on their ecological characteristics. The field floristic survey is obviously insufficient. The reasons are as follows: 1. The classification of most of the algae in Taiwan still has not yet been systemized. 2. Due to the actions of current, tide and wave, it is more difficult to study marine algae than land plants.

1. Department of Botany, Taiwan Museum, Taipei 100, Taiwan, Republic of China.
2. Corresponding author.

Basically, the completion of biological records in a region is the first step to conduct biological resource development, use and ecological conservation. It is also the first priority theme and policy when all the countries are calling for the stress on the biodiversity (Grumbine, 1994; Norton *et al.*, 1996; Peck, 1998). The maritime space of northeastern Taiwan is one of the most important fishing grounds in Taiwan and embraces rich marine biological resources owing to the influence of the Kuroshio Current (Chu, 1963, 1971; Annon, 1988; Tang and Tang, 1994). It is valuable in both application and academic studies. However, the investigation on seaweeds of this area is rare. In the past, Su *et al* (1986, 1991) engaged in the marine ecological study in the Yen-liao around the Northern Nuclear Plant and recorded 45 species of marine algae. In addition, Yang *et al* (1994) discovered 52 species of algae around Peng-Chia-Yu. Wang and Chen (1980), ranged from Bi-tou-chiao to San-tiao-chiao, studied 56 species of algae in the littoral zone. However, there is nothing done on the algal floristic survey in the sublittoral zone.

The author has studied the benthic marine algae of northeastern Taiwan since 1995. It was found that the algal resources of the sublittoral zone in this region were very rich. Besides, there are a great number of useful species, such as *Grateloupia*, *Eucheuma*, *Halymenia, Gelidium* and *Pterocladiella*, which harvested by local people for food or agar extract. This study provides more information about the composition, distribution, habitat and seasonal occurrence of the benthic marine algae in this region. In the meantime, statistical methods were employed to characterize changes in the algal community of this area.

MATERIALS AND METHODS

The ecological environment and algal community survey

Six sampling stations were set up along the coastal line from Nan-Ya to Tou-Cheng (Fig. 1). At each site, the algal communities from the supralittoral fringe to 20 meters depth were investigated every month during the time from September 1995 to August 1997. Skin and SCUBA diving equipment were used for underwater observation and recording the species, distributions, occurrence and abundance (Taniquti, 1976). In order to deal with a large number of data, Jaccard's coefficient, matrix-analysis method and UPGMA method (Sneath & Sokal, 1973) were taken to analyze the spatial and temperal similarity between stations. Specimens were either dried or preserved in 10% formalin seawater for the further morphological examination (Tsuda & Abbott, 1985). All the voucher specimens were deposited in the Herbarium of Taiwan Museum (TMB). The variation in air temperature, water temperature and salinity of studied area were recorded for each visit. In addition, the latest information about the climate, currents, tide and hydrologic data along the coast of northeastern Taiwan were collected from Central Weather Bureau, Taiwan Fisheries Research Institute (Infrared imagery of the NOAA satellites) and National Science Council (Kuroshio Edge Exchange Processes; KEEP program).

Phytogeographic study

The latest reports and phytogeographic records in the neighboring areas were studied, including Japan (Okamura, 1936; Segawa, 1974; Chihara, 1983; Yoshida *et al.*, 1990; Tsuda, 1991; Yoshida, 1998); Korea (Rho, 1958; Kang, 1966; Sohn, 1998; Yoshida, 1998),

Mainland China (Tseng, 1936, 1943, 1962, 1983; Hodgkiss & Lee, 1983), Philippines (Cordero, 1977a, b; Silva *et al.*, 1987; Callumpong, *et al.*, 1997; Trono, 1997, 1998), Vietnam (Dawson, 1954; Thoi, 1969; Nguyen and Huynh. 1993; Silva *et al.*, 1996), Malaysia (Silva *et al.*, 1996; Phang, 1998), Singapore (Wei and Chin, 1983), Indonesia (Silva *et al.*, 1996; Sri *et al,* 1998), South Pacific Islands (Dawson, 1956; Saito, 1969; Womersley & Bailey, 1970; Mshigeni, 1978a, b; Magruder & Hunt, 1979; N'yeurt and South, 1997) and Australia (Womersley, 1967; Cribb, 1983; Silva *et al.*, 1996). It was aimed at discussing the interrelations of the algal flora between the northeastern Taiwan and the neighboring areas.

RESULTS AND DISCUSSION

General description of environment

The northeast part of Taiwan is located between E 121°65'～122°15' and N 24°50'～25°25', range from Nan-ya to Tou-cheng, with a coastal line of 67 kilometers and maritime space of 4,275 hectares (Fig. 1). The shoreline features of northeastern Taiwan have different kind of topography. There are steep cliffs (such as station I), bays, sandy beach, terrace platform (such as stations II and V), coral reef (such as stations III and IV) and rochy cuestas (such as staion VI). The northeasterly monsoon appears from September to February. In winter, the wind speed is frequently over Beaufort 6 degrees and this always causes big waves along the coast (Fig. 2). The coastline between Nan-ya and San-tiao-chiao is vertical to the northeast monsoon, and is usually eroded by the strong winds and waves. On the other hand, the coastline between the south of San-tiao-chiao and Tou-cheng is parallel to the direction of monsoon. It is therefore relatively less affected by waves.

The average annual air temperature is about 21℃, up to 30℃ in summer and down to 15 ℃ in winter (Fig. 3). Two currents meet in this area. The warm Kuroshio Current from the Philippines is the major current in summer, and the cold China Coastal Current accompanied with the northeast monsoon is the main one in winter (Chern and Wang, 1989, 1990, 1994). In April and May, the influence of the Kuroshio Current becomes greater and makes the water temperature rise to above 25℃ (Fig. 3). In July and August, the water temperature can reach over 28℃. The seasonal change in salinity ranged between 32.0‰ and 35.5‰. In the spring rainy season, the salinity of surface water may be lowered to 28～30‰. The pH value varied from 8.0 to 8.5 throughout a year. There was very low industrial pollution in the studied area.

The Composition and Distribution of Seaweeds

There are totally 179 species of seaweeds identified in this study. They belong to 105 genera and 50 families, and include 3 species of Cyanophyta (2%), 42 species of Chlorophyta (23%), 27 species of Phaeophyta (15%), and 107 species of Rhodophyta (60%) (Tables 1, 2 and Fig. 4). Among them, 9 species are new records in Taiwan. They are *Grateloupia livida* (Harvey) Yamada, *Amphiroa dilatata* Lamouroux, *Mesophyllum simulans* (Foslie) Lemoine, *Serraticardia maxima* (Yendo) Silva, *Gracilaria textorii* (Suringar) De Toni, *Schizymenia dubyi* (Chauvin *in* Duby) J. Agardh, *Titanophora weberae* Boergesen, *Sebdenia flabellata* (J. Agardh) Parkinson, and *Claudea multifida* Harvey. Among them, *Serraticardia*, *Schizymenia*, and *Titanophora* are genera new to Taiwan.

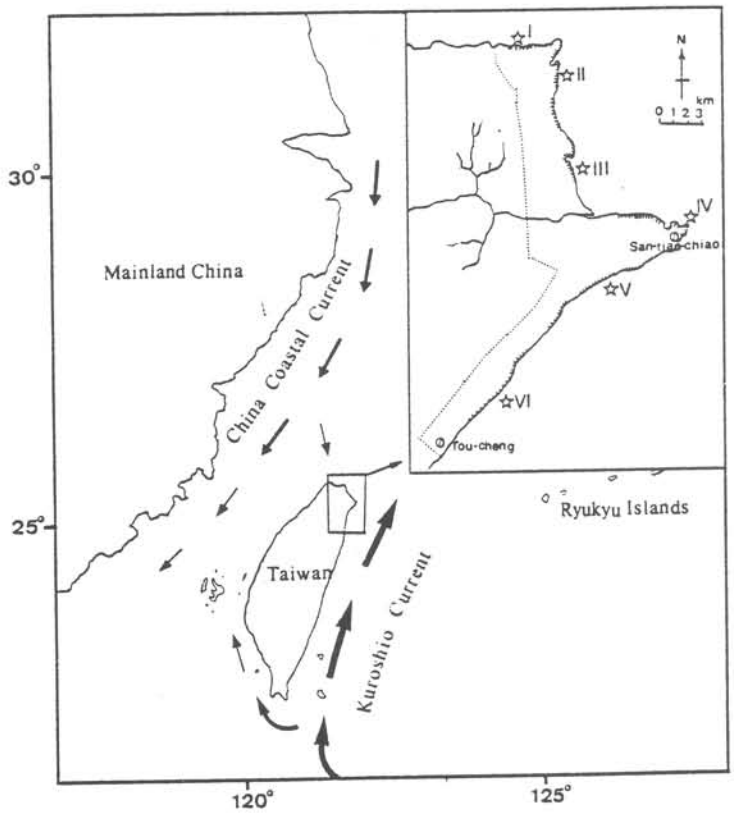

Fig.1. Map of northeastern Taiwan, showing six sampling sites and the adjacent current. I. Nan-ya; II. Lung-tung; III. Ao-di; IV. Ma-kang; V. Shih-cheng; VI. Pei-kuan.

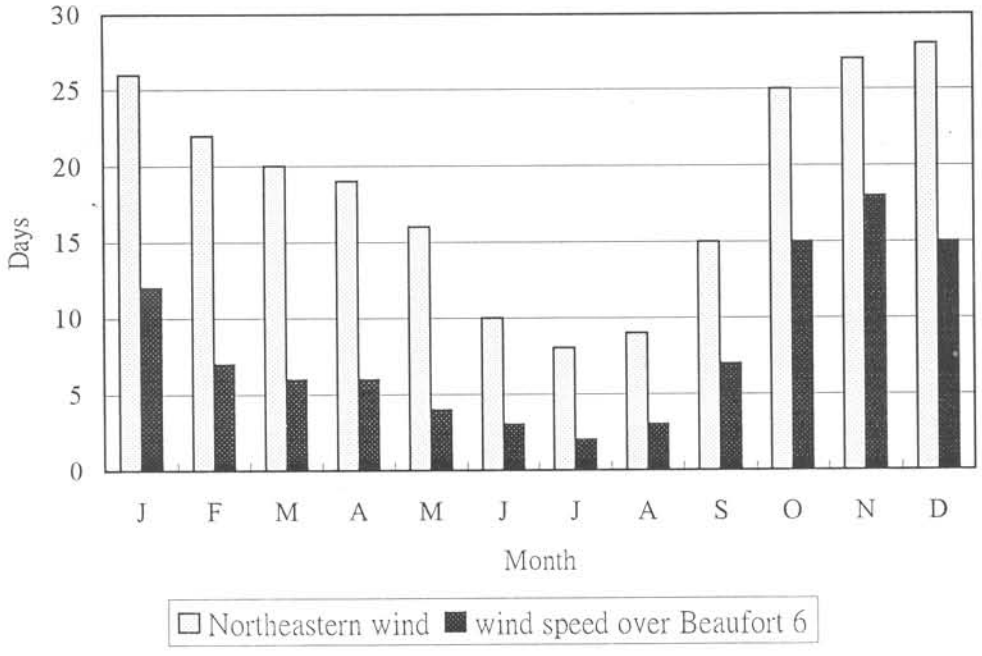

Fig. 2. Monthly variation of days with northeasterly wind and days with wind speed over Beaufort 6 degree in the studied area.

