# Spatial and Temporal Variations in Diversity, Abundance and Distribution of Macroalgae at Sirinat Marine National Park, Phuket Province, Thailand

Pimonrat Thongroy

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Ecology
Prince of Songkla University
2006

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| **Author** | Miss Pimonrat Thongroy |
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The Graduate School, Prince of Songkla University, has approved this thesis as partial fulfillment of the requirements for Master of Science Degree in Ecology

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(Assoc. Prof. Dr. Surapon Arrykul)

Dean of Graduate School

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| **ชื่อวิทยานิพนธ์** | ความหลากหลาย ความหนาแน่น และการกระจายของสาหร่ายทะเล ในช่วงเวลาและสถานที่ต่างกัน ณ อุทยานแห่งชาติสิรินาถ จังหวัดภูเก็ต |
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## บทคัดย่อ


การศึกษาความหลากหลาย ความหนาแน่น และการกระจายของสาหร่ายทะเลที่มีความสัมพันธ์ต่อสภาพแวดล้อม (การเปิดรับต่อการกระทำของคลื่น ความเค็ม อุณหภูมิ และปริมาณไนเตรต และฟอสเฟต) ณ อุทยานแห่งชาติสิรินาถ จังหวัดภูเก็ต ในระหว่างเดือนมกราคม พ.ศ. 2547 ถึงเดือนพฤศจิกายน พ.ศ. 2547 โดยแบ่งพื้นที่ศึกษาเป็น 3 บริเวณ ตามระดับความใกล้-ไกลจากชายหาด (ตอนบน ตอนกลาง และตอนล่าง) และ 3 บริเวณ ตามระดับการเปิดรับต่อแรงกระทำของคลื่น (พื้นที่ที่มีแนวกันคลื่น พื้นที่เปิดรับแรงกระทำของคลื่นปานกลาง และพื้นที่ที่เปิดรับแรงกระทำของคลื่นมาก) พบสาหร่ายทั้งสิ้น 52 ชนิด ในจำนวนนี้ มี 9 ชนิด พบเป็นครั้งแรกในประเทศไทย ค่าเฉลี่ยดัชนีความหลากหลายในพื้นที่ที่มีแนวกันคลื่น พื้นที่เปิดรับแรงกระทำของคลื่นปานกลาง และพื้นที่ที่เปิดรับแรงกระทำของคลื่นมาก มีความแตกต่างกันเล็กน้อย มีค่าคือ 0.92±0.07 1.00±0.13 และ 0.94±0.16 ตามลำดับ จากการทดสอบทางสถิติแบบนอนพาราเมตริก พบว่าความหนาแน่นของสาหร่ายมีความแตกต่างกันอย่างมีนัยสำคัญ ในระหว่างพื้นที่และฤดูกาล ($P<0.05$) โดยทั่วไป พบว่าสาหร่าย *Lyngbya majuscula* มีความหนาแน่นมากที่สุด ครอบคลุมพื้นที่ 31.66±7.21% ในพื้นที่ที่เปิดรับแรงกระทำของคลื่นปานกลาง ที่บริเวณตอนกลาง ในเดือนมีนาคม พ.ศ. 2547

สำหรับรูปแบบการแตกกิ่งและการสืบพันธุ์ของสาหร่าย *Acanthophora spicifera* และ *Chondrophycus tronoi* ซึ่งเป็นชนิดเด่นในพื้นที่ จากการศึกษาสาหร่ายจำนวน 540 ต้น ในแต่ละชนิด พบว่า ในพื้นที่ที่เปิดรับแรงกระทำของคลื่นมาก สาหร่ายมีความสูงน้อยกว่าในพื้นที่ที่มีแนวกันคลื่น($P<0.05$) จากการศึกษาในครั้งนี้ ไม่พบอวัยวะสืบพันธุ์ (สปอร์ cystocarps และ spermatangia) ของสาหร่ายทั้งสองชนิด ดังนั้น การหักเป็นท่อนจึงน่าจะเป็นการปรับตัวเพื่อการสืบพันธุ์ของสาหร่าย *Acanthophora spicifera* ทำให้มีการกระจายอย่างกว้างขวาง ทั้งในพื้นที่ศึกษานี้ และทั่วโลก

**Thesis Title** Spatial and Temporal Variations in Diversity, Abundance and Distribution of Macroalgae at Sirinat Marine National Park, Phuket Province, Thailand

**Author** Miss Pimonrat Thongroy

**Major Program** Ecology (International Program)

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## ABSTRACT

Diversity, abundance and distribution of intertidal macroalgae were investigated in relation to environmental conditions (wave exposure, salinity, temperature, $NO_3^-$ and $PO_4^{3-}$) at Sirinat Marine National Park, Phuket province, Thailand, from January 2004 to November 2004. The shore was divided into 3 sites according to shore level: upper, mid and lower shores; and 3 sites according to degree of wave exposure: sheltered, semi-exposed and exposed area. A total of 52 species of macroalgae were recorded. Of the total number, 9 species were considered to be new records for the Thai marine flora. The average diversity index of macroalgae at each degree of wave exposure was slightly different: 0.92±0.07, 1.00±0.13 and 0.94±0.16, respectively. Non parametric tests revealed that there was significant difference in abundance among sites and season ($P$<0.05). *Lyngbya majuscula* was the most abundant species. It covered of 31.66±7.21% (X±S.E.) in semi-exposed area at mid shore level during March 2004.

Branching patterns and reproduction of *Acanthophora spicifera* and *Chondrophycus tronoi*, two other common algae, were investigated. Five hundred and forty plants of each species were examined. The results showed that plants in the

exposed area were significantly smaller than those in the sheltered area ($P<0.05$). Reproductive structures (spores, cystocarps and spermatangia) of neither species were not found in this study. Fragmentation might be an adaptation for reproduction of *Acanthophora spicifera* which cause greater distribution both in this study and is known worldwide.

**ACKNOWLEDGEMENT**

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Pimonrat Thongroy

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# 1. INTRODUCTION

## Background and Rationale

The natural environment provides the basic conditions without which humanity could not survive. Biological diversity is the key to the ability of the biosphere to continue providing us with these ecological goods and services and thus is our species life assurance policy. Biodiversity is one of the most important factors in human subsistence. People from all over the world use and consume natural resources as food, clothing, housing equipment and medicines. Diversity is often expressed in terms of the wide variety of plants, animals and microorganisms. So far, about 1.75 million species have been identified, most of which are small creatures such as insects and microorganisms (http://www.biodiv.org).

The Convention on Biological Diversity (CBD) was set out to maintain and conserve ecological process and ecosystems for biodiversity conservation and the sustainable use based on the equitable benefit-sharing principle. Therefore, the Global Taxonomic Initiative (GTI) and Convention on Biological Diversity (CBD) were established. GTI aims to make taxonomic information, at all levels of biodiversity (genetic, species and ecosystem) and for all organisms, available in order to implement the three goals of the CBD: 1) the conservation of biological biodiversity, 2) the sustainable use of its components and 3) the fair and equitable sharing of the benefits arising from the use of genetic resources (http://bch-cbd.naturalsciences.be/belgium/cooperation/projects/gticontent.htm).

Thailand signed the CBD on 12 June 1992. The government then started to pay considerably more attention to biodiversity research (Hatacharern and

Cunningham, 2004). However, there is very little research regarding taxonomy in Thailand on any level of biodiversity (http://brt.biotec.or.th/Executive 2004.htm; http://brt.biotec.or.th/years.html).

**Seaweed Biodiversity**

Seaweeds, or macroalgae are an ecologically and economically important component of marine ecosystems worldwide. They are primary producers, shelter, nursery grounds and food sources for marine organisms. In addition, they are used around the world as foods and fertilizers, and for the extraction of valuable commercial products, such as industrial gums and chemicals (agars, carageenans and alginates). Recent research has pointed to new opportunities, particularly in the field of medicine, associated with bioactive properties of molecules extracted from seaweeds. Because of its importance, seaweed biodiversity studies and seaweed database have been carried out and are being established.

AlgaeBase was set up in 1996, initially as an attempt to list all of the marine algae reported from Ireland and Britain. Later, the list was extended to the Northeastern Alantic and the Mediteranean. At the same time, lists of marine algae from all over the world were added in an attempt to make the list as comprehensive as possible. Currently, AlgaeBase probably contains information on more than eighty-five per cent of currently accepted names of marine macroalgae worldwide. The data included mainly concern taxonomy, nomenclature and distribution and, predictably, are most complete for the North Atlantic and Mediteranean (Nic Dhonncha and Guiry, 2002). In addition, there are a few other databases and collections of seaweed around the world eg. Smithsonian, USA; Hawaii, USA; Townsville, Australia;

Hokkaido, Japan and Manila, The Philippines. However, very little has been known about seaweed biodiversity in Thailand. Only a few research have been carried out on seaweed study in recent years and the number of seaweed study in Thailand has sharply declined (Powtongsook, 2000).

Here, we would like to investigate:

1) Number of seaweed species at Sirinat Marine National Park to provide more information of seaweed biodiversity in Thailand.

2) What physical factors influence diversity, distribution and abundance of seaweeds?

3) Are there any variations in morphology and reproduction of some common seaweed among sites and seasons?

**Review of Literature**

**Seaweed Biodiversity in Thailand**

The very first report of marine algal flora in Thailand was published in 1866 in "Die Preussische Expedition nach Ost-Asien" (Martens, 1866), followed by "Flora of Koh Chang" (Schmidt, 1900-1916) and "List des algues du siboga" (Weber van Bosse, 1913-1928). Later, there were a few studies of marine algae reported in Thailand (Egerod, 1971, 1974, 1975; Velasquez and Lewmanomont, 1975; Lewmanomont, 1976, 1978; Abbott, 1988; Lewmanomont and Ogawa, 1995; Lewmanomont *et al.*, 1995; Aungtonya and Liao, 2002; Lewmanomont and Chirapart, 2004). Recently, there have been a series of taxonomical studies on red algae such as *Gracilaria* in Thailand (Lewmanomont, 1994, 1995; Lewmanomont and Chirapart, 2004). Recent studies show that 333 species of marine algae were found in Thailand (Lewmanomont *et al.*, 1995) and 180 algal records, collected from the Andaman Sea area off the coast of Thailand, are deposited in the Reference Collection of the Phuket Marine Biological Center (Aungtonya and Liao, 2002).

In addition, there were a few Master theses on seaweed biodiversity as follows:

Jindapon (1976) studied the taxonomy of marine algae on the coast of Trang Province. Five divisions, 53 genera were found along the coastal line. They were: 15 genera of Chlorophyta, 2 genera of Chrysophyta, 4 genera of Cyanophyta, 6 genera of Phaeophyta, 23 genera of Rhodophyta and 3 genera were not identified.

Pirompakdee (1976) studied the taxonomy of marine algae on the coast of Trad Province. Six divisions, 54 genera were found at the study site. They were: 12 genera of Chlorophyta, 2 genera of Chrysophyta, 1 genus of Pyrrophyta, 10 genera of Phaeophyta, 22 genera of Rhodophyta, 7 genera of Cyanophyta and 4 genera were not identified.

Sakuntab (1976) studied distribution, ecology, morphology and taxonomy of the marine macroalgae on the coast of Phuket Island. The study covered a period of time from March 1, 1975 until February 23, 1976. There were 3 divisions, 46 genera distributed on coast of Phuket. The genera were: 13 genera of Chlorophyta, 6 genera of Phaeophyta and 22 genera of Rhodophyta

Mesang (1987) studied the taxonomy, zonation and distribution of macroscopic marine algae at Ko Samui, Suratthani Province. Sample were monthly collected from December 1985 to November 1986 by belt transect method. There were 12 genera of marine algae: 2 genera of Chlorophyta, 4 genera of Phaeophyta and

6 genera of Rhodophyta. Most genera were in the intertidal zone. Only 2 genera, *Sargassum* and *Turbinaria,* were in subtidal.

Supowkit (1988) studied the distribution of red algae on the Eastern Coast of the Gulf of Thailand. The study was made during September 1987 to August 1988. Forty- two species of red algae were collected and identified. The most abundant species were *Centroceras clavulatum, C. minutum, Ceramium byssodeum* and *Gracilaria* spp.

Sangchan (1989) investigated the distribution, morphology, taxonomy and habitat of useful marine benthic algae on Nakhornsithummarat coastal line. The study covered a period of time from January 1987 until December 1987. There were 3 divisions, 13 genera, 19 species found that Nakhornsithummarat coastal line. The species were: 4 genera, 5 species of Chlorophyta, 5 genera, 7 species of Phaeophyta and 4 genera, 7 species Rhodophyta.

Pengseng (1992) studied species composition of the benthic marine algae at Ao Phe, Rayong Province. It was investigated by monthly collection for 12 months from April 1991 to March 1992. Forty- five genera, and 67 species were found growing on rock, gravels, dead corals, shells, sand and other seaweeds. Among these, 34 genera and 47 species were found in this study and 43 genera and 62 species were previously reported. They were: 3 genera, 3 species of Cyanophyta, 11 genera, 13 species of Chlorophyta, 7 genera, 13 species of Phaeophyta, 13 genera and 18 species of Rhodophyta. The greatest abundance was observed during April to September 1991. The most common genera were *Enteromorpha, Neomeris, Padina, Sargassum, Hypnea* and *Acanthophora.*

**Effects of Physical Factors on Seaweeds**

The major environmental factors affecting intertidal organisms including seaweeds are wave motion, nutrient availability, light, temperature and salinity (Lobban and Harrison, 1994; Nybakken, 2001). These physical factors are known to affect diversity, abundance, distribution and variation in morphology of marine algae (Kilar and McLachlan, 1986a, 1986b; Cecere *et al.,* 2000; Cecere and Perrone, 2002) and various marine organisms (Levinton, 2001; Boaventura *et al.*, 2002).

Wave motion affects macroalgae in three ways: 1) The velocity and acceleration of the fluid impose forces on plants. In areas of rapid water motion, these forces are substantial and may even break the plant or dislodge the holdfast. 2) Metabolism requires that inorganic nutrients and $CO_2$ be taken up from the water surrounding the plant and that wastes be expelled into the water. If the water is not moving, nutrients may become saturated, the rate of diffusion sets a limit to the rate at which metabolic processes may occur. This limit is increased substantially if the water is moving relative to the plant. 3) Many species of macroalgae depend on water movement to transport gametes and to disperse spores and propagules. The movement of water not only affects how far and in what direction spores will disperse, but may also determine which areas are hydrodynamically suitable for settlement (Littler and Littler, 1985). Wave exposure has been shown to play a significant role in seaweed community composition, specifically in relation to diversity and species richness. (Díez *et al.*, 2003).

Nutrients are a limiting factor for seaweeds (Lobban and Harrison, 1994). Nitrogen and phosphorus are the most important and are often the limiting factor in the growth of seaweeds and phytoplankton. After nitrogen (nitrate and ammonium forms) is taken up, it is usually used to synthesize amino acids and proteins for growth. Phosphorus plays key roles in the formation of many biomolecules, such as nucleic acids, proteins, and phospholipids (the latter are important components of membranes). However, its most important role is in energy transfer through ATP and other high-energy compounds in photosynthesis and respiration and in "priming" molecules for metabolic pathways. Experimental study on nutrients by Karez *et al.* (2004) showed that the composition of the ephemeral assemblage changed with nutrient richness. Therefore, nutrients can play an important role in the biodiversity, abundance and distribution of seaweeds.

Light and temperature are important abiotic factors affecting plants. The primary importance of light to seaweeds is in providing the energy for photosynthesis (Lobban and Harrison, 1994). Also, light controls the formation of tetrasporangia in the tetrasporophytes of some seaweeds (Guiry, 1992), among its many other physiological effects. Temperature is a singularly important factor governing the life processes and the distribution of organisms. Marine organisms are extremely susceptible to desiccation due to exposure to high temperatures (Nybakken, 2001). This especially affects intertidal organisms, which have evolved mechanisms to counteract the effects of desiccation. Often there will be temperatures at which growth is optimal, although these may vary with different life cycle stages. Therefore, water temperature influences growth (Kubler Dudgeon, 1996), abundance and distribution of some seaweeds (Gordon Guist *et al.*, 1982; Peckol, 1983; North *et al.,* 1986; Guiry, 1992; Kubler and Dudgeon, 1996; Scrosati, 2001).

The most important effects of salinity are the osmotic consequences of the movement of water molecules along water-potential gradients and the flow of ions along electrochemical gradients. It has been shown that salinity changes may control distribution of the seaweed *Macrocystis* (North *et al.,* 1986).

***Acanthophora* and *Chondrophycus***

Preliminary study showed that *Acanthophora spicifera* and *Chondrophycas tronoi*, which have a wide distribution in both tropical and subtropical habitats, occurs primarily in the tidal and subtidal zones, are also dominant at Sirinat Marine National Park, Phuket. *A. spicifera* is an economic species. They are used for abalone feeding, which increases abalone growth and survival rate (personal communication). *C. tronoi* contains rich secondary compounds and very common on this shore (Prathep, 2005). In addition, there are some other interesting characters of both species. Fragmentation is a significant mode asexual reproduction of *A. spicifera.* It increases their distribution on the shore. Its branching pattern and number of branches vary with the amount of wave exposure (Kilar and McLachlan, 1986a). In addition, Gupta *et al.* (1991) discovered antimicrobial activity in *A. spicifera.*

Saito (see Saito and Womersley, 1974) divided the Japanese species of *Laurencia* Lamouroux into two subgenera: *Laurencia* and *Chondrophycus.* 1) *Laurencia* has secondary pit-connections between the epidermal cells and parallel arrangement of tetrasporangia, while *Chondrophycus* lacks such secondary pit-connections between epidermal cells and has a right-angle (cruciate) arrangement of tetrasporangia. 2) *Chondrophycus tronoi* was known as *Laurencia tronoi* Ganzon-Fortes (1982) subgenus *Chondrophycus, Laurencia* subgenus *Chondrophycus* was recently raised to generic status as *Chondrophycus* (Tokida *et* Saito) Garbary *et* Harper (see Nam, 1999). Previous studies have focused on secondary metabolites of

*Laurencia* spp.; the chemical compounds produced by this species (Masuda *et al.*, 1997; Masuda *et al.*, 2002; Takahashi *et al.*, 1998).

Both *Acanthophora* and *Chondrophycus* are invasive marine algae in Hawaii. These two species have been studied extensively at the University of Hawaii (ALIEN-HOME.htm; http://www.botany.hawaii.edu/invasive). Therefore, it also would be interesting to study branching pattern and reproductive cycle of both species here in Thailand since they are potential economic species and common on the shore.

**Hypotheses**

1. Differences in physical factors seasonally cause differences in diversity, abundance and distribution of macroalgae.

2. Differences in wave action cause differences in morphology of *Acanthophora spicifera* and *Chondrophycus tronoi.*

**Objectives**

The purposes of this study are to:

1) Assess the biodiversity of macroalgae at Sirinat Marine National Park, Phuket.

2) Study the effects of physical factors (wave motion, nutrient concentrations: $NO_3^-$, $PO_4^{3-}$, salinity, temperature, light) on diversity, abundance and distribution of macroalgae.

3) Compare morphology of *Acanthophora spicifera* and *Chondrophycus tronoi* at different degree of wave exposure sites.

## 2. MATERIALS AND METHODS

### Study sites

Preliminary observations showed that there is a high diversity of marine organisms, including macroalgae at Sirinat Marine National Park. Also, since Sirinat Marine National Park is a protected area, it is an ideal place for an area based marine study (Prathep, 2005).

The study site is located at the coastal area of Sirinat Marine National Park, Phuket, Southern Thailand (8°05'N, 98°17'E) (Figure 1). The park has a variety of habitats including rocky shores, coral reefs and seagrass beds. In addition, there are variations in the degree of wave exposure. Therefore, sampling sites were divided along the shoreline at the intertidal level with different degrees of wave exposure: sheltered, semi-exposed and exposed. In the exposed area, organisms were directly affected by wave action, which was less in semi-exposed and sheltered areas due to protection by fringing reefs. The water current was measured at each site during March 2004 using mini current meter model SD-4 (4A) (Sensordata a.s., Bergen, Norway). The average water current at the bottom was 2 m/s at the sheltered, 4.8 m/s at the semi-exposed and 6.8 m/s at the exposed areas, respectively.

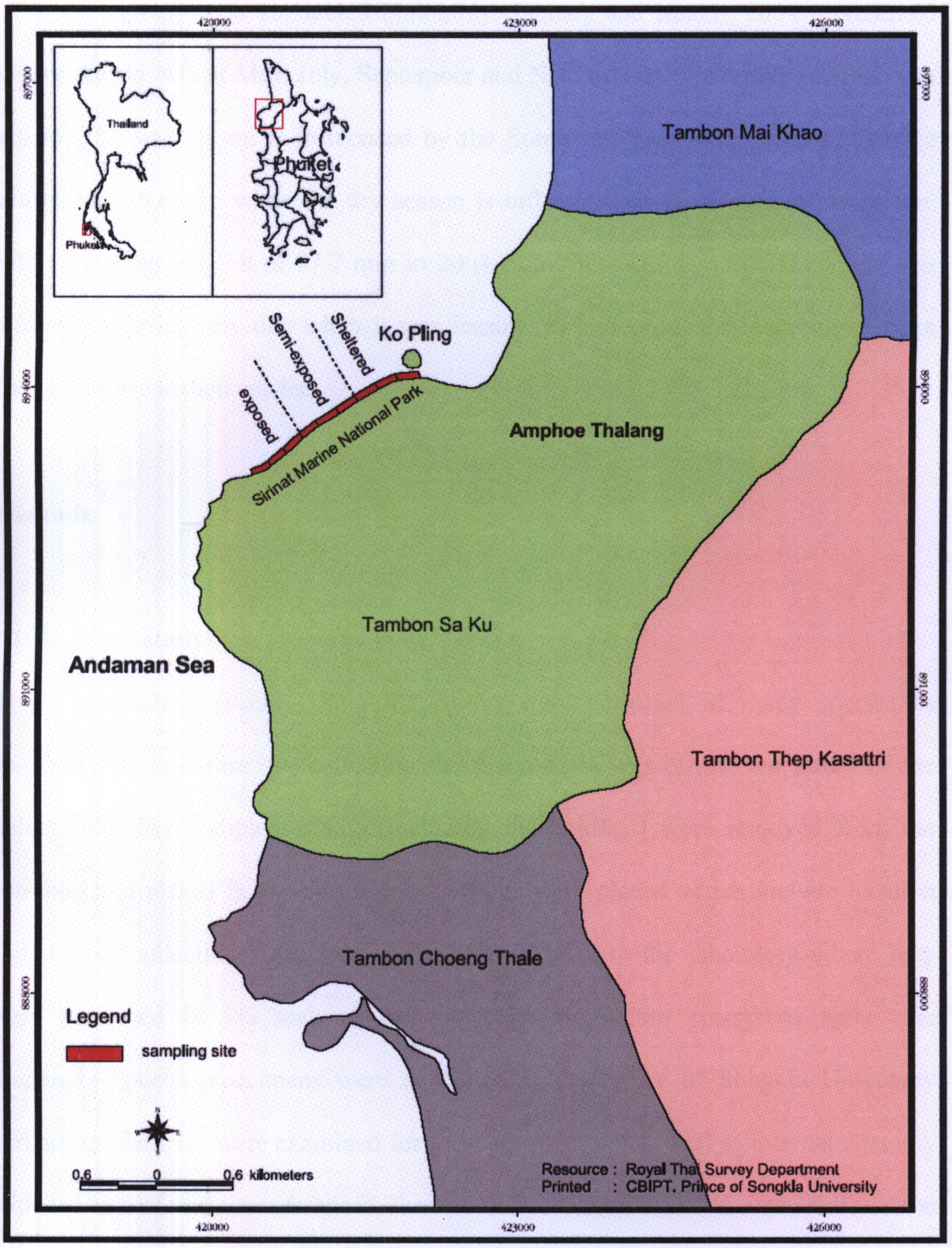



Figure 1. Study area. Location of the transects along the coast of Sirinat Marine National Park, Phuket, Southern Thailand.

Samplings were conducted bimonthly. January and March, 2004 represented the dry season, whilst May, July, September and November, 2004 represented the wet season. The wet season is influenced by the Southwest Monsoon, with an average rainfall of 289.8 mm while the dry season is influenced by the Northeast Monsoon, with an average rainfall of 87.7 mm in 2004 (http://www.tmd.go.th). The study was carried out during low tide when it was feasible to collect all the macroalgae. Skin diving was used when needed.

**Methods**

**2.1 Diversity study**

Macroalgae species along the shores were collected as many species as possible. The best time for collecting the macroalgae was during the hours of the falling tide. The complete plants (including the holdfast) were removed from the substrate and placed in the plastic bags. Labels were placed which include location and date of collection. Specimens were brought back to the laboratory where they were preserved in 4% seawater-formaldehyde. Herbarium specimens were also prepared. Voucher specimens were deposited at the Prince of Songkla University herbarium. Samples were examined for gross morphology as well as internal anatomy with the use of various references, the systematic arrangement of algae follows the scheme of Lewmanomont and Ogawa (1995) and others such as Egerod (1971, 1974, 1975), Wei and Chin (1983), Abbott (1988), Huisman (2000) and Littler and Littler (2000).

## 2.2 Abundance and distribution study

Sampling sites were selected along the shoreline at different degrees of wave exposure: sheltered, semi-exposed and exposed area according to the water currents. In the exposed area, organisms were directly affected by wave action, which was less in semi-exposed and sheltered areas due to protection by fringing reefs. Line transects perpendicular to the shoreline were used to sample macroalgae distribution. Ten of 120 m long equidistant transects were conducted among the different degrees of wave exposure which were located perpendicular to the shore at interval of 100 m. Three lines each were set on the sheltered and exposed areas, and four lines were set on the semi-exposed area. Three of 50cm×50cm quadrats were used to estimate percentage cover of macroalgae at 20 m intervals along the transect, at three shore levels: 0-40 m was upper shore level, 41-80 m was mid shore level and 81-120 m was lower shore level (Figure 2). Percentage cover of macroalgae was estimated visually and the substrates of macroalgae were recorded at the site.

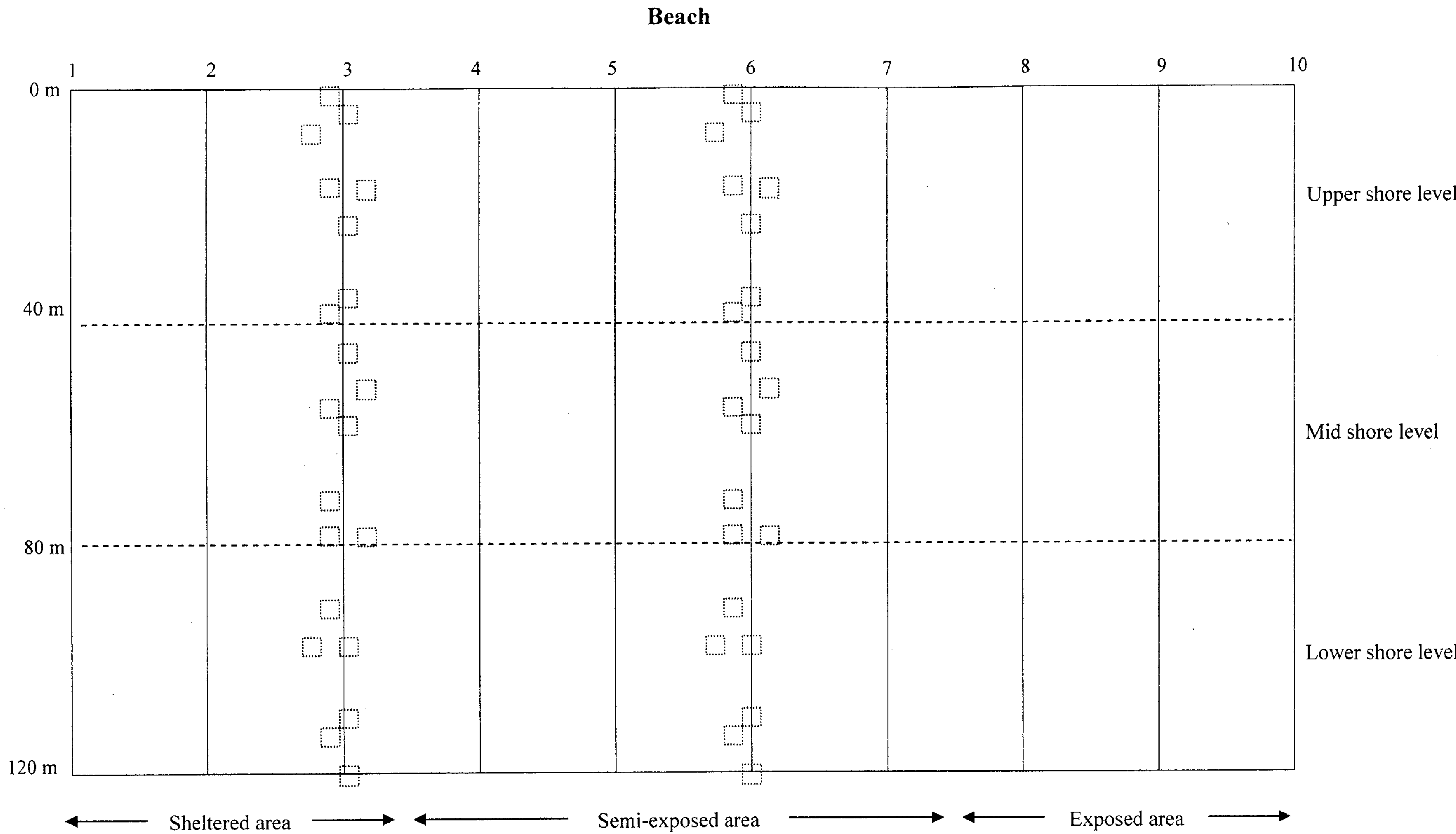



Figure 2. Map of the transects, which were located perpendicular to the shore.

