

Benthic Marine Algae of Lan-Yu (Orchid Island), Taiwan

蘭嶼底棲性海藻之研究

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Abstract

The marine algae collected from Lan-Yu (Orchid Island) were identified and listed. A total of 159 species of seaweed, including 3 species of Cyanophyta, 59 of Chlorophyta, 22 of Heterokontophyta, and 75 of Rhodophyta are reported here. Among them, 50 species are firstly recorded in Lan-yu. Most of algae in Lan-Yu are of tropical or subtropical elements. The effects of current on the distribution of algae and the floristic affinity of this island are also discussed.

Key words: Marine algae, New record, Phytogeography, Lan-Yu, Orchid Island, Taiwan.

摘要

本文為 2005 年間在臺灣東南部海域之蘭嶼進行海藻的採集及調查研究。共有 159 種海藻被發現，包括藍藻 3 種，綠藻 59 種，褐藻 22 種，紅藻 75 種，其中有 50 種海藻為蘭嶼的首次記錄。在海藻組成上，蘭嶼具有印度-西太平洋特有之熱帶性海藻，有關洋流對本區海藻相之影響亦在本文中討論。

關鍵詞：海藻，新記錄種，植物地理，蘭嶼，臺灣。

Introduction

Lan-Yu (Orchid Island) is a volcanic island located about 64 km off southeastern Taiwan in the Pacific. It has a coastline of approximately 38.5 km and an area of about 45.7 km² (Fig. 1). It has an irregular rhomboid topography with a 548 m maximum elevation on the western side. Well-developed coral reefs line the southeastern and northwestern shores. The prevailing northeast wind blows strongly in winter and the warm Kuroshio Current passes northward through this area in summer (Chu, 1971).

The marine algal flora of Taiwan and its offshore islands have been studied by several workers (Yamada, 1925a, b, 1936, 1950; Okamura, 1931, 1936; Ishijima, 1941, 1942; Shen and Fan, 1950; Fan, 1951, 1974; Chiang, 1960, 1962a, b, 1972, 1973a, b; Taniguti, 1976; Chen, 1977, 1980; Wang and Chiang, 1977; Chiang and Chou, 1980; Wang and Chen, 1980; Chen and Chiang, 1981a, b; Chou and Chiang, 1981; Chiang and Chen, 1982, 1983; Yang and Chiang, 1982, 1995; Chiang and Wang, 1987; Chiang *et al.*, 1985, 1990; Lewis and Norris, 1987; Chen, 1991; Wang *et al.*, 1993; Wang and Chiang, 1993, 1994, 2001; Yang 1981, 1995; Yang *et al.*, 1994; Giu, 1994; Chang, 1995; Huang, 1990, 1991, 1997, 1998, 1999a, 1999b, 2000, 2002, 2003, 2005; Huang and Chang, 1999; Huang and Yang, 1999; Lewis, 2000; Chang *et al.*, 2002, 2003; Lin, 2002, 2004; Lin and Fredericq, 2003; Lin *et al.*, 2002, 2004.). However, only a few of these works have included the algae of Lan-Yu (Okamura, 1931; Ishijima, 1941, 1942; Shen and Fan, 1950; Wang *et al.*, 1993; Wang and Chiang, 1993). Besides, the previous works were only focused on algal check-list; minor on algal distribution or habitat characteristics. The field floristic survey is obviously insufficient. This study provides more information about the composition, distribution and habitat of the benthic marine algae in this region.

Material and Methods

Algal specimens were collected from the littoral and sublittoral zones of Lan-Yu (Fig. 1) during 14-18 April, 2005 and 20-24 August, 2005. Skin and SCUBA diving equipment were used for underwater collections and surveys. Specimens were either dried and mounted, or preserved in 10% formalin seawater. Liquid-preserved and dried herbarium specimens were used for this study. Sections were made by hand or with a freezing microtome. All voucher specimens are deposited in the Herbarium of National Taiwan Museum (TAIM). In order to deal with a large number of data, Jaccard's coefficient was taken to analyze the similarity between areas (Sneath and Sokal, 1973).

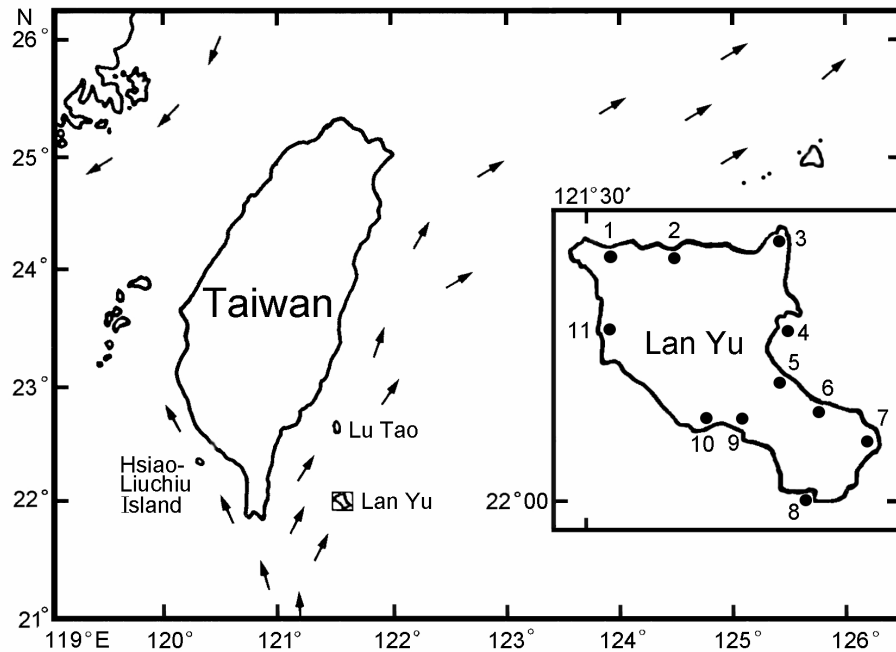


Fig. 1: Map showing geographic position of Lan-Yu and the adjacent currents. 1. Crocodile rock (鱷魚岩) 2. Langdou (朗島) 3. Warship rock (軍艦岩) 4. Dongqing bay (東清灣) 5. Yeyin (野銀) 6. Nuclear waste plant (核廢場) 7. Elephant-nose rock (象鼻岩) 8. Longmen dock (龍門碼頭) 9. Hongtou village (紅頭村) 10. Yuren village (漁人村) 11. Kaiyuan Harbor (開元港)