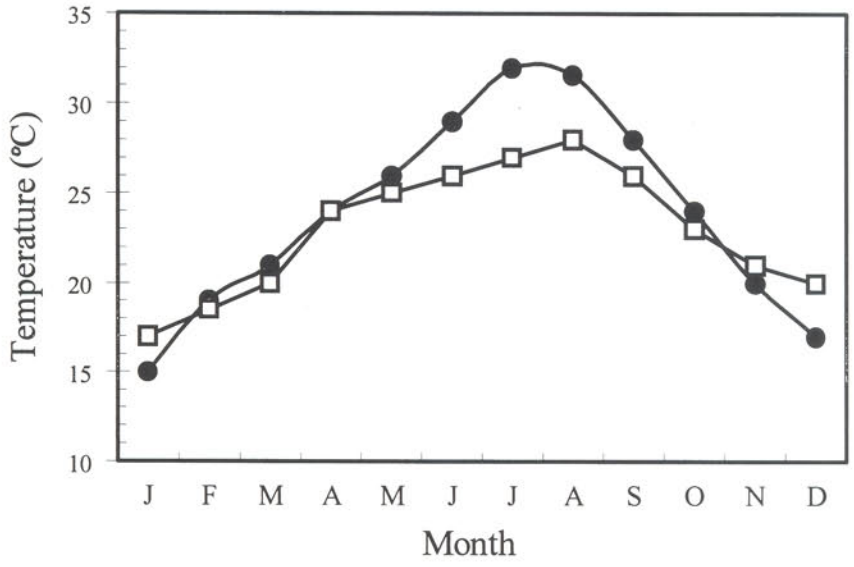

Fig. 3. Monthly variation of average air temperature (●—●) and water temperature (□—□) of northeastern Taiwan.

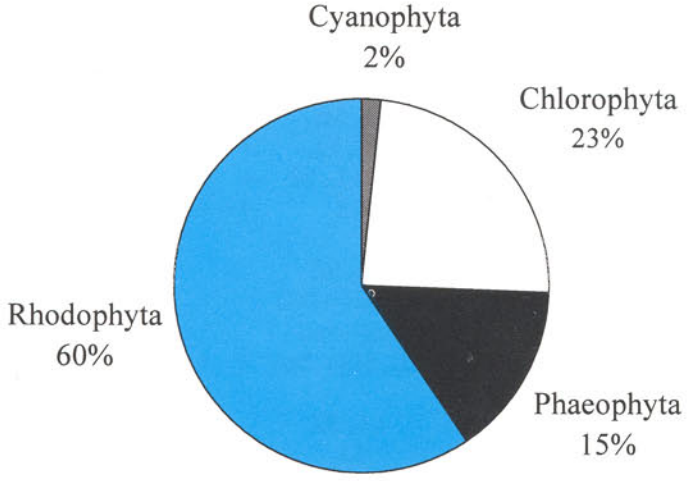

Fig. 4. Percentage of each Division in the floristic list.

As shown in Table 1, the occurrences of 177 species were checked in six studied sites. It was found that 43 families and 52 species of algae appeared in all six stations. They are: *Enteromorpha compressa, E. intestinalis, Ulva conglobata, U. fasciata, U. lactuca, Chaetomorpha spiralis, Cladophoropsis herpestica, Valoniopsis pachynema, Caulerpa peltata, Codium arabicum, Hincksia mitchellae, Dictyota bartayresii, Dilophus okamurae, Lobophora variegata, Padina arborescens, Zonaria diesingiana, Ishige okamurae, Colpomenia sinuosa, Petalonia binghamiae, Hydroclathrus clathratus, Sargassum duplicatum, Porphyra crispata, Galaxaura marginata, Tricleocarpa fragilis, Gelidium*

Table 1. The composition, distribution and seasonal occurrence of seaweeds of northeastern Taiwan.
＊: new records for Taiwan.
SF: Supralittoral fringe; UL: Upper littoral zone; ML: Middle littoral zone;
LL: Lower Littoral zone; SZ: Sublittoral zone.

List of Species	Sampling sites						Vertical distribution	Month											
	I	II	III	IV	V	VI		J	F	M	A	M	J	J	A	S	O	N	D
CYANOPHYTA																			
Oscillatoriaceae																			
Lyngbya majuscula	+	+	+	+	+	+	UL, ML	+	+					+	+	+	+	+	+
Phormidiaceae																			
Symploca hydnoides	+						UL, ML					+	+	+					
Mastigocladaceae																			
Brachytrichia quoyi					+	+	SF, UL					+	+	+					
CHLOROPHYTA																			
Ulotrichaceae																			
Ulothrix flacca			+	+	+		UL, ML			+	+	+	+	+	+				
Monostromataceae																			
Monostroma nitidum	+	+	+	+	+		UL, ML	+	+	+	+	+					+	+	+
Ulvaceae																			
Enteromorpha clathrata				+	+		UL, ML	+	+	+	+							+	+
Enteromorpha compressa	+	+	+	+	+	+	UL, ML	+	+	+	+	+	+	+	+	+	+	+	+
Enteromorpha intestinalis	+	+	+	+	+	+	UL, ML	+	+	+	+	+	+	+	+	+	+	+	+
Enteromorpha linza	+	+	+		+	+	ML, LL			+	+	+	+						
Enteromorpha prolifera			+	+	+		ML			+	+	+							
Ulva conglobata	+	+	+	+	+	+	UL, ML	+	+	+	+	+	+	+	+				
Ulva fasciata	+	+	+	+	+	+	ML, LL	+	+	+	+	+	+	+	+	+	+	+	+
Ulva lactuca	+	+	+	+	+	+	ML, LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Ulva pertusa		+	+	+	+		SZ	+	+	+	+	+	+	+				+	+
Anadyomenaceae																			
Anadyomene wrightii		+	+	+	+		LL, SZ				+	+	+						
Microdictyon nigrescens				+	+	+	LL,SZ(1-2m)		+	+	+	+	+	+	+				
Microdictyon okamurae				+			SZ(1-5m)			+	+								
Valoniopsis pachynema	+	+	+	+	+	+	LL, SZ(1-2m)	+	+	+	+	+	+	+	+	+	+	+	+
Cladophoraceae																			
Chaetomorpha antennina				+	+	+	LL, SZ				+	+	+						
Chaetomorpha crassa			+	+	+	+	LL	+	+	+	+	+	+	+					
Chaetomorpha linum				+	+		LL			+	+	+	+						
Chaetomorpha spiralis	+	+	+	+	+	+	UL, ML			+	+	+	+	+	+	+			
Cladophora catenata			+	+		+	ML, LL		+	+	+	+	+	+					
Cladophora fascicularis			+	+	+	+	LL		+	+	+	+	+	+	+				
Cladophora sp.		+		+	+		ML, LL		+	+			+	+					
Siphonocladaceae																			
Boergesenia forbesii				+	+	+	LL, SZ				+	+	+	+					
Cladophoropsis herpestica	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+					+
Boodleaceae																			
Boodlea composita		+	+	+			LL, SZ(1-5m)	+	+	+	+	+	+	+	+				
Struvea enomotoi		+			+		LL, SZ					+	+						
Valoniaceae																			
Dictyosphaeria cavernosa		+	+	+			LL, SZ(1-2m)	+	+	+	+	+	+	+	+	+	+	+	+
Valonia aegagropila		+	+	+			LL, SZ(1-3m)			+	+	+	+	+					
Ventricaria ventricosa				+		+	LL, SZ(1-3m)		+	+	+	+	+	+					

Table 1. Continued.

List of Species	Sampling sites						Vertical distribution	Month											
	I	II	III	IV	V	VI		J	F	M	A	M	J	J	A	S	O	N	D
Bryopsidaceae																			
Bryopsis plumosa	+	+	+	+			LL, SZ(1-2m)		+	+	+	+	+	+	+				
Caulerpaceae																			
Caulerpa parvifolia		+	+	+	+	+	SZ(1-10m)	+	+	+	+	+	+						
Caulerpa peltata	+	+	+	+	+	+	SZ(1-5m)		+	+	+	+	+	+	+	+			
Caulerpa racemosa v. *laete-virens*		+	+	+	+	+	LL, SZ(1-10m)	+	+	+	+	+	+	+					
Caulerpa racemosa v. *clavifera* f. *macrophysa*		+	+	+		+	LL, SZ	+	+	+	+	+	+						
Caulerpa serrulata v. *serrulata* f. *lata*					+	+	SZ(1-10m)				+		+						
Udoteaceae																			
Chlorodesmis caespitosa				+			SZ(1-5m)			+	+	+	+	+	+				
Codiaceae																			
Codium arabicum	+	+	+	+	+	+	SZ(1-5m)	+	+	+	+	+	+	+	+	+	+	+	+
Codium contractum		+		+	+		SZ(3-10m)			+	+	+	+						
Codium geppiorum			+	+	+		SZ(1-7m)		+	+	+	+	+	+	+				
Codium intricatum				+	+	+	SZ(4-5m)			+	+	+	+	+	+				
Codium mamillosum		+		+			SZ(1-15m)	+	+	+	+	+	+	+	+	+	+	+	+
Polyphysaceae																			
Acetabularia parvula					+	+	LL, SZ				+	+	+	+					
PHAEOPHYTA																			
Ectocarpaceae																			
Hincksia breviarticulatus	+	+	+	+	+		ML, LL		+	+	+								
Hincksia mitchellae	+	+	+	+	+	+	UL, ML	+	+	+	+	+		+			+	+	+
Dictyotaceae																			
Dictyopteris divaricata			+	+	+		SZ(1-5m)				+	+	+	+	+				
Dictyopteris repens		+	+	+	+	+	SZ(1-10m)		+	+	+	+	+	+	+				
Dictyopteris undulata	+	+	+	+			SZ(1-10m)			+	+	+	+						
Dictyota bartayresii	+	+	+	+	+	+	SZ(1-5m)	+	+	+	+	+	+	+	+	+	+	+	+
Dictyota dichotoma		+	+	+	+	+	SZ(2-5m)			+	+	+	+	+	+				
Dictyota divaricata		+	+	+	+		SZ(1-2m)					+	+	+	+	+	+		
Dictyota friabilis	+	+	+	+	+		SZ(1-5m)	+	+	+	+	+	+	+	+				
Dictyota linearis		+	+	+	+		SZ(1-3m)	+	+	+	+	+	+						
Dilophus okamurae	+	+	+	+	+	+	SZ(1-3m)	+	+	+	+	+	+						
Lobophora variegata	+	+	+	+	+	+	SZ(1-5m)	+	+	+	+	+	+	+	+	+	+	+	+
Pachydictyon coriaceum		+		+	+		SZ(1-10m)	+	+	+	+	+							
Padina arborescens	+	+	+	+	+	+	SZ(1-10m)	+	+	+	+	+	+	+	+				
Padina australis		+	+	+	+		LL, SZ			+	+	+	+	+					
Padina crassa		+	+				SZ(1-20m)				+	+	+	+	+				
Padina minor		+	+	+	+	+	LL, SZ				+	+	+	+					
Spatoglossum pacificum				+	+		SZ(1-10m)				+	+	+	+	+				
Zonaria diesingiana	+	+	+	+	+	+	SZ(1-10m)	+	+	+	+	+	+	+	+	+	+	+	+
Zonaria stipitata			+	+			SZ(1-5m)				+	+	+	+	+				
Ishigeaceae																			
Ishige okamurae	+	+	+	+	+	+	UL		+	+	+	+	+	+					
Chnoosporaceae																			
Chnoospora implexa					+		LL, SZ					+							

Table 1. Continued.