### 2.3 Variations in morphology and reproduction of *Acanthophora spicifera* and *Chondrophycus tronoi*

Thirty individuals of *Acanthophora spicifera* and *Chondrophycus tronoi* were collected from the sheltered, semi-exposed and exposed areas. Length, diameter and pattern of branching were measured.

The reproductive stages of *Acanthophora spicifera* and *Chondrophycus tronoi* were identified, by compound microscope.

Length was measured from holdfast to the highest portion of a main axis. The plants were cross sectioned at the middle portion of the main axis and their diameters were measured by a micrometer.

The pattern of branching was measured using the Strahler method. Apical branches were referred as primary branch, and two of these meet to form a second order branches and so on to main stem (Barker *et al.*, 1973; Garbary *et al.*, 1980).

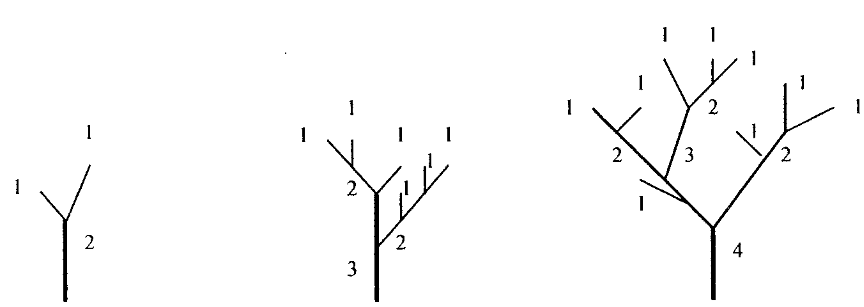


Figure 3. Branching system ordered by the Strahler method (Garbary *et al.*, 1980).

### 2.4 Physical factors study

Physical factors were measured. A mini-current meter was used to record wave motion. Water samples were collected from study sites and sent for $NO_3^-$ and

$PO_4^{3}$ nutrient analysis at the Scientific Equipment Center of Faculty of Science. Salinity, temperature and light were recorded in situ using a salinometer, a thermometer and a lux-meter, respectively.

**2.5 Statistical analyses**

Non-parametric statistics, the Friedman test, was employed to test percentage cover of each species against different sites and seasons. The abundance of each species was calculated by a mean cover value. Distribution of each species was expressed by using mean cover plotted against distance.

The diversity was calculated as a modified Shannon-Wiener index (Díez *et al.*, 2003) as:

$$H' = - \Sigma (n_i /N) \log_2 (n_i /N)$$

where $N$ is the total algal cover and $n_i$ is the cover of the $i$th species.

Canonical correspondence analysis (McCune and Grace, 2002) was used to examine the relationships between species distributions and environmental factors. Canonical correspondence analysis (CCA) was selected among unimodal methods because this is a direct gradient analysis that displays the variation of vegetation in relation to the included environmental factors by using environmental data to order samples.

Two ways ANOVA were employed to test the effects of sites and seasons on length, diameter and branching pattern of *A. spicifera* and *C. tronoi* using SPSS version 11.5 for windows.

# 3. RESULTS

## 3.1 Diversity study

A total of 52 species were identified representing 22 species of Rhodophyta, 16 species of Chlorophyta, 9 species of Phaeophyceae in Chromophyta and 5 species of Cyanobacteria (Table 1). Of these, 9 species are believed to be new records for the Thai marine flora.

Species numbers varied during the study period and ranged from a low of 15 species (March 2004) to a high of 29 species (May and July 2004). *Lyngbya majuscula, Halimeda opuntia, Boergesenia forbesii, Valonia aegagropila, Dictyosphaeria cavernosa, Boodlea composita, Acanthophora spicifera, Chondrophycus tronoi, Ceramium mazatlanense, Gelidiella acerosa, Gracilaria salicornia, Hypnea spinella* and *Padina australis* were found throughout the year. On the other hand, *Symploca* sp., *Bryopsis pennata, Caulerpa racemosa* var. *peltata, Acetabularia pusilla, A. exigua, A. parvula, Enteromorpha flexuosa* subsp. *paradoxa, Valoniopsis pachynema, Chondrophycus papillosus, Polysiphonia sphaerocarpa, Corallophila huysmansii, Gracilaria irregularis, G. rhodymenioides,* and *Sargassum* spp. had only a single occurrence.

Table 1. Seasonality of macroalgae at Sirinat Marine National Park, Phuket Province, Thailand, between January 2004 and November 2004.

| Taxa | Sheltered | | | | | | Semi-exposed | | | | | | Exposed | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Mar | May | Jul | Sep | Nov | Jan | Mar | May | Jul | Sep | Nov | Jan | Mar | May | Jul | Sep | Nov |
| **Division Cyanobacteria** | | | | | | | | | | | | | | | | | | |
| *Calothrix scopulorum* (Weber & Mohr) C. Agardh | | | | + | + | | | | | | | | | | | + | | |
| *Lyngbya majuscula* (Dillwyn) Harvey | + | + | + | + | | | + | + | + | | | | + | + | + | | | |
| *Lyngbya* sp. | | | | + | | | | | | | | | | | | | | |
| *Symploca hydnoides* (Harvey) Kützing | | | | + | + | | | | + | + | + | + | | | | + | + | + |
| *Symploca* sp. | | | | | | | | | | | + | | | | | | | |
| **Division Chlorophyta** | | | | | | | | | | | | | | | | | | |
| *Bryopsis pennata* Lamouroux | | | | | | | | | | | | | | | | + | | |
| *Caulerpa racemosa* var. *peltata* (Lamouroux) Eubank | | | | | | | | | | | | | | | | + | | |
| *Halimeda opuntia* (Linnaeus) J.V. Lamouroux | | + | | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Chlorodesmis hildebrandtii* A. Gepp & E. Gepp | | | | | | | | | | | | | | | | | + | |
| *Acetabularia pusilla* (Howe) Collins* | | | | | | | | | + | | | | | | | | | |
| *Acetabularia exigua* Solms-Laubach | | | | | | | | | + | | | | | | | | | |
| *Acetabularia parvula* Solms-Laubach | | | | | | | | | + | | | | | | + | | | |
| *Enteromorpha flexuosa* (Wulfen) J. Agardh subsp. *paradoxa* (C. Agardh) Bliding | | | | | | | | | | | | | | | | + | | |
| *Anadyomene wrightii* Harvey ex J. Gray | | | + | + | | | | | + | + | | + | | | + | + | | + |
| *Boergesenia forbesii* (Harvey) J. Feldmann | + | + | + | + | + | + | | + | + | + | + | + | | + | + | + | + | + |
| *Cladophoropsis sundanensis* Reinbold | | | | | | | | | | + | + | + | | | | + | + | |
| *Valonia aegagropila* C. Agardh | + | | | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Valoniopsis pachynema* (G. Martens) Børgesen | | | | | | | | | | | | | | | | + | | |
| *Dictyosphaeria cavernosa* (Forsskål) Børgesen | | + | + | + | + | + | + | + | + | + | + | + | + | | + | + | + | + |
| *Boodlea composita* (Harvey) F. Brand | + | + | + | + | + | + | + | | | + | + | + | | | + | + | + | + |
| *Struvea anastomosans* (Harvey) Piccone & Grunow ex Piccone | + | + | + | + | | | | | | + | | | | | + | + | | |
| **Division Rhodophyta** | | | | | | | | | | | | | | | | | | |
| *Jania capillacea* Harvey | + | + | + | | + | | | | + | | + | | + | | | + | | |
| *Tolypiocladia glomerulata* (C. Agardh) Schmitz | | | | | | | | | + | + | + | + | | | + | + | + | |
| *Acanthophora spicifera* (M. Vahl) Børgesen | + | + | + | | + | + | + | + | + | + | | + | | + | + | + | | + |
| *Chondrophycus papillosus* (C. Agardh) Greville | | | + | | | | | | | | | | | | | | | |
| *Chondrophycus tronoi* (Ganzon-Fortes) Nam* | + | + | + | + | + | + | + | + | + | + | + | + | | + | + | + | + | + |

Table 1. (Continued)

| Taxa | Sheltered | | | | | | Semi-exposed | | | | | | Exposed | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Mar | May | Jul | Sep | Nov | Jan | Mar | May | Jul | Sep | Nov | Jan | Mar | May | Jul | Sep | Nov |
| *Chondrophycus dotyi* (Saito) Nam* | | | | | | | | | | | | + | | | + | | | |
| *Polysiphonia sphaerocarpa* Børgesen* | | | | | | | | | + | | | | | | + | | | |
| *Centroceras clavulatum* (C. Agardh) Montagne | | | | | | | | | + | | | | | | | + | | |
| *Ceramium mazatlanense* Dawson | + | + | + | | | | + | + | + | | | | + | + | + | | | + |
| *Champia parvula* (C. Agardh) Harvey | | | + | | + | | | | + | | | | | | | | | |
| *Corallophila huysmansii* (Weber-van Bosse) R.E. Norris* | | | | | | | | | + | | | | | | | | | |
| *Gelidiopsis variabilis* (J. Agardh) F. Schmitz* | | | | + | + | + | | | | | + | | | | | | | |
| *Gelidiella acerosa* (Forsskål) Feldmann & G. Hamel | | | + | + | | + | + | + | + | + | + | + | + | | + | + | + | + |
| *Gelidiella pannosa* (J. Feldmann) J. Feldmann & G. Hamel | | | | | | | | | | | + | | | | | | | |
| *Gelidium pusillum* (Stackhouse) Le Jolis | | | | | | | | | | + | | | | | | | | + |
| *Wurdemannia miniata* (Sprengel) J. Feldmann & G. Hamel* | | | | | | | | | + | | | | | | | | | |
| *Gracilaria salicornia* (C. Agardh) Dawson | + | + | | | | | + | + | + | + | + | + | + | + | | + | + | + |
| *Gracilaria irregularis* Abbott | | | | | | | | | | | | | | | + | | | |
| *Gracilaria rhodymenioides* Millar | | | + | | | | | | | | | | | | + | | | |
| *Hydropuntia eucheumatoides* (Harvey) Gurgel & Fredericq | | | | | | | | | | | + | | | | | | + | + |
| *Hypnea spinella* (C. Agardh) Kützing* | + | + | + | + | + | + | | + | + | + | | + | + | + | | + | | + |
| *Hypnea pannosa* J. Agardh | | | | | | + | | | | | | | | | | + | | |
| **Class Phaeophyceae** | | | | | | | | | | | | | | | | | | |
| *Dictyota dichotoma* (Hudson) Lamouroux | + | | | | | + | + | | | | | + | | | | | | + |
| *Padina australis* Hauck | + | + | + | | | + | + | + | + | + | + | | + | + | + | + | + | + |
| *Sargassum polycystum* C. Agardh | | | | + | + | | | | | | | | | | | | | |
| *Sargassum cristaefolium* C. Agardh* | | | | | | | | | | | + | | | | | | | |
| *Sargassum* sp.1 | | | | | + | | | | | | | | | | | | | |
| *Sargassum* sp.2 | | | | | + | | | | | | | | | | | | | |
| *Turbinaria conoides* (J. Agardh) Kützing | | | | | + | | | | | | | | | | | | | |
| *Turbinaria ornata* (Turner) J. Agardh | | | | + | + | + | | | | | | + | | | | + | + | |
| *Turbinaria decurrens* Bory de Saint-Vincent | | | | | | | | | | | + | | | | | | + | |

Diversity index : Sheltered area = 0.92 ± 0.07
Semi-exposed area = 1.00 ± 0.13
Exposed area = 0.94 ± 0.16

* new record for Thailand

**Division Cyanobacteria**

***Calothrix scopulorum* (Weber & Mohr) C. Agardh** (Figure 4a, b)

Maosen and Chengkui 1985, p. 16, fig. 2; Umezaki and Lewmanomont 1991, p. 33; Lewmanomont *et al.* 1995, p. 26

Basionym: *Conferva scopulorum* Weber & Mohr

Thallus hemispherical, to 15 mm in diameter, green to dark green. Trichomes embedded in firm gelatinous matrix, 2-7 μm diameter. Gelatinous sheaths, colorless or yellow. Filament 1500-2000 μm long, 5-7 μm in diameter. Heterocysts basal, spherical to oval, 7-10 μm long.

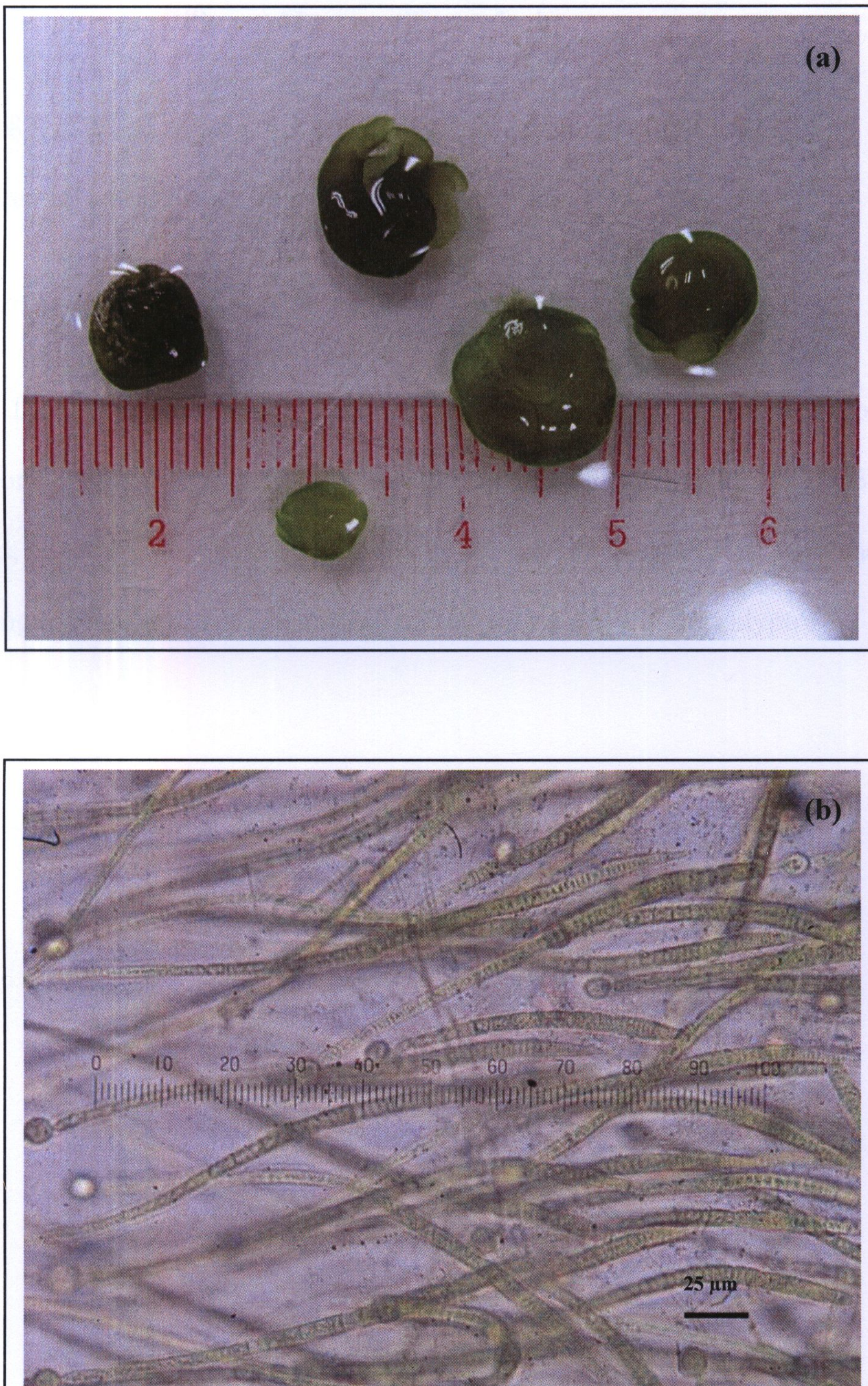


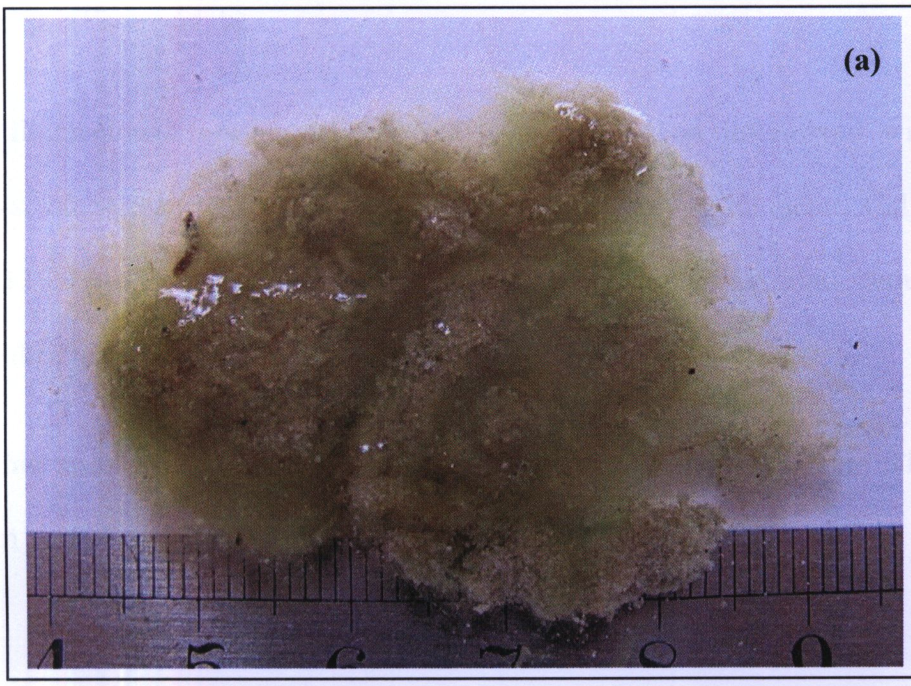

Figure 4. *Calothrix scopulorum* (Weber & Mohr) C. Agardh (a) thallus hemispherical, (b) hairlike filaments with heterocysts

***Lyngbya majuscula* (Dillwyn) Harvey** (Figure 5a, b)

Tseng 1983, p. 26, pl. 17, fig. 4; Umezaki and Lewmanomont 1991, p. 37; Lewmanomont and Ogawa 1995, p. 19; Lewmanomont *et al.* 1995, p. 17

Basionym: *Conferva majuscula* Dillwyn

Hairlike filaments, blue-green, yellowish or blackish green. Filaments elongated, straight or slightly flexuous, 20-25 µm in diameter. Sheath hyaline, up to 3 µm in thickness, generally lamellated. Trichome 15-20 µm in diameter. Cell very short, 2-3 µm in length, cross wall not constricted, apical cell round, without calyptra.



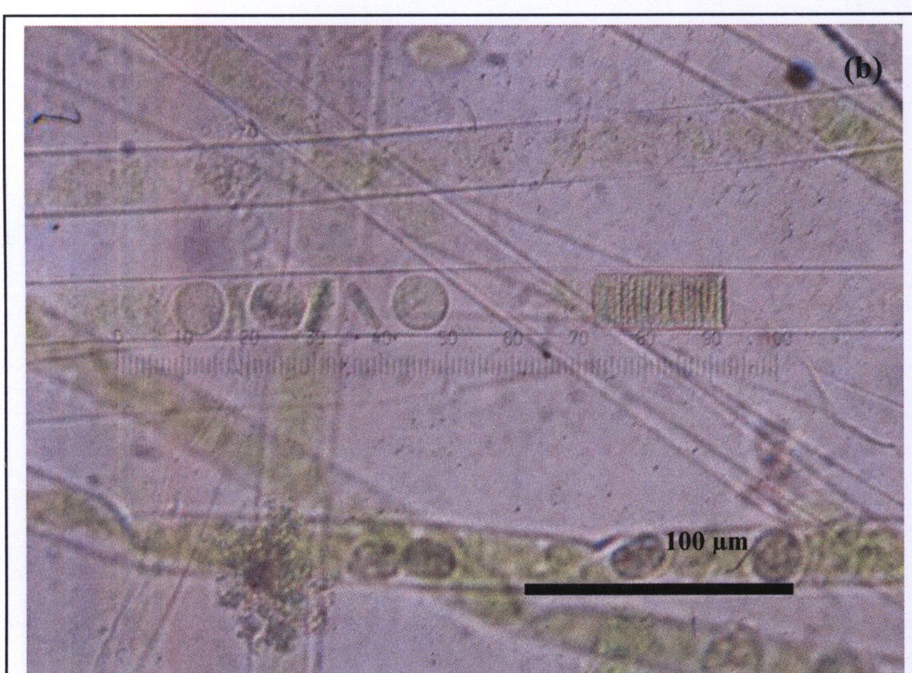




Figure 5. *Lyngbya majuscula* (Dillwyn) Harvey (a) forming tangled masses, (b) hairlike filaments with hyaline sheath

***Lyngbya* sp.** (Figure 6a, b)

Thallus filamentous, forming tangled masses, binding and intermixed with fine sediments, blue-green to black-green. Filament 18-20 μm in diameter, Cells disc-shaped, 17-20 μm in diameter, 2-3 μm in length. Sheaths colorless, thin, about 1 μm thick, broken quite easily.

Note: This species is similar to *Lyngbya majuscula* (Dillwyn) Harvey. They are similar in size of trichome, but it has a very thin sheath.

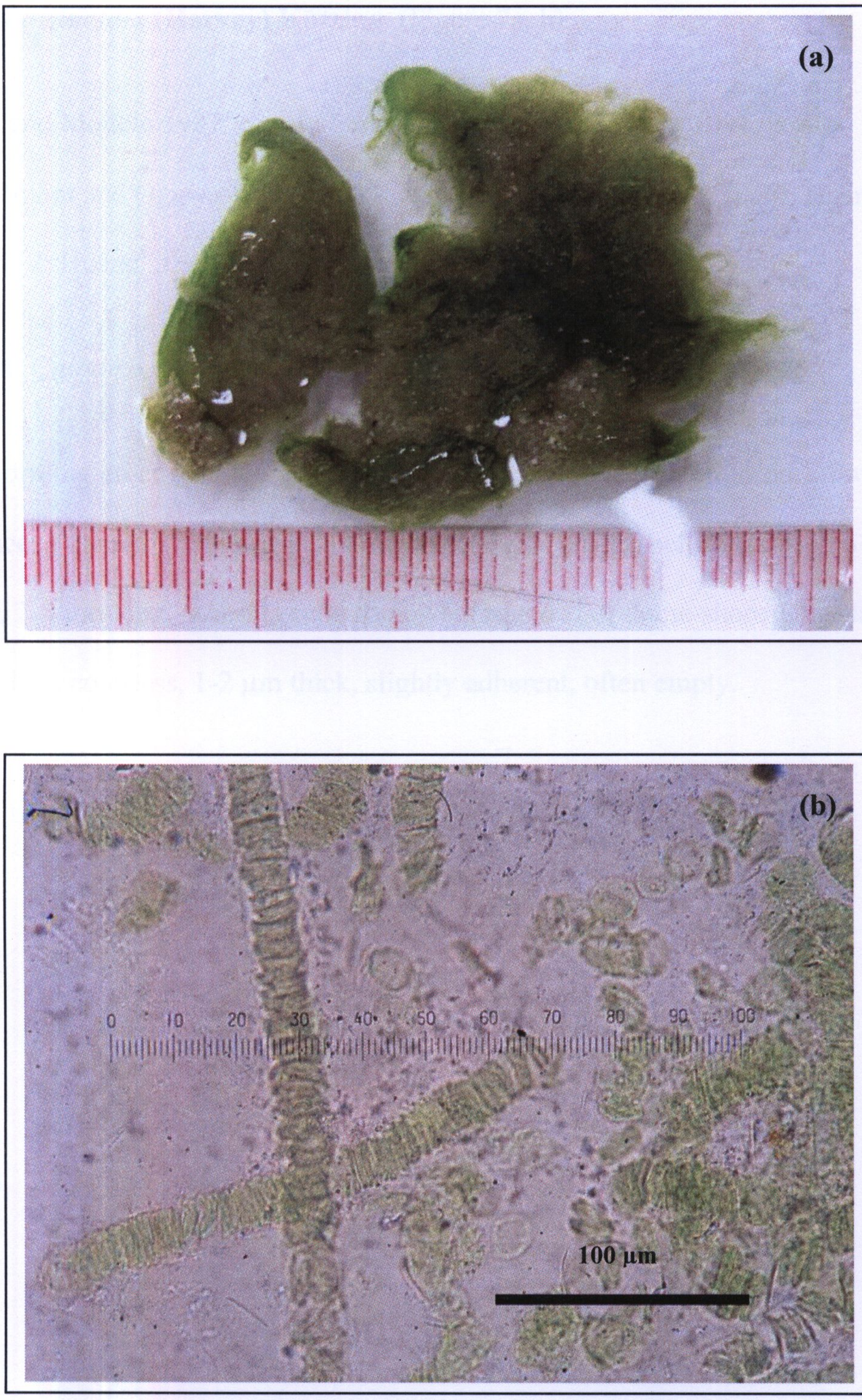



Figure 6. *Lyngbya* sp. (a) forming tangled masses, (b) filaments with thin sheaths

***Symploca hydnoides* (Harvey) Kützing** (Figure 7a, b)

Umezaki and Modelo 1987, p. 110; Umezaki and Lewmanomont 1991, p. 40; Lewmanomont and Ogawa 1995, p. 20; Lewmanomont *et al.* 1995, p. 20; Huang 1998, p. 112; Huang 2000, p. 208

Basionym: *Calothrix hydnoides* Harvey

Thallus forming erect bundles, wick-like, to 3 cm high, blue-green to dark brown on the surface. Filaments 5-8 µm in diameter, straight, not branched. Cells 5-6 µm in diameter, 2-4 µm long, terminal cells somewhat rounded or dome-shaped, not tapered. Sheaths clear, colorless, 1-2 µm thick, slightly adherent, often empty.