Results

There are a total of 159 species of marine algae identified in this study. They belong to 103 genera and 45 families, and include 3 species of Cyanophyta, 59 species of Chlorophyta, 22 species of Heterokontophyta, and 75 species of Rhodophyta (Table 1). Among them, 50 species are firstly recorded in Lan-yu.

Table 1. Numbers of algal taxa during studying period in Lan-yu.

Phylum	No. of families	No. of genera	No. of species	No. of new records for Lan-Yu
Cyanophyta	3	3	3	1
Chlorophyta	14	29	59	21
Heterokontophyta	6	13	22	4
Rhodophyta	22	58	75	24
Total	45	103	159	50

Table 2. Numbers of algal taxa in sampling stations.

Sampling stations	Cyanophyta	Cholophyta	Heterokontophyta	Rhodophyta	Total
Crocodile rock	1	9	11	24	45
Langdou	2	10	7	15	34
Warship rock	1	6	6	6	19
Dongqing bay	0	5	4	6	15
Yeyin	0	6	8	8	22
Nuclear waste plant	1	24	4	13	42
Elephant-nose rock	1	15	4	8	28
Longmen dock	2	23	10	35	70
Hongtou village	1	14	4	17	36
Yuren village	0	19	9	28	56
Kaiyuan Harbor	0	25	7	19	51

As shown in table 2, the station Longmen dock has the richest flora with 70 species of algae. Station Yuren village has the second richest with 56 species. Station Kaiyuan Harbor has 51 species and Station Crocodile rock has 45 species. The station Dongqing bay has the least number of species, only 15 species.

The structure of algal communities was also analyzed. In general, the flora of the upper wave-washed regions (upper littoral regions) was dominated by *Bostrychia tenella*, *Brachytrichia* spp. and *Ulva* spp. In the middle littoral region, there was a mixture of *Ulva* spp., *Chaetomorpha* spp., *Boergesenia forbesii*, *Dictyosphaeria cavernosa*, *Colpomenia sinuosa*, and *Padina* spp. On the exposed rock of the lower littoral region or subtidal fringe, the scattered patches of *Valoniopsis pachynema*, *Padina* spp., *Caulerpa* spp., *Amphiroa* spp., *Chaetomorpha* spp., *Cladophora* spp., *Acrocystis nana*, *Centroceras clavulatum* and *Sargassum* spp. In the sublittoral zone, there was a mixture of *Dictyota* spp., *Laurencia* spp., *Halimeda* spp., *Turbinaria* spp., *Sargassum* spp., *Liagora* spp., *Ganonema farinosum*, *Chlorodesmis* spp., *Neomeris* spp., *Chondria* spp., *Ceratodictyon spongiosum*, etc. The orders of the floristic list of algae are arranged according to Algaebase (Guiry, 2006), while families, genera and species are arranged alphabetically.

CHECKLIST OF SPECIES

*: New record for Lan-yu

CYANOPHYTA OSCILLATORIALES OSCILLATORIACEAE

***Lyngbya majuscula* (Dillwyn) Harvey**

Distribution: Langdou, Longmen dock, Hongtou village.

Habitat: Thalli widely expanded on upper to lower intertidal rocks.

PHORMIDIACEAE

* ***Symploca hydroides* (Harvey) Kützing**

Distribution: Langdou, Warship rock, Longmen dock

Habitat: Growing on upper intertidal rocks.

STIGONEMATALES MASTIGOCLADACEAE

***Brachytrichia quojii* (C. Agardh) Bornet & Flahault**

Distribution: Crocodile rock, Nuclear waste plant, Elephant-nose rock.

Habitat: Growing on upper intertidal rocks.

CHLOROPHYTA ULVALES MONOSTROMATACEAE

* ***Monostroma nitidum* Wittrock**

Distribution: Dongqing bay, Yeyin, Nuclear waste plant.

Habitat: Growing on upper intertidal rocks.

ULVACEAE

***Ulva clathrata* (Roth) C. Agardh**

Synonym: *Enteromorpha clathrata*; *Enteromorpha crinita*; *Enteromorpha clathrata* var. *crinita*

Distribution: Langdou, Dongqing bay.

Habitat: Growing on middle to lower intertidal rocks.

***Ulva compressa* Linnaeus**

Synonym: *Enteromorpha compressa*

Distribution: Nuclear waste plant, Elephant-nose rock, Longmen dock, Kaiyuan harbor.

Habitat: Growing on middle to lower intertidal rocks.

***Ulva conglobata* Kjellman**

Distribution: Nuclear waste plant, Elephant-nose rock.

Habitat: Growing on upper and middle intertidal rocks covered with sand.

***Ulva fasciata* Delile**

Distribution: Longmen dock, Yuren village, Kaiyuan harbor.

Habitat: Growing on middle intertidal rocks and in rock pools.