List of Species	Sampling sites						Vertical distribution	Month											
	I	II	III	IV	V	VI		J	F	M	A	M	J	J	A	S	O	N	D
Scytosiphonaceae																			
Colpomenia sinuosa	+	+	+	+	+	+	LL, SZ		+	+	+	+	+	+	+				
Hydroclathrus clathratus	+	+	+	+	+	+	LL, SZ			+	+	+	+						
Petalonia binghamiae	+	+	+	+	+	+	UL	+	+	+	+							+	+
Sargassaceae																			
Sargassum cristaefolium	+	+	+	+	+	+	LL, SZ(1-10m)		+	+	+	+	+	+	+	+			
Sargassum hemiphyllum		+	+				SZ(1-10m)					+	+	+					
RHODOPHYTA																			
Bangiaceae																			
Bangia atropurpurea	+	+	+	+			SF	+	+								+	+	+
Porphyra crispata	+	+	+	+	+	+	SF, UL	+	+	+	+	+					+	+	+
Porphyra dentata	+	+	+	+	+		SF UL	+	+	+							+	+	+
Porphyra suborbiculata	+	+	+	+	+		SF, UL	+	+	+									+
Dermonemataceae																			
Dermonema frappieri		+	+			+	LL, SZ(1m)	+	+	+	+	+							
Galaxauraceae																			
Galaxaura marginata	+	+	+	+	+	+	SZ(3-10m)	+	+	+	+	+	+	+	+	+	+	+	+
Scinaia moniliformis		+	+	+	+	+	SZ(3-10m)	+	+	+	+	+	+	+	+				
Scinaia pseudojaponica					+	+	SZ(5-10m)			+	+	+							
Scinaia latifrons		+	+				SZ(5m)				+	+	+	+					
Tricleocarpa fragilis	+	+	+	+	+	+	SZ(1-10m)	+	+	+	+	+	+	+	+	+			
Liagoraceae																			
Helminthocladia australia					+		SZ(5-10m)						+	+	+				
Liagora ceranoides					+	+	SZ(2-5m)				+	+	+						
Liagora orientalis					+	+	SZ(8m)						+	+	+				
Nemaliacea																			
Trichogloea requienii		+		+	+	+	SZ(1-10m)				+	+	+	+	+				
Bonnemaisoniaceae																			
Asparagopsis taxiformis		+	+	+	+		LL, SZ	+	+	+	+	+	+	+	+				
Delisea japonica		+	+	+	+		SZ(1-10m)				+	+	+	+	+				
Gelidiaceae																			
Gelidiella acerosa				+	+		ML, LL				+	+	+	+					
Gelidium amansii	+	+	+	+	+	+	LL, SZ(1-3m)	+	+	+	+	+	+	+	+	+	+	+	+
Gelidium divaricatum		+		+			LL	+	+	+	+							+	+
Gelidium japonicum	+	+	+	+	+	+	LL, SZ(1-10m)	+	+	+	+	+	+	+	+	+	+	+	+
Gelidium pusillum		+		+			LL	+	+	+	+								+
Pterocladiella capillacea	+	+	+	+	+	+	LL, SZ(1-10m)	+	+	+	+	+	+	+	+	+	+	+	+
Caulacanthaceae																			
Caulacanthus ustulatus		+	+	+	+		Ul, ML	+	+	+	+	+	+					+	+
Dumontiaceae																			
Dudresnaya japonica		+	+	+			SZ(3-15m)	+	+	+	+	+	+	+	+				
Rhodopeltis borealis			+		+	+	SZ(1-5m)			+	+	+	+	+					
Endocladiaceae																			
Gloiopeltis furcata		+	+	+	+	+	SF, UL		+	+	+	+	+						
Gloiopeltis tenax		+		+	+	+	SF, UL		+	+	+	+	+						
Gigartinaceae																			
Chondracanthus intermedius	+	+	+	+	+	+	ML, LL	+	+	+	+	+	+	+	+	+	+	+	+
Chondrus ocellatus		+	+	+	+	+	ML, LL	+	+	+	+	+	+						+
Chondrus verrucosa	+	+	+	+	+	+	ML, LL	+	+	+	+	+	+	+	+				+

Table 1. Continued.

List of Species	Sampling sites						Vertical distribution	Month											
	I	II	III	IV	V	VI		J	F	M	A	M	J	J	A	S	O	N	D
Halymeniaceae																			
Carpopeltis formosana		+		+			LL, SZ		+	+	+	+							
Carpopeltis maillardii		+	+	+			SZ(3-5m)			+	+	+	+	+	+				
Grateloupia filicina	+	+	+	+	+	+	LL, SZ(1-5m)	+	+	+	+	+	+					+	+
* *Grateloupia livida*	+	+	+	+	+		LL, SZ	+	+	+	+							+	+
Grateloupia okamurae	+	+	+	+	+	+	LL, SZ	+	+	+	+	+						+	+
Grateloupia sparsa	+	+	+	+	+	+	SZ(3-5m)	+	+	+	+	+	+					+	+
Halymenia dilatata		+	+	+			SZ(3-10m)	+	+	+	+	+	+	+				+	+
Halymenia floresia		+	+	+	+	+	SZ(3-10m)	+	+	+	+	+	+	+	+	+	+	+	+
Polyopes polyideoides	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+				+
Prionitis ramosissima	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+				+
Hypneaceae																			
Hypnea boergesenii		+	+	+			LL, SZ	+	+	+	+	+	+	+					
Hypnea charoides	+	+	+	+	+		LL, SZ	+	+	+	+	+	+	+	+				
Hypnea chordaceae		+	+	+	+	+	LL, SZ	+	+	+	+	+	+						
Hypnea japonica	+	+	+	+	+	+	ML, LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Hypnea pannos		+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Hypnea saidana	+	+	+	+	+		LL, SZ		+	+	+	+	+						
Hypnea spinella		+	+	+	+				+	+	+	+	+	+	+				
Peyssonneliaceae																			
Peyssonnelia conchicola		+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Peyssonnelia distenta	+	+	+	+	+	+	SZ(1-5m)	+	+	+	+	+	+	+	+	+	+	+	+
Phyllophoraceae																			
Ahnfeltiopsis flabelliformis	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Plocamiaceae																			
Plocamium telfairiae				+			SZ(1-5m)				+	+							
Rhizophyllidaceae																			
Portieria hornemannii		+	+	+	+	+	LL, SZ(1-5m)		+	+	+	+	+						
Sarcodiaceae																			
Sarcodia montagneana	+	+	+	+	+	+	LL, SZ				+	+	+	+					
Schizymeniaceae																			
* *Schizymenia dubyi*				+		+	SZ(5-10m)			+	+	+	+	+					
* *Titanophora weberae*		+				+	SZ(1-10m)			+	+	+	+	+	+				
Sebdeniaceae																			
* *Sebdenia flabellata*			+		+	+	SZ(5-10m)			+	+	+	+	+	+				
Solieriaceae																			
Eucheuma denticulatum		+	+				SZ(1-10m)	+	+	+	+	+	+	+					
Eucheuma serra	+	+	+	+	+	+	SZ(3-10m)	+	+	+	+	+	+	+	+	+	+	+	+
Meristotheca coacta		+	+	+	+		SZ(1-15m)	+	+	+	+	+	+	+					
Meristotheca papulosa	+	+	+	+	+	+	SZ(1-15m)	+	+	+	+	+	+	+	+	+	+	+	+
Corallinaceae																			
* *Amphiroa dilatata*				+	+		SZ(1-10m)		+	+	+	+	+	+	+	+	+		
Amphiroa ephedraea	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Amphiroa. foliacea	+	+	+	+			LL, SZ	+	+	+	+	+	+						
Amphiroa fragilissima		+	+	+			ML, LL, SZ			+	+	+	+	+	+				
Cheilosporum acutilobum		+		+			LL, SZ			+	+	+	+	+					
Corallina pilulifera	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Corallina sp.			+	+			LL, SZ			+	+	+	+						

Table 1. Continued.

List of Species	Sampling sites						Vertical distribution	Month											
	I	II	III	IV	V	VI		J	F	M	A	M	J	J	A	S	O	N	D
Jania adhaerens	+	+	+	+	+	+	LL, SZ		+	+	+	+	+	+	+	+			
Jania ungulata		+	+	+	+		SZ				+	+	+	+					
Marginisporum aberrans	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Marginisporum crassissimum		+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Mastophora rosea	+	+	+	+	+	+	LL, SZ		+	+	+	+	+	+	+				
* *Mesophyllum simulans*		+		+			SZ(1-5m)		+	+	+	+	+	+	+				
* *Serraticardia maxima*		+			+		SZ(1-5m)				+	+	+	+					
Gracilariaceae																			
Gracilaria arcuata				+	+		LL, SZ			+	+	+	+	+					
Gracilaria coronopifolia		+		+			ML, LL				+	+	+	+	+				
Gracilaria gigas		+		+	+	+	SZ(1-5m)			+	+	+	+	+	+				
* *Gracilaria textorii*		+	+	+			LL, SZ		+	+	+	+	+	+	+				
Gracilaria veillardii		+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+				
Champiacaeae																			
Champia parvula		+	+	+	+		LL, SZ	+	+	+	+	+	+	+	+				
Rhodymeniaceae																			
Ceratodictyon spongiosum	+	+	+	+	+	+	LL, SZ(1-10m)		+	+	+	+	+	+	+				
Gelidiopsis repens		+	+	+	+	+	SZ(1-10m)			+	+	+	+	+	+	+			
Halichrysis micans		+	+	+		+	SZ(1-10m)			+	+	+	+	+					
Ceramiaceae																			
Centroceras clavulatum	+	+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+	+	+	+	+	+
Ceramium flaccidum				+		+	SZ(1-10m)			+	+	+	+	+	+				
Crouania minutissima			+	+			SZ(1-10m)			+	+	+	+	+	+				
Dasyphila plumarioides				+		+	SZ(5-10m)				+	+	+	+	+				
Spyridia filamentosa				+		+	SZ			+	+	+	+	+					
Wrangelia argus				+	+		SZ(1-10m)		+	+	+	+	+	+	+				
Delesseriaceae																			
* *Claudea mutifida*				+	+		SZ(5-10m)			+	+	+	+	+	+	+			
Martensia fragilis		+	+	+	+		SZ(1-10m)		+	+	+	+	+	+					
Neoomartensia flabelliformis		+	+	+			SZ(1-10m)		+	+	+	+	+	+					
Vanvoorstia coccinea		+	+			+	SZ(1-7m)		+	+	+	+	+	+	+	+			
Rhodomelaceae																			
Acanthophora spicifera		+		+	+		SZ(1-5m)				+	+	+	+	+				
Acrocystis nana			+			+	LL, SZ			+	+	+	+	+					
Bostrychia tenella				+		+	SF			+	+	+	+						
Chondria armata		+	+	+	+		SZ(1-15m)	+	+	+	+	+	+	+	+				
Laurencia brongniartii	+	+	+	+	+	+	SZ(1-10m)	+	+	+	+	+	+	+	+	+	+	+	+
Laurencia nipponica	+	+	+	+	+	+	LL, SZ(1-5m)	+	+	+	+	+	+	+	+	+	+	+	+
Laurencia intermedia	+	+	+	+	+	+	LL, SZ(1-5m)	+	+	+	+	+	+	+	+	+	+	+	+
Laurencia okanyrae		+	+	+	+	+	LL, SZ	+	+	+	+	+	+	+					+
Laurencia papillosa		+	+	+			LL, SZ			+	+	+	+	+	+				
Laurencia. undulata		+	+	+			LL, SZ		+	+	+	+	+	+	+				
Leveillea jungermannioides					+	+	SZ(1-10m)			+	+	+	+	+					
Melanamansia glomerata				+	+		LL, SZ				+	+	+						
Neurymenia fraxinifolia				+	+	+	SZ(1-15m)			+	+	+	+						

Table 2. Numbers of algal taxa during the time of study in northeastern Taiwan.

Phylum	No. of families	No. of genera	No. of species	No. of new records for Taiwan
Cyanophyta	3	3	3	0
Chlorophyta	13	21	42	0
Phaeophyta	6	16	27	0
Rhodophyta	28	65	107	9
Total	50	105	179	9

amansii, G. japonicum, Pterocladiella capillacea, Grateloupia filicina, G. okamurae, G. sparsa, Polyopes polyideoides, Prionitis ramosissima, Peyssonnelia distenta, Amphiroa ephedraea, Corallina pilulifera, Jania adhaerens, Marginisporum aberrans, Mastophora rosea, Chondracanthus intermedius, Chondrus verrucosa, Hypnea japonica, Ahnfeltiopsis flabelliformis, Sarcodia montagneana, Eucheuma serra, Meristotheca papulosa, Ceratodictyon spongiosum, Centroceras clavulatum, Laurencia brongniartii, L. glandulifera, L. intermedia ◦ These species are frequently seen and serve as the representative of the major algal community in northeastern Taiwan.