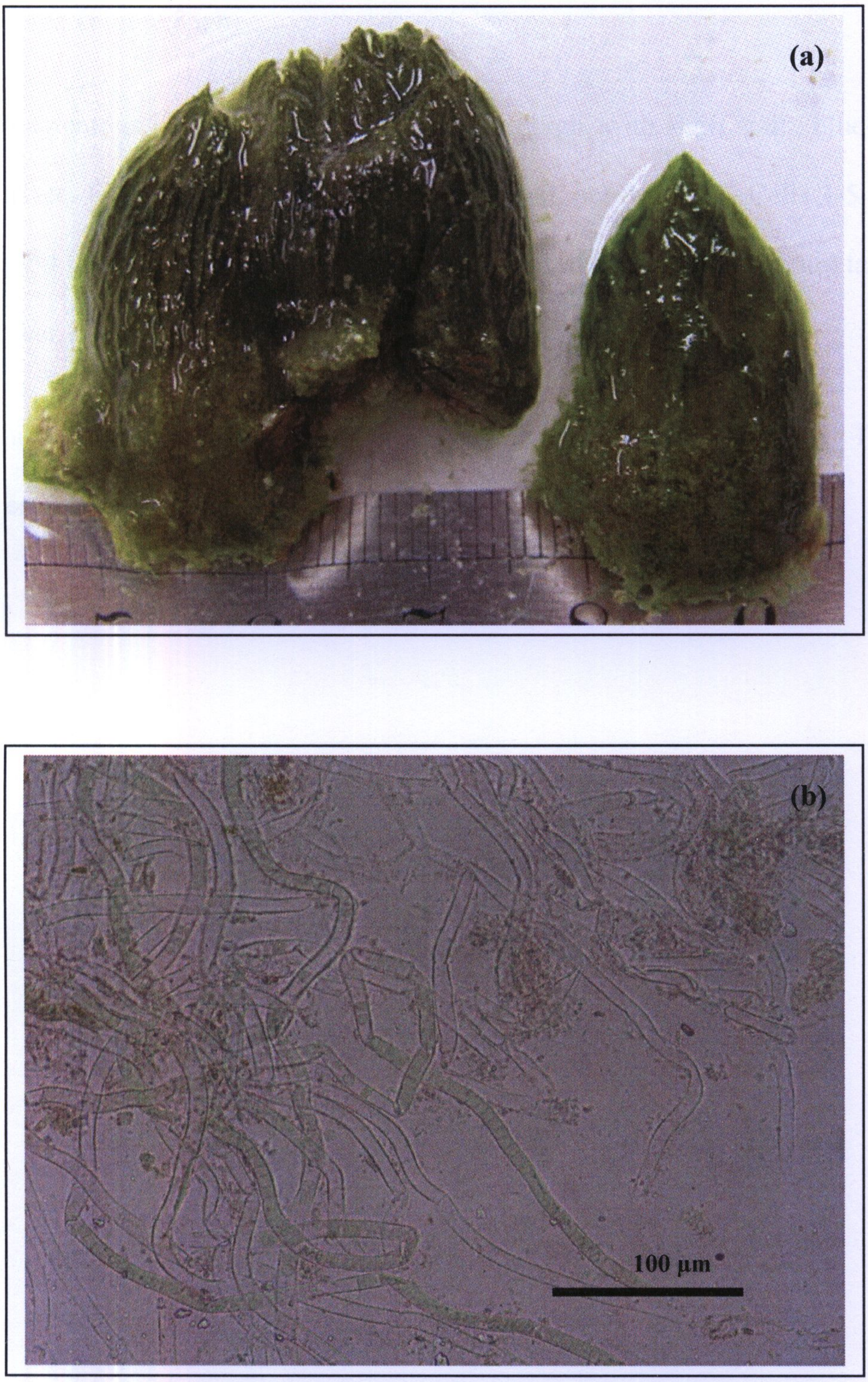



Figure 7. *Symploca hydnoides* (Harvey) Kützing (a) thallus forming erect bundles, (b) straight filaments

***Symploca* sp.** (Figure 8a, b)

Thallus filamentous, forming erect bundle, 3-4 cm high, with short stalk, blue-green on the surface. Filaments 4-6 µm in diameter, straight, not branched. Cells 3-5 µm in diameter, 2-4 µm long, terminal cells somewhat rounded or dome-shaped, not tapered. Sheaths clear, colorless, 1-2 µm thick.

Note: This species is similar to *Symploca hydnoides* (Harvey) Kützing. Thallus forming erect bundle with short stalk. It is rather small in size of trichome.

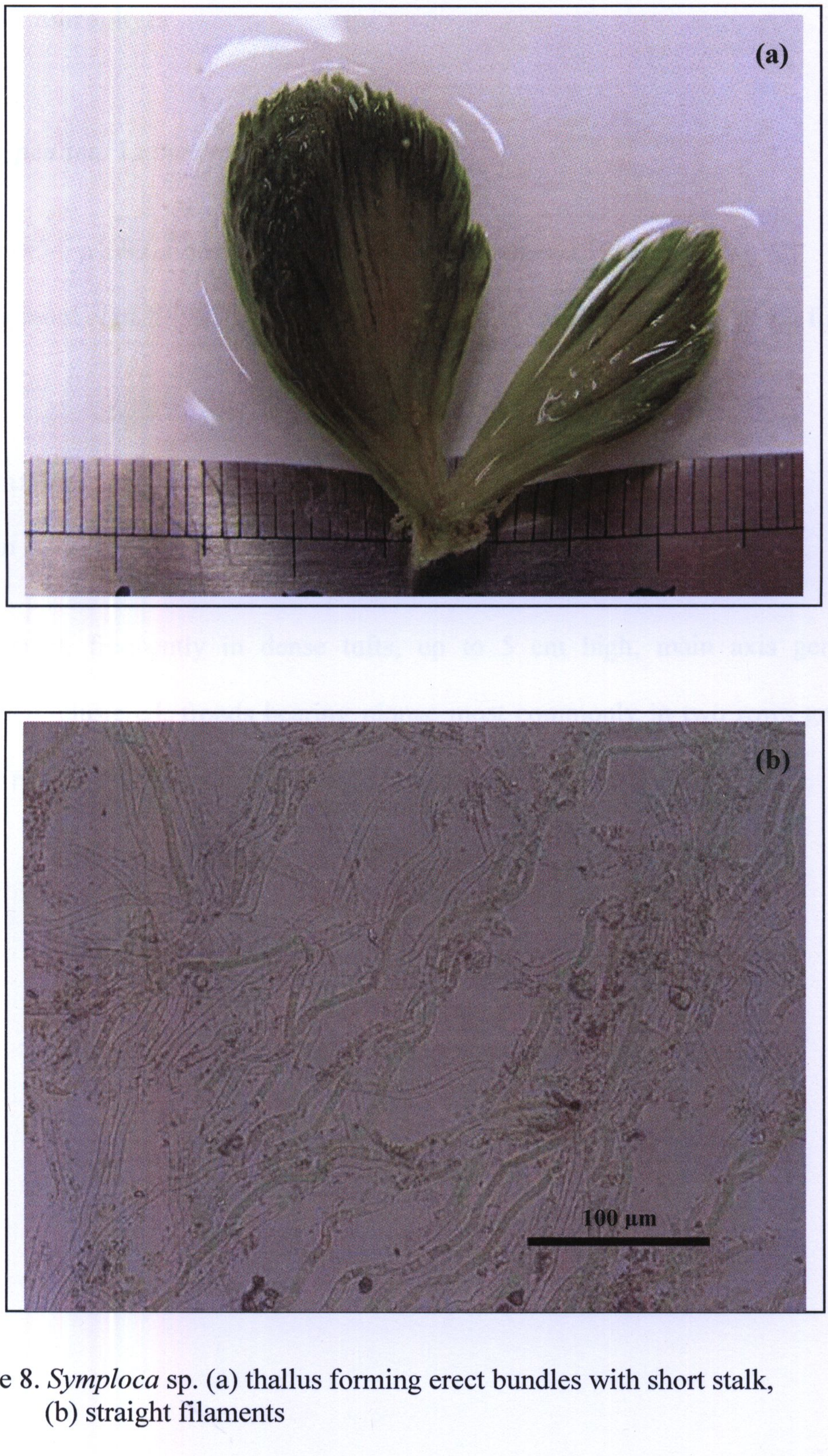



Figure 8. *Symploca* sp. (a) thallus forming erect bundles with short stalk, (b) straight filaments

**Division Chlorophyta**

***Bryopsis pennata* Lamouroux** (Figure 9a, b)

Dawson 1954, p. 393, fig. 11a; Lewmanomont and Ogawa 1995, p. 28; Lewmanomont *et al.* 1995, p. 42; Coppejans and Van Den Heede 1996, p. 52, figs. 8, 9, 12, 16, 20

Synonym: *Bryopsis plumosa* (Hudson) C. Agardh var. *pennata* (Lamouroux) Børgesen

Thallus erect, frequently in dense tufts, up to 5 cm high, main axis generally unbranched, clustered, fronds bearing pinnae most commonly in two rows growing from the margins of the axes, constricted at their base.

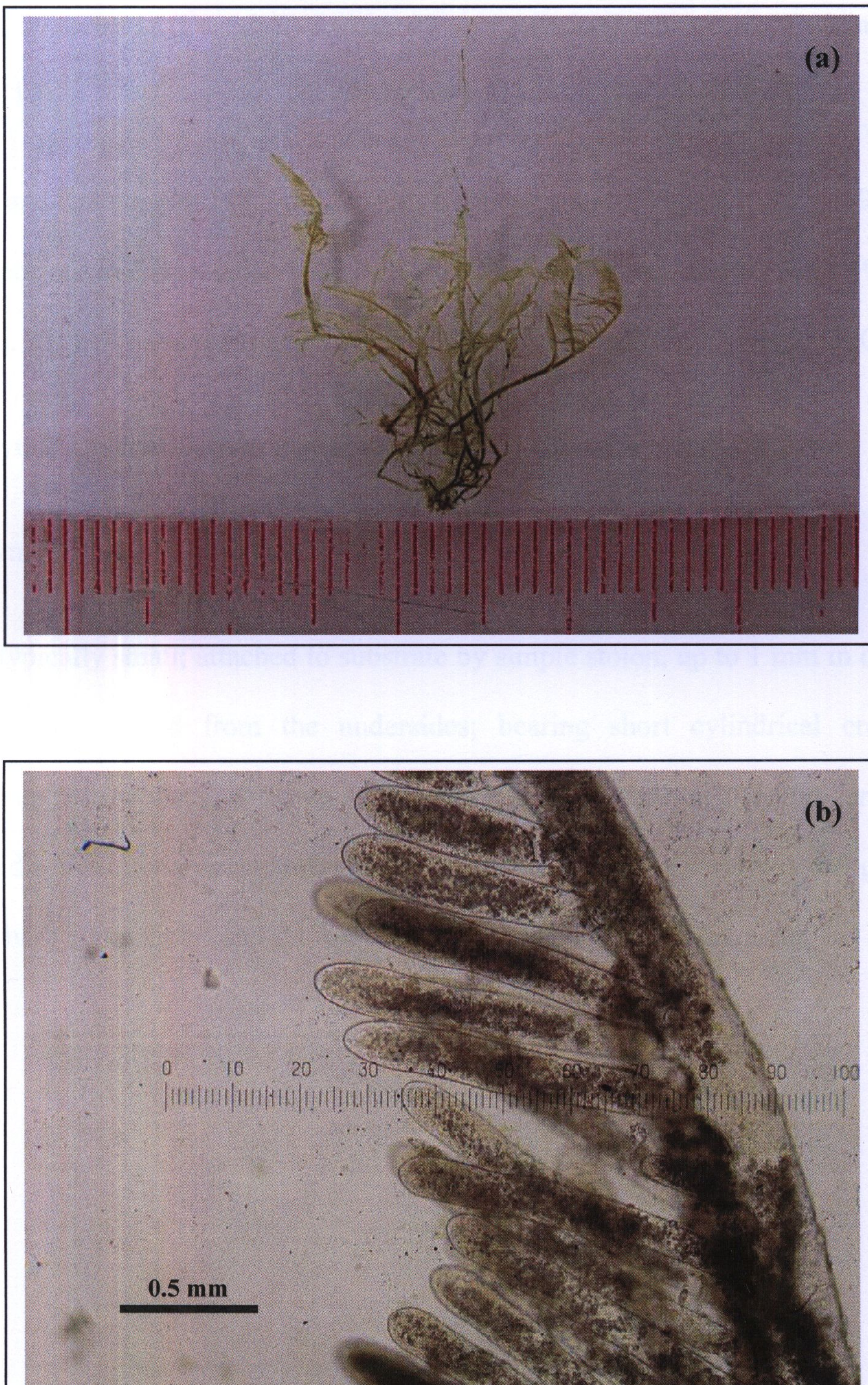



Figure 9. *Bryopsis pennata* Lamouroux (a) plant habit, (b) details of branchlets

***Caulerpa racemosa* (Forsskål) J. Agardh var. *peltata* (Lamouroux) Eubank**

(Figure 10)

Meñez and Calumpong 1982, p. 8, pl. 2k; Coppejans and Meinesz 1988, p. 191, fig. 24; Coppejans and Beeckman 1989, p. 388, figs. 27-29; South and N'Yeurt 1993, p. 130, fig. 23; Lewmanomont *et al.* 1995, p. 48; Skelton and South 2004, p. 300

Basionym: *Caulerpa peltata* Lamouroux

Synonyms: See Silva *et al.* (1996, p. 829)

Plants typically small; attached to substrate by simple stolon, up to 1 mm in diameter, with rhizoids issued from the undersides; bearing short cylindrical erect axes producing peltate discs, 3-5 mm in diameter, either single at the end, or bearing several discs axially arranged around the main branches. This variety is recognized as having both compressed and sub-globose racemes on an individual plant.


Figure 10. *Caulerpa racemosa* var. *peltata* (Lamouroux) Eubank

***Halimeda opuntia*** **(Linnaeus) Lamouroux** (Figure 11)

Dawson 1954, p. 395; Lewmanomont and Ogawa 1995, p. 52; Lewmanomont *et al.* 1995, p. 44; Trono 1997, p. 59, fig. 60

Basionym: *Corallina opuntia* Linnaeus

Synonyms: See Silva *et al.* (1996, p. 871)

Thallus composed of many calcified kidney-shaped segments, 0.2-0.5 mm long, broader than long, forming irregularly loose clumps attached by fine rhizoids at various points where segments of the thallus come in contact with the substratum, joints between segments uncalcified. Light green in color.


Figure 11. *Halimeda opuntia* (Linnaeus) J.V. Lamouroux

***Chlorodesmis hildebrandtii*** **A. Gepp & E. Gepp** (Figure 12a, b)

Ducker 1967, p. 164, pl. 6, 16; Egerod 1974, p. 143, figs. 44-49; Egerod 1975, p. 58; Lewmanomont and Ogawa 1995, p. 43; Lewmanomont *et al.* 1995, p. 41; Trono 1997, p. 72, fig. 49

Thallus up to 5 cm high, forming dark green tufts on rocky substrates, attached to substrate by rhizoidal filaments. Filaments uniformly cylindrical, 100-150 μm in diameter, repeatedly and dichotomously branched filaments with evenly placed supradichotomal constrictions.

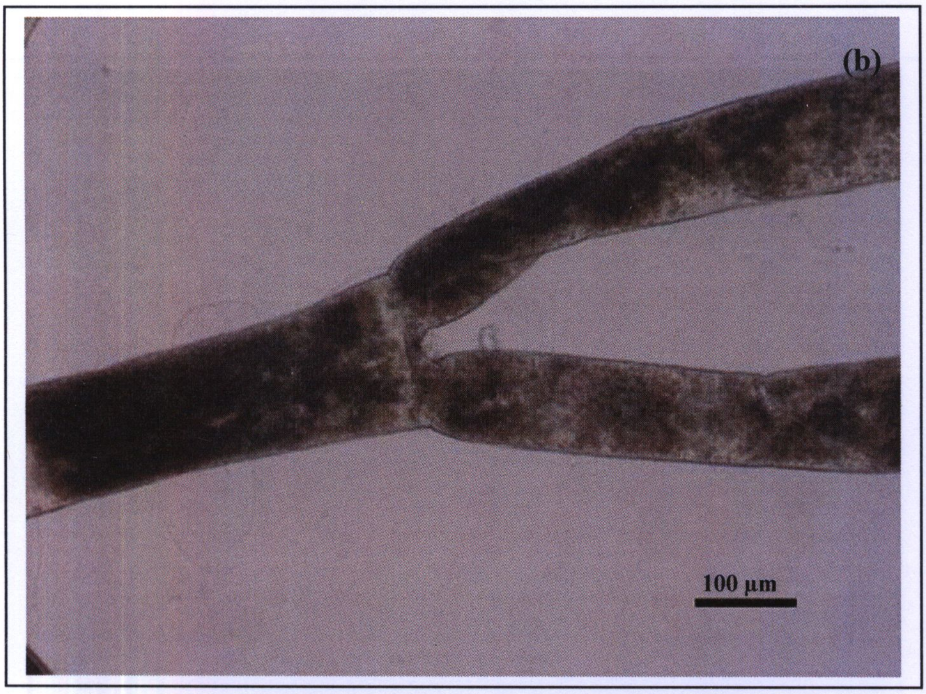




Figure 12. *Chlorodesmis hildebrandtii* A. Gepp & E. Gepp (a) plant habit, (b) dichotomously branched filaments

***Acetabularia exigua* Solms-Laubach** (Figure 13)

Egerod 1975, p. 62, figs. 34-35; Trono *et al.* 1978, p. 84, figs. 4b-f; Moorjani 1980, p. 474, fig. 4; Dong and Tseng 1985, p. 14, fig. 12, pl. 1, fig. 8; Lewmanomont *et al.* 1995, p. 51; Trono 1997, p. 89, fig. 62

Synonym: *Polyphysa exigua* (Solms-Laubach) Wynne

Thallus slightly calcified, 2-4 mm high, stipe short, slightly rugose, bearing a single apical disc. The discoid cap is composed of 7-8 gametangial rays, each ray ovoid with mammilate apex.

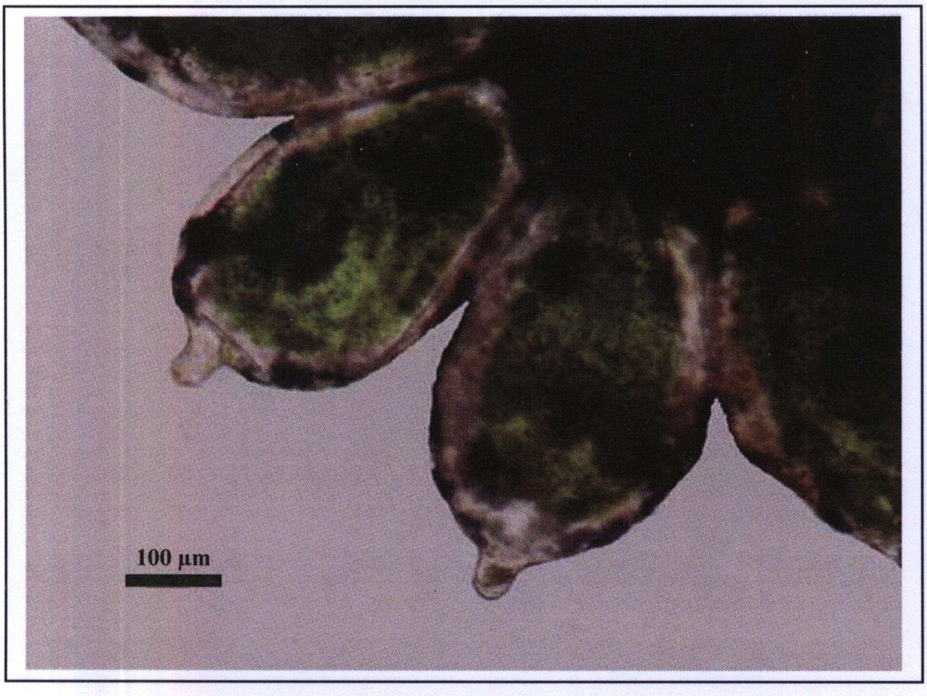



Figure 13. *Acetabularia exigua* Solms-Laubach

***Acetabularia parvula* Solms-Laubach** (Figure 14)

Egerod 1975, p. 63, figs. 36-38; Dong and Tseng 1985, p. 14, fig. 13, pl. 1, figs. 5-6, pl. 2, fig. 1; Lewmanomont *et al.* 1995, p. 51

Synonym: *Acetabularia moebii* Solms-Laubach; Trono *et al.* 1978, p. 87, fig. 4a; Moorjani 1980, p. 472, fig. 3; Trono 1997, p. 91, fig. 64

Thallus slightly calcified, 4-8 mm high, stipe slightly rugose, bearing a single flat apical gametangial disc, composed of 12-19 rays, each ray cuneate with smooth broadly rounded or emarginated distal margin.

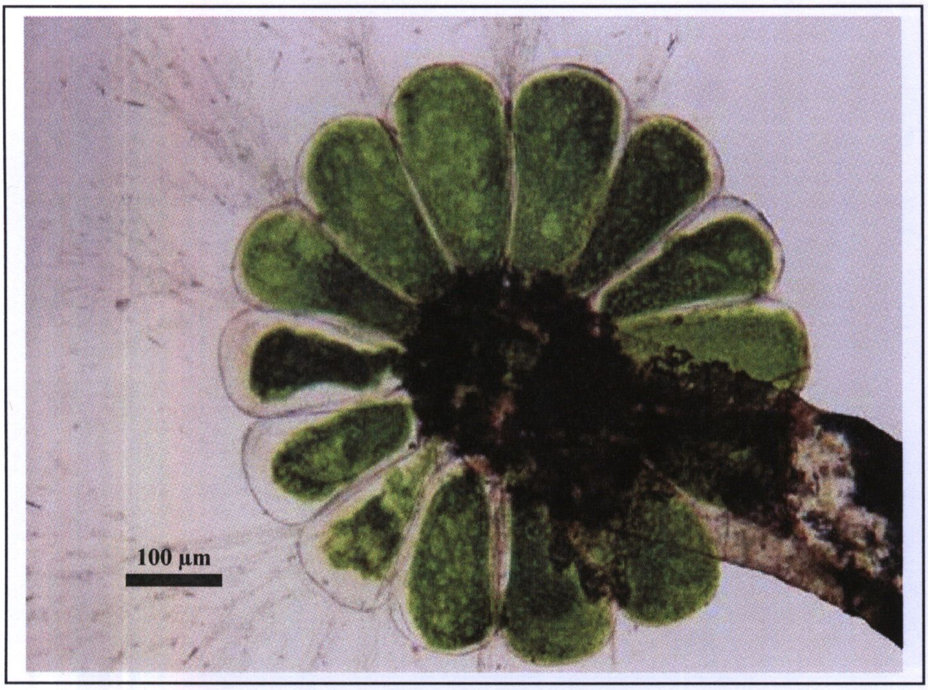



Figure 14. *Acetabularia parvula* Solms-Laubach

***Acetabularia pusilla* (Howe) Collins** (Figure 15)

Dong and Tseng 1985, p. 12, fig. 10

Basionym: *Acetabulum pusillum* Howe

Thallus slightly calcified, 1-3 mm high, slightly rugose, bearing an apical gametangial disc. Disc nearly flat, 1 mm diameter, composed of 9-11 gametangial rays. The ray slightly cemented together laterally through calcification, obovoid-clavate to clavate-subfusiform, with blunt or obtusely apical points.

This is a new record for Thailand.

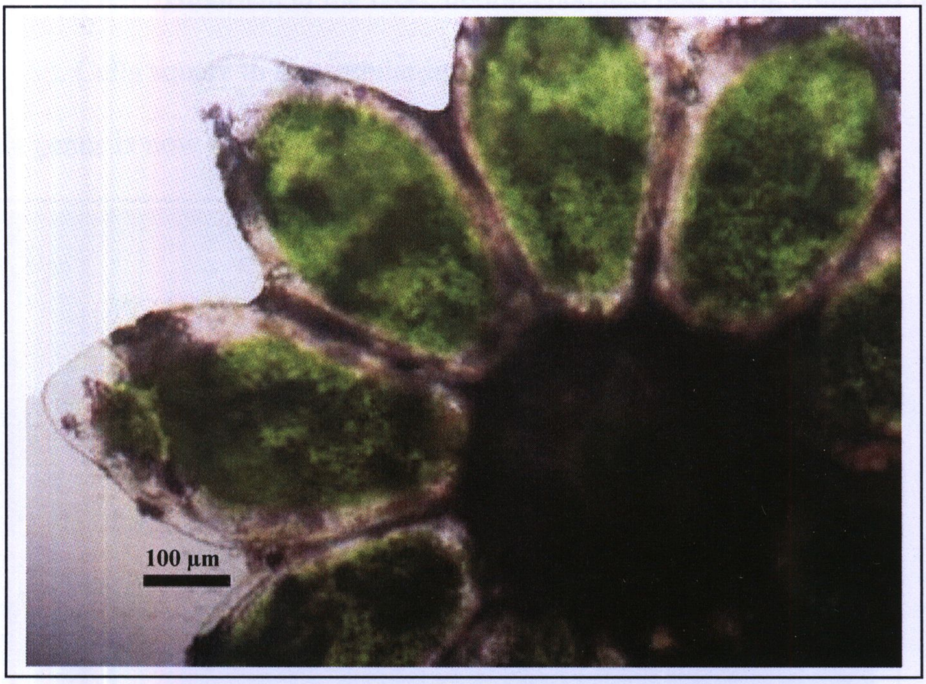



Figure 15. *Acetabularia pusilla* (Howe) Collins

**Enteromorpha flexuosa* (Wulfen) J. Agardh subsp. *paradoxa* (C. Agardh) Bliding**

(Figure 16)

Joshi and Krishnamurthy 1972, p. 122, figs. 1e, 2d, t; Egerod 1974, p. 133, figs. 1-3; Lewmanomont *et al.* 1995, p. 31; Trono 1997, p. 7

Basionym: *Conferva paradoxa* Dillwyn

Synonyms: See Silva *et al.* (1996, p. 733)

Thallus forms light to dark green mass, forming thick tufts on the substratum, attached to substratum by a small, round basal disk, producing simple or branched frond with tubular, cylindrical stalk. Branching only at the basal portion, the branches hollow, narrow and cylindrical at the base, unbranched and becoming enlarged toward the distal end. Cells square to rectangular in surface view.

Note: This genus is now belong to *Ulva* (Tan *et al.,* 1999).


Figure 16. *Enteromorpha flexuosa* (Wulfen) J. Agardh subsp. *paradoxa* (C. Agardh) Bliding

***Anadyomene wrightii* Harvey ex J. Gray** (Figure 17a, b)

Sartoni 1992, p. 292, figs. 2b-e, figs. 3b, c; Lewmanomont *et al.* 1995, p. 30

Plants consist of fan-shaped, rounded, crisp, bright green, blades up to 5 cm high, composed of polychotomously branched filaments with numerous lateral branches. Vein uniseriate, cell cylindrical. Attached to solid substrate by rhizoidal holdfast.

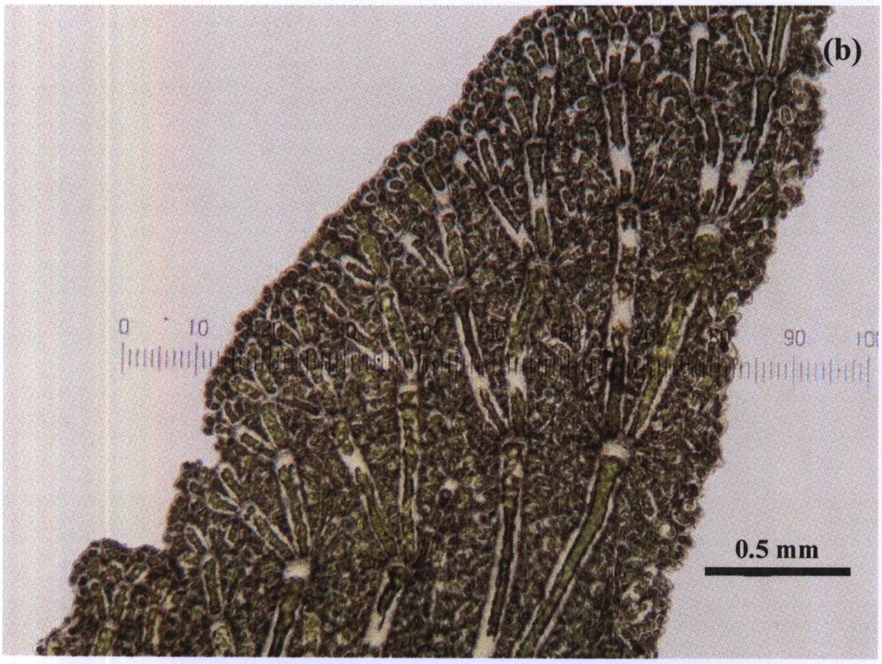




Figure 17. *Anadyomene wrightii* Harvey ex J. Gray (a) plant habit, (b) polychotomously branched filaments with lateral branches

***Cladophoropsis sundanensis*** **Reinbold** (Figure 18a, b)

Egerod 1974, p. 141, figs. 32-36; Egerod 1975, p. 46, figs. 8-10; Sartoni 1992, p. 313; Lewmanomont *et al.* 1995, p. 37; N'Yeurt 2001, p. 706, fig. 16

Thallus forming bright green tufts, to 7 cm across, composed of soft, fine filaments, up to 2.5 cm in length and up to 180 μm in diameter, filaments having the same diameter throughout, with segmented basal portion attached to the substrate by many hapteroid rhizoids. Unilaterally branched, with lateral branches arising beneath a cross wall.