***Ulva intestinalis* Linnaeus**

Synonym: *Enteromorpha intestinalis*

Distribution: Crocodile rock, Langdou, Yeyin, Nuclear waste plant, Elephant-nose rock.

Habitat: Growing on middle to lower intertidal rocks.

***Ulva lactuca* Linnaeus**

Distribution: Around all coasts of Lan-Yu.

Habitat: Growing on middle intertidal rocks and in rock pools.

***Ulva linza* Linnaeus**

Synonym: *Enteromorpha linza*

Distribution: Crocodile rock, Warship rock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Ulva pertusa* Kjellman**

Distribution: Longmen dock, Warship rock.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

***Ulva prolifera* O.F. Müller**

Synonym: *Enteromorpha prolifera*

Distribution: Nuclear waste plant, Elephant-nose rock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Ulva reticulata* Forsskål**

Distribution: Longmen dock.

Habitat: Growing on lower intertidal to subtidal rocks (2 m deep).

***Umbraulva japonica* (Holmes) Bae & Lee**

Synonym: *Ulva japonica*; *Letterstedtia japonica*.

Distribution: Langdou.

Habitat: Growing on lower intertidal to subtidal rocks (7 m deep).

CLADOPHORALES

ANADYOMENACEAE

***Anadyomene wrightii* Harvey in Gray**

Distribution: Yeyin, Nuclear waste plant, Elephant-nose rock.

Habitat: Growing on subtidal rocks 0.5-1 m deep.

***Valoniopsis pachynema* (Martens) Børgesen**

Synonym: *Valonia confervoides*

Distribution: Around all coasts of Lan-Yu.

Habitat: Growing on lower intertidal rock.

CLADOPHORACEAE

***Chaetomorpha antennina* (Bory de Saint-Vincent) Kützing**

Synonym: *Chaetomorpha media*

Distribution: Crocodile rock, Nuclear waste plant, Longmen dock, Hongtong village, Yuren village.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Chaetomorpha crassa* (C. Agardh) Kützing**

Distribution: Langdou, Yuren village

Habitat: Growing in shallow rock pools in the upper intertidal zone.

***Chaetomorpha linum* (O.F. Müller) Kützing**

Distribution: Langdou, Dongqing bay, Yuren village.

Habitat: Growing on middle to lower intertidal rocks.

****Chaetomorpha spiralis* Okamura**

Distribution: Crocodile rock, Langdou, Nuclear waste plant.

Habitat: Growing on lower intertidal and subtidal rocks.

****Cladophora catenata* (Linnaeus) Kützing**

Synonym: *Cladophora fuliginosa*

Distribution: Crocodile rock, Langdou, Nuclear waste plant, Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Cladophora dotyana* Gilbert**

Synonym: *Cladophora meridionalis*; *Cladophora patula*

Distribution: Elephant-nose rock, Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal and subtidal rocks.

***Cladophora patentiramea* (Montagne) Kützing**

Distribution: Crocodile rock, Nuclear waste plant, Elephant-nose rock, Hongtou village, Kaiyuan harbor.

Habitat: Growing on lower intertidal and subtidal rocks.

**DASYCLADALES
DASYCLADACEAE**

****Bornetella nitida* Sonder**

Distribution: Hongtou village.

Habitat: Growing on lower intertidal rocks or in rock pools.

****Neomeris annulata* Dickie**

Distribution: Longmen dock, Hongtou village.

Habitat: Growing on subtidal rocks (10-20 m deep).

****Neomeris van-bosseae* M.A. Howe**

Distribution: Longmen dock, Hongtou village, Yuren village, Kaiyuan harbor.

Habitat: Growing on subtidal rocks of sandy bottom (10-20 m deep).

POLYPHYSACEAE

****Acetabularia ryukyuensis* Okamura & Yamada ex Okamura**

Distribution: Hongtou village, Kaiyuan harbor.

Habitat: Growing on subtidal rocks of sandy bottom (10-15 m deep).

****Parvocaulis parvula* (Solms-Laubach) S. Berger *et al***

Synonym: *Acetabularia parvula*

Distribution: Kaiyuan harbor.

Habitat: Growing on subtidal rocks of sandy bottom (5-10 m deep).

SIPHONOCLADALES

BOODLEACEAE

***Boodlea composita* (Harvey *et* Hooker) Brand**

Synonym: *Boodlea siamensis*

Distribution: Warship rock, Nuclear waste plant, Longmen dock, Hongtou village.

Habitat: Thalli forming spongy masses on rocks in the lower intertidal and subtidal zone 0.5-1 m deep.

***Phylloctyton anastomosans* (Harvey) Kraft & Wynne**

Synonym: *Struvea anastomosans*; *Struvea delicatula*

Distribution: Nuclear waste plant.

Habitat: Thalli are epiphytic on coarser algae or growing on rocks in lower intertidal zone.

SIPHONOCLADACEAE

****Boergesenia forbesii* (Harvey) J. Feldmann**

Synonym: *Valonia forbesii*

Distribution: Nuclear waste plant, Elephant-nose rock.

Habitat: Growing on middle intertidal sandy bottoms of rock pools.

***Chamaedoris orientalis* Okamura & Higashi in Okamura**

Distribution: Elephant-nose rock, Longmen dock.

Habitat: Growing on subtidal rocks (10-20 m deep).

****Cladophoropsis javanica* (Kützing) P.C. Silva**

Synonym: *Cladophoropsis zollingeri*

Distribution: Longmen dock.

Habitat: Thalli forming dense clumps on somewhat muddy mid-lower intertidal rock, preferably by the sides of rock pools.

* *Siphonocladus tropicus* (P.L. Crouan & H.M. Crouan) J. Agardh

Distribution: Yuren village.

Habitat: Growing on subtidal rocks (5-10 m deep).