On the other hand, *Symploca hydnoides, Brachytrichia quoyi, Microdictyon okamurae, Chlorodesmis caespitosa, Caulerpa serrulata* f. *lata, Chnoospora implexa, Liagora ceranoides, Liagora orientalis,* and *Serraticardia maxima* are appeared only in a few stations. They all belong to the rare species, due to the low abundance and narrow distribution.

As shown in table 3, the station IV (Ma-kang) has the richest flora with 154 species of algae. Station II (Lung-tung) and station V (Shih-cheng) are the second richest with 128 species. Station III (Ao-di) has 126 species and station VI (Pei-kuan) has 103 species. The station I (Nan-ya) has the least number of species, only 63 species. It was found that the Jaccard's similarities are all over 40% among these stations. Between stations II-III and stations II-IV, it is even larger than 70% (Table 4), suggesting that the algal flora among stations is quite similar.

Table 3. Numbers of algal taxa in six sampling stations.

Phylum	Station I	Station II	Station III	Station IV	Station V	Station VI
Cyanophyta	2	1	1	1	2	2
Chlorophyta	13	25	27	38	32	24
Phaeophyta	14	22	23	24	23	14
Rhodophyta	34	80	75	91	71	63
Total	63	128	126	154	128	103

Sampling stations can be divided into two clusters when analyzed with UPGMA cluster method (Fig 5). Station I (Nan-ya) is a separate cluster, and stations II～VI are a combined one. This is possibly related to the geographic and topographic characteristics of stations. At station I (Nan-ya), it is north to other stations, and has steep shoreline. Besides, this site encountered with stronger winds and waves. Therefore, it has the least number of species. On the contrary, the station IV (Ma-kang) has a lot of different topographic features, such as broad platform, coral reef, ditches, drains and tide pools. It is suitable for the growth of algae and therefore has the highest abundance in the species.

Table 4. Matrix analysis showing the similarity among sampling stations based on occurrence of algal flora.

1	2	3	4	5	6	Stations
	49.6	49.2	40.4	46.2	49.1	1
◇		77.6	70.9	62.0	52.3	2
◇	◎		69.7	61.4	57.1	3
◇	◎	○		68.9	51.5	4
◇	○	○	○		64.1	5
◇	◇	○	◇	○		6

Jaccard's similarity index (Jc); Jc = C/(A+B-C)(×100%)
A =Number of species in station A. B = Number of species in station B
C = Number of species appeared in both A and B stations.
◇: 40-54.9%, ○: 55-69.9%, ◎: 70-85%

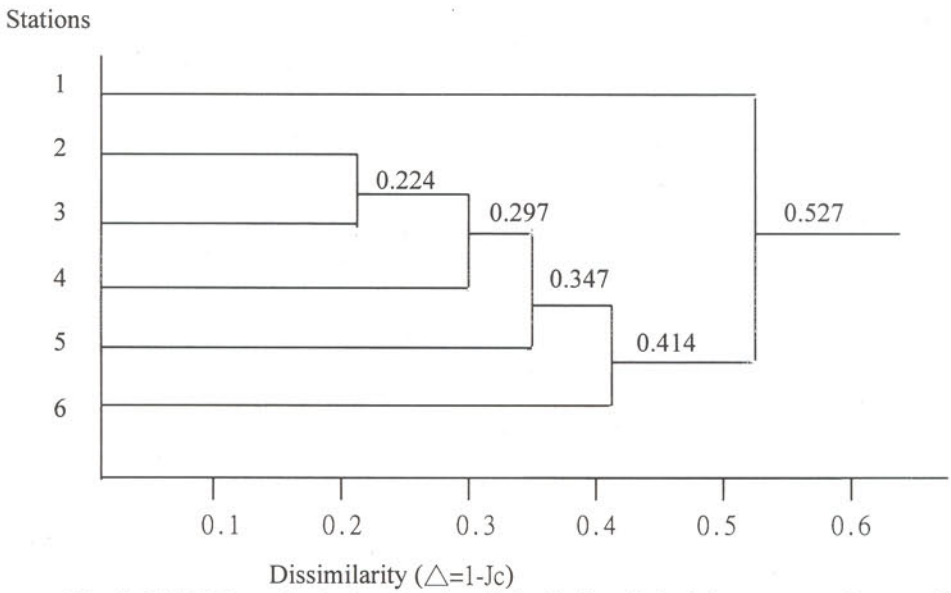

Fig. 5. UPGMA-analysis showing the dissimilarity of algal flora among the sampling stations.

Zonation and Succession

From table 1, the vertical distribution was analyzed. The supralittoral fringe was generally poorly vegetated. Only about 8 species of algae grow there. *Bangia atropurpurea and Porphyra* spp. are dominant species, and usually appear from October to next February. *Gloiopeltis furcata* and *Gloiopeltis tenax* always appear on the open rochy shoreline from February to June.

There are 25 species of algae grow on the upper and middle littoral zone. It was dominated by the green algae, such as *Enteromorpha* spp., *Ulva* spp., *Monostroma nitidum,* and *Cladophora* spp. They are more abundant in winter and spring than in summer. During summer time (from July to September), most of the algae in the littoral zone were disappeared.

On the exposed rocks of the lower littoral region or infralittoral fringe, the algal community was a mixture of eighty five species. Among them, *Dictyosphaeria cavernosa,*

Valoniopsis pachynema, Caulerpa spp., Padina spp., *Sargassum cristaefolium Colpomenia sinuosa, Gelidium* spp., *Pterocladiella capillacea, Grateloupia* spp., *Polyopes polyideoides, Prionitis ramosissima, Amphiroa spp., Corallina pilulifera, Marginisporum aberrans, Chondracanthus intermedius, Chondrus* spp., *Hypnea japonica, Ahnfeltiopsis flabelliformis, Sarcodia montagneana, Centroceras clavulatum,* and *Laurencia spp.*, appeared all year round. *Gelidium*, *Pterocladia*, and *Grateloupia* were collected by local people for food and agar extract. The amount of harvest was always exceed 10 tons per year. From June to September, there are fewer algae in the lower littoral zone, During this time, *Sargassum cristaefolium* is the dominant species around the infralittoral fringe.

The algal community of the sublittoral zone is quite complicated. 143 species were revealed in this zone. Species such as *Ulva lactuca, Codium arabicum, Codium mamillosum, Dictyota bartayresii, Lobophora variegata, Dilophus okamurae, Zonaria diesingiana, Gelidium amansii, Gelidium japonicum, Pterocladella capillacea, Peyssonnelia distenta, Dudresnaya japonica, Marginisporum aberrans, Meristotheca papulosa, Halymenia floresia, Eucheuma serra*, *Vanvoorstia coccinea, Chondria armata, Hypnea japonica, Galaxaura marginata* often appeared throughout a year.

According to the data obtained, most of species appear in April and May, and the least number in October (Fig. 6). From February to August, the similarities of algal composition between month are all over 40%. Particularly, the Jaccard's value is over 70% between March and June (Table 5). In October, there was the least number of species and the lowest similarity with other period of time. It seems that this month may be the canopy stage of the floristic changes. Based on UPGMA-analysis, it can be divided into 2 clusters (Fig. 7): algal flora from January to August a cluster, and that from September to December an one. This suggests that the seasonal succession of the algal flora occurs twice a year: one during the time of December and January, and the other during August and September.

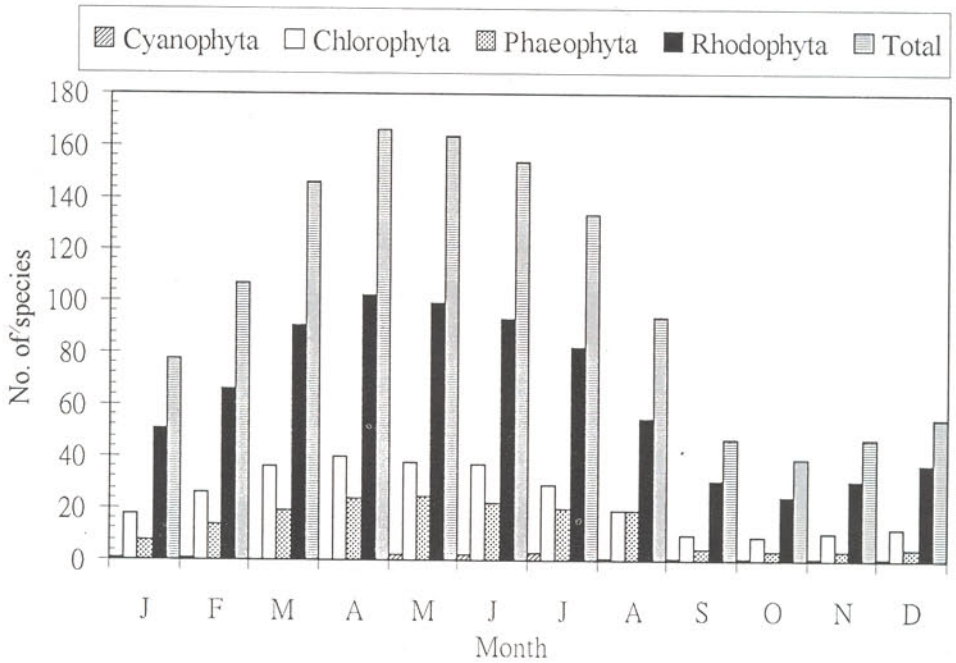

Fig. 6. The variation of occurrence of species in different months.

Table 5. Matrix analysis showing the similarity among different month based on occurrence of algal flora.

J	F	M	A	M	J	J	A	S	O	N	D	Month
	71.3	50.3	43.5	39.9	36.5	38.6	39.8	34.4	44.4	60.2	68.4	J
◎		70.9	59.6	55.7	53.5	50.6	46.7	31.6	33.9	43.9	50.0	F
◇	◎		82.5	76.1	72.4	53.0	50.0	25.3	26.7	31.3	34.9	M
◇	○	◎		86.4	82.9	67.6	52.0	23.1	19.9	26.0	29.2	A
△	○	◎	◎		89.3	75.3	53.6	24.1	20.1	28.7	29.6	M
△	◇	◎	◎	◎		82.3	57.0	25.6	19.9	21.8	24.4	J
△	◇	◇	○	◎	◎		79.5	30.2	24.5	25.7	26.9	J
△	◇	◇	◇	◇	○	◎		42.4	33.0	30.5	29.6	A
△	△	△	▽	▽	△	△	◇		59.3	49.2	43.6	S
◇	△	△	▽	▽	▽	▽	△	○		72.0	62.1	O
○	◇	△	△	△	▽	△	△	◇	◎		85.4	N
○	◇	△	△	△	▽	△	△	◇	○	◎		D

▽: 10-24.9%, △: 25-39.9%, ◇: 40-54.9%, ○: 55-69.9%, ◎: 70-85%

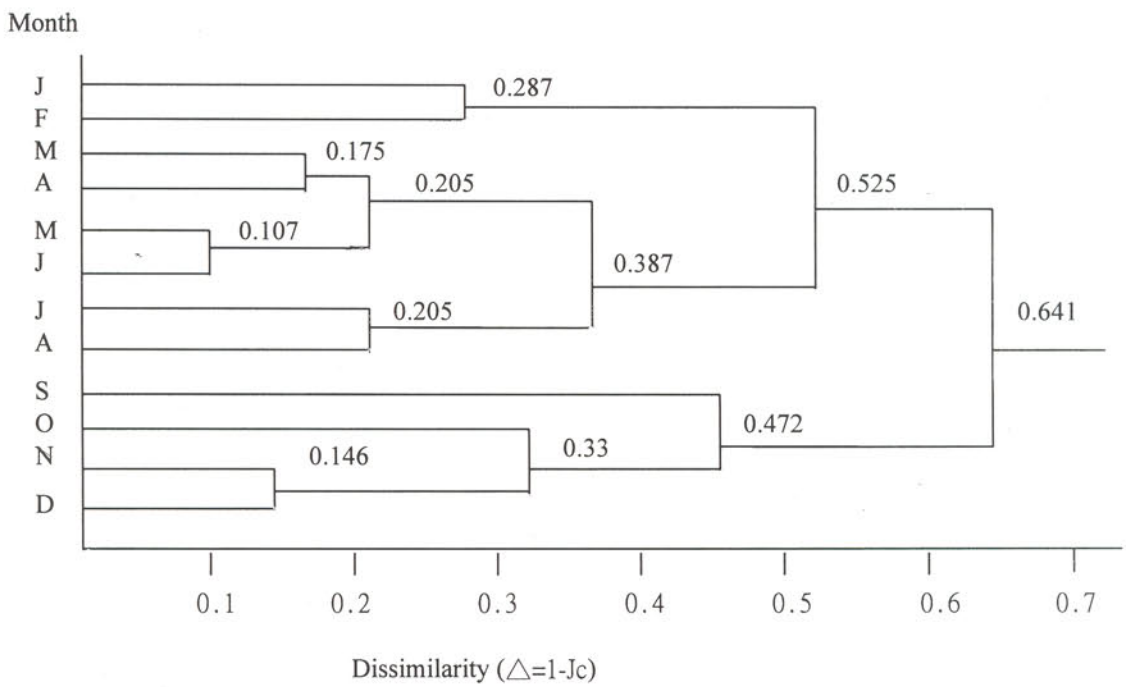

Fig. 7. UPGMA-analysis showing the dissimilarity of algal flora among the different month.