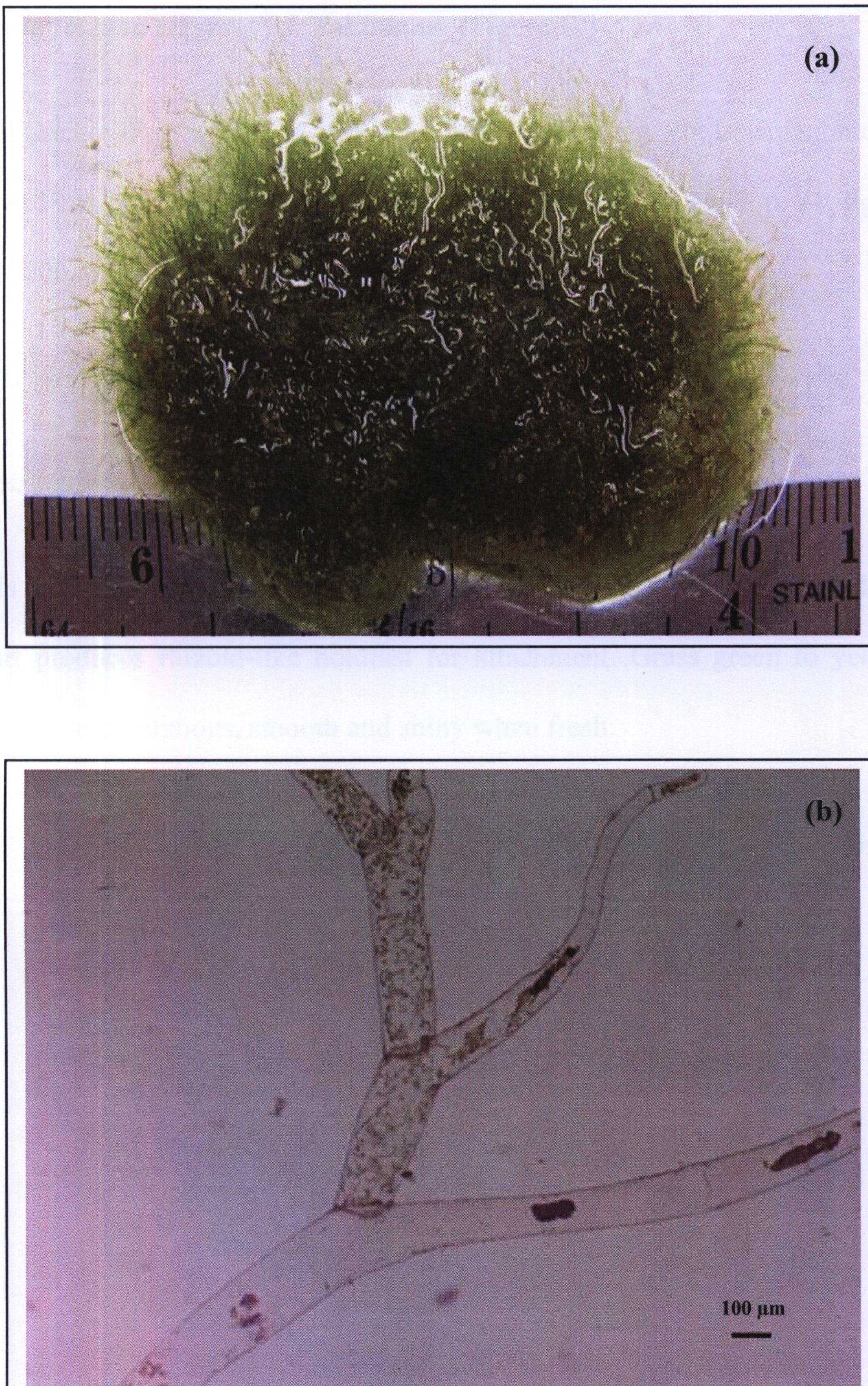



Figure 18. *Cladophoropsis sundanensis* Reinbold (a) thallus forming tufts, (b) unilaterally branched filaments

***Boergesenia forbesii* (Harvey) J. Feldmann** (Figure 19)

Trono and Ganzon-Fortes 1980, p. 9; Sartoni 1992, p. 306, fig. 7b; Lewmanomont and Ogawa 1995, p. 27; Lewmanomont *et al.* 1995, p. 34; Trono 1997, p. 21, fig. 10; Huisman 2000, p. 237

Basionym: *Valonia forbesii* Harvey

Synonym: *Pseudovalonia forbesii* (Harvey) Iyengar

Thallus is solitary or colonial, with club-shaped vesicle 2-4 cm long, liquid-filled, lower part produces rhizoid-like holdfast for attachment. Grass green to yellowish green in color, membranous, smooth and shiny when fresh.

Figure 19. *Boergesenia forbesii* (Harvey) J. Feldmann

***Valonia aegagropila* C. Agardh** (Figure 20)

Trono and Ganzon-Fortes 1980, p. 11; Lewmanomont and Ogawa 1995, p. 61; Lewmanomont *et al.* 1995, p. 33; Trono 1997, p. 26, fig. 14

Thallus composed of large, vesicular, clavate segments, 3-10 mm long, 2-3 mm in diameter, forming succulent mats of various sizes, often clumped. Vesicles slightly constricted at the base. Light green to dark green in color.

Figure 20. *Valonia aegagropila* C. Agardh

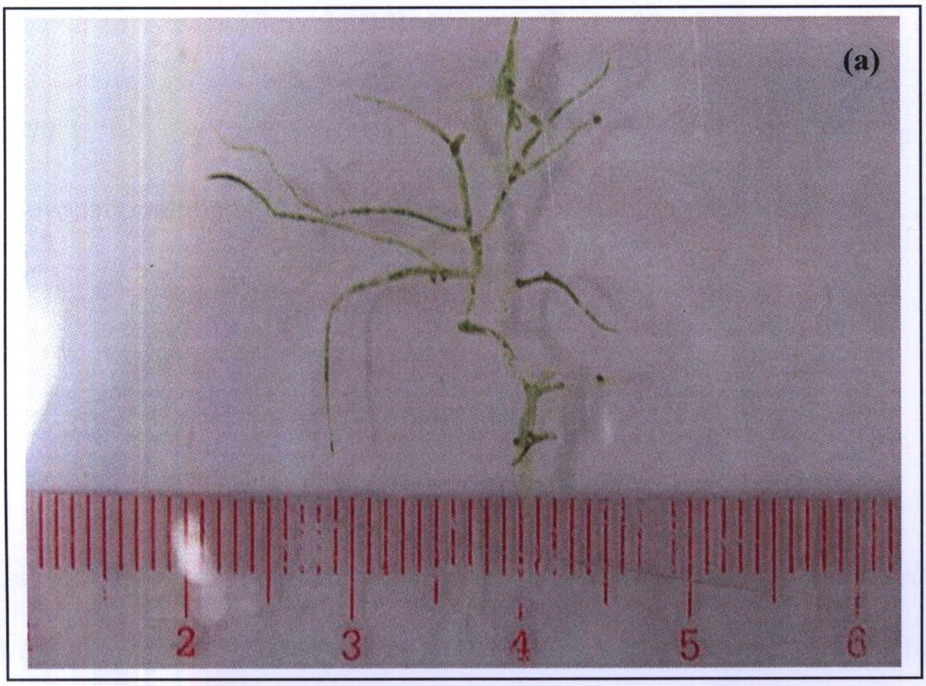
***Valoniopsis pachynema*** **(G. Martens) Børgesen** (Figure 21a, b)

Egerod 1974, p. 140, fig. 29; Egerod 1975, p. 46; Tseng 1983, p. 272, pl. 135, fig. 2; Sartoni 1992, p. 323, fig. 14d; Lewmanomont *et al.* 1995, p. 34

Basionym: *Bryopsis pachynema* G. Martens

Synonym: *Valonia confervoides* Harvey ex J. Agardh

Thallus bright green, loosely entangled, forming wide cushions, attached to substrate by irregularly branched and septate rhizoids. Branches unilateral or palmate, the coenocytes cylindrical, 3-5 mm long, 500-850 μm in diameter.



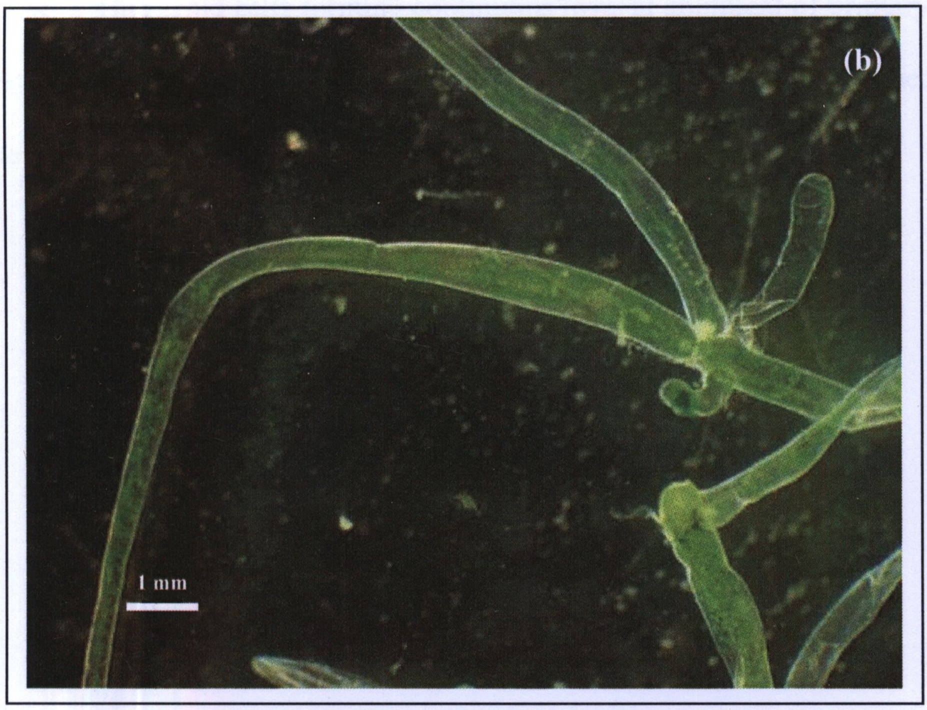




Figure 21. *Valoniopsis pachynema* (G. Martens) Børgesen (a) plant habit, (b) palmate branching

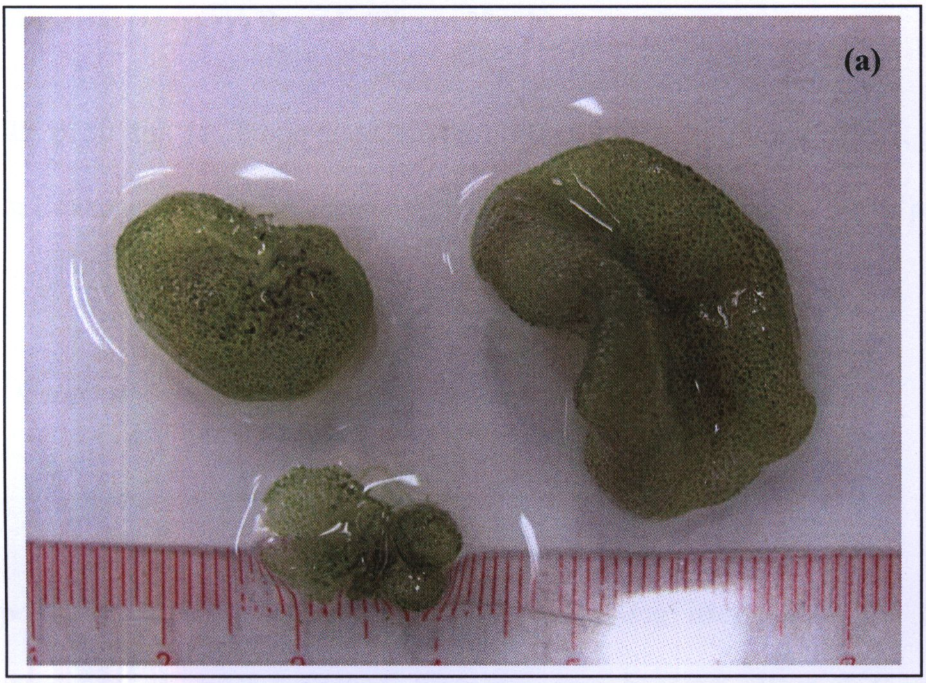
***Dictyosphaeria cavernosa* (Forsskål) Børgesen** (Figure 22a, b)

Egerod 1974, p. 140, fig.30; Tseng 1983, p. 268, pl. 133, fig. 5; Sartoni 1992, p. 319, fig. 13a; Lewmanomont and Ogawa 1995, p. 48; Lewmanomont *et al.* 1995, p. 35; Trono 1997, p. 24, fig. 12

Basionym: *Ulva carvernosa* Forsskål

Synonyms: See Silva *et al.* (1996, p. 795)

Thallus sac-like, hollow, spherical when young, irregularly lobed and ruptured when old, to 3 cm diam., light green. Primary cells spherical 0.5 mm in diameter, forming one layer, appearing honeycomb-like, adhering to one another by microscopic hapteroid cells. Hapteroid cells forming continuous rows at abutment of primary cells, alternately opposite one another. Rhizoids short, branched or unbranched, issued from cell in the basal region.



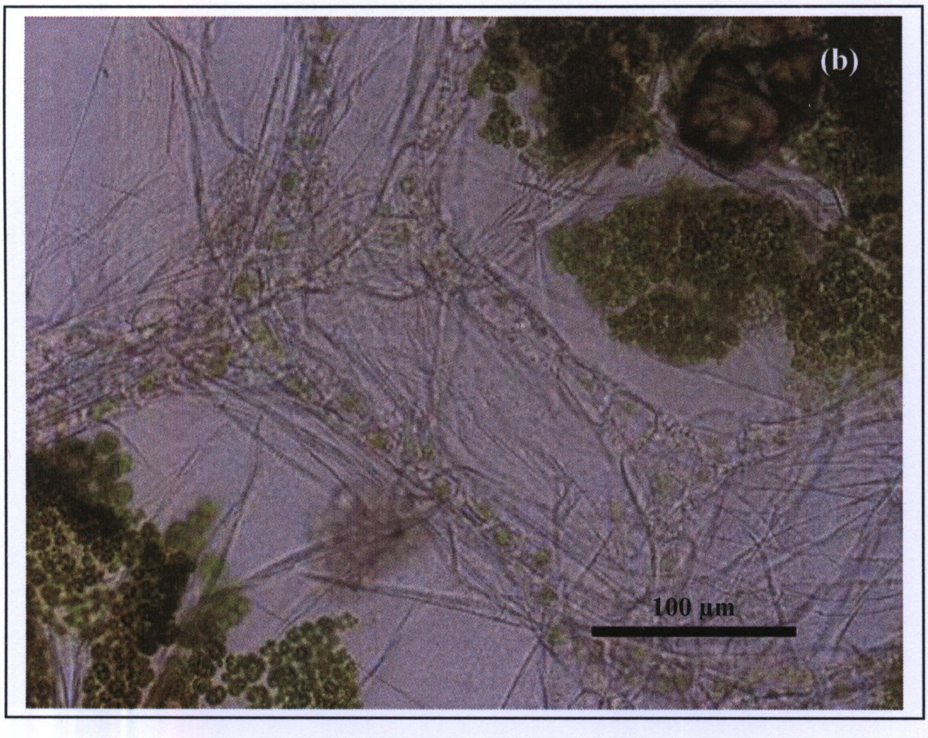




Figure 22. *Dictyosphaeria cavernosa* (Forsskål) Børgesen (a) thallus sac-like, (b) hapteroid cells forming continuous rows

***Boodlea composita* (Harvey) Brand** (Figure 23a, b)

Egerod 1975, p. 50, fig. 19; Trono and Ganzon-Fortes 1980, p. 15; Sartoni 1992, p. 306, fig. 7c; Lewmanomont and Ogawa 1995, p. 26; Lewmanomont *et al.* 1995, p. 36; Trono 1997, p. 22, fig. 11; Huisman 2000, p. 238

Basionym: *Conferva composita* Harvey

Synonyms: See Silva *et al.* (1996, p. 789)

Thallus spongiose, forming reticulate cushions, branching irregular in the basal portion, composed of much-branched filaments that become attached to other branches, forming amorphous sponge-like tufts, with soft texture and bright green color.

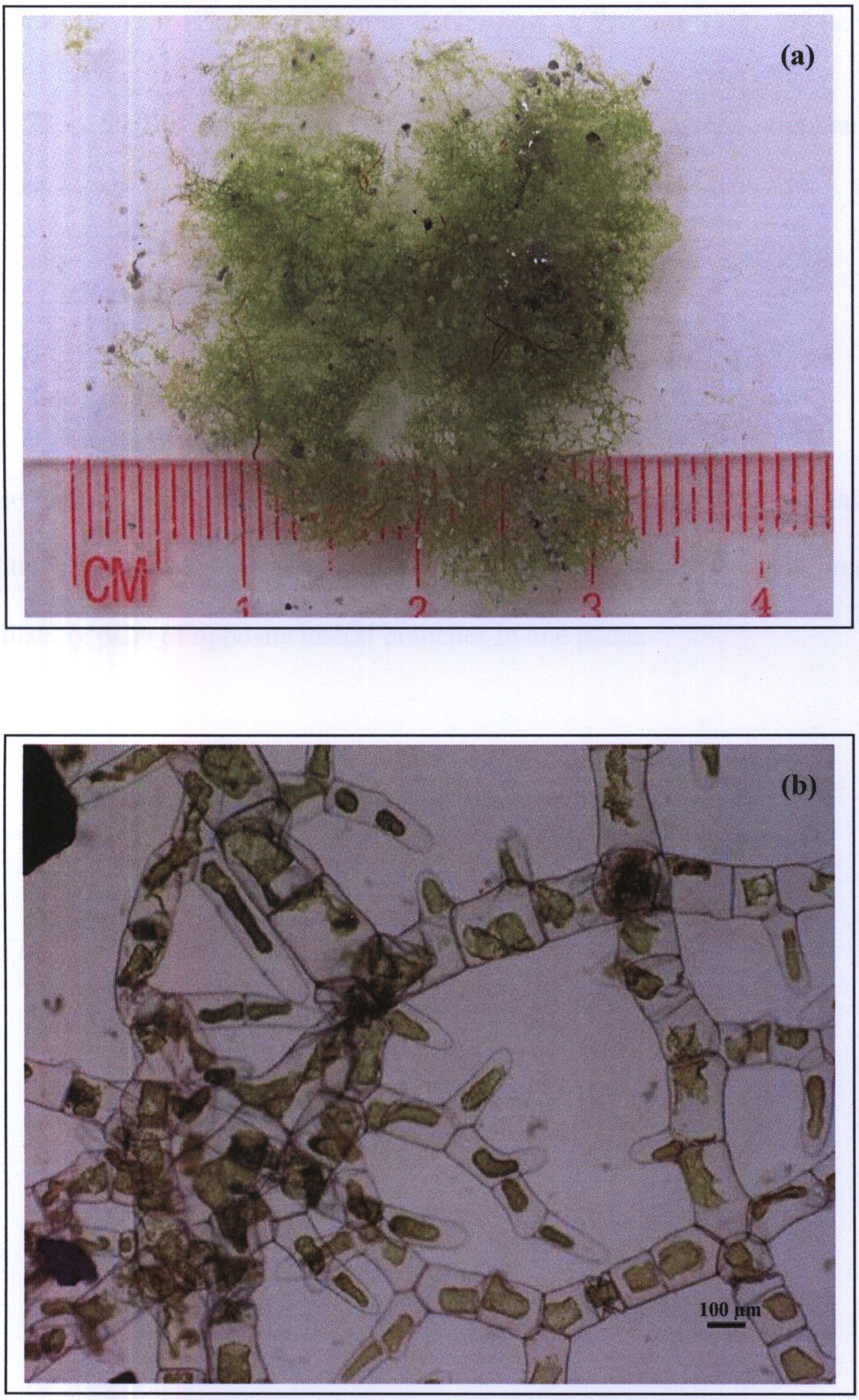



Figure 23. *Boodlea composita* (Harvey) F. Brand (a) thallus spongiose,
(b) irregulary branches

***Struvea anastomosans* (Harvey) Piccone & Grunow ex Piccone** (Figure 24a, b)

Egerod 1975, p. 50, fig. 15; Sartoni 1992, p. 317, figs. 12b, c; Lewmanomont and Ogawa 1995, p. 57; Lewmanomont *et al.* 1995, p. 36; Trono 1997, p. 23

Basionym: *Cladophora anastomosans* Harvey

Synonym: See Silva *et al.* (1996, p. 798) as *Struvea delicatula* Kützing

Reticulate leaf-like thallus about 1 cm high, arising from a segmented, stoloniferous system attached to the substrate by septate rhizoids. Stipe simple or rarely branched, bearing distally pairs of opposite lateral branches in one plane.

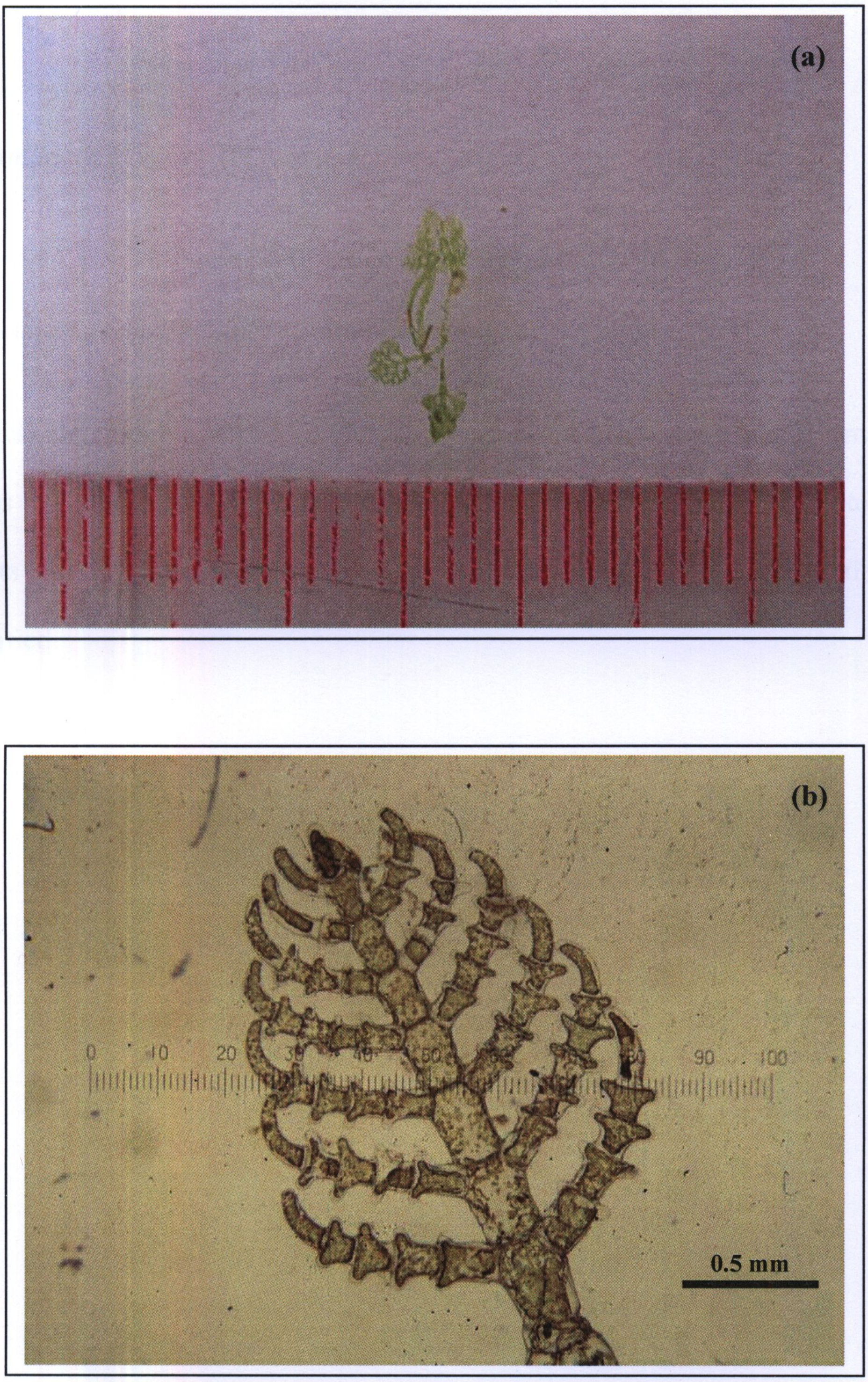



Figure 24. *Struvea anastomosans* (Harvey) Piccone & Grunow ex Piccone
(a) leaf-like thallus, (b) pairs of opposite lateral branches

**Division Rhodophyta**

***Jania capillacea*** **Harvey** (Figure 25a, b)

Dawson 1954, p. 432, figs. 41a, b; Trono and Ganzon-Fortes 1980, p. 69; Lewmanomont *et al.* 1995, p. 78; Littler and Littler 2003, p. 34

Plants delicate, tightly packed in clumps or small cushions, less than 1 cm high. Branches are cylindrical, slender, calcified, branching repeatedly dichotomous. Segments are 100-200 μm in diameter and are 1000-1500 μm long. Joints flexible, not calcified.

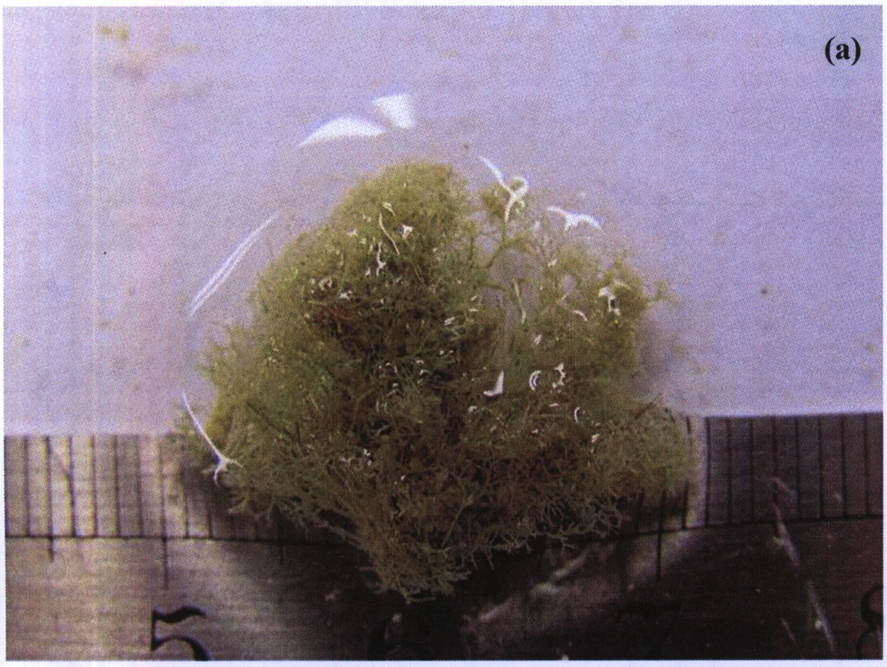




Figure 25. *Jania capillacea* Harvey (a) plant habit, (b) dichotomous branching, not calcified at joints

***Tolypiocladia glomerulata* (C. Agardh) Schmitz** (Figure 26a-d)

Dawson 1954, p. 452, figs. 59b, c; Cribb 1983, p. 135, pl. 68, fig. 4; Tseng 1983, p. 160, fig. 4; Lewmanomont *et al.* 1995, p. 90; Millar *et al.* 1999, p. 575; Huisman 2000, p. 179

Basionym: *Hutchinsia glomerulata* C. Agardh

Synonyms: See Silva *et al.* (1996, p. 555)

Thallus dark brownish red, soft membranous, erect, fine, attached by unicellular rhizoids. Main axis alternately branched, branches arranged spirally around the axis. Structurally the thallus is uniaxial with each axial cell surrounded by a ring of four pericentral cells. Tetrasporangia on the ultimate branchlets, tetrahedrally divided.