* *Ventricaria ventricosa* (J. Ag.) Olsen et West

Distribution: Nuclear waste plant, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (3-8 m deep).

VALONIACEAE

Dictyosphaeria cavernosa (Forsskal) Boergesen

Distribution: Crocodile rock, Langdou, Nuclear waste plant, Longmen dock, Yuren village, Kaiyuan harbor.

Habitat: Growing on middle and lower intertidal to subtidal rocks 1m deep.

Valonia aegagropila C. Agardh

Distribution: Nuclear waste plant, Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks.

BRYOPSIDALES

BRYOPSIDACEAE

Bryopsis harveyana J. Agardh

Distribution: Nuclear waste plant.

Habitat: Growing on lower intertidal to subtidal rocks 1m deep.

Bryopsis plumosa (Hudson) C. Agardh

Distribution: Nuclear waste plant, Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools in sheltered places though often exposed to moderate surf.

CAULERPACEAE

* *Caulerpa brachypus* f. *parvifolia* (Harvey) A.B. Cribb

Synonym: *Caulerpa parvifolia*

Distribution: Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (3-8 m deep), or epiphytic on other coarser algae

Caulerpa microphysa (Weber-van Bosse) J. Feldmann

Synonym: *Caulerpa racemosa* var. *clavifera* f. *microphysa*

Distribution: Warship rock, Nuclear waste plant, Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (5-10 m deep), or epiphytic on other coarser algae

Caulerpa peltata J.V. Lamouroux

Synonym: *Caulerpa racemosa* var. *peltata*; *Caulerpa peltata* f. *typical*; *Caulerpa racemosa* var. *laete-virens*

Distribution: Nuclear waste plant, Yuren village.

Habitat: Growing on middle intertidal rocks covered with sand.

Caulerpa racemosa var. *macrophysa* (Sonder ex Kützing) W.R. Taylor

Synonym: *Caulerpa racemosa* var. *clavifera* f. *macrophysa*

Distribution: Longmen dock.

Habitat: Growing on lower intertidal rocks or subtidal rocks covered with sand.

Caulerpa serrulata f. *lata* (Weber-van Bosse) C.K. Tseng

Synonym: *Caulerpa freycineti* var. *freycineti* f. *lata*

Distribution: Hongtou village, Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or subtidal rocks covered with sand.

* ***Caulerpa sertularioides f. longipes* (J. Agardh) Collins**

Distribution: Yeyin, Yuren village.

Habitat: Growing on lower intertidal rocks or subtidal rocks covered with sand.

* ***Caulerpa taxifolia* (Vahl) C. Agardh**

Distribution: Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or subtidal rocks covered with sand.

***Caulerpa webbiana f. tomentella* (Harvey ex J. Agardh) Weber-van Bosse**

Distribution: Kaiyuan Harbor.

Habitat: Growing on lower intertidal rocks or subtidal rocks covered with sand.

CODIACEAE

***Codium geppiorum* O.C. Schmidt**

Synonym: *Codium geppii*; *Codium divaricatum*

Distribution: Elephant-nose rock, Longmen dock.

Habitat: Growing on lower intertidal rocks or subtidal rocks covered with sand.

***Codium intricatum* Okamura**

Distribution: Elephant-nose rock.

Habitat: Growing on lower intertidal rocks.

***Codium repens* P.L. Crouan & H.M. Crouan in Vickers**

Distribution: Elephant-nose rock, Longmen dock.

Habitat: Growing on lower intertidal rocks or subtidal rocks 1-5 m deep.

HALIMEDACEAE

* ***Halimeda discoidea* Decaisne**

Distribution: Kaiyuan harbor.

Habitat: Growing on subtidal rocks or old coral fragments (1-5 m deep).

* ***Halimeda macroloba* Decaisne**

Distribution: Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

***Halimeda opuntia* (Linnaeus) J.V. Lamouroux**

Distribution: Nuclear waste plant, Elephant-nose rock, Hongtou village, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

UDOTEACEAE

***Avrainvillea erecta* (Berkeley) A. Gepp et E. S. Gepp**

Distribution: Hongtou village, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

* ***Avrainvillea riukiensis* Yamada**

Distribution: Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

***Chlorodesmis caespitosa* J. Agardh**

Synonym: *Chlorodesmis formosana*

Distribution: Nuclear waste plant, Elephant-nose rock, Longmen dock, Hongtou village, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-3 m deep).

***Chlorodesmis fastigiata* (C. Agardh) Ducker**

Synonym: *Chlorodesmis comosa*

Distribution: Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-10 m deep).

****Rhipidosiphon javensis* Montagne**

Synonym: *Udotea javensis*

Distribution: Hongtou village, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

****Tydemania expeditionis* Weber-van Bosse**

Distribution: Kaiyuan harbor.

Habitat: Growing on subtidal rocks (3-10 m deep).

****Udotea argentea* Zanardini 1858: 290**

Distribution: Yuren village, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (1-10 m deep).

***Udotea fragilifolia* Tseng et Dong**

Distribution: Yuren village, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (1-10 m deep).

HETEROKONTOPHYTA

ECTOCARPALES

ACINETOSPORACEAE

***Asteronema breviarticulatum* (J. Agardh) Ouriques & Bouzon**

Synonym: *Hincksia breviarticulatus*; *Ectocarpus breviarticulatus*.

Distribution: Dongqing bay, Yeyin.

Habitat: Growing on lower intertidal to subtidal rocks (1 m deep)

***Hincksia mitchelliae* (Harvey) P.C. Silva in P.C. Silva et al.**

Synonym: *Giffordia mitchelliae*; *Ectocarpus mitchelliae*.

Distribution: Yeyin, Hongtou village.