Phytogeographic study

Comparing the algl composition with the other areas of Taiwan, it was found that 53 species of algae in this study were appeared also in southern Taiwan (Chiang, 1962b, 1973a; Chiang and Wang, 1987; Huang, 1990; Huang, 1998), but not in northern Taiwan (Okamura, 1936; Chiang, 1960, 1962a, 1973a; Chen, 1977). As shown in table 6, they are *Symploca hydnoides*, *Brachytrichia quoyi*, *Anadyomene wrightii*, *Microdictyon nigrescens*, *Chaetomorpha antennina*, *Cladophoropsis herpestica*, *Struvea anastomosans*, *Ventricaria ventricosa*, *Valonia aegagropila*, *Valoniopsis pachynema*, *Caulerpa brachypus* f. *parvifolia*, *Caulerpa serrulata* f. *lata*, *Codium* spp., *Chlorodesmis caespitosa*, *Acetabularia parvula*, *Dictyopteris repens*, *Dictyota cervicornis*, *Lobophora variegata*, *Zonaria stipitata*, *Galaxaura marginata*, *Tricleocarpa fragilis*, *Liagora ceranoides*, *Liagora orientalis*, *Trichogloea requienii*, *Asparagopsis taxiformis*, *Gelidiella acerosa*, *Rhodopeltis borealis*, *Dudresnaya japonica*, *Carpopeltis maillardii*, *Peyssonnelia conchicola*, *Cheilosporum acutilobum*, *Mesophyllum* sp., *Gracilaria arcuata*, *Gracilaria coronopifolia*, *Hypnea cervicornis*, *Hypnea charoides*, *Hypnea pannos*, *Champia parvula*, *Ceratodictyon spongiosum*, *Crouania minutissima*, *Dasyphila plumarioides*, *Spyridia filamentosa*, *Wrangelia argus*, *Martensia fragilis*, *Vanvoorstia coccinea*, *Acanthophora spicifera*, *Acrocystis nana*, *Melanamansia glomerata*, *Bostrychia tenella*, *Laurencia intermedia*, *Laurencia papillosa*, *Laurencia undulata* and *Neurymenia fraxinifolia*. Most of them are tropical species, appearing in tropical West Pacific Ocean, such as the Ryukyu Islands, the Philippines, Indonesia, Malaysia, Hawaii Islands, Solomon Islands and Australia (Thoi, 1969; Saito, 1969; Womersley & Bailey, 1970; Cordero, 1977a,b; Mshigeni, 1978a,b; Magruder & Hunt, 1979; Tseng, 1983; Hodgkiss & Lee, 1983; Silva *et al.*, 1987; Nguyen and Huynh. 1993; Silva *et al.*, 1996; Callumpong, *et al.*, 1997; Trono, 1997, 1998).

The reason for such a difference in distribution is possibly related to the Kuroshio Current. The Kuroshio Current originates from the Northern Equatorial Current and flows northward along the eastern coast of Taiwan (Chu, 1971; Chern and Wang, 1990). At the northeast offshore of Taiwan, it encounters the sharply curved continental slope of the East China Sea (ECS). The main stream of the Kuroshio turns northeast along the edge of the ECS (Guan, 1983; Hsueh *et. al.*, 1993). Lin and Shyu. (1990) analyzed the sea-surface temperature data (SST data) from the NOAA-HRPT satellite (National Oceanic and Atmospheric Administration High Resolution Picture Transmission satellite remote sensing system), and found that eddy structures prevail throughout the year bringing in warmer eater to the region. Liu *et al* (1992), Tang and Tang (1994) found that there is a warm upwelling along the edge of northeast of Taiwan, bringing the high salinity seawater from Kuroshio to the continental shelf. Chern and Wang (1994) pointed out that the Kuroshio surface water intruded onto the continental shelf in the spring and there was a thick mixed layer and weak vertical stratification in the Kuroshio at that time. The Kuroshio Current is high in temperature and salinity (Li, 1991). Under its influence, the northeast coast of Taiwan thus enjoyed abundant coral reef and many other tropical creatures. That was why the algal flora in this region shows stronger affinities with that of the Philippines than Mainland China. The representatives of them are *Symploca hydnoides*, *Zonaria stipitata*, *Claudea mutifida*, *Martensia flabelliformis* and *Neurymenia fraxinifolia*. As shown in Fig. 8, they are mostly distributed from tropical West Pacific Ocean in a triangle shape with the northern Kuroshio Current as the top of the triangle.

Table 6. Comparison of marine algal flora from the northeastern Taiwan with neighboring regions. N: Northern Taiwan; H: Hsiao-Liu-Chiu island; S: Southern Taiwan; O: Orchid island; Kor: Korea; Jap: Japan; Ryu: Ryukyu Islands; Chi: Mainland China (including Hong Kong, Hainan, Xisha Islands, Dongsha Islands); Phi: Philippines; SPI: South Pacific Islands (including Hawaii, Solomon Islands, Marshall Islands, Fiji etc.); Vie: Vietnem; Ind: Indonesia; Mal: Malaysia; Aus: Australia.

Scientific name	Taiwan				Kor	Jap	Ryu	Chi	Phi	SPI	Vie	Ind	Mal	Aus
	N	H	S	O										
CYANOPHYTA														
Oscillatoriaceae														
Lyngbya majuscula	+	+	+	+		+	+	+	+	+	+	+	+	
Phormidiaceae														
Symploca hydnoides		+	+						+	+	+	+		
Mastigocladaceae														
Brachytrichia quoyi			+	+				+					+	
CHLOROPHYTA														
Ulotrichaceae														
Ulothrix flacca	+				+	+	+	+			+			
Monostromataceae														
Monostroma nitidum	+	+	+		+	+	+	+	+		+			
Ulvaceae														
Enteromorpha clathrata	+			+	+	+		+	+		+		+	+
E. compressa	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. intestinalis	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. linza	+	+	+	+	+	+	+	+						
E. prolifera	+				+	+	+	+	+	+		+	+	+
Ulva conglobata	+	+	+	+	+	+	+	+	+				+	+
U. fasciata	+	+	+	+		+	+	+	+	+	+	+	+	
U. lactuca	+	+	+	+	+	+	+	+	+	+	+	+	+	+
U. pertusa	+				+	+		+	+			+	+	
Anadyomenaceae														
Anadyomene wrightii		+	+			+	+	+	+	+	+	+	+	
Microdictyon nigrescens		+	+				+		+					
Mi. okamurae							+	+	+	+	+			
Valoniopsis pachynema		+	+	+		+	+	+	+	+	+	+	+	
Cladophoraceae														
Chaetomorpha antennina		+	+			+	+	+	+	+	+	+	+	
C. crassa	+	+	+	+	+	+	+	+	+	+	+	+	+	
C. linum	+	+	+	+	+		+	+	+	+	+	+	+	+
C. spiralis	+	+	+			+		+	+	+			+	
Cladophora catenata	+					+	+	+	+	+	+			
C. fascicularis						+	+	+	+	+	+	+	+	+
Siphonocladaceae														
Boergesenia forbesii	+	+	+			+	+	+	+	+	+	+	+	+
Cladophoropsis herpestica		+	+		+	+	+	+	+	+	+	+	+	+
Boodleaceae														
Boodlea composita	+	+	+	+		+	+	+	+	+	+	+	+	
Struvea enomotoi		+	+			+	+	+	+	+	+	+	+	+
Valoniaceae														
Dictyosphaeria cavernosa	+	+	+		+	+	+	+	+	+	+	+	+	+
Valonia aegagropila		+	+	+			+	+	+	+	+	+	+	
Ventricaria ventricosa		+	+			+	+	+	+	+	+	+	+	+

Table 6. Continued.

Scientific name	Taiwan				Kor	Jap	Ryu	Chi	Phi	SPI	Vie	Ind	Mal	Aus
	N	H	S	O										
Bryopsidaceae														
Bryopsis plumosa	+		+		+	+	+	+	+	+	+	+	+	+
Caulerpaceae														
Caulerpa parvifolia		+	+			+	+		+			+	+	+
C. peltata	+	+	+	+		+	+	+	+	+	+	+	+	
C. racemosa v. *laete-virens*	+	+	+	+		+	+	+	+	+	+	+	+	+
C. racemosa v. *clavifera* f. *macrophysa*		+	+	+		+	+	+	+	+	+	+	+	
C. serrulata v. *serrulata* f. *lata*		+	+				+	+	+	+	+	+	+	
Udoteaceae														
Chlorodesmis caespitosa		+	+	+		+	+	+	+	+		+	+	+
Codiaceae														
Codium arabicum	+		+		+	+	+	+	+	+	+	+	+	+
C. contractum		+	+		+	+	+		+					
C. geppiorum				+				+	+	+	+	+	+	
C. intricatum	+	+	+			+	+	+	+					
C. mamillosum					+	+	+		+					+
Polyphysaceae														
Acetabularia parvula		+	+			+	+	+	+	+	+	+	+	
PHAEOPHYTA														
Ectocarpaceae														
Hincksia breviarticulatus	+			+			+	+	+	+	+			
H. mitchellae	+	+		+	+	+	+	+	+	+	+	+	+	+
Dictyotaceae														
Dictyopteris divaricata	+			+	+	+		+	+					
D. repens		+	+			+	+	+	+	+				
D. undulata	+				+	+	+	+	+					
Dictyota bartayresii	+						+		+	+	+	+	+	
D. dichotoma	+				+	+	+	+	+	+	+	+	+	
D. divaricata	+			+	+	+	+	+	+	+			+	
D. friabili							+	+	+	+	+		+	
D. lineais					+	+	+	+	+					
Dilophus okamurae	+				+	+	+	+	+					
Lobophora variegata		+	+			+	+	+	+	+	+	+	+	+
Pachydictyon coriaceum	+				+	+	+	+						
Padina arborescens	+				+	+		+	+					
P. australis	+	+	+	+	+	+	+	+	+	+	+	+	+	+
P. crassa	+				+	+	+	+	+					
P. minor	+	+	+	+	+	+	+	+	+	+	+			
Spatoglossum pacificum	+				+	+		+						
Zonaria diesingiana	+				+	+	+	+	+					+
Z. stipitata			+				+		+	+	+			
Ishigeaceae														
Ishige okamurae	+				+	+		+						
Chnoosporaceae														
Chnoospora implexa	+	+	+				+	+	+	+	+	+	+	
Scytosiphonaceae														
Colpomenia sinuosa	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 6. Continued.