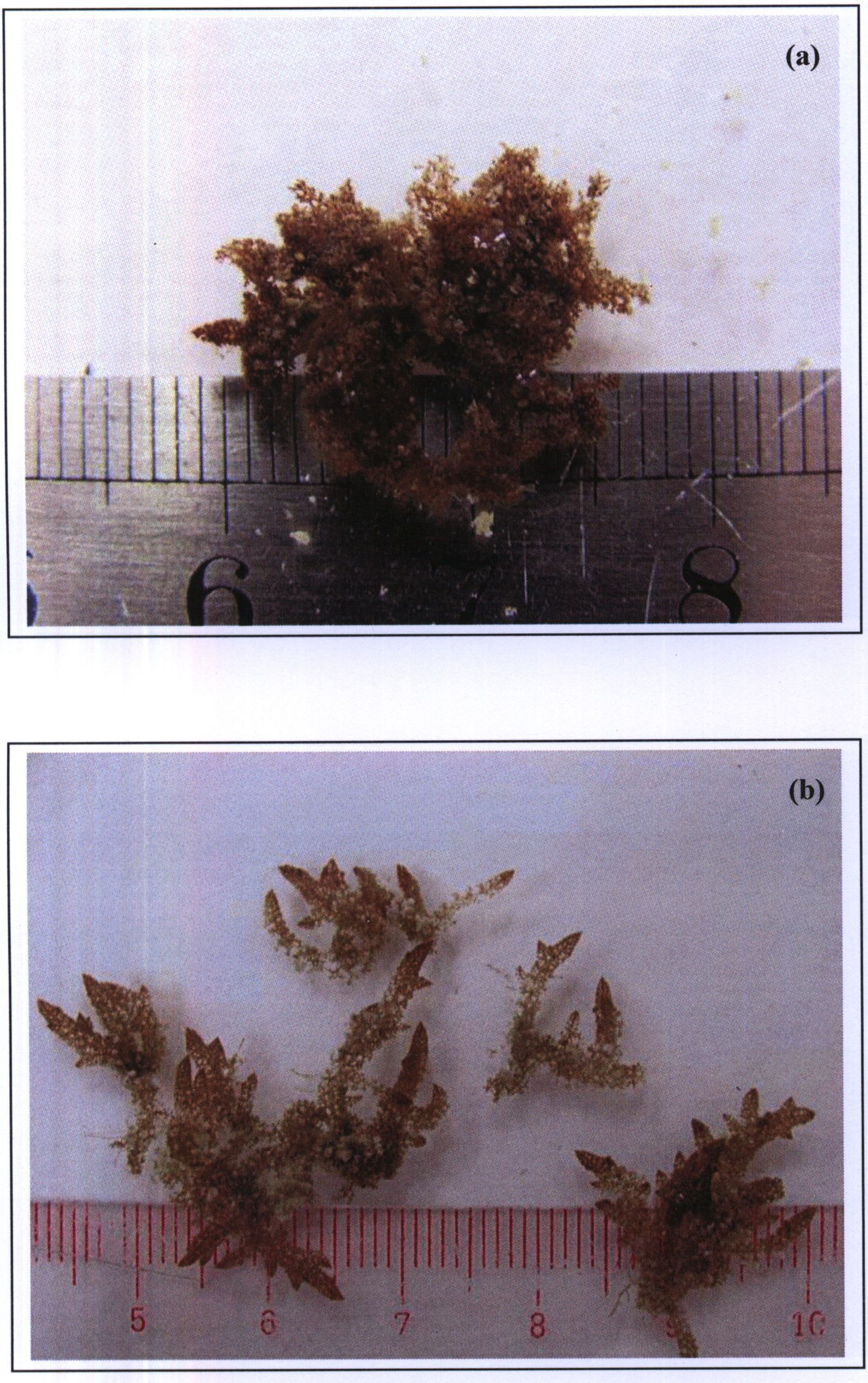



Figure 26. *Tolypiocladia glomerulata* (C. Agardh) Schmitz (a) thallus forming dense tuft, (b) plant habit

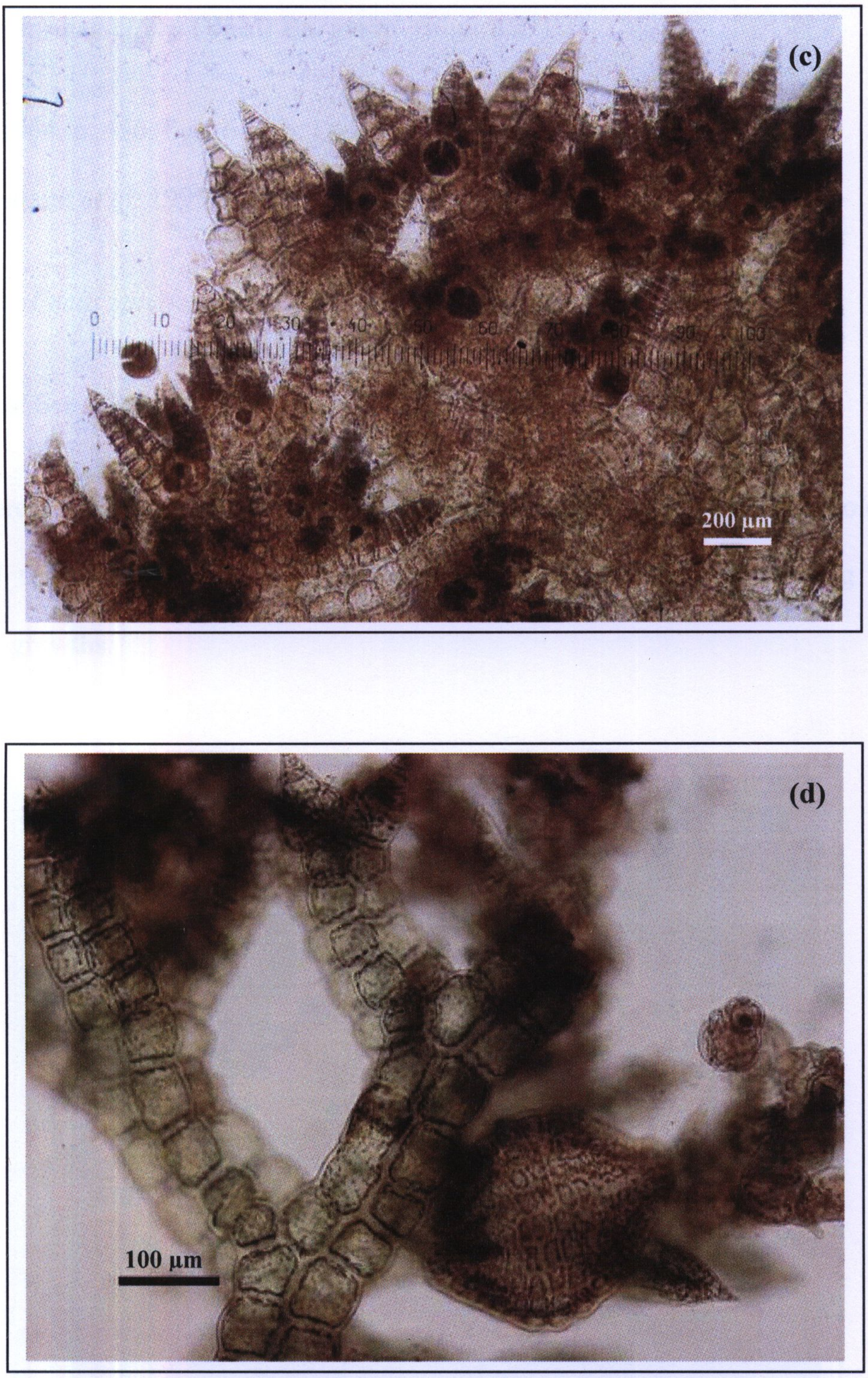



Figure 26. (Continued) (c) tetrasporangia on the ultimate branchlets, (d) cystocarp on the main branch

***Acanthophora spicifera* (Vahl) Børgesen** (Figure 27)

Dawson 1954, p. 456, figs. 61a, b; Lewmanomont and Ogawa 1995, p. 90; Lewmanomont *et al.* 1995, p. 89; Trono 1997, p. 255, fig. 159

Basionym: *Fucus spicifer* Vahl

Synonyms: See Silva *et al.* (1996, p. 471)

Thallus erect, succulent, up to 15 cm tall, laxly branched, with small discoid holdfast; branches terete throughout, cover by spirally arranged branchlets bearing short spinelike growths.

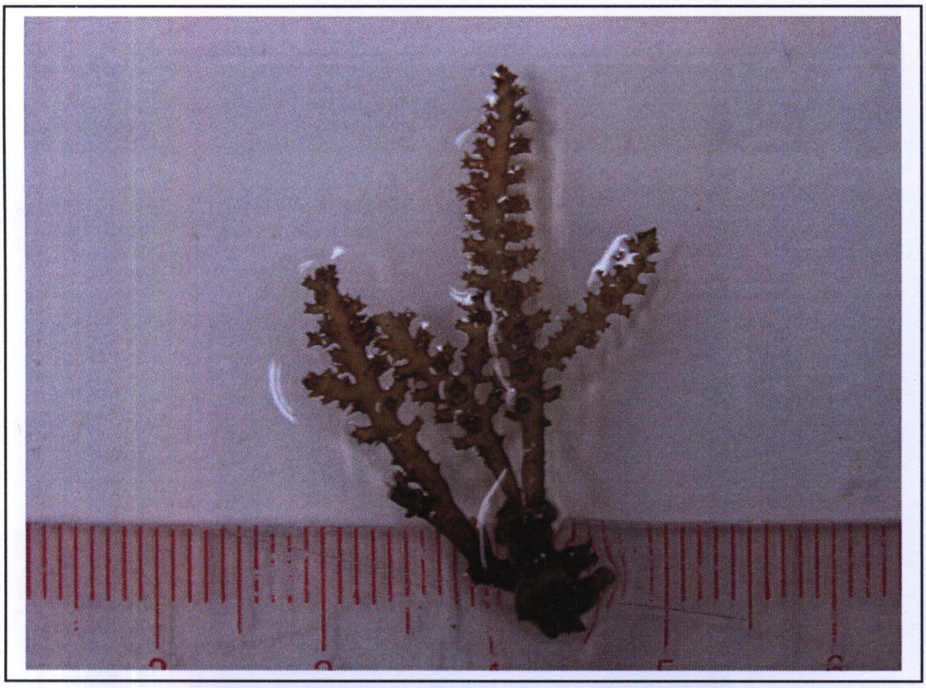


Figure 27. *Acanthophora spicifera* (M. Vahl) Børgesen

***Chondrophycus papillosus* (C. Agardh) Garbary and Harper** (Figure 28)

Garbary and Harper 1998, p. 195

Basionym: *Chondria papillosa* C. Agardh

Synonym: *Laurencia papillosa* (C.Agardh) Greville; Trono and Ganzon-Fortes 1980, p. 103; Nam and Saito 1991, p. 87; Lewmanomont and Ogawa 1995, p. 128; Lewmanomont *et al.* 1995, p. 92; Trono 1997, p. 266, fig. 166

Thallus cylindrical, cartilaginous, dark brown to purple, composed of several erect branches, 6-12 cm high, growing from small holdfast. Branching irregular, branches densely covered by wartlike growths.

Figure 28. *Chondrophycus papillosus* (C. Agardh) Greville

***Chondrophycus tronoi* (Ganzon-Fortes) Nam** (Figure 29)

Nam 1999, p. 463

Basionym: *Laurençia tronoi* Ganzon-Fortes 1982, p. 404, figs. 1-2

Synonym: *Laurencia* sp.; Ganzon-Fortes and Trono 1982, p. 39, figs. 1-2

Thallus dark brown or purple, cartilaginous, forming thick clumps or dense mats on sandy or rocky substrates. Branching is irregularly alternate. Branches are cylindrical to slightly compressed with tapered, subacute apices.

This is a new record for Thailand.

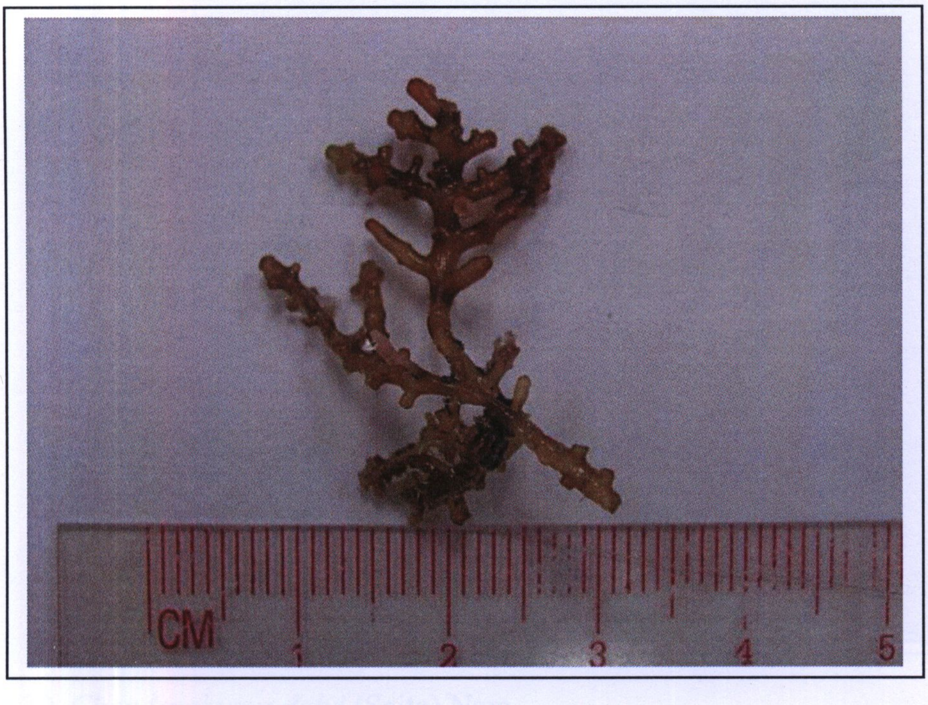



Figure 29. *Chondrophycus tronoi* (Ganzon-Fortes) Nam

***Chondrophycus dotyi* (Saito) Nam** (Figure 30)

Nam 1999, p. 463

Basionym: *Laurencia dotyi* Saito 1969, p. 154, fig. 9a-c, 10a-b; Wynne 1993, p. 17

Forming clumps which have a few erect axes standing on a discoid holdfast, without stoloniferous basal branches, up to 5 cm high, cartilaginous. Branching alternately or oppositely, distichous. Colour brownish purple or somewhat greenish when fresh, changing to black upon drying.

This is a new record for Thailand.

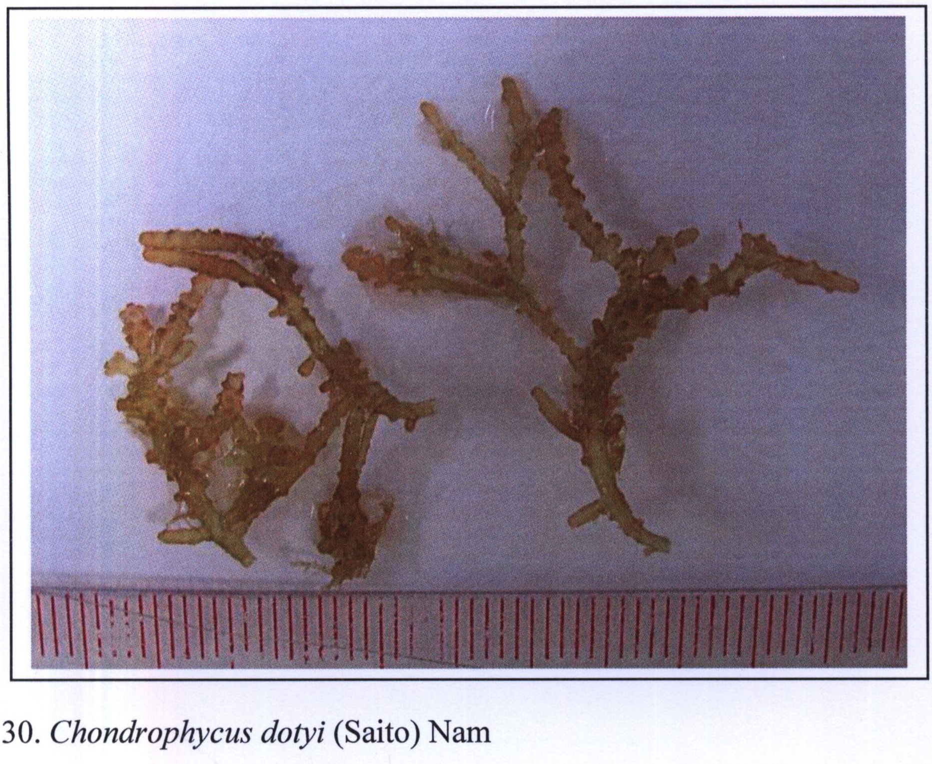


Figure 30. *Chondrophycus dotyi* (Saito) Nam

***Polysiphonia sphaerocarpa*** **Børgesen** (Figure 31a, b)

Taylor 1960, p. 576; Hollenberg 1968, p. 87, figs. 10, 21, 24, 26, 27, 28; Kapraun 1980, p. 81, figs. 190-192; Kapraun and Norris 1982, p. 233, fig. 112; Cribb 1983, p. 134; Yoon 1986, p. 22, fig. 13; Coppejans and Millar 2000, p. 338

Thallus 0.5-1.5 cm high, forming mats, attached by unicellular rhizoids. Filaments 50-200 µm in diameter, 100-180 µm long, pseudodichotomously branched, branches arising independent of trichoblasts, at intervals of 7-11 segments, with 4 pericentral cells, uncorticated. Tetrasporangia 50 µm in diameter, numerously and spirally seriate on upper and middle parts of branchlets.

This is a new record for Thailand.

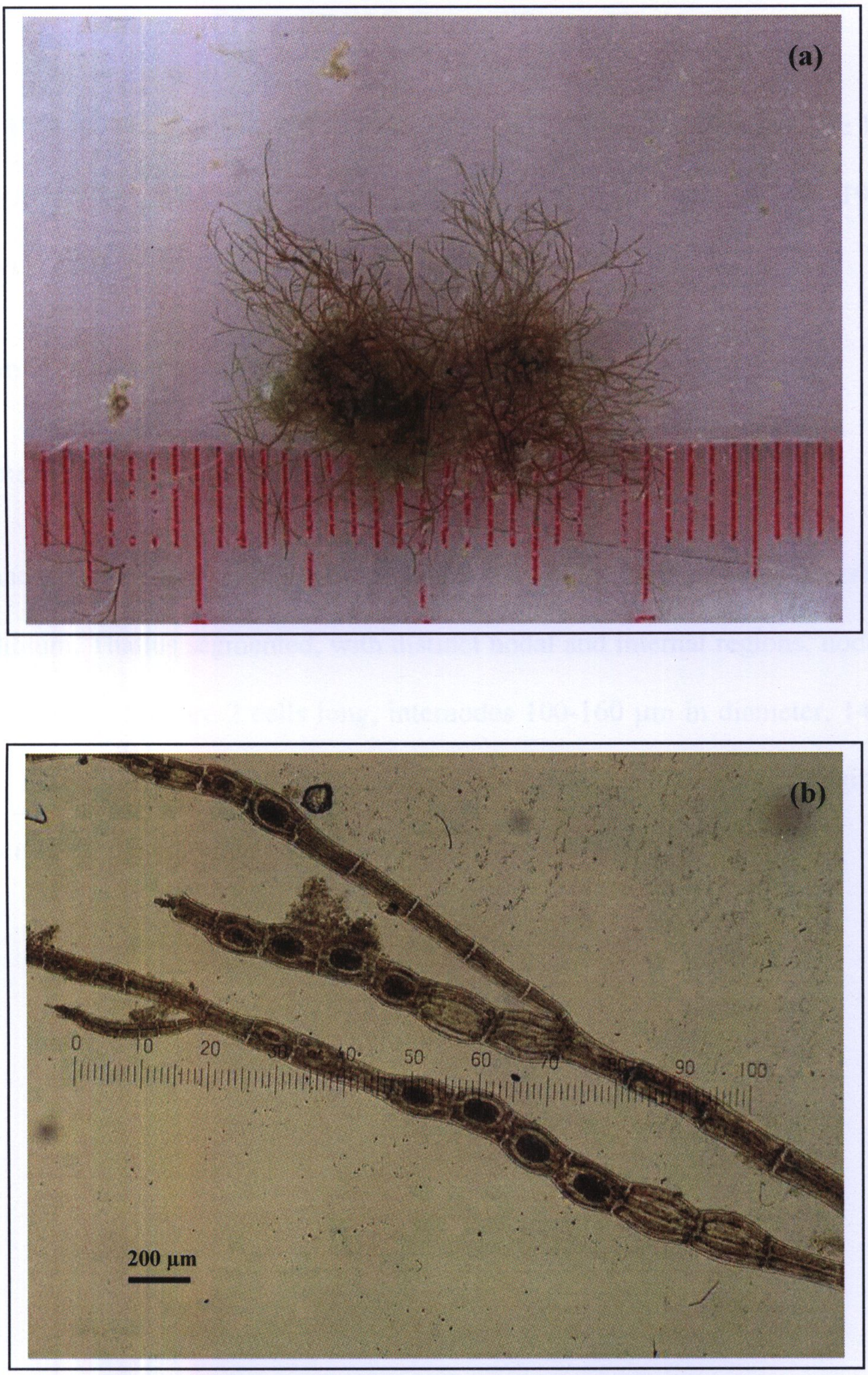



Figure 31. *Polysiphonia sphaerocarpa* Børgesen (a) thallus forming mats, (b) pseudodichotomously branches with tetrasporangia

***Centroceras clavulatum* (C. Agardh) Montagne** (Figure 32a, b)

Dawson 1954, p. 446, fig. 54h; Cribb 1983, p.75, pl. 25, figs. 2-3; Boo and Lee 1985, p.298, figs. 1-6; Lewmanomont and Ogawa 1995, p. 98; Lewmanomont *et al.* 1995, p. 89; N'Yeurt 2001, p. 816

Basionym: *Ceramium clavulatum* C. Agardh

Synonyms: See Silva *et al.* (1996, p. 389)

Fine branched filaments forming a dense turf 3-4 cm high, filaments erect to creeping on substratum. Thallus segmented, with distinct nodal and internal regions, node with verticillate spines that are 2 cells long, internodes 100-160 μm in diameter, 140-175 μm long in mid-thallus. Axial cells completely covered by a cortex of longitudinal rows of cells, rectangular in surface view.

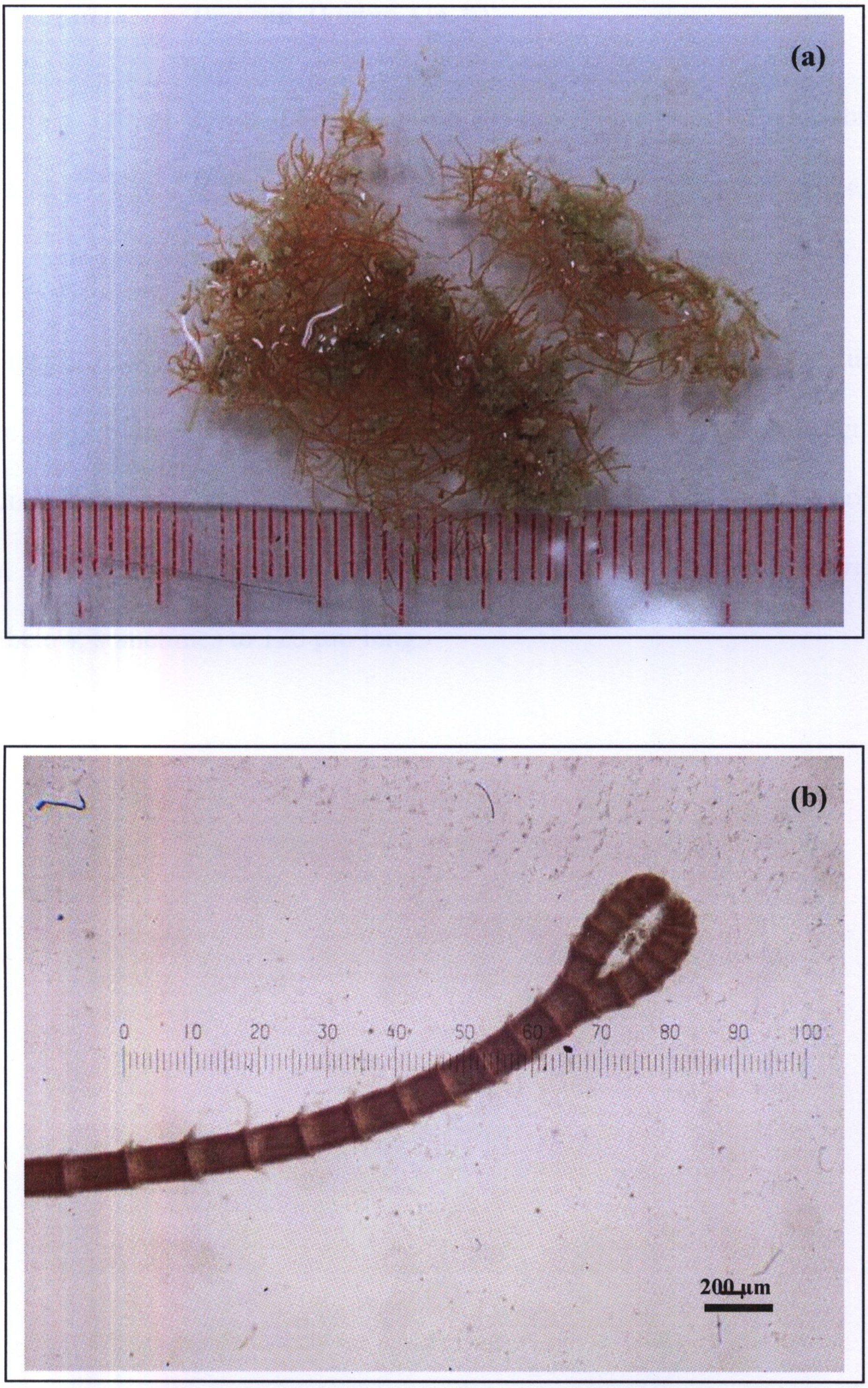



Figure 32. *Centroceras clavulatum* (C. Agardh) Montagne (a) thallus forming dense turf, (b) verticillate spines at nodes

***Ceramium mazatlanense* Dawson** (Figure 33a, b)

Dawson 1950, p. 130, pl. 2, figs. 14-15; Dawson 1954, p. 448, figs. 55e,f; Dawson 1962, p. 59, pl. 23, figs. 1-2; Cribb 1983, p. 85, pl. 62, figs. 1-3; Lewmanomont *et al.* 1995, p. 86

Thallus epiphytic, 3-4 mm high, attached by rhizoids issued from the ventral surface of prostrate, basal filaments; erect filaments 90-100 µm in diameter, rather irregularly dichotomously branched, corticated only at the nodes, without secondary cortical expansion, cortical band very short, 25-30 µm in greatest diameter. Internodes elongated below, sometimes to 120 µm long.