Habitat: Thalli attached on the lower intertidal rocks.

CHORDARIACEAE

***Chnoospora minima* (K. Hering) Papenfuss**

Synonym: *Chnoospora pacifica*

Distribution: Warship rock, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-3 m deep)

***Hydroclathrus clathratus* (C. Agardh) Howe**

Synonym: *Hydroclathrus cancellatus*

Distribution: Crocodile rock, Langdou.

Habitat: Growing on lower intertidal and subtidal rocks.

SCYTOSIPHONACEAE

***Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier in Castagne**

Distribution: Crocodile rock, Warship rock, Longmen dock.

Habitat: Thalli growing on lower intertidal rocks.

DICTYOTALES

DICTYOTACEAE

***Dictyopteris repens* (Okamura) Boergesen**

Synonym: *Neurocarpus repens*

Distribution: Nuclear waste plant, Longmen dock.

Habitat: Thalli creeping on the other marine algae in the lower intertidal rocks and subtidal region 1 m deep.

****Dictyota bartayresiana* J.V. Lamouroux**

Synonym: *Dictyota patens*

Distribution: Crocodile rock, Longmen dock, Kaiyuan harbor.

Habitat: Thalli creeping on the other marine algae in the lower intertidal rocks and subtidal region 1 m deep.

***Dictyota dichotoma* var. *intricata* (C. Agardh) Greville**

Synonym: *Dictyota divaricata*

Distribution: Elephant-nose rock, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep)

***Lobophora variegata* (Lamouroux) Womersley ex Oliveira**

Synonym: *Zonaria nigrescens*

Distribution: Longmen dock, Kaiyuan harbor.

Habitat: Thalli creeping on the other marine algae in the lower intertidal rocks and subtidal region 1-3 m deep.

***Padina australis* Hauck**

Distribution: Crocodile rock, Langdou, Yeyin, Yuren village, Kaiyuan harbor.

Habitat: Growing in the subtidal zone 2-10 m deep.

***Padina minor* Yamada**

Distribution: Dongqing bay, Yeyin, Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks.

****Zonaria stipitata* Tanaka et Nozawa**

Distribution: Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks.

FUCALES

CYSTOSEIRACEAE

***Hormophysa cuneiformis* (J.F. Gmelin) P.C. Silva)**

Synonym: *Hormophysa triquetra*

Distribution: Crocodile rock, Dongqing bay, Yeyin.

Habitat: Growing on subtidal rocks (1-5 m deep) covered with sands.

SARGASSACEAE

***Sargassum crassifolium* J. Agardh**

Distribution: Crocodile rock, Dongqing bay, Yeyin, Hongtou village, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

****Sargassum crispifolium* Yamada**

Distribution: Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

***Sargassum cristaefolium* C. Agardh**

Synonym: *Sargassum duplicatum*; *Sargassum berberifolium*

Distribution: Crocodile rock, Langdou, Warship rock, Longmen dock, Hongtou village, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

***Sargassum glaucescens* J. Agardh**

Distribution: Crocodile rock, Langdou, Warship rock, Nuclear waste plant, Elephant-nose rock, Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (1-8 m deep).

****Sargassum hemiphyllum* (Turner) C. Agardh**

Distribution: Longmen dock.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

***Sargassum polycystum* C. Agardh**

Synonym: *Sargassum microphyllum*

Distribution: Crocodile rock, Langdou, Warship rock, Longmen dock, Dongqing bay, Yeyin, Nuclear waste plant.

Habitat: Growing on lower intertidal to subtidal rocks (1-10 m deep).

***Turbinaria conoides* (J. Agardh) Kützing**

Distribution: Crocodile rock, Langdou.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

***Turbinaria ornata* (Turner) J. Agardh**

Distribution: Around all the coasts of Lan-yu.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

***Turbinaria trialata* (J. Agardh) Kützing**

Distribution: Elephant-nose rock, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

RHODOPHYTA

BANGIALES

BANGIACEAE

***Porphyra crispata* Kjellman**

Distribution: Crocodile rock, Warship rock, Longmen dock.

Habitat: Growing on upper intertidal rocks.

***Porphyra vietnamensis* T. Tanaka & Pham-Hoàng Ho**

Distribution: Crocodile rock.

Habitat: Growing on upper intertidal rocks.

NEMALIALES

GALAXAURACEAE

****Actinotrichia fragilis* (Forsskål) Børgesen**

Distribution: Nuclear waste plant, Longmen dock.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep)

***Galaxaura cylindrica* (Solander) J.V. Lamouroux**

Distribution: Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (3-8 m deep)

****Galaxaura filamentosa* R. Chou in W.R. Taylor**

Distribution: Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (5-10m deep)

***Tricleocarpa fragilis* (Linnaeus) Huisman & Townsend**

Synonym: *Galaxaura oblongata*

Distribution: Hongtou village, Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal or subtidal rocks (1-10 m deep).

SCINAIACEAE

***Dichotomaria marginata* (Ellis & Solander) Lamarck**

Synonym: *Galaxaura arborea*; *Galaxaura marginata*; *Galaxaura tenera*; *Galaxaura veprecula*

Distribution: Yuren village.

Habitat: Growing on subtidal rocks 3-10 m deep.

***Scinaia moniliformis* J. Agardh**

Distribution: Yuren village.

Habitat: Growing on subtidal rocks 5-10 m deep.

LIAGORACEAE

***Dermonema virens* (J. Agardh) Pedroche & Ávila Ortíz**

Synonym: *Dermonema frappieri*; *Dermonema gracile*; *Dermonema dichotomusm*

Distribution: Crocodile rock, Langdou, Dongqing bay, Yeyin.

Habitat: Growing on exposed intertidal rocks.