Scientific name	Taiwan				Kor	Jap	Ryu	Chi	Phi	SPI	Vie	Ind	Mal	Aus
	N	H	S	O										
Hydroclathrus clathratus	+	+	+	+	+	+	+	+	+		+	+	+	+
Petalonia binghamiae	+				+	+	+	+		+				+
Sargassaceae														
Sargassum cristaefolium	+	+	+	+		+	+	+	+	+	+	+	+	+
Sargassum hemiphyllum	+				+	+		+	+					
RHODOPHYTA														
Bangiaceae														
Bangia atropurpurea	+				+	+		+	+		+			+
Porphyra crispata	+				+	+	+	+	+	+	+			
P. dentata	+				+	+		+						
P. suborbiculata	+				+	+	+	+	+					
Dermonemataceae														
Dermonema frappieri	+		+	+		+	+	+	+	+	+	+	+	
Galaxauraceae														
Galaxaura marginata		+	+	+		+	+	+	+	+	+	+	+	+
Scinaia moniliformis	+	+	+	+		+	+	+	+					+
S. latifrons					+	+	+	+	+					
Tricleocarpa fragilis		+	+	+		+	+	+	+	+	+	+	+	+
Liagoraceae														
Helminthocladia australis			+		+	+	+	+	+					+
Liagora ceranoides		+	+			+	+	+	+		+	+	+	+
L. orientalis		+	+				+		+		+	+		
Nemaliaceae														
Trichogloea requienii		+	+			+	+	+	+	+			+	+
Bonnemaisoniaceae														
Asparagopsis taxiformis		+	+	+	+	+	+	+	+	+	+	+	+	+
Delisea japonica	+				+	+								+
Gelidiaceae														
Gelidiella acerosa		+	+	+		+	+	+	+	+	+	+		
Gelidium amansii	+				+	+	+	+	+			+	+	
G. divaricatum	+				+	+	+	+	+		+			
G. japonicum	+				+	+	+	+						
G. pusillum	+				+	+	+	+	+	+	+	+	+	+
Pterocladiella capillacea	+				+	+	+	+	+	+	+	+		+
Caulacanthaceae														
Caulacanthus ustulatus					+	+	+	+		+		+		+
Dumontiaceae														
Dudresnaya japonica			+		+	+								
Rhodopeltis borealis		+	+	+			+	+	+					+
Endocladiaceae														
Gloiopeltis furcata	+				+	+	+	+						
G. tenax	+				+	+		+						
Gigartinaceae														
Chondracanthus intermedius	+	+	+	+	+	+		+			+			
Chondrus ocellatus	+				+	+		+						
C. verrucosa	+					+								
Halymeniaceae														
Carpopeltis formosana	+	+	+	+			+		+	+	+			
C. maillardii		+	+	+		+	+		+	+			+	
Grateloupia filicina	+		+		+	+		+	+	+	+		+	+
G. livida					+	+		+						
G. okamurae	+				+	+		+						
G. sparsa					+	+		+						

Table 6. Continued.

Scientific name	Taiwan				Kor	Jap	Ryu	Chi	Phi	SPI	Vie	Ind	Mal	Aus
	N	H	S	O										
Halymenia dilatata						+	+	+	+	+	+			
H. floresia	+	+	+	+		+	+		+	+			+	+
Polyopes polyideoides	+					+		+						
Prionitis ramosissima	+					+	+	+	+		+			
Hypneaceae														
Hypnea boergesenii	+							+	+	+	+			+
H. charoides		+	+		+	+	+	+	+	+	+	+	+	+
H. chordacea	+					+		+		+		+		
H. japonica	+				+	+	+	+	+	+	+	+		+
H. pannos		+	+	+		+	+	+	+	+	+	+	+	+
H. saidana			+		+	+		+	+					+
H. spinella		+	+			+	+	+	+	+	+	+		+
Peyssonneliaceae														
Peyssonnelia conchicola		+	+	+	+	+	+	+	+	+	+	+		+
P. distenta	+	+	+	+			+	+	+					
Phyllophoraceae														
Ahnfeltiopsis flabelliformis	+	+	+	+	+	+		+	+	+	+			
Plocamiaceae														
Plocamium telfairiae	+		+		+	+	+	+	+					+
Rhizophyllidaceae														
Portieria hornemannii	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sarcodiaceae														
Sarcodia montagneana	+	+	+	+	+	+	+	+	+			+	+	+
Schizymeniaceae														
Schizymenia dubyi					+	+		+						+
Titanophora weberae						+	+	+	+	+	+	+	+	
Sebdeniaceae														
Sebdenia flabellata					+	+		+						+
Solieriaceae														
Eucheuma denticulatum	+		+			+	+	+	+			+	+	+
E. serra	+	+	+	+		+	+	+	+			+	+	
Meristotheca coacta						+								
Meristotheca papulosa	+	+	+		+	+	+	+	+			+	+	+
Corallinaceae														
Amphiroa dilatata	+	+			+	+		+			+			+
A. ephedraea		+	+	+	+	+		+	+				+	+
A. foliacea	+	+		+			+	+	+	+	+	+	+	
A. fragilissima		+	+				+	+	+		+		+	+
Cheilosporum acutilobum	+						+	+	+	+		+	+	
Corallina pilulifera	+	+	+	+	+	+		+						
Jania adhaerens	+			+		+	+	+	+		+	+	+	+
J. ungulata					+	+		+	+		+			
Marginisporum aberrans					+	+		+						
M. crassissimum	+	+	+	+	+	+		+						
Mastophora rosea		+	+			+	+	+	+	+	+	+	+	
Mesophyllum simulans					+	+	+	+	+	+		+	+	
Serraticardia maxima						+								
Gracilariaceae		+												
Gracilaria arcuata		+	+		+	+	+	+	+		+	+		
G. coronopifolia			+				+	+	+	+	+			
G. gigas					+	+		+	+				+	
G. textorii	+				+	+		+	+			+	+	+
G. veillardii							+	+	+			+	+	

Table 6. Continued.

Scientific name	Taiwan				Kor	Jap	Ryu	Chi	Phi	SPI	Vie	Ind	Mal	Aus
	N	H	S	O										
Champiacaeae														
Champia parvula		+	+	+	+	+	+	+	+	+	+	+	+	+
Rhodymeniaceae														
Ceratodictyon spongiosum		+	+	+		+	+	+	+	+	+	+	+	+
Gelidiopsis repens	+	+	+	+		+	+	+	+	+	+	+	+	+
Halichrysis micans						+					+	+		
Ceramiaceae														
Centroceras clavulatum	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ceramium flaccidum	+				+	+	+	+	+	+		+		+
Crouania minutissima		+					+		+	+				
Dasyphila plumarioides		+		+			+		+	+				
Spyridia filamentosa		+			+	+	+	+	+	+	+	+	+	+
Wrangelia argus		+			+	+	+	+	+	+	+	+		+
Delesseriaceae														
Claudea mutifida									+				+	
Martensia fragilis		+	+		+	+	+			+		+	+	+
Neomartensia flabelliformis	+						+		+	+			+	
Vanvoorstia coccinea		+	+			+	+	+	+				+	
Rhodomelaceae														
Acanthophora spicifera		+	+	+		+	+	+	+	+	+	+	+	+
Acrocystis nana		+	+	+		+	+	+	+	+	+	+	+	
Bostrychia tenella		+	+	+		+	+	+	+	+	+	+	+	+
Chondria armata	+	+	+	+		+	+	+	+	+		+	+	
Laurencia brongniartii	+		+	+	+	+	+		+			+		+
L. intermedia		+	+		+	+		+	+					
L. nipponica	+				+	+			+				+	
L. okanyrae	+	+			+	+		+	+	+	+		+	
L. papillosa		+	+		+	+	+	+	+	+	+	+	+	+
L. undulata		+	+		+	+		+	+	+				
Leveillea jungermannioides	+	+	+		+	+	+	+	+	+	+	+	+	+
Melanamansia glomerata		+	+	+			+	+	+	+	+	+	+	+
Neurymenia fraxinifolia		+	+	+			+		+	+	+	+	+	+

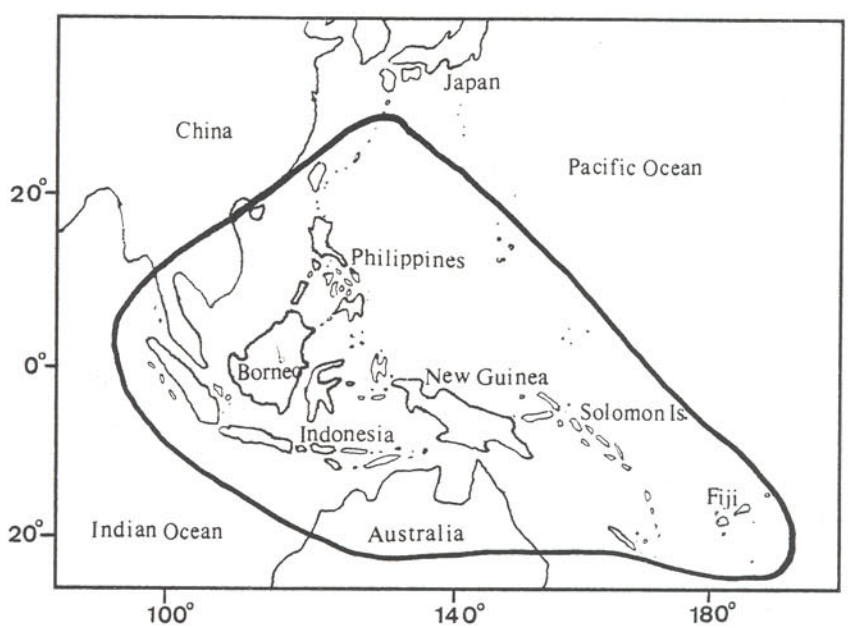

Fig. 8. Distribution of *Valonia aegagropila, Neurymenia fraxinifolia* and *Peyssonneia rubra*.

On the contrary, there are still a few temperate species of algae found in the northeastern Taiwan. They are *Spatoglossum pacificum*, *Pachydictyon coriaceum*, *Ishige okamurae*, *Petalonia binghamiae*, *Bangia atropurpurea, Porphyra dentata, Gelidium japonicum, Pterocladiella capillacea*, *Gloiopeltis furcata, Gloiopeltis tenax*, *Chondrus ocellatus*, *Polyopes polyideoides*, *Grateloupia livida, Grateloupia okamurae, Grateloupia sparsa* and *Corallina pilulifera*. These species are well distributed in Korea, Japan and Mainland China, but not in the Philippines and other tropical areas (Table 6). Based on the Chu's schematic pattern of ocean currents near Taiwan, the China Coastal Current with low temperature and low salinity flows off the east coast of mainland China into Taiwan Strait (Chu, 1971). In winter season, a small branch of cold China Coastal current accompanying with strong northeastern wind passes through the northeastern Taiwan. It seems that the cold China Coastal Current may play an important role in the distribution of those species from Korea and Japan into the northeastern Taiwan. As shown in Fig. 9, the temperate species are mainly distributed along the coast of Korea, Japan and Mainland China in a reversal-triangle shape.