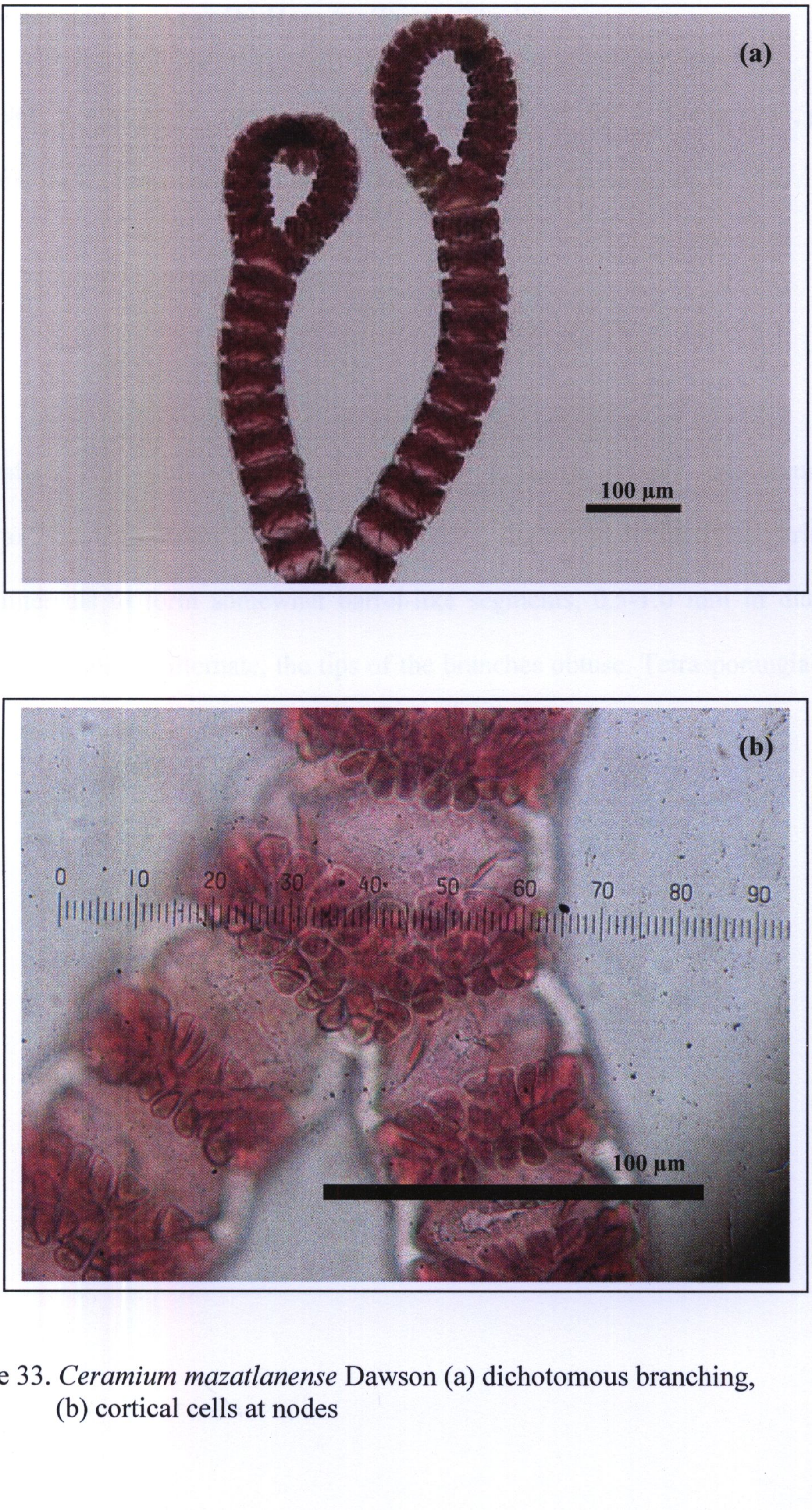



Figure 33. *Ceramium mazatlanense* Dawson (a) dichotomous branching, (b) cortical cells at nodes

***Champia parvula* (C. Agardh) Harvey** (Figure 34a, b)

Taylor 1960, p. 490, pl. 61, fig. 4; Cribb 1983, p. 70, pl. 21, fig. 1; Tseng 1983, p. 122, pl. 64, fig. 2; Lewmanomont *et al.* 1995, p. 85; Millar *et al.* 1999, p. 564

Basionym: *Chondria parvula* C. Agardh

Synonyms: See Silva *et al.* (1996, p. 346)

Plants tufted, pale, dull red, pinkish brown or greenish, crisply membranous in texture, to 3 cm high. Branches cylindrical, hollow, slightly to distinctly constricted at regular intervals to form somewhat barrel-like segments, 0.5-1.0 mm in diameter, branching irregular to alternate, the tips of the branches obtuse. Tetrasporangia 30-50 μm in diameter, scattered in the branches, tetrahedrally divided.

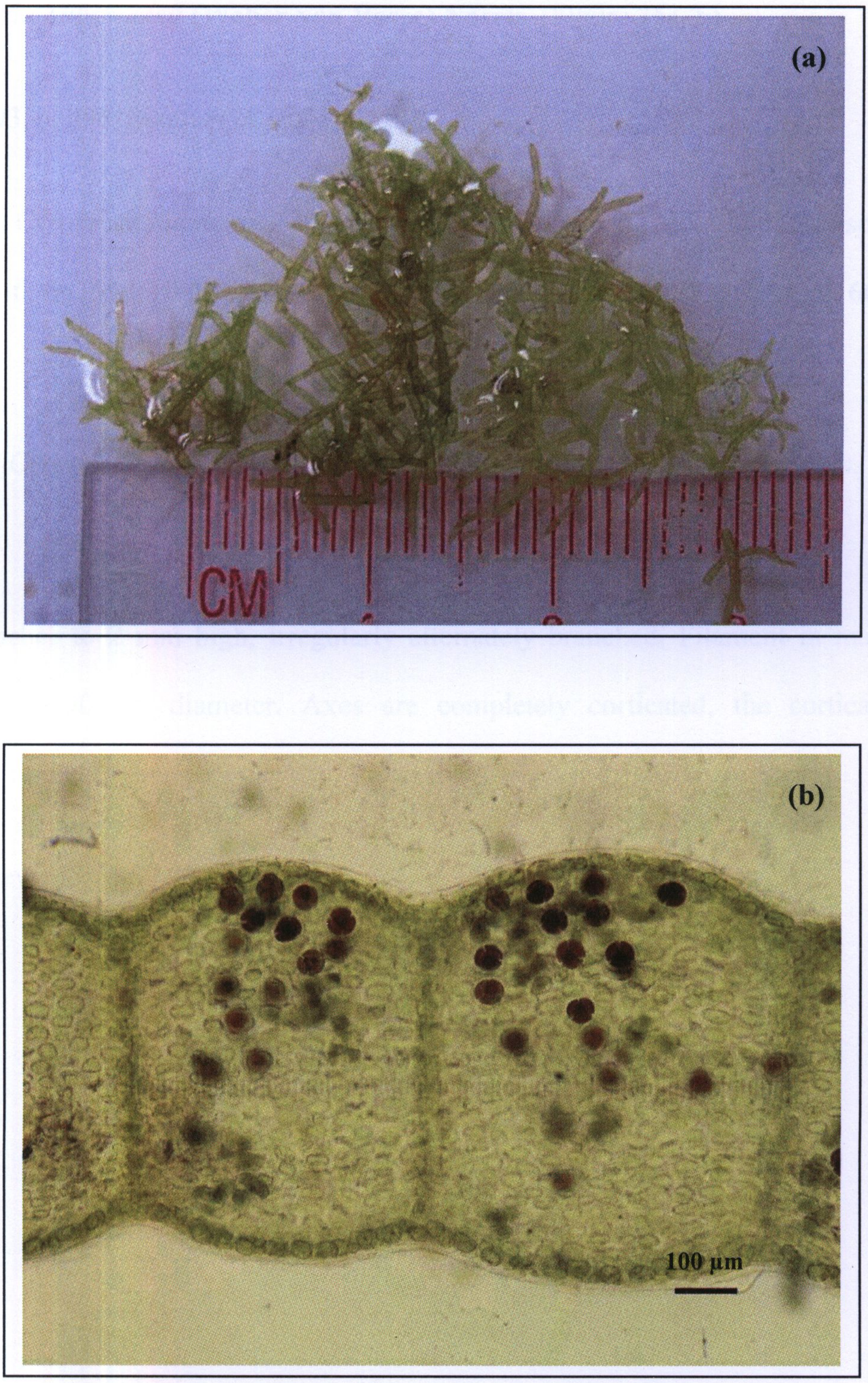



Figure 34. *Champia parvula* (C. Agardh) Harvey (a) plant habit, (b) tetrasporangia in the segments

***Corallophila huysmansii* (Weber-van Bosse) Norris** (Figure 35a, b)

Norris 1993, p. 396; South *et al.* 2001, p. 563

Basionym: *Ceramium huysmansii* Weber-van Bosse 1923, p. 322, fig. 115; Dawson 1954, p. 446, fig. 55d; Hommersand 1963, p. 238; fig. 28; Cribb 1983, p. 83, pl. 60, figs. 1-2

Synonym: *Ceramiella huysmansii* (Weber-van Bosse) Børgesen 1953, p. 47, figs. 18-19

Erect branches to 2 mm high, irregularly alternately branched. Filament in mature portions 100-200 μm diameter. Axes are completely corticated, the cortication comprised of units.

This is a new record for Thailand.

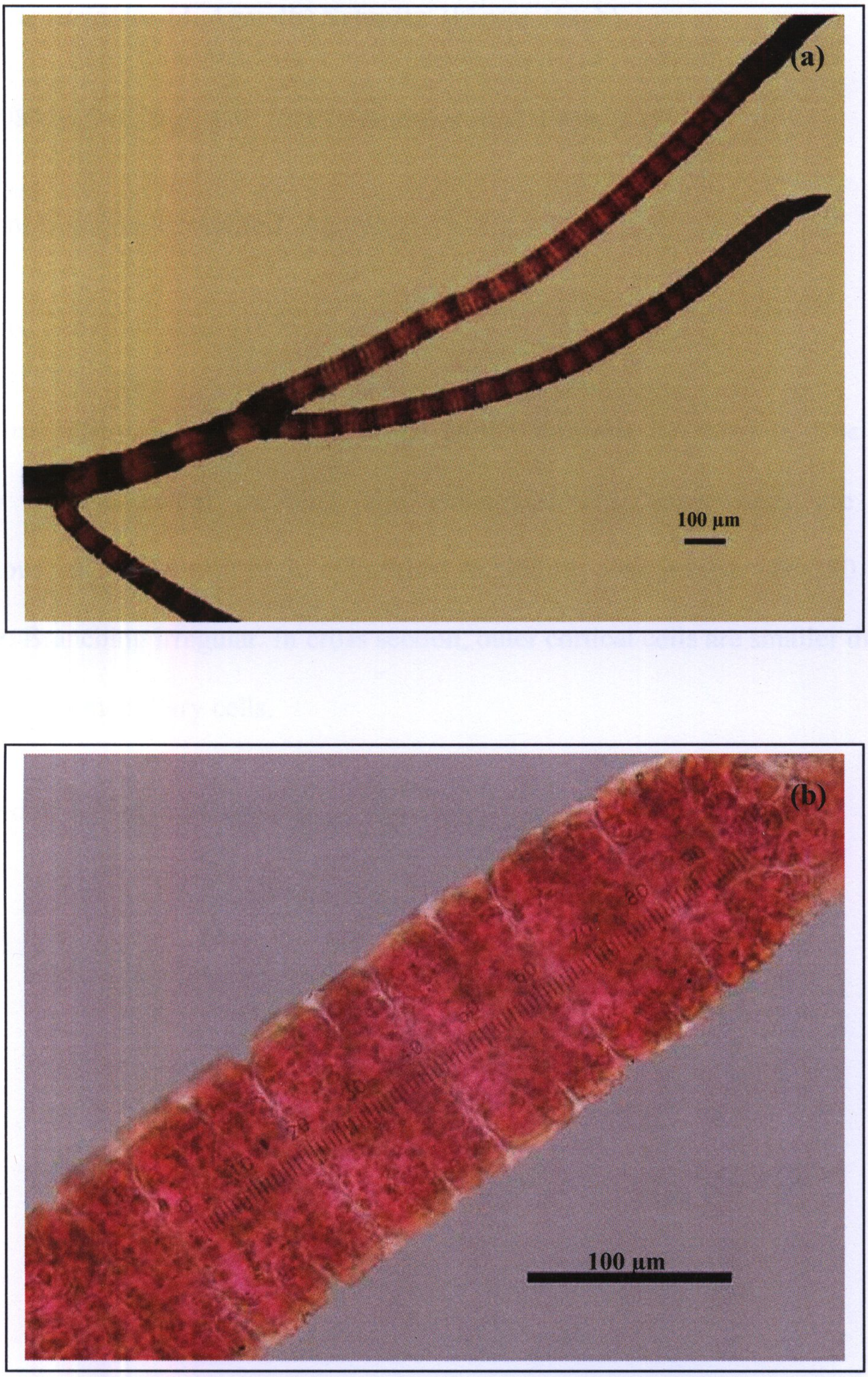



Figure 35. *Corallophila huysmansii* (Weber-van Bosse) R.E. Norris
(a) irregularly branching, (b) completely cortication

***Gelidiopsis variabilis* (J. Agardh) Schmitz** (Figure 36a, b)

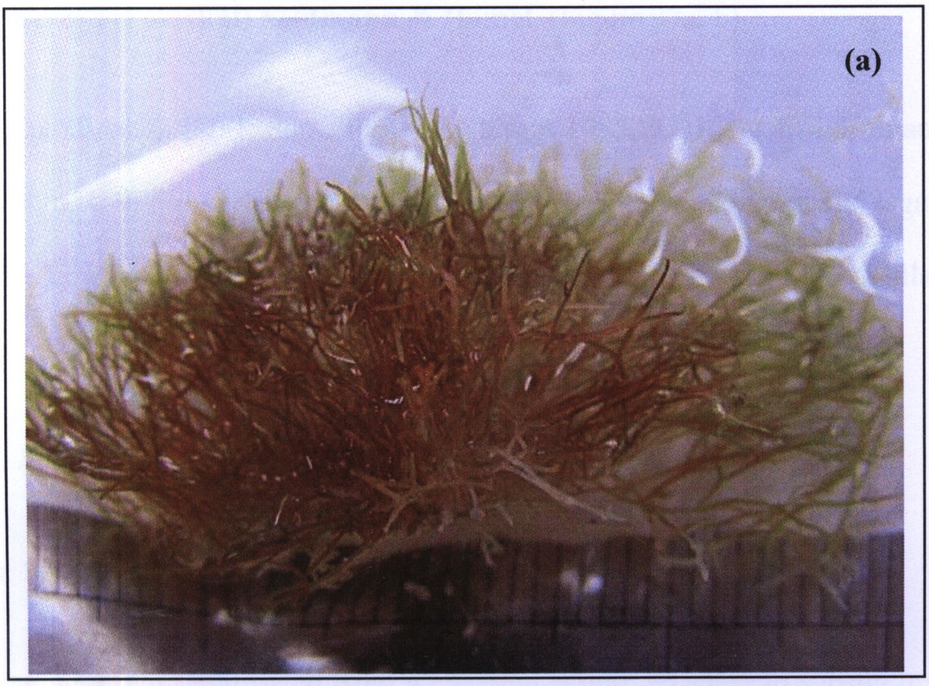
Norris 1987, p. 240, figs. 1-9, 12-13; Saunders *et al.* 1999, p.35

Basionym: *Gelidium variabile* J. Agardh

Synonyms: See Silva *et al.* (1996, p. 362)

Thalli form bushy, wiry clumps, attached to the substrate by rhizoids. The lower branches are somewhat creeping and entangled. The upper ones are erect, filamentous, about 2-4 mm high, cylindrical to slightly compressed, 180-250 μm in diameter. Branching irregular. In cross section, outer cortical cells are smaller than the central core of medullary cells.

This is a new record for Thailand.



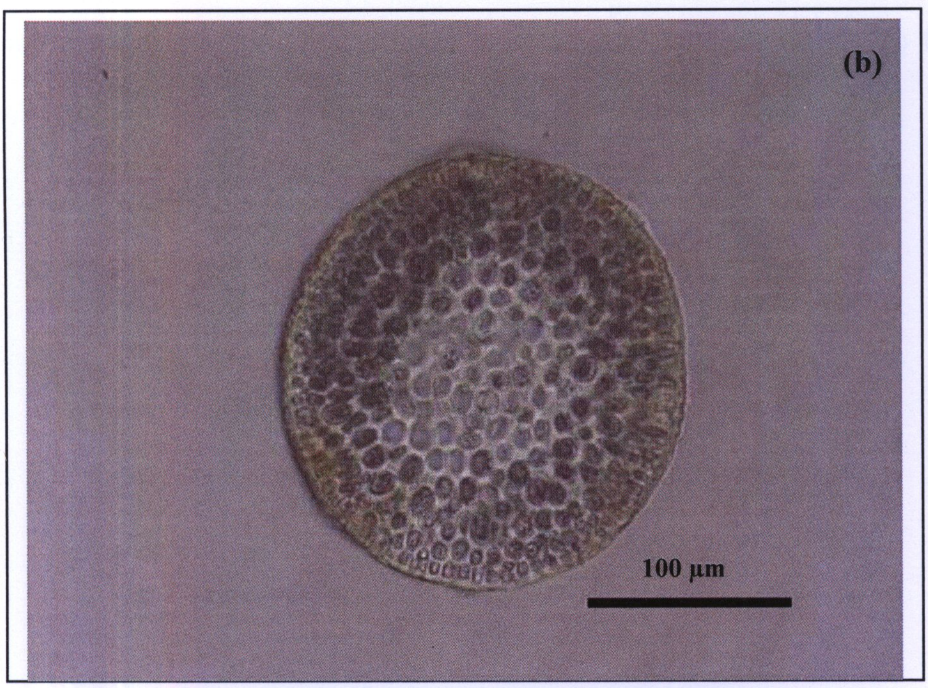




Figure 36. *Gelidiopsis variabilis* (J. Agardh) F. Schmitz (a) plant habit, (b) thallus cross section

***Gelidiella acerosa* (Forsskål) Feldmann & Hamel** (Figure 37a, b)

Cribb 1983, p. 29, pl. 6, fig. 1; Santelices and Stewart 1985, p. 21, fig. 6; Jun-fu and Enzhan 1988, p. 109, fig. 1; Santelices 1988, p. 93, fig. 1; Lewmanomont and Ogawa 1995, p. 105; Lewmanomont *et al.* 1995, p. 75; Trono 1997, p. 179, fig. 113; Millar *et al.* 1999, p. 554; Santelices and Flores 2004, p. 109, figs. 1-3

Basionym: *Fucus acerosus* Forsskål

Synonyms: See Silva *et al.* (1996, p. 149)

Thallus forming a loose mat rising from a creeping stolon, attached to substratum by stoloniferous rhizoids. Thallus up to 5 cm high, erect axes are cylindrical or very slightly compressed, normally with opposite or subopposite pinnae which are fine, needle-like.

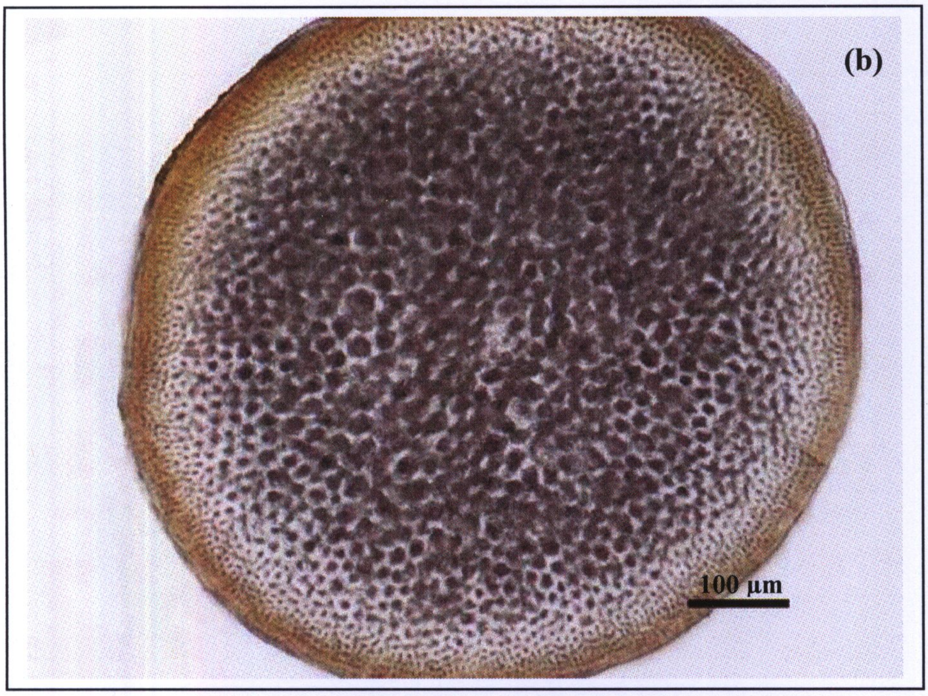




Figure 37. *Gelidiella acerosa* (Forsskål) Feldmann & G. Hamel (a) plant habit, (b) thallus cross section

***Gelidiella pannosa* (J. Feldmann) J. Feldmann & G. Hamel** (Figure 38a, b)

Egerod 1971, p. 127, figs. 29-31; Cribb 1983, p. 31, pl.6, fig. 2; Hatta and Prud'homme van Reine 1991, p. 356, fig. 5; Lewmanomont *et al.* 1995, p. 75

Basionym: *Echinocaulon pannosum* J. Feldmann

Synonym: *Gelidiella tenuissima* Feldmann & Hamel; Dawson 1954, p. 422, fig. 33e

Thallus cartilaginous, cylindrical or somewhat compressed, up to 10 mm high, basal stolons branched, attached to the substrate by fibrous peg-like haptera; erect portions terete to slightly compressed, simple to sparsely divided, linear fronds, mat-forming,

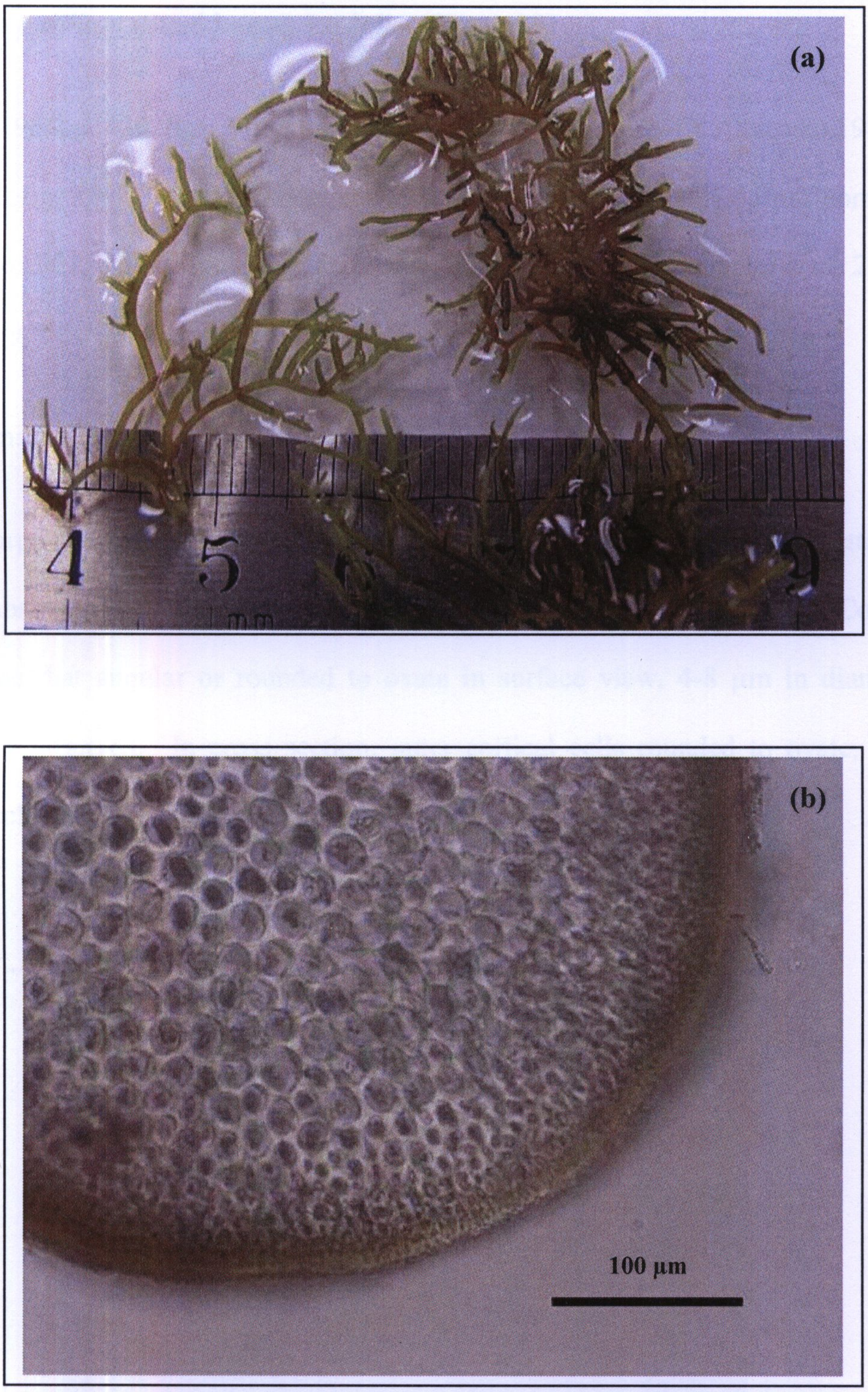



Figure 38. *Gelidiella pannosa* (J. Feldmann) J. Feldmann & G. Hamel (a) plant habit, (b) thallus cross section

***Gelidium pusillum* (Stackhouse) Le Jolis** (Figure 39)

Dawson 1954, p. 420, figs. 31a-c; Egerod 1971, p. 129, figs. 32-49; Akatsuka 1981, p. 453, pl. 1, fig. 3, pl. 3, fig.11; Santelices 1988, p. 102, fig. 9; Hatta and Prud'homme van Reine 1991, p.364, fig. 8; Lewmanomont *et al.* 1995, p. 74; Bangmei *et al.* 2002, p. 193, figs. 50-53

Basionym: *Fucus pusillus* Stackhouse

Plants purplish red, subcartilaginous, small, up to 10 mm high, mat-forming, attached to the substratum by disk-like haptera. Branching irregular, in many plane. Cortical cells somewhat angular or rounded to ovate in surface view, 4-8 µm in diameter, irregularly arranged. In cross section, outer cortical cells rounded to ovate, inner cortical cell rounded, in 2-3 layers, medulla cells also rounded.

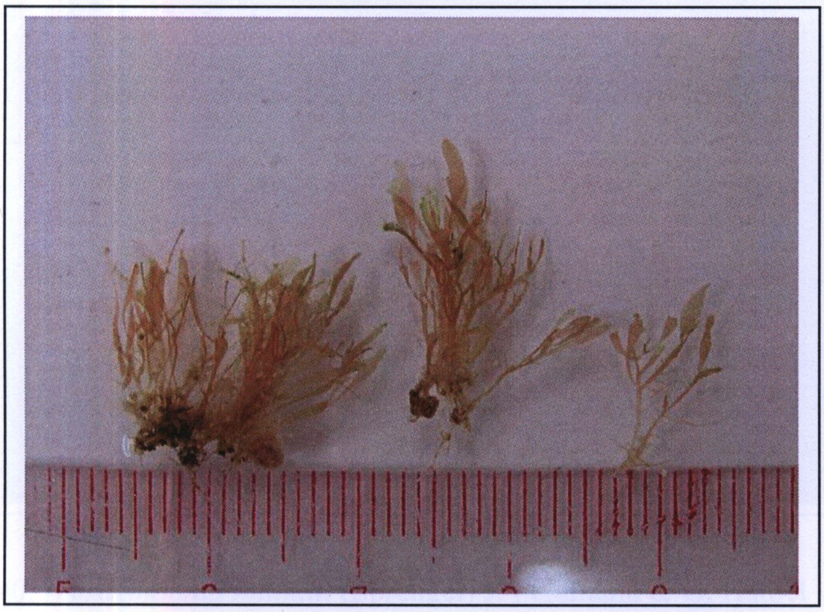


Figure 39. *Gelidium pusillum* (Stackhouse) Le Jolis

***Wurdemannia miniata* (Sprengel) J. Feldmann & G. Hamel** (Figure 40)

Børgesen 1929, p. 77; Dawson 1944, p. 263; Dawson 1954, p. 424, fig. 35; Taylor 1960, p. 361; Hatta and Prud'homme van Reine 1991, p. 375, fig. 14

Plants tufted, 10-20 mm high, consisting of terete prostrate axes, 100-200 μm in diameter, attached to substratum by disk-like haptera. Branching irregular. Cortical cells in surface view angular, longitudinally elongate, somewhat regularly arranged in longitudinal rows. In cross section outer layer cortical cells subquadrangular, inner cortical cells and medullar cells rounded.