****Ganonema farinosum* (J.V. Lamouroux) K.C. Fan & Y.C. Wang**

Synonym: *Liagora farinosa*

Distribution: Crocodile rock, Hongtou village, Yuren village, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (5-15 m deep).

****Izziella orientalis* (J. Agardh) Huisman & Schils**

Synonym: *Liagora orientalis*; *Liagora formosana*

Distribution: Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks

***Liagora boergesenii* Yamada**

Distribution: Longmen dock, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (3-10 m deep).

***Liagora valida* Harvey**

Distribution: Hongtou village.

Habitat: Growing on lower intertidal to subtidal rocks (5-10 m deep).

***Yamadaella caenomyce* (Decaisne) Abbott**

Synonym: *Liagora annulata*; *Liagora caenomyce*; *Liagora rugosa*

Distribution: Crocodile rock, Longmen dock, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-3 m deep)

BONNEMAISONIALES

BONNEMAISONIACEAE

***Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon**

Synonym: *Asparagopsis sanfordiana*

Distribution: Hongtou village.

Habitat: Growing on lower intertidal to subtidal rocks (5-10 m deep).

GELIDIALES

GELIDIELLACEAE

***Gelidiella acerosa* (Forsskål) Feldmann et Hamel**

Synonym: *Gelidiopsis rigida*

Distribution: Crocodile rock, Yeyin, Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

GIGARTINALES

DUMONTIACEAE

****Gibsmithsia hawaiiensis* Doty**

Distribution: Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep)

****Rhodopeltis borealis* Yamada**

Distribution: Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep)

GIGARTINACEAE

* ***Chondracanthus intermedius* (Suringar) Hommersand**

Synonym: *Gigartina intermedia*

Distribution: Crocodile rock, Langdou, Dongqing bay, Nuclear waste plant.

Habitat: Growing on lower intertidal to subtidal rocks (1-3 m deep)

HYPNEACEAE

***Hypnea charoides* Lamouroux**

Synonym: *Hypnea seticulosaa*

Distribution: Crocodile rock, Nuclear waste plant.

Habitat: Growing on middle to lower intertidal rocks.

***Hypnea pannosa* J. Agardh**

Distribution: Crocodile rock, Nuclear waste plant, Kaiyuan harbor.

Habitat: Growing on middle to lower intertidal rocks.

***Hypnea spinella* (C. Agardh) Kützing**

Synonym: *Hypnea cervicornis*

Distribution: Crocodile rock, Nuclear waste plant.

Habitat: Growing on lower intertidal rocks or in rock pools.

PEYSSONNELIACEAE

* ***Peyssonnelia distenta* (Harvey) Yamada**

Distribution: Langdou, Hongtou village.

Habitat: Growing on lower intertidal to subtidal rocks (1-10 m deep).

***Peyssonnelia rubra* (Greville) J. Agardh**

Distribution: Langdou, Hongtou village.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

PHYLLOPHORACEAE

***Ahnfeltiopsis flabelliformis* (Harvey) Masuda**

Synonym: *Gymnogongrus flabelliformis*

Distribution: Langdou.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

RHIZOPHYLLIDACEAE

***Portieria hornemannii* (Lyngbye) P.C. Silva**

Synonym: *Chondrococcus hornemannii*

Distribution: Longmen dock, Hongtou village, Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

SARCODIACEAE

***Sarcodia montagneana* (J.D. Hooker & Harvey) J. Agardh**

Synonym: *Sarcodia ceylanica*

Distribution: Crocodile rock.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

SCHIZYMENIACEAE

***Titanophora pulchra* E.Y. Dawson**

Distribution: Langdou, Hongtou village.

Habitat: Growing on subtidal rocks (3-10 m deep).

* ***Titanophora weberae* Børgesen**

Distribution: Yuren village.

Habitat: Growing on subtidal rocks (8-15 m deep).

HALYMENIALES

HALYMENIACEAE

***Carpopeltis maillardii* (Montagne & Millardet) Chiang**

Synonym: *Carpopeltis rigida*

Distribution: Nuclear waste plant, Longmen dock, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (1-5 m deep).

***Carpopeltis prolifera* (Hariot) Kawaguchi & Masuda**

Distribution: Nuclear waste plant.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

****Halymenia dilatata* Zanardini**

Distribution: Yuren village, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (8-15 m deep).

***Halymenia microcarpa* (Montagne) P.C. Silva**

Synonym: *Halymenia cyelanica*; *Halymenia durvillei* var. *cyelanica*

Distribution: Longmen dock, Hongtou village, Yuren village.

Habitat: Growing on subtidal rocks (10-15 m deep).

***Prionitis angusta* (Okamura) Okamura**

Synonym: *Carpopeltis angusta*

Distribution: Nuclear waste plant, Elephant-nose rock, Longmen dock.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

***Yonagunia formosana* (Okamura) Kawaguchi & Masuda**

Synonym: *Carpopeltis formosana*

Distribution: Elephant-nose rock, Longmen dock.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep)

SEBDENIACEAE

***Sebdenia flabellata* (J. Agardh) P.G. Parkinson**

Synonym: *Sebdenia agardhii*

Distribution: Longmen dock, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (10-15 m deep).

PLOCAMIALES

PLOCAMIACEAE

***Plocamium serrulatum* Okamura**

Synonym: *Plocamium costatum*

Distribution: Yuren village, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (3-10 m deep).

CORALLINALES

CORALLINACEAE

***Amphiroa foliacea* J.V. Lamouroux in Quoy & Gaimard**

Distribution: Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or in rock pools.