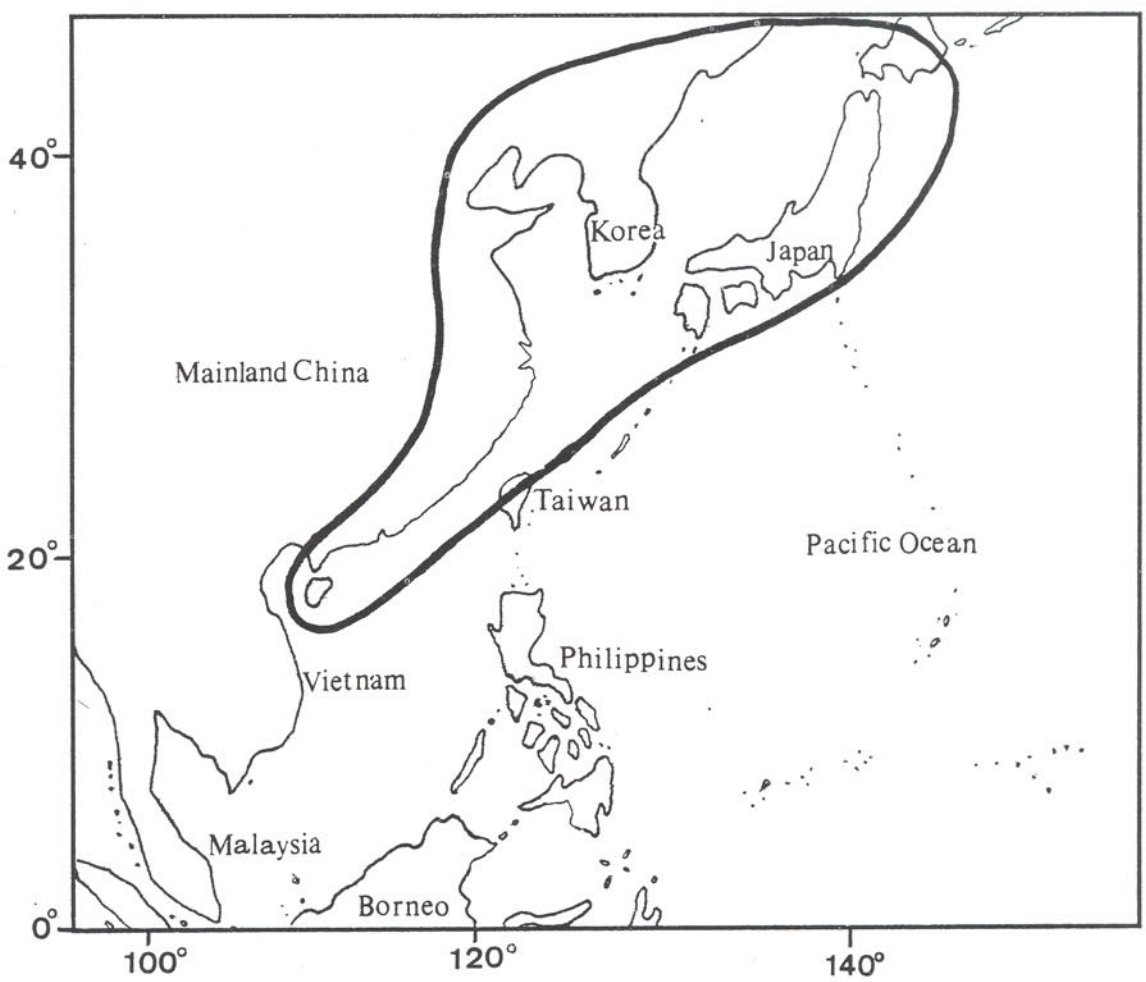

Fig. 9. Distribution of *Spatoglossum pacificum, Ishige okamurae, Porphyra dentata* and *Grateloupia livida*.

CONCLUSIONS

A total of 179 species of benthic marine algae were identified in this study. Among them, 9 species of them are new records in Taiwan. There are 52 species of algae appeared in all sampling stations, which are representative of the major algal community of northeastern Taiwan. These species are mostly tropical in nature. The difference in topographic feature affects the comoposition and distribution of seaweeds. In general, more complicated topography has higher diversity of species. Most of species in northeastern Taiwan are seasonal, they are more abundant in winter and spring than in summer. Bsed on the present study, it seems that the interrelations of the Kuroshio Current, China Coastal Current and the northeast monsoon maybe the main foctors causing such a high degree of biodiversity of algal flora in this area.

ACKNOWLEDGEMENTS

This study was financially supported by the Taiwan Museum. I wish to extend my deep gratitude to the following people for their helps during the present survey: Dr. William T. Lin for kindly reading the manuscript; Dr. Lawrence M. Liao, University of San-Carolina, Philippine, for kindly checking the list of species; Dr. Jane E. Lewis, for her encourage and supplying of references; Mr. K.-C. Hsia and Mr. J.-S. Chang, for their constant asistance in the field work.

LITERATURE CITED

Annon, E. 1988. Fisheries Yearbook Taiwan Area. Taiwan Fisheries Bureau, Dept. of Agriculture and Forestry, Provincial Government of Taiwan, 236pp.

Callumpong P. H. and F. G. Menez. 1997. Field Guide to the common mangroves, seagrasses and algae of the Philippines. Bookmark, Philippines. 197pp.

Chen, C. and Y.-M. Chiang. 1981a. On the Helminthocladiaceae of Taiwan. Chinese Biosci. **18**: 53-56. (In Chinese).

Chen, C. and Y.-M. Chiang. 1981b. Morphological studies on the family Helminthocladiaceae (Nemaliales, Rhodophycophyta) of Taiwan. I. *Helminthocladia.* Biol. Bull. Natl. Taiwan Normal Univ. **16**: 27-32. (In Chinese).

Chen, C. and Y.-M. Chiang, 1982. Morphological studies on the family Helminthocladiaceae (Nemaliales, Rhodophycophyta) of Taiwan. II. *Dermonema*. Biol. Bull. Natl. Taiwan Normal Univ. **17**: 95-101. (In Chinese).

Chen C.-S. 1977. An ecological and floristic study of marine algal community along the coastal area of Ho-Pin-Tao. Bull. Tai. Fish. Res. Inst. **28**: 113-121.

Chen, H.-K. 1991. The taxonomic studies of *Laurencia* Lamouroux (Rhodophyta, Ceramiales) of Taiwan. M. S. thesis, Institute of Oceanography, National Taiwan University. (In Chinese).

Chern, C.-S. and J. Wang. 1989. On the water masses at northern offshore area of Taiwan. Acta Oceanogr. Taiwanica **22**: 14-32.

Chern, C.-S. and J. Wang. 1990. On the Kuroshio branch current north of Taiwan. Acta Oceanogr. Taiwanica **25**: 5-64.

Chern, C.-S., J. Wang and D.-P Wang. 1990. The exchange of Kuroshio and East China Sea shelf water. J. Geophys. Res. **95:** 16017-16023.

Chern, C.-S. and J. Wang. 1994. Influence of the seasonal thermocline on the intrusion of Kuroshio across the continental shelf northeast of Taiwan. Jour. Oceanography **50**: 691-711.

Chiang, Y.-M. 1960. Marine algae of northern Taiwan (Cyanophyta, Chlorophyta, Phaeophyta). Taiwania **7**: 51-75.

Chiang, Y.-M. 1962a. Marine algae of northern Taiwan (Rhodophyta). Taiwania **8**: 167-180.

Chiang, Y.-M. 1962b. Marine algae collected from Penghu (Pescadores). Taiwania **8**: 167-180.

Chiang, Y.-M. 1972. Key to the genera of marine algae of Taiwan. Taiwania **17**: 8-13.

Chiang, Y.-M. 1973a. Studies on the marine flora of southern Taiwan. Bull. Jap. Soc. Phycol. 21: 97-102.

Chiang, Y.-M. 1973b. Notes on marine algae of Taiwan. Taiwania **18**: 13-17.

Chiang, Y.-M. 1992a. Mass culture of a carrageenophyte, *Halymenia microcarpa* (Halymeniaceae, Rhodophyta). Fourteenth International Seaweeds Symposium. P.68.

Chiang, Y.-M. 1992b. A review of phycological work on the algae of Taiwan. Inst. Bot., Academia Sinica Monogr. Ser., **11**: 101-118.

Chiang, Y.-M. 1993. The developmental sequence of the marine red alga *Grateloupia filicina* in culture. Kor. J. Phycol. **8**: 231-237.

Chiang, Y.-M. and C. Chen. 1982. The genus *Liagora* of Taiwan. Acta Oceanogr. Taiwanica **13**: 181-196.

Chiang, Y.-M. and C. Chen. 1983. Studies on *Dotyophycus yamadae* (Ohmi et Itono) Abbott et Yoshizaki (Nemaliales, Rhodophycophyta) from southern Taiwan. Jap. J. Phycol. **31**: 132-149.

Chiang, Y.-M. and H.-N. Chou. 1980. The occurrence of *Zonaria stipitata* on the southern coasts of Taiwan. Jap. J. Phycol. **28**: 165-167.

Chiang, Y.-M. and W.-L. Wang. 1987. Distribution of seaweeds of the Hengchum Peninsula. Taiwan. In: Chang, K.-H. (ed.). Marine Science. National Science Council Symposium series No. **10**: 71-87.

Chihara, M. 1983. The seaweeds of Japan. Gakken Co., Tokyo. 290pp. (In Japanese).

Chou, H.-N. and Y.-M. Chiang. 1981. The *Sargassum* of Taiwan. Acta Oceanogr. Taiwania. **12**: 132-149.

Chu, T.-Y. 1963. The oceanography of the surrounding waters of Taiwan. Inst. Fish. Biol. Nat. Taiwan Univ. Rep. **1**: 29-44. (In Chinese).

Chu, T.-Y. 1971. Environmental study of the surrounding waters of Taiwan. Acta Oceanography Taiwanica Science Report, National Taiwan University **1**: 15-32.

Cordero, P. A. 1977a. The marine algae of Batan Island, northern Philippines. II. Chlorophyceae. Fish. Res. Jour., Philippines. **2**: 12-55.

Cordero, P. A. 1977b. Studies on Philippines Marine Red algae. Seto Marine Biological Lab. Special Publi. Ser. IV. No.632. 258pp.

Cribb, A. B. 1983. Marine algae of the southern Great Barrier Reef: Rhodophyta. Australian Coral Reef Soc. Watson Ferguson and Co., Brisbane.175pp.

Critchley A. T. and M. Ohno. 1998. Seaweed resources of the world. Japan International Cooperation Agency, Japan. 431 pp.

Dawson, E. Y. 1954. Marine plants in the vicinity of the Institut Oceanographique de Nha Trang, Viet Nam. Pac. Sci. **8**: 373-481.

Dawson, E. Y. 1956. Some marine algae of the southern Marshall Islands.Pac. Sci. **10**: 140-153.

Fan, K.-C. 1951. The Genera *Gelidium* and *Pterocladia* of Taiwan. Taiwan Fisheries Research Institute, Laboratory of Biology Report, **2**: 1-22.

Grumbine, R. Edward (ed.). 1994. Environmental Policy and Biodiversity. Island Press, Washingtion, D. C.

Guan, B. 1983. A sketch of the current structures and eddy characteristics in the East China Sea. In: Acta Oceanologia sinica, Beijing, China, ed. Proceedings of International Symposium on Sedimentation on the continental Shelf, with Special Reference to the East China Sea. China Ocean Press, Beijing. pp 52-73.

Heydrich, F. 1894. Bietrage zur kenntniss der algenflora von Ost-Asien besonders der Insel Formosa, Mollukken und Liukiu-Insen. Hedwigia, **33**: 267-306.

Hodgkiss, I. J. and K.-Y. Lee, 1983. Hong Kong Seaweeds. Urban Council. Hong Kong. pp.i-xi, 1-122.

Hsueh, Y., C.-S. Chern and J. Wang. 1993. Blocking of the Kuroshio by the continental shelf northeast of Taiwan. J. Geophys. Res. **98**: 12351-12359.

Hruby, T. 1975. Seasonal changes in two algae populations from the coastal waters of Washington State. J. Ecol., **63**: 881-889.

Huang, S.-F. 1990. The marine algal flora of Hsiao-Liuchiu Island. Bot. Bull. Acad. Sinica **32**: 245-255.

Huang, S.-F. 1991. Additions to the marine algal flora of Taiwan. Jap. J. Phycol. **39**: 263-269.

Huang, S.-F. 1997. The resource of seaweeds and their use in Taiwan. Journal of Taiwan Natural Science **15**: 76-87. (In Chinese).

Huang, S.-F. 1998, Guide book of Seaweeds of Southern Taiwan. Ping-tung County Museum of Natural History. (In Chinese).