This is a new record for Thailand.

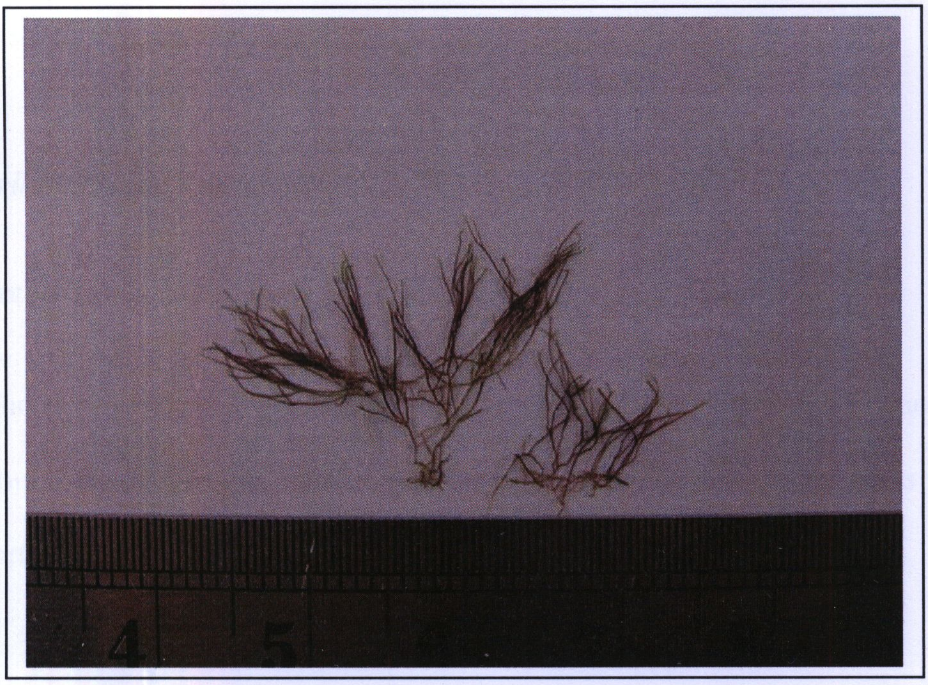


Figure 40. *Wurdemannia miniata* (Sprengel) J. Feldmann & G. Hamel

***Gracilaria salicornia* (C. Agardh) Dawson** (Figure 41a, b)

Abbott 1994, p. 116; Lewmonomont *et al.* 1995, p. 82; Yamamoto and Siew- Moi 1997, p. 91, figs. 1-13; Ohno *et al.* 1999, p. 109, fig. 9; Terada *et al.* 1999, p.121, figs. 1-3

Basionym: *Sphaerococcus salicornia* C. Agardh

Synonyms: See Silva *et al.* (1996, p. 175)

Plants succulent and firm, creeping to nearly erect, up to 3-6 cm long, attached by irregularly discoid holdfast that gives rise to a single axis or many aggregated fronds. Fronds distinctly segmented, branched 2-4 times; each segment clavate, tapering below, inflated distally with depressed truncate apices. Color variable, maroon to pink when fresh, turning darker upon drying.

***Congracilaria babae* Yamamoto**

Yamamoto 1986, p. 287, figs. 1- 16; Yamamoto 1991, p. 382, figs. 1-9

Thalli hemiparasitic on *Gracilaria salicornia* surfaces, distributed randomly throughout. Fronds typically mushroom-like appearance, or convoluted mass with a very short stipe or none at all, up to 3 mm high, up to 3 mm in diameter.

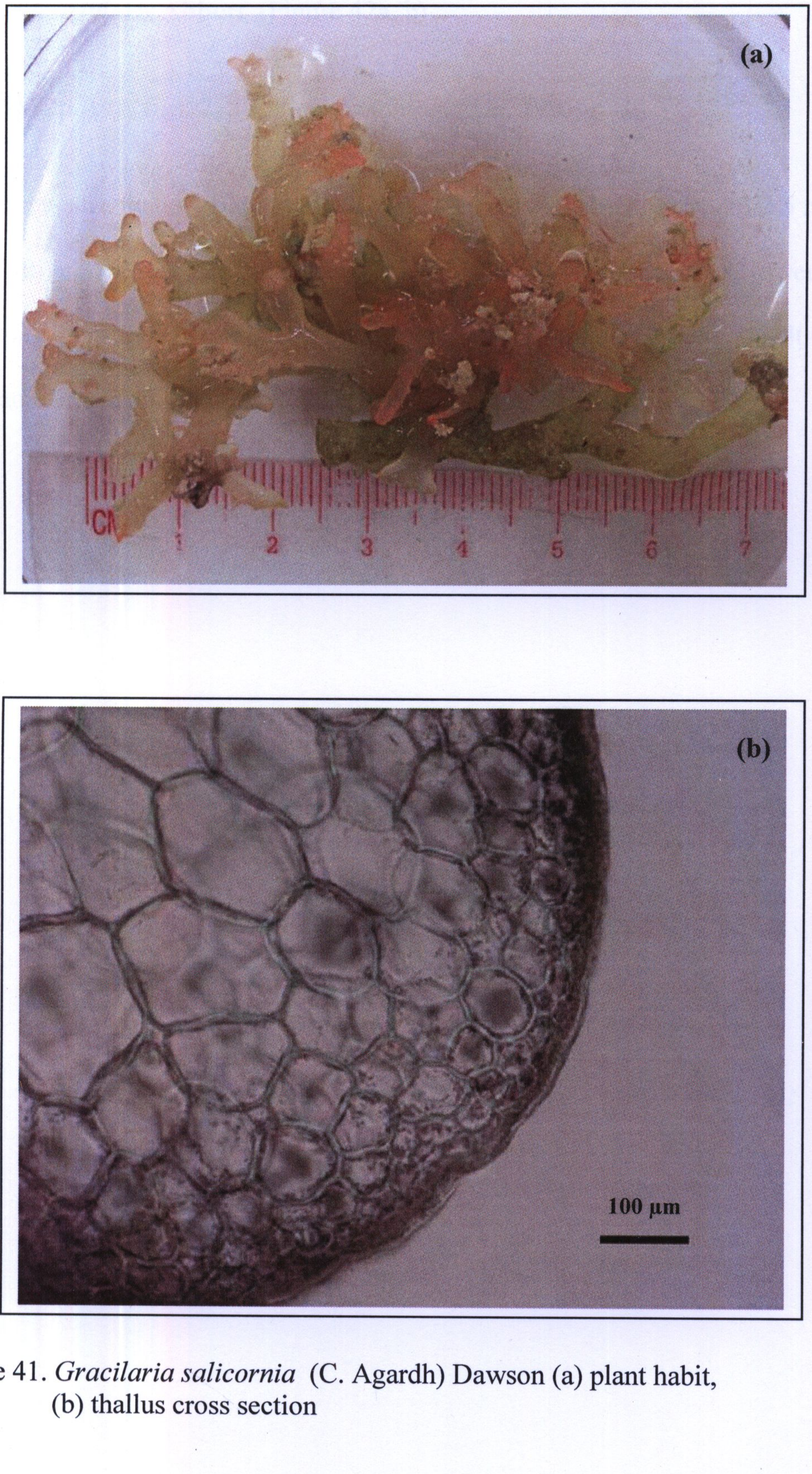



Figure 41. *Gracilaria salicornia* (C. Agardh) Dawson (a) plant habit, (b) thallus cross section

***Gracilaria irregularis* Abbott** (Figure 42a, b)

Abbott 1988, p. 141, figs. 2, 5-6; Lewmanomont *et al.* 1995, p. 80

Thallus erect, succulent, 3-10 cm tall with a percurrent cylindrical axis, 2.0-2.5 mm in diameter. Branching irregular, occasionally secund; branches always narrower than main axes. Fronds in transverse section consisting of medulla of large cells, 300-750 µm in diameter, cortex one to two cells thick, cells much smaller.

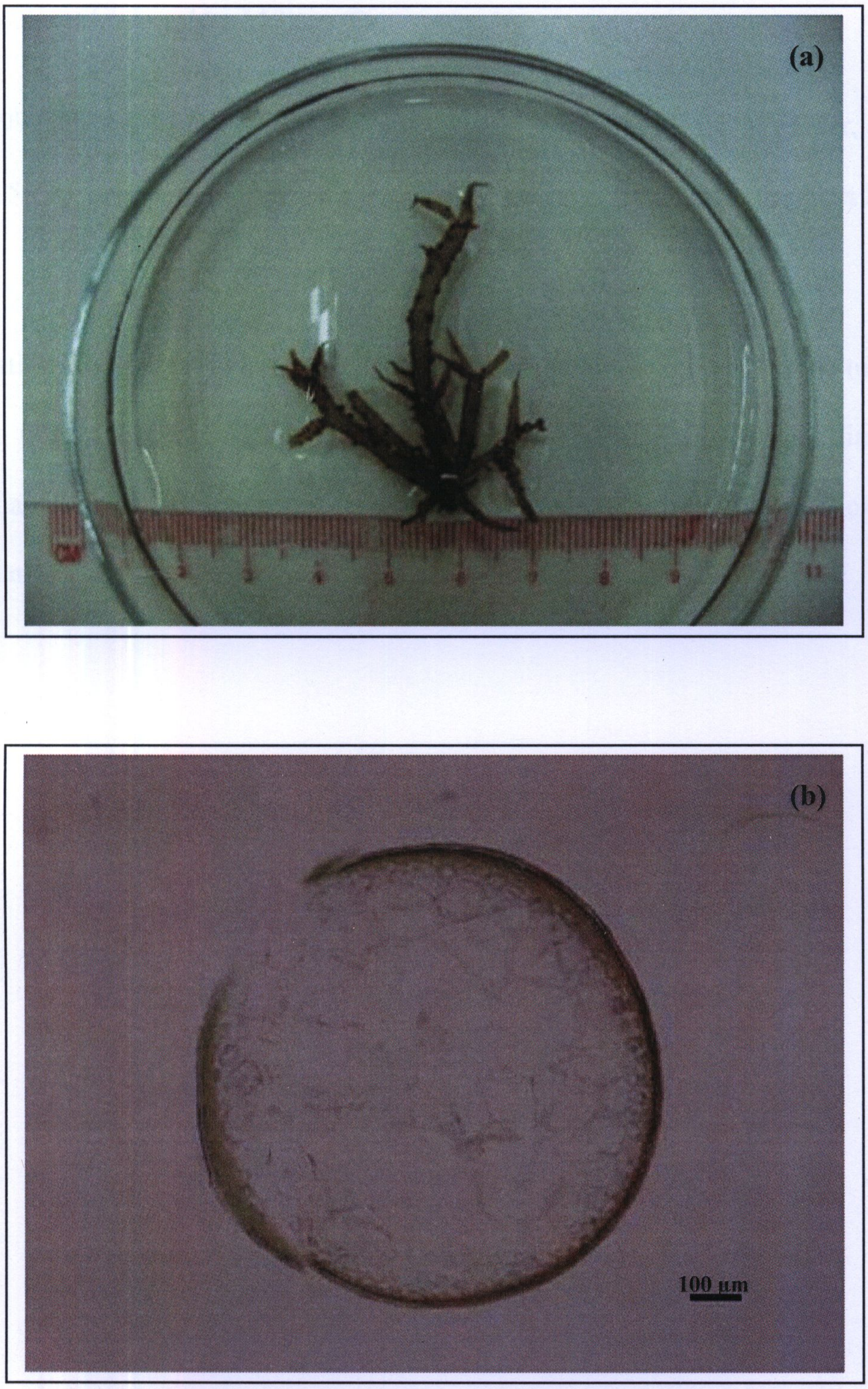



Figure 42. *Gracilaria irregularis* Abbott (a) plant habit, (b) thallus cross section

***Gracilaria rhodymenioides* Millar** (Figure 43a, b)

Millar 1997, p. 114, figs. 5-12; Millar and Bangmei 1999, p. 114, fig. 1; Millar, *et al.* 1999, p. 555; Coppejans and Millar 2000, p. 318; Lewmanomont and Chirapart 2004, p. 206

Plant cartilaginous, erect to horizontally spreading, growing in loose to dense tuft, 2-5 cm high, fronds flattened except for terete stipe, 3-7 mm long and 2-4 mm diameter. Blades flattened, di- or trichotomously divided, 2-5 mm wide, 200-250 μm thick, with entire margins and obtuse apices.

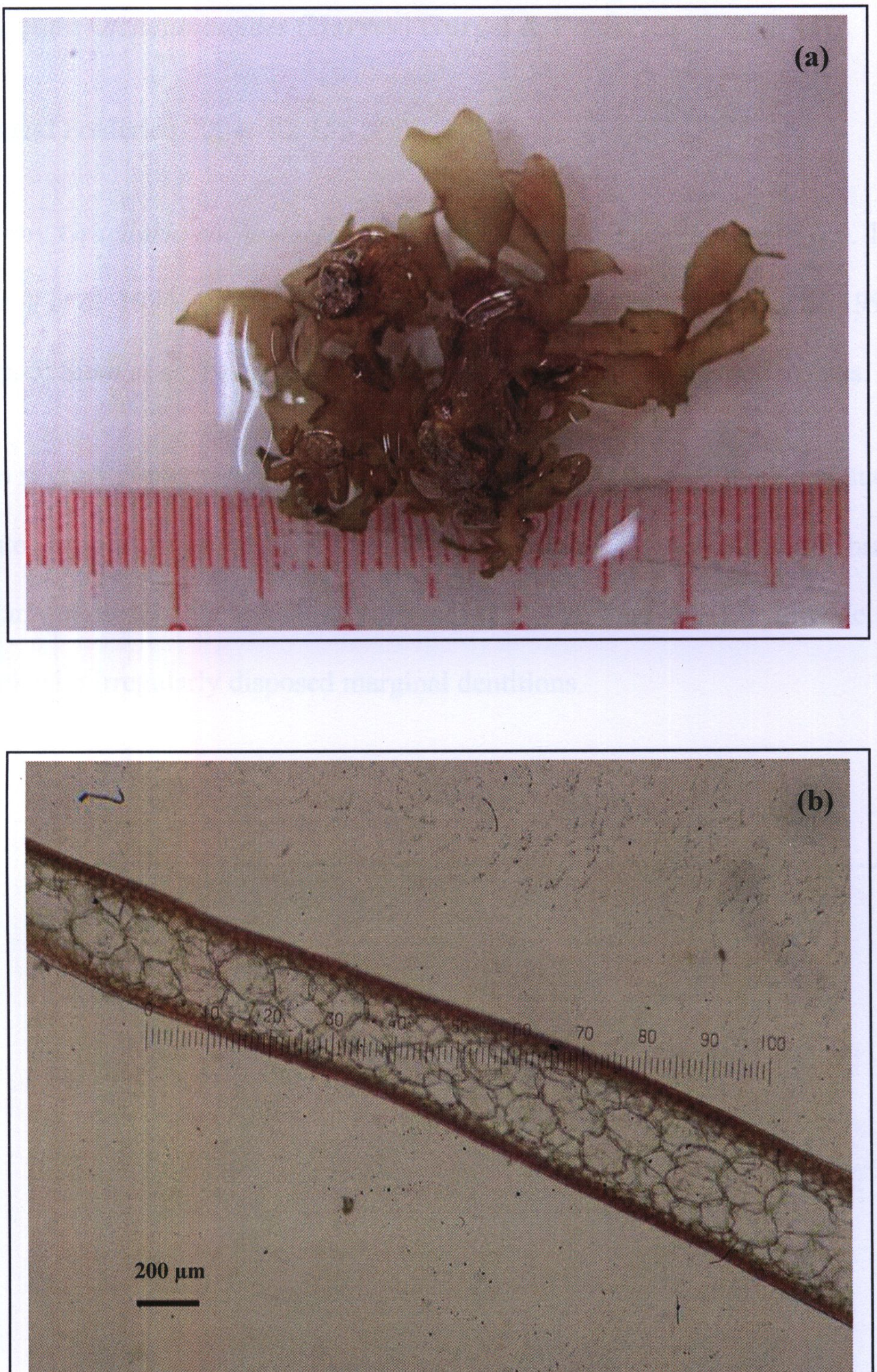



Figure 43. *Gracilaria rhodymenioides* Millar (a) plant habit, (b) thallus cross section

***Hydropuntia eucheumatoides*** **(Harvey) Gurgel & Fredericq** (Figure 44)

Gurgel and Fredericq 2004: 40: 155

Basionym: *Gracilaria eucheumatoides* Harvey; Meneses and Abbott 1987, p. 192, fig. 6; Withell *et al.* 1994, p. 311; Lewmanomont *et al.* 1995, p. 80; Ohno *et al.* 1999, p. 104, fig. 5; Silva *et al.* 1996, p. 168; Terada and Yamamoto 2002, p. 226, figs. 1-7

Thallus slightly compressed, varying in length, up to 19 cm long, thick and succulent, prostrate on rock, attached to the substratum by small discoid holdfasts, branching irregularly, pinnately, dichotomously. Branches 1-3 cm long, 0.5-1.0 cm wide, 0.2-0.5 cm thick with irregularly disposed marginal dentitions.

Figure 44. *Hydropuntia eucheumatoides* (Harvey) Gurgel & Fredericq

***Hypnea pannosa* J. Agardh** (Figure 45)

Trono and Ganzon-Fortes 1980, p. 81; Tseng 1983, p. 100, pl. 53, fig. 1; Lewmanomont and Ogawa 1995, p. 125; Lewmanomont *et al.* 1995, p. 83; Chiang 1997, p. 173; Huisman 2000, p. 78

Synonym: *Hypnea musciformis* (Wulfen) Lamouroux var. *cornuta* Harvey, see Silva *et al.* (1996, p. 304)

Thallus turf-like, forming thick mats, branching irregular, branches cylindrical to slightly compressed, 0.3-2.0 mm broad, with pointed ultimate branchlets. In cross section, a single central axial cell is present at the center of the frond, surrounded by medullary cells.

Figure 45. *Hypnea pannosa* J. Agardh

***Hypnea spinella*** **(C. Agardh) Kützing** (Figure 46a, b)

Cribb 1983, p. 60, pl. 15, fig. 4; Chiang 1997, p. 175, fig. 15; Trono 1997, p. 239; Yamagishi and Masuda 1997, p. 149, figs. 30-32

Basionym: *Sphaerococcus spinellus* C. Agardh

Synonyms: See Silva *et al.* (1996, p. 307)

Thallus subcartilaginous in texture, forming small, compact tufts on rocks, attached to substratum by primary discoid holdfasts. Branching irregular, issued in all directions, the branches spreading, the smallest, ultimate branchlets spine-like; main branches slender, with variable lengths, terete, 1-2 mm in diameter, in cross section medullary cells large, surrounding an axial cell, becoming progressively smaller outward. Tetrasporangia formed in the proximal, middle or distal, swollen part of ultimate branchlets.

This is a new record for Thailand.

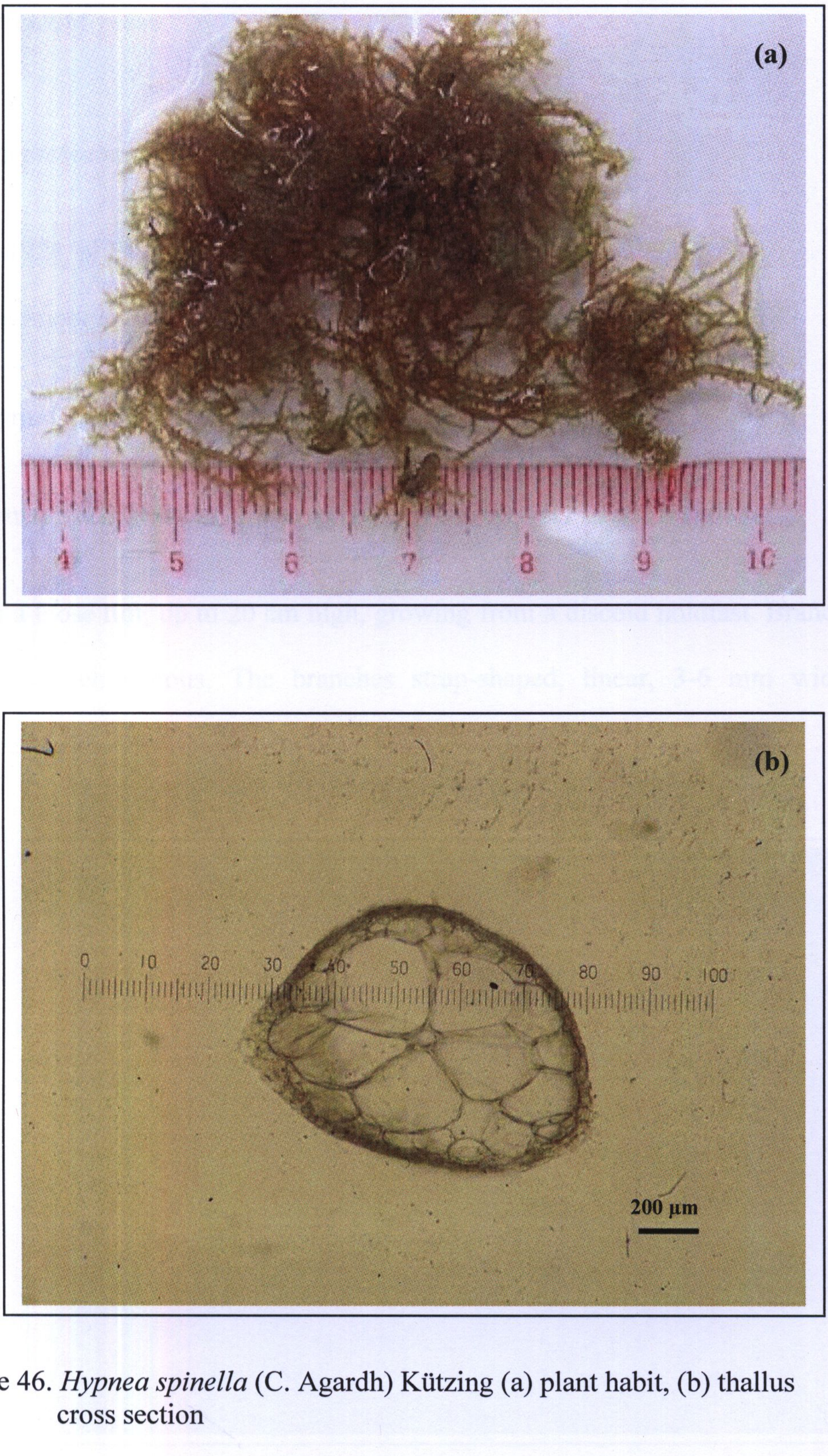



Figure 46. *Hypnea spinella* (C. Agardh) Kützing (a) plant habit, (b) thallus cross section

**Class Phaeophyceae**

***Dictyota dichotoma*** **(Hudson) Lamouroux** (Figure 47)

Egerod 1974, p. 149, figs. 75-79; Lewmanomont and Ogawa 1995, p. 71; Lewmanomont *et al.* 1995, p. 56; Trono 1997, p. 107; Huisman 2000, p. 189

Basionym: *Ulva dichotoma* Hudson

Synonyms: See Silva *et al.* (1996, p. 590)

Thallus a loose tuft, up to 20 cm high, growing from a discoid holdfast. Branching is irregularly dichotomous. The branches strap-shaped, linear, 3-6 mm wide, tips bifurcate and rounded.


Figure 47. *Dictyota dichotoma* (Hudson) Lamouroux

***Padina australis*** **Hauck** (Figure 48a, b)

Lewmanomont 1980, p. 757, pl. 1, fig. 1, pl. 2, figs. 5-6; Allender and Kraft 1983, p. 85, figs. 5c, 6b; Farrant and King 1989, p. 388, figs. 11-12; Lewmanomont and Ogawa 1995, p. 75; Lewmanomont *et al.* 1995, p. 58; Trono 1997, p. 112, fig. 77; Geraldino *et al.* 2005, p. 109, fig. 1f, 2a

Thallus fan-shaped, growing in tufts, 3-8 cm high, surfaces lightly calcified. The blade is divided into several fan-shape lobes, to 2-6 cm wide, with inrolled outer margins, composed of 2 layers of cells throughout, cell of upper layer smaller than those of the lower. Hair lines alternate on the lower and upper surfaces. Sporophyte with tetrasporangial sori, 0.5-0.8 mm wide, usually median in position in the glabrous zone, without indusium.

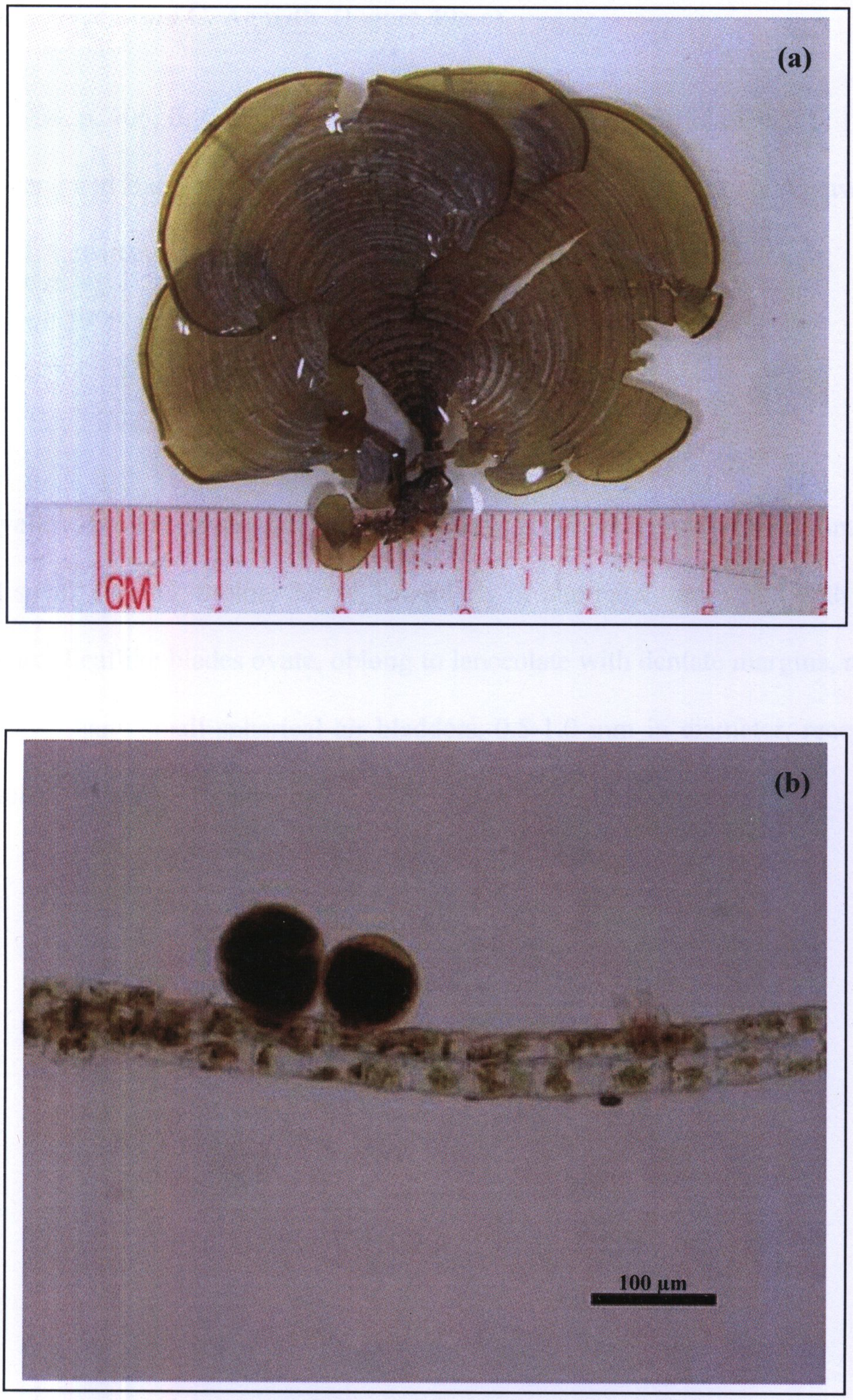



Figure 48. *Padina australis* Hauck (a) plant habit, (b) two cell layers with tetrasporangia

***Sargassum polycystum* C. Agardh** (Figure 49a-c)

Dawson 1954, p. 406, figs. 22t, u; Tseng 1983, p. 236, fig. 1; Yoshida 1988, p. 17, fig. 14; Tseng and Baoren 1988, p. 47, figs. 13, 26-27; Lewmanomont and Ogawa 1995, p. 84; Lewmanomont *et al.* 1995, p. 65; Trono 1997, p. 147, figs. 96a, b; Ajisaka *et al.* 1999, p. 36, figs. 6a, b

Synonym: See Silva *et al.* (1996, p. 695)

Thallus yellow-brown, up to 150 cm long, with short cylindrical stipe 5-10 mm long. Holdfast small, discoid. Stolons terete, irregularly or alternately branched with many small spines. Leaflike blades ovate, oblong to lanceolate with dentate margins, midrib conspicuous, many small spherical air bladders, 0.5-1.0 mm in diameter, receptacle cylindrical.