****Amphiroa fragilissima* (Linnaeus) Lamouroux**

Distribution: Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Amphiroa zonata* Yendo**

Distribution: Elephant-nose rock, Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Arthrocardia anceps* (Yendo) Johansen**

Synonym: *Cheilosporum anceps*

Distribution: Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Cheilosporum acutilobum* (Decaisne) Piccone**

Synonym: *Cheilosporum jungermannioides*

Distribution: Longmen dock, Hongtou village.

Habitat: Growing on lower intertidal rocks or in rock pools.

****Hydrolithon farinosum* (J.V. Lamouroux) D. Penrose & Y.M. Chamberlain**

Synonym: *Melobesia farinosa*

Distribution: Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Jania decussato-dichotoma* (Yendo) Yendo**

Synonym: *Corallina decussato-dichotoma*

Distribution: Crocodile rock, Longmen dock, Hongtou village, Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Jania pacifica* Areschoug**

Synonym: *Jania mexicana*

Distribution: Crocodile rock, Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Jania rubens* (Linnaeus) J.V. Lamouroux**

Distribution: Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Mastophora rosea* (C. Agardh) Setchell**

Synonym: *Mastophora macrocarpa*

Distribution: Crocodile rock, Longmen dock, Hongtou village.

Habitat: Growing on lower intertidal rocks or in rock pools.

GRACILARIALES

GRACILARIACEAE

****Congracilaria babae* Yamamoto**

Distribution: Dongqing bay, Yeyin.

Habitat: Thalli are epiphytic on *Gracilaria salicornia* or growing on rocks in lower intertidal zone.

****Gracilaria canaliculata* (Kützing) Sonder**

Synonym: *Gracilaria crassa*

Distribution: Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

****Gracilaria salicornia* (C. Agardh) Dawson**

Distribution: Dongqing bay, Yeyin.

Habitat: Growing on lower intertidal rocks or in rock pools.

* ***Gracilaria vieillardii* P.C. Silva**

Synonym: *Gracilaria denticulatus*

Distribution: Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Hydropuntia eucheumatoides* (Harvey) Gurgel & Fredericq**

Synonym: *Gracilaria eucheumioides*

Distribution: Elephant-nose rock, Longmen dock, Yuren village.

Habitat: Growing on lower intertidal rocks or in rock pools.

RHODYMENIALES

LOMENTARIACEAE

***Ceratodictyon spongiosum* Zanardini**

Synonym: *Ceratodictyon spongioides*

Distribution: Longmen dock, Kaiyuan harbor.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Gelidiopsis repens* (Kützing) Weber-van Bosse**

Distribution: Crocodile rock, Langdou, Yeyin, Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

RHODYMENIACEAE

***Botryocladia skottsbergii* (Børgesen) Levring**

Distribution: Hongtou village.

Habitat: Growing on subtidal rocks (8-10 m deep).

CERAMIALES

CERAMIACEAE

***Centroceras clavulatum* (C. Agardh) Montagne**

Synonym: *Ceramium clavulatum*

Distribution: Around all the coasts of Lan-yu.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Dasyphila plumarioides* Yendo**

Distribution: Langdou, Longmen dock.

Habitat: Growing on subtidal rocks (5-10 m deep).

* ***Wrangelia tanegana* Harvey**

Synonym: *Wrangelia tayloriana*

Distribution: Longmen dock, Yuren village.

Habitat: Growing on lower intertidal rocks or in rock pools.

DELESSERIACEAE

* ***Claudea batanensis* Tanaka**

Distribution: Elephant-nose rock, Longmen dock.

Habitat: Growing on subtidal rocks (3-10 m deep).

* ***Martensia flabelliformis* Harvey ex J. Agardh**

Synonym: *Neomartensia flabelliformis*

Distribution: Longmen dock.

Habitat: Growing on subtidal rocks (3-8 m deep).

* ***Vanvoorstia coccinea* Harvey ex J. Agardh**

Distribution: Longmen dock, Yuren village.

Habitat: Growing on subtidal rocks (5-10 m deep).

RHODOMELACEAE

***Acanthophora spicifera* (M. Vahl) Børgesen**

Distribution: Crocodile rock, Langdou, Nuclear waste plant, Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Acrocystis nana* Zanardini**

Distribution: Crocodile rock, Langdou, Warship rock, Nuclear waste plant, Longmen dock.

Habitat: Growing on lower intertidal rocks or in rock pools.

***Bostrychia tenella* (Lamouroux) J. Agardh**

Distribution: Around all the coasts of Lan-yu.

Habitat: Growing on upper intertidal rocks.

***Chondria armata* (Kützing) Okamura**

Distribution: Langdou, Yuren village.

Habitat: Growing on subtidal rocks (3-5 m deep).

****Chondria crassicaulis* Harvey**

Distribution: Longmen dock, Yuren village, Kaiyuan harbor.

Habitat: Thalli are epiphytic on Polychaetes or growing on rocks in lower intertidal zone.

***Chondrophyucus papillosus* (C. Agardh) Garbary & Harpe**

Synonym: *Laurencia papillosa*

Distribution: Crocodile rock, Langdou, Warship rock, Longmen dock.

Habitat: Growing on lower intertidal to subtidal rocks (8 m deep).

****Chondrophyucus undulatus* (Yamada) Garbary & Harper**

Synonym: *Laurencia undulata*

Distribution: Yeyin.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

***Digenea simplex* (Wulfen) C. Agardh**

Distribution: Longmen dock, Yuren village, Kaiyuan harbor.

Habitat: Growing on lower intertidal to subtidal rocks (3 m deep).

****Laurencia brongniartii* J. Agardh**

Synonym: *Laurencia grevilleana*

Distribution: Yuren village.

Habitat: Growing on subtidal rocks or old coral fragments (1-5 m deep).

***Laurencia okamurae* Yamada**

Distribution: Langdou, Warship rock, Longmen dock.