Huynh, Q. N. and H. D. Nguyen. 1998. The seaweed resources of Vietnam. Pp. 62-69. In: Crutcgket, A. T. and M. Ohno (ed.). 1998. Seaweed resources of the world. Japan International Cooperation Agency. Yokosuka, Japan.

Itono, H. 1973. Notes on marine algae from Hateruma Island. Ryukyu. Bot. Mag. Tokyo **86**: 155-168.

Itono, H. 1977. Studies on the Ceramiaceous Algae (Rhodophyta) from Southern Parts of Japan. Bibliotheca Phycologia. No. 35. Vaduz. Germany.

Kang, J.-W. 1966. On the geographical distribution of marine algae in Korea. Bull. Pusan Fish. Coll. **7**: 1-136.

Lewis, J. and J.-N. Norris. 1987. A History and annotated account of the benthic marine algae of Taiwan. Smith. Contr. Mar. Sci., **29**: 1-38.

Li, H. W. 1991. Geostrophic current and associated vertical motion off northeastern Taiwan. In: K. Takano (ed.) Oceanography of Asian Marginal Seas. Amsterdam, Elsevier. Pp. 335-344.

Liu, K.-K., G.-C. Gong, C.-Z. Shyu, S.-C. Pai, C.-L. Wei and S.-Y. Chao. 1992. Response of Kuroshio upwelling to the onset of northeast monsoon in the sea north of Taiwan:

observations and a numerical simulation. J. Geophys. Res. **97**: 12511-12526.
Magruder W. H. and J. W. Hunt. 1979. Seaweeds of Hawaii: a photographic identification guide. The Oriental Publishing company, Honolulu, Hawaii.
Mshigeni, K. E. 1978a. Taxonomic studies on the Hawaiian Hypneaceae with special reference to the genus *Hypnea* Lamouroux (Rhodophyta). Nova Hedwigia, **29**: 859-894.
Mshigeni, K. E. 1978b. The biology and ecology of benthic algae with special reference to *Hypnea* (Rhodophyta, Gigartinales). A review of the literature. J. Cramer. Vaduz. Pp.1-168.
Nguyen, H. D. and Q. N. Huynh. 1993. Marine algae of North Vietnam. Nha xurat ban KH-KT, HaNoi, 364pp. (In Vietnamese).
Norton, T. A., M. Melkonian and R. A.nderson. 1996. Algal biodiversity. Phycologia **35**: 308-326.
N'yeurt, A. D. R. and G. R. South. 1997. Biodiversity and biogeography of benthic marine algae in the Southwest Pacific, with specific reference to Rotuma and Fiji. Pacific Science.
Okamura, K. 1931. On the marine algae from Kotosho (Botel Tobago). Bull. Biogeogr. Soc. Jap. **2**: 95-110.
Okamura, K. 1936. Nippon Kaiso-shi. [Marine Algae of Japan.] Uchi-da-ro-kaku-ho, Tokyo. 964 pp.
Oshima, M. 1915. Taiwan san Tengusa. [*Gelidium* in Taiwan.] Transactions of the Natural History Society of Taiwan, **5**: 55.
Peck, Shelia. 1998. Planning for Biodiversity: Issues and Examples. Island Press. Washington, D.C.
Phang, S. M. 1998. The seaweed resources of Malaysia. In: Crutcgket, A. T. and M. Ohno (ed.). 1998. Seaweed resources of the world. Japan International Cooperation Agency. Yokosuka, Japan.
Rho, J. H. 1958. A preliminary survey of the marine algae of Korea. Collectio Theseon, Scienta Naturalis, Universitas Sung Kyun Kwan, **3**: 41-143.
Saito, Y. 1969. The algal genus *Laurencia* from the Hawaiian Islands, the Philippine Islands and adjacent areas. Pac. Sci. **23**: 149-160.
Saito, Y., K. Taniguchi, S. Atobe, and S. Naganawa. 1971. Phytosociological study of the intertidal marine algae. II. The algae communities on the vertical substratum faces on several directions. Japanese J. of Ecology. **20**: 230-232.
Segawa, S. 1974. Coloured Illustrations of the Seaweeds of Japan. Hoikusha Tokyo. Publ. Co. 175pp..
Shen, Y.-F. and K.-C. Fan. 1950. Marine algae of Formosa. Taiwania **1**: 317-345.
Silva, P. C., E. C. Menez, and R. L. Moe. 1987. Catalog of the benthic marine algae of the Philippines. Smithsonian Contribution Marine Science **27**: 1-179.
Silva, P. C., P. W. Basson, and R. L. Moe. 1996. Catalogue of the benthic marine algae of the Indian Ocean. University of California Press, Berkeley. 1259pp.
Sneath, P. H. A. and R.R. Sokal. 1973. Principles of numerical taxonomy. Freeman, San Francisco. Pp. 114-307.
Sohn, C. H. 1998. The seaweed resources of Korea. In: Critchley and Ohno, (ed.), 1998. Seaweed Resources of the World. Pp.15-33. Japan International Cooperation Agency.

Su, Z.-C., S.-C. Hong, Y.-M. Chiang, Z.-T. Chen, T.-S. Tang, K.-S. Chang, K.-Z. Shau. 1986. The marine ecological study in the Yen-liao arouond the northern nuclear plant. Acad. Sinica International Environment Committee. No. 42.

Su, Z.-C., S.-C. Hong, Y.-M. Chiang, Z.-T. Chen, T.-S. Tang, K.-S. Chang, K.-Z. Shau, P.-P. Huang, K.-T. Li, L.-C. Chen, Z..-C. Huang, K.-L. Fang, H.-U. Chen, U.-L. Li. 1991. Ecological studies in the Yen-liao arouond the northern nuclear plant. Acad. Sinica International Environment Committee. No. 83.

Sri. I., A. Zatnika and W. Sujatmiko. 1998. In: Crutcgket, A. T. and M. Ohno, (ed.). 1998. Seaweed resources of the world. Pp.92-105. Japan International Cooperation Agency. Yokosuka, Japan.

Tang, T.-Y. and W.-T. Tang. 1994. Current on the edge of the continental shelf northeast of Taiwan. Terrestrial Atmospheric Oceanic Sci.(TAOS), **5**: 335-348.

Thoi, L. V. 1969. Marine algae of Southern Vietnam. Trung-Tam. 558pp.

Trono, G. C. Jr., 1997. Field guide and atlas of the seaweed resources of the Philippines. Bookmark Inc., Philippines. 306pp.

Trono, G. C. Jr., 1998. The seaweed resources of the Philippines. In: Critchley and Ohno (ed.). 1998. Seaweed Resources of the World. Pp.47-61. Japan International Cooperation Agency.

Tseng, C.-K. 1936. Notes on the marine algae from Amoy. Mar. Biol. Bull. **1**: 1-86.

Tseng, C.-K. 1943. Marine algae of Hong Kong IV. The genus *Laurencia*. Paers, Mich. Acad. Sci., Arts, and letters **28**: 185-208, pls. I-IV.

Tseng, C.-K. 1962. Economic Seaweeds Flora of China. Science Press. Beijing. 198pp.

Tseng, C.-K. 1983. Common Seaweeds of China. Science Press. Beijing. 316pp.

Tsuda, R. T. 1991. Catalog of the marine benthic algae from the Ryukyu Islands. Japan. Galaxea **10**: 35-64.

Tsuda, R. T. and I. A. Abbott. 1985. Collection, Handling, Preservation and Logistics. In: Littler, M. M. and D. S. Littler (eds.). Handbook of Phycological Methods, Ecological Field Methods: Macroalgae. Cambridge Univ. Press. Pp. 67-86.

Wang, C.-C. and C.-S. Chen. 1980. Study on the community structure of intertidal macroflora on rockyshore at northeastern part of Taiwan. J. Fish. Soc. Taiwan. **7**: 1-12.

Wang, J.-C. and Y.-M. Chiang, 1977. Notes on marine algae of Taiwan. II. The genus *Porphyra*. Taiwania **22**: 105-112.

Wang, W.-L. H.-K. Chen and Y.-M. Chiang. 1993. Notes on marine algae new to Taiwan. Bot. Mar. **36**: 545-553.

Wang, W.-L. and Y.-M. Chiang. 1993. Marine algae of Lan Yu (Orchid Island), Taiwan. Acta Oceanographica Taiwania **31**: 83-100.

Wang, W.-L. and Y.-M. Chiang. 1994. Potential Economic Seaweeds of Hengchun Peninsula, Taiwan. Economic Botany **48**: 182-189.

Wei, T.-L. and W.-Y. Chin. 1983. Seaweeds of Singapore. Singapore University Press Pte Ltd, Kent Ridge, Singapore, 123pp.

Womersley, H. B. S. 1967. A critical survey of the marine algae of southern Australia. II. Phaeophyta. Aust. J. Bot. **15**: 189-270.

Womersley, H. B. S. 1984. The marine benthic flora of southern Australia. Part. 1. Government Printer. Adelaide.

Womersley, H. B. S. and A. Bailey. 1970. Marine algae of the Solomon Islands. Phil. Trans. Roy. Soc. Land. **B259**: 257-352.

Yamada. Y. 1950. A list of marine algae from Ryukyusho, Formosa. I: Chlorophyceae and Phaeophyceae. Sci. Pap. Inst. Algol. Res. Fac. Sci., Hokkaido Imp. Univ. **3**: 173-194.

Yang, H.-N. 1981. Taxonomical Study on the articulated coralline algae of Taiwan. M.S. thesis of Department of Botany. National Taiwan University. (In Chinese.)

Yang, H.-N. and Y.-M. Chiang. 1982. Taxonomical study on the *Gracilaria* of Taiwan. J. Fish. Soc. Taiwan. **9**: 55-71.

Yang, H.-N. , W.-L. Wang and L.-M. Liao. 1994. Marine algal flora of Pengchia Yu and its special place in the marine phytogeography of Taiwan. Botanica Marina **37**: 419-432.

Yoshida, T., Y. Nakajuma and N. Yoshikazu. 1990. Check-list of marine algae of Japan. Jpn. J. Phycol. **38**: 269-320.

Yoshida, T. 1998. Marine algae of Japan. Uchida Rokakuho Publ. Co., LTD, Tokyo, Japan. 1222pp.

臺灣東北角海藻群聚結構及植物地理之研究

黃淑芳[1, 2]

（收稿日期：1999 年 4 月 3 日；接受日期：1999 年 5 月 9 日）

摘　　要

本文旨在調查研究臺灣東北部海域底棲性海藻的種類、分佈及季節消長，並進行其群聚結構及植物地理親緣之探討。本研究共記錄有 50 科 、105 屬、179 種海藻，包括藍藻 3 種，綠藻 42 種，褐藻 27 種，紅藻 107 種。其中，有 9 種是臺灣的新記錄種。在六個採集站均出現的種類有 42 屬 50 種，是本區藻類相的主要群聚結構之代表。比較六個採集站之藻相，其 Jaccard's 相似值均在 40%以上。利用 UPGMA 方法可將各站分為二亞群，其中第 1 站(南雅)為獨立一群，第 2 站至第 6 站則為共同一群。在垂直分佈方面，生長在飛沫帶的藻類有 8 種，在潮間帶上、中部有 25 種，在潮間帶下部及低潮線附近有 85 種，在亞潮帶有 143 種。所有藻類之生長具有明顯的季節性變化，一般在冬、春藻相最豐富，夏、秋的種數最少。利用矩陣及群聚分析上，發現其消長演替發生在 12～1 月及 8～9 月之間。根據海藻的植物地理分佈分析，本區海藻相不僅具有濃厚熱帶色彩，也有不少溫帶性種類，這些海藻之分佈與黑潮暖流和大陸沿岸冷流之交會有密切之關係。

關鍵詞：臺灣、東北角、海藻相、群聚生態、植物地理、新記錄種。

1. 臺灣省立博物館植物組，台北 100，臺灣，中華民國。
2. 通信聯絡員。