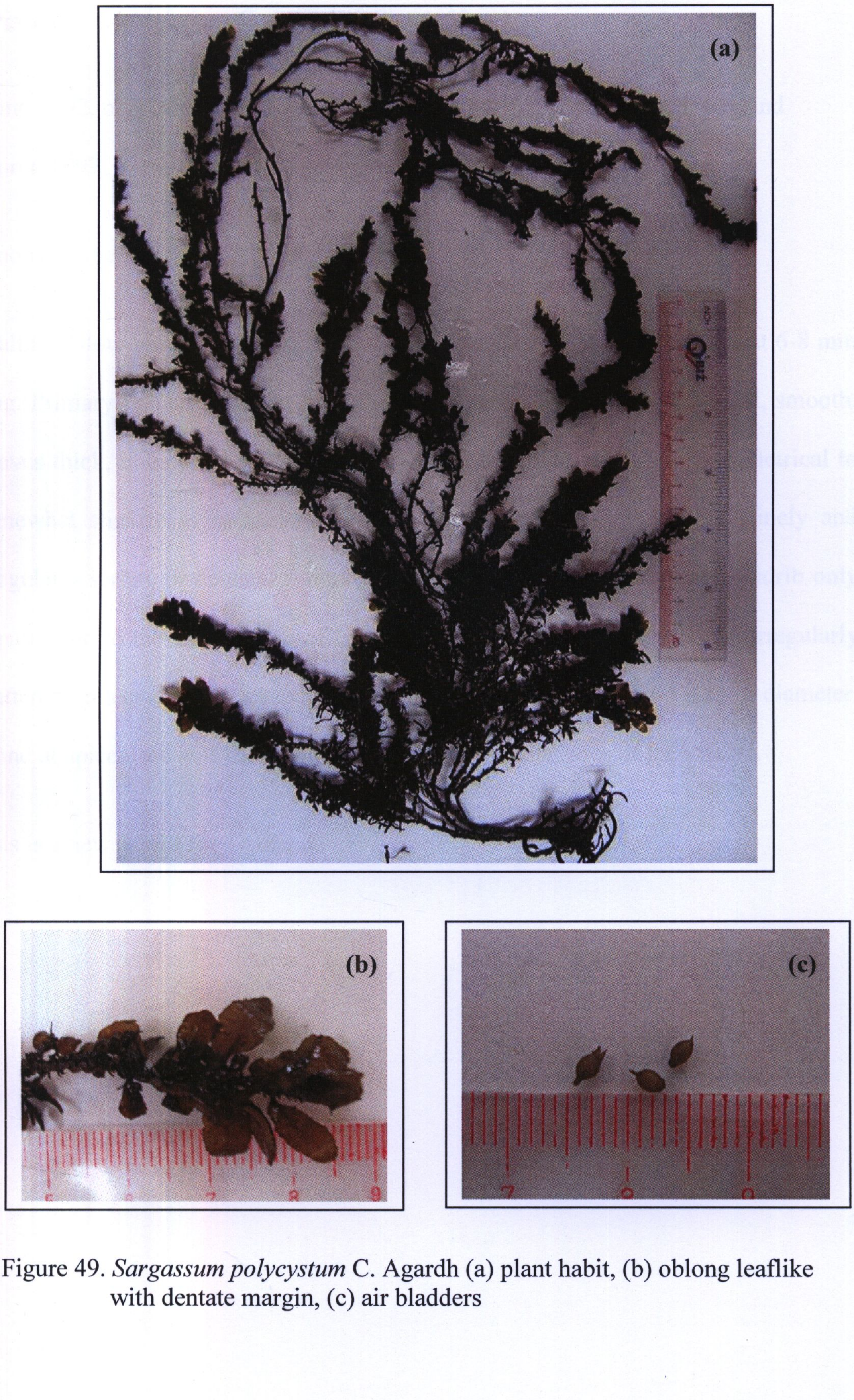



Figure 49. *Sargassum polycystum* C. Agardh (a) plant habit, (b) oblong leaflike with dentate margin, (c) air bladders

***Sargassum cristaefolium* C. Agardh** (Figure 50a-c)

Trono 1992, p. 50, figs. 12-15, 113; Trono 1977, p. 133, figs. 89a, b; Tseng and Baoren 1997, p. 16, figs. 3, 10

Synonyms: See Silva *et al.* (1996, p. 665)

Thallus yellow-brown. Holdfast discoid, producing a stipe, cylindrical, about 6-8 mm long. Primary branches arising from the upper parts of the axis, cylindrical, smooth. Leaves thick, oblong, up to 2.0- 2.5 cm long, 1.0-1.5 cm wide, base symmetrical to somewhat slightly asymmetrical in some, cuneate, stalk short, margin finely and irregularly serrate or dentate, some teeth duplicated, tip obtuse-rounded, midrib only apparent up to the mid-portion of leaf, cryptostomata distinct, numerous, irregularly scattered on leaves. Vesicles cylindrical or subcylindrical, about 4-5 mm in diameter, round at apices, most of them with earlike wings on both sides of the vesicle.

This is a new record for Thailand.

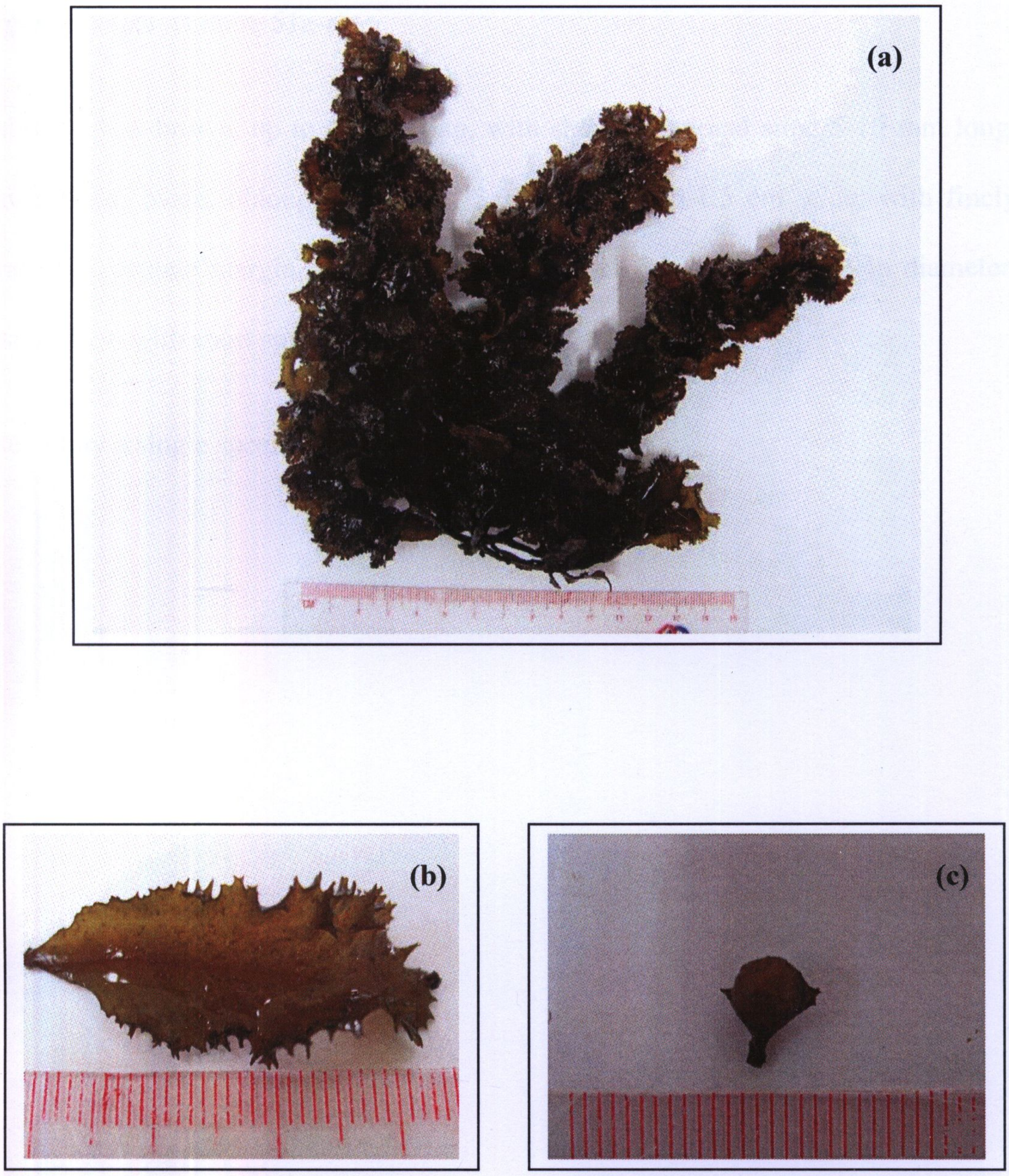



Figure 50. *Sargassum cristaefolium* C. Agardh (a) plant habit, (b) irregulary serrate margin of leaf, (c) ear like wings of the vesicle.

***Sargassum* sp.1** (Figure 51a-c)

Thallus yellow-brown, up to 40 cm long,. with short cylindrical stipe 5-10 mm long. Leaves thick, ovate, oblong, up to 1.5- 3.0 cm long, 1.0-1.5 cm wide, with finely serrate and dentate margin. Many small spherical air bladder, 3-5 mm in diameter, most of them with short spine at apices.

Note: Only a single specimen

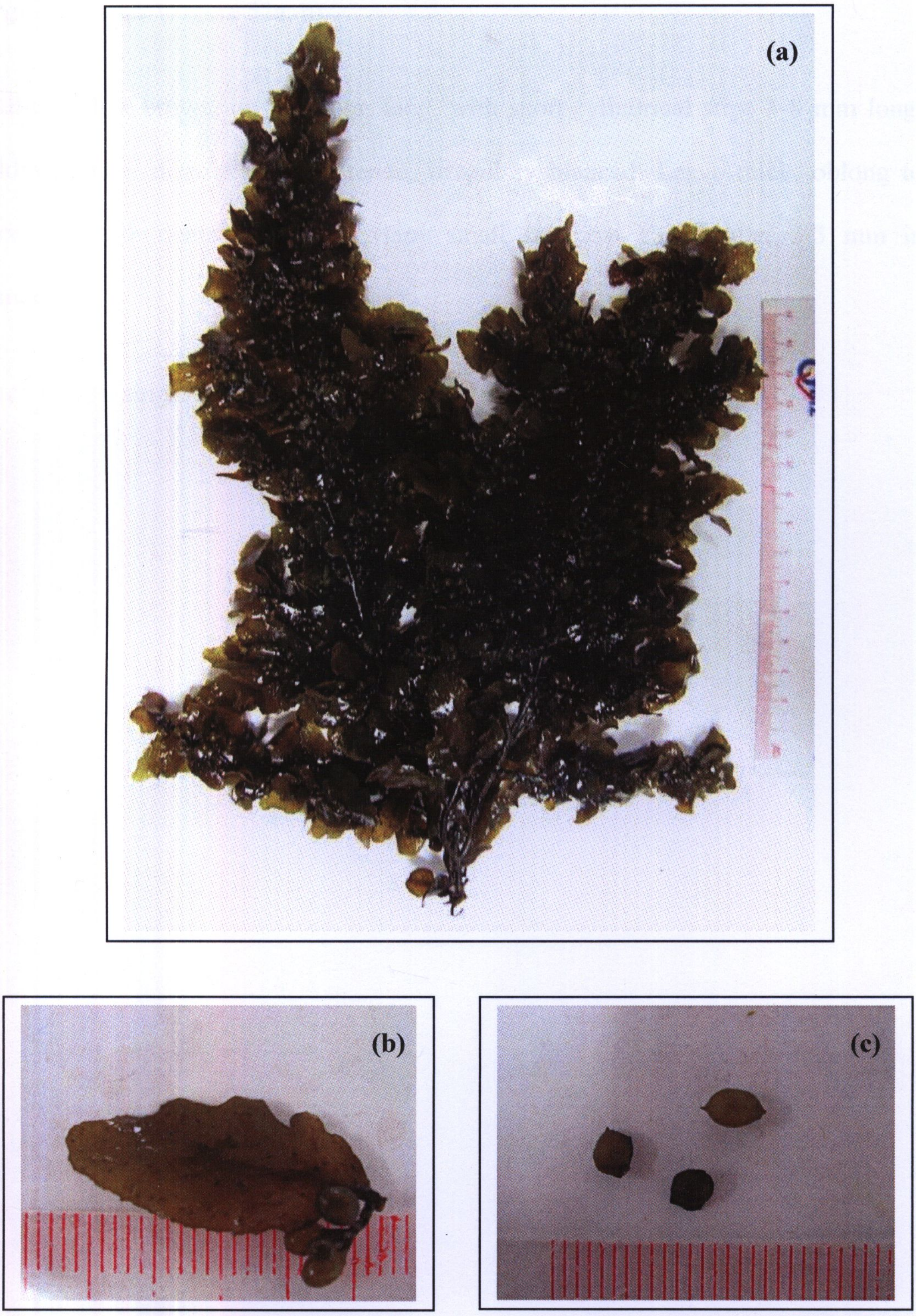



Figure 51. *Sargassum* sp.1 (a) plant habit, (b) oblong leaflike with dentate margin, (c) spherical air bladder

***Sargassum* sp.2** (Figure 52a, b)

Thallus yellow-brown, up to 55 cm long, with short cylindrical stipe 5-8 mm long. Holdfast small, discoid. Stolons terete, irregulary branced. Leave thick, oblong to lanceolate with dentate margins. Many small spherical air bladder, 2-3 mm in diameter.

Note: Only a single specimen


Figure 52. *Sargassum* sp.2 (a) plant habit, (b) lanceolate leaflike with dentate margins

***Turbinaria conoides* (J. Agardh) Kützing** (Figure 53)

Tseng 1983, p. 240, pl. 121, fig. 3; Lewmanomont and Ogawa 1995, p. 85; Lewmanomont *et al.* 1995, p. 66; Trono 1997, p. 152, fig. 98

Basionym: *Turbinaria vulgaris* J. Agardh var. *conoides* J. Agardh

Synonym: *Turbinaria denudata* Bory de Saint-Vincent

Thallus erect, up to 20 cm high, arising from a spreading branched holdfast. Main axes terete, smooth. Blade composed of slender stalk, 0.5-1.0 cm long, expanded into subcircular, trumpet-shaped foliar parts, the expanded portions with irregularly dentate margin. Receptacles in clusters, attached to the stalk of blade. Yellowish-brown to dark brown in color.

Figure 53. *Turbinaria conoides* (J. Agardh) Kützing

***Turbinaria ornata* (Turner) J. Agardh** (Figure 54)

Dawson 1954, p. 405, fig. 21; Tseng 1983, p. 242, pl. 122, fig. 2; Lewmanomont and Ogawa 1995, p. 87; Lewmanomont *et al.* 1995, p. 66; Trono 1997, p. 155, fig. 100; Huisman 2000, p. 226

Basionym: *Fucus turbinatus* Linnaeus var. *ornata* Turner

Synonyms: See Silva *et al.* (1996, p. 713)

Thallus erect, dark brown, to 15 cm high, with branches issued irregularly in all directions. Blade 1-2 cm long, blade stalk cylindrical, expanded into a nearly circular foliar part resembling a stout trumpet, with irregularly toothed margin and 3-5 distinctive intramarginal crown teeth, with an embedded air bladder in the middle. Receptacles attached to the stalk of blade.

Figure 54. *Turbinaria ornata* (Turner) J. Agardh

***Turbinaria decurrens* Bory de Saint-Vincent** (Figure 55)

Lewmanomont and Ogawa 1995, p. 86; Lewmanomont *et al.* 1995, p. 67; Trono 1997, p. 154, fig. 99

Synonym: *Turbinaria vulgaris* J. Agardh var. *decurrens* (Bory de Saint-Vincent) J. Agardh

Thallus erect, up to 15 cm high, main axis with few branches arising from a spreading branched holdfast. Blade 1-2 cm long, obpyramidal, blades arranged spirally around the main axis, triangular in cross section, expanded at the end, the edges with fine serrations, containing a central air bladder. Receptacles attached to the base of the stalk.

Figure 55. *Turbinaria decurrens* Bory de Saint-Vincent

## 3.2 Abundance and distribution study

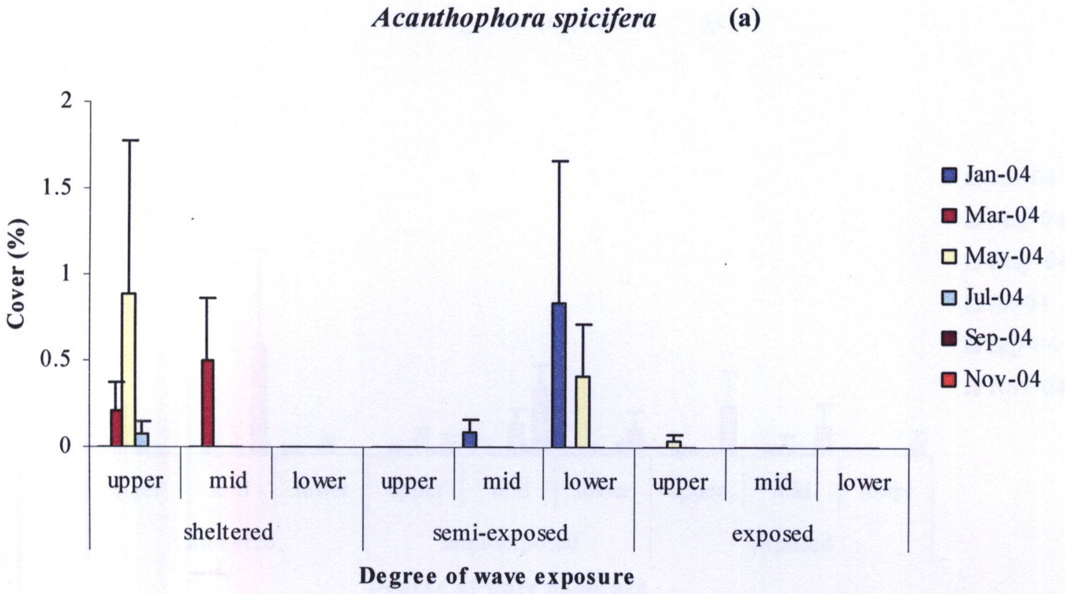
### 3.2.1 Abundance and distribution of macroalgae in each season at each site.

Species diversity index (*H′*) was relatively similar throughout the year. Fluctuations in *H′* were more pronounced spatially than seasonally. Diversity averaged 0.92±0.07, 1.00±0.13 and 0.94±0.16 for the sheltered, semi-exposed and exposed areas, respectively. The highest diversity was found at the semi-exposed area, while the lowest diversity was found at the sheltered area.

The seasonality of macroalgae species at the site was less uniform. During both dry season and wet season, *Lyngbya majuscula* and *Padina australis* showed greatest average of percentage cover, 31.66% and 27.77%, respectively (Figure 56o, p). *Acanthophora spicifera* (Figure 56a), *Boodlea composita* (Figure 56d), *Gracilaria salicornia* (Figure 56l), *Hypnea spinella* (Figure 56m) and *Valonia aegagropila* (Figure 56t) had greatest percentage cover during dry season and became less abundant during wet season. In contrast, during wet season, *Boergesenia forbesii* (Figure 56c), *Ceramium mazatlanense* (Figure 56e), *Chondrophycus tronoi* (Figure 56g) *Gelidiella acerosa* (Figure 56j) exhibited a higher percentage cover than dry season.

Generally, most seaweed species exhibited greatest abundance at the semi-exposed area such as *Anadyomene wrightii, Dictyosphaeria cavernosa, Gelidium pusillum* and *Lyngbya majuscula.* The green alga, *Boodlea composita,* however, was common at the sheltered area. It showed the greatest percentage cover at the sheltered area and becoming less in abundance at semi-exposed and exposed areas. Some species, *Gelidiella acerosa* and *Chondrophycus tronoi* were common at the exposed area. There was no significantly difference in percentage cover of algae among shore levels (*P*>0.05). However, some species became dominant at certain shore level, for example, three species of brown algae (*Turbinaria conoides, Turbinaria decurrens, Turbinaria ornat*a) were common at the lower intertidal area.

Thirteen species were found throughout the entire study period. These included one species of blue-green algae, *Lyngbya majuscula,* five species of green algae, *Halimeda opuntia, Boergesenia forbesii, Valonia aegagropila, Dictyosphaeria cavernosa, Boodlea composita,* six species of red algae, *Acanthophora spicifera, Chondrophycus tronoi, Ceramium mazatlanense, Gelidiella acerosa, Gracilaria salicornia, Hypnea spinella* and one species of brown algae, *Padina australis*.



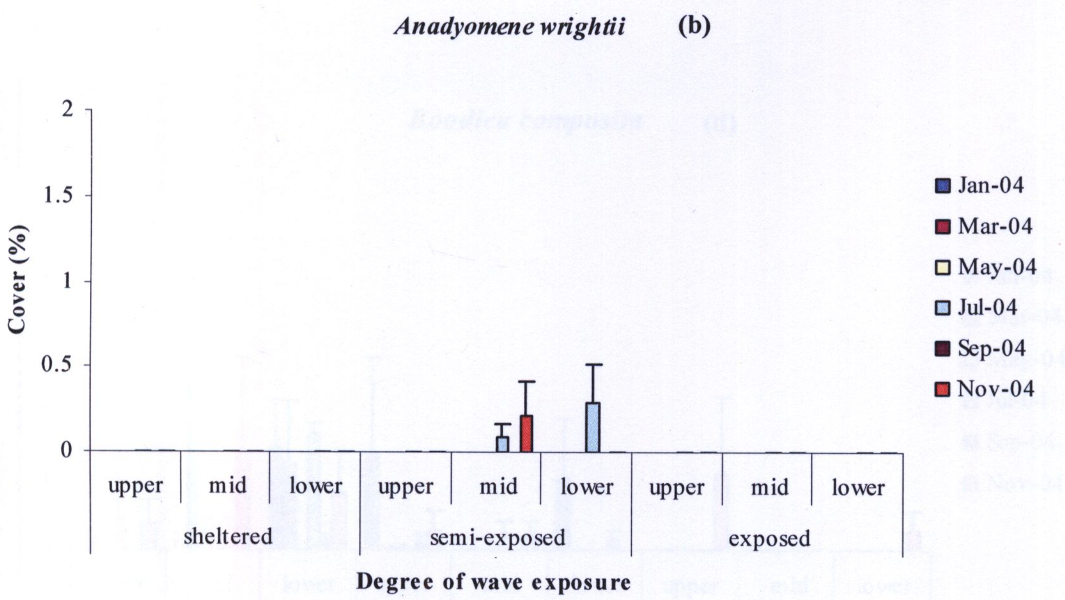
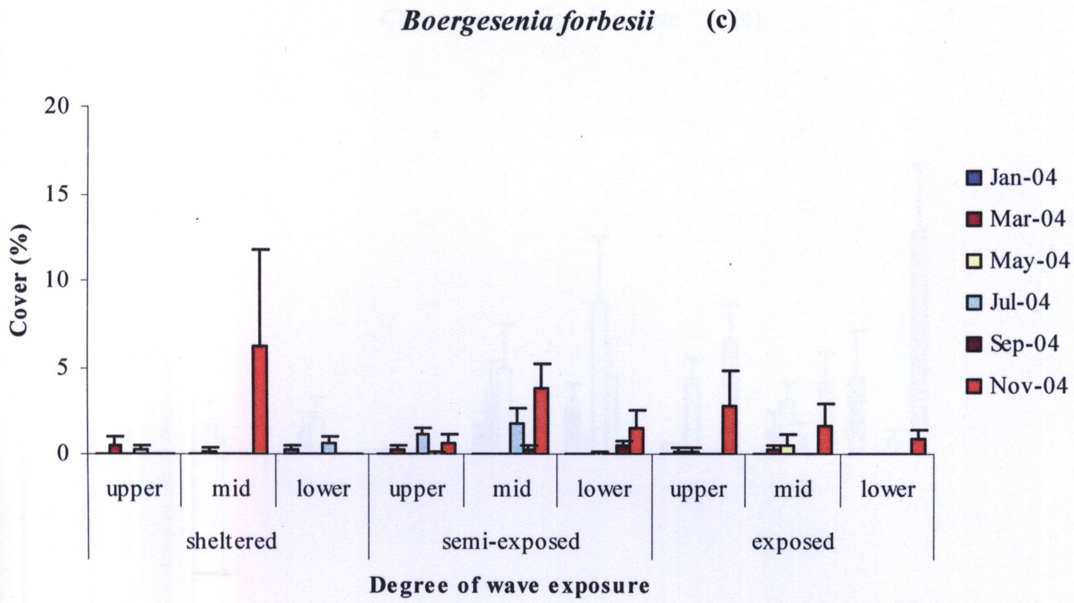




Figure 56. Effect of wave exposure (sheltered, semi-exposed and exposed areas) in each season on algal percentage cover which showed significant relationships.



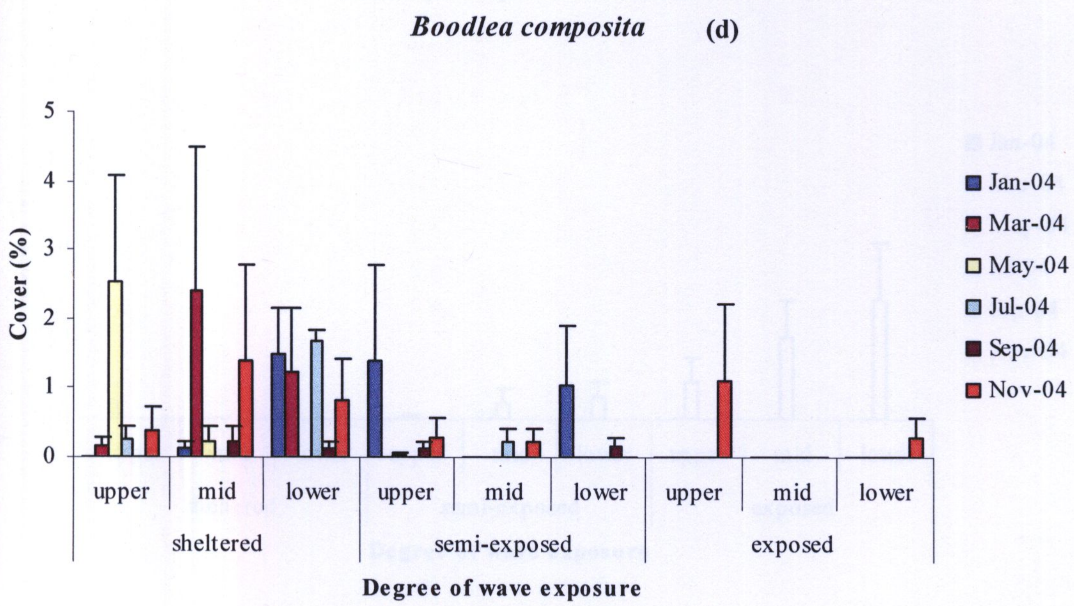