Habitat: Growing on lower intertidal to subtidal rocks (1-8 m deep).

***Leveillea jungermannioides* (Hering et Martens) Harvey**

Distribution: Crocodile rock, Nuclear waste plant, Elephant-nose rock, Longmen dock.

Habitat: Thalli are epiphytic on coarser algae or growing on rocks in lower intertidal zone.

***Melanamansia glomerata* (C. Agardh) Norris**

Synonym: *Amansia glomerata*

Distribution: Crocodile rock, Hongtou village, Yuren village.

Habitat: Growing on lower intertidal to subtidal rocks (5 m deep).

***Neurymenia fraxinifolia* (Mertens et Turner) J. Agardh**

Distribution: Crocodile rock, Kaiyuan harbor.

Habitat: Growing on subtidal rocks (5-15 m deep).

***Osmundaria obtusiloba* (Martens ex C. Agardh) Norris**

Synonym: *Vidalia obtusiloba*

Distribution: Crocodile rock.

Habitat: Growing on subtidal rocks (5-10 m deep).

Discussion

In the records of seaweeds of Taiwan (Lewis and Norris, 1987; Chen, 1991; Huang, 1990, 1991; Wang *et al.*, 1993; Wang and Chiang, 1993, 1994, 2001; Yang *et al.*, 1994; Chang, 1995; Huang, 1997, 1998, 1999a, 1999b, 1999c, 2000, 2002, 2003, 2005; Huang and Yang, 1999; Lewis, 2000; Chang *et al.*, 2002, 2003; Lin, 2002, 2004; Lin and Fredericq, 2003; Lin *et al.*, 2004.), there are about 520 species of marine algae listed. There are 159 species of marine algae registered in this study, taking about 30% of Taiwan's species. Though Lan-yu has an area of only 45.7 km², its marine algal flora is rather complicated.

The difference in topographic feature affects the composition and distribution of seaweeds. In general, more complicated topography has higher diversity of species. In this study, it was found that the station Longmen dock 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. On the contrary, the station Dongqing bay has a simple topography with sandy bottom which is not suitable for the growth of algae.

Comparing the algal composition of Lan-yu with the other areas of Taiwan, it was found that 142 species of algae in this study were appeared also in southern Taiwan (Chiang, 1962b, 1973a; Chiang and Wang, 1987; Huang, 1990; Huang, 1998). According to the Jaccard's index analysis ($J_c = C/(A+B-C)(\times 100\%)$), the similarity of Lan-yu and southern Taiwan is 76%. It is suggested that the algal flora of Lan-yu is quite similar to southern Taiwan.

Analyzing the composition of marine algae in Lan-yu, most of them are red algae (47%), then green algae (37%), brown algae (14%), and last blue green algae (2%). According to the (R+C)/P hypothesis of Cheney (Cheney, 1977; Wang and Chiang, 1993), the ratio of red and green to brown algae of Lan-yu is 6.1, indicating a characteristic tropical nature. This agrees with the fact that most of algae in Lan-yu are of tropical or subtropical species.

According to the phytogeographical study, it is also found that the algal flora in this region shows strong affinities with tropical west Pacific Ocean. For example, *Symploca hydroides*, *Brachytrichia quojii*, *Chaetomorpha antennina*, *Ventricaria ventricosa*, *Ulva reticulata*, *Halimeda* spp., *Codium* spp., *Neomeris van-bosseae*, *Bornetella nitida*, *Acetabularia ryukyuensis*, *Chamaedoris orientalis*, *Siphonocladus tropicus*, *Avrainvillea* spp., *Tydemania expeditionis*, *Udotea* spp., *Hormophysa cuneiformis*, *Sargassum polycystum*, *Turbinaria* spp., *Ganonema farinosum*, *Yamadaella caenomyce*, *Rhodopeltis borealis*, *Neurymenia fraxinifolia*, *Cheilosporum* spp., *Gibsmithsia hawaiiensis* and *Ceratodictyon spongiosum*, are all widely distributed in tropical seas, such as the Ryukyu Islands, the Philippines, Indonesia, Malaysia,

Hawaii Islands, Solomon Islands and Australia (Thoi, 1969; Saito, 1969; Womersley and Bailey, 1970; Cordero, 1977a,b; Magruder and Hunt, 1979; Tseng, 1983; Hodgkiss and Lee, 1983; Silva *et al.*, 1987; Nguyen and Huynh, 1993; Silva *et al.*, 1996; Callumpong, *et al.*, 1997; Trono, 1997, 1998; Guiry, 2005). Especially, some of algae occurred only in tropical seas, such as *Tydemania expeditionis* and *Chamaedoris orientalis*, which appeared in Lan-yu, Philippines and Hawaii Islands, but not appeared in Taiwan. It seems that Lan-yu is more affinities with tropical areas than Taiwan.

The reason for such affinities with tropical areas is possibly related to the Kuroshio Current. The Kuroshio Current with high temperature and high salinity originates from the Northern Equatorial Current and flows northward along the eastern coast of Taiwan (Chu 1963, 1971; Guan, 1983; Chern and Wang, 1990; Li, 1991; Hsueh *et al.*, 1993). Recently, there are several researches analyzing the variation of ocean temperature from the NOAA-HRPT satellite (National Oceanic and Atmospheric Administration High Resolution Picture Transmission satellite remote sensing system), and it was found that the warming phenomena of Kuroshio (Lin and Shyu, 1990; Antonov *et al.*, 1998; Levitus *et al.*, 2000a, b). The Lan-yu is just located on the way of Kuroshio. It seems that the Kuroshio Current maybe the main factor causing the abundant coral reef and tropical creatures in this area.

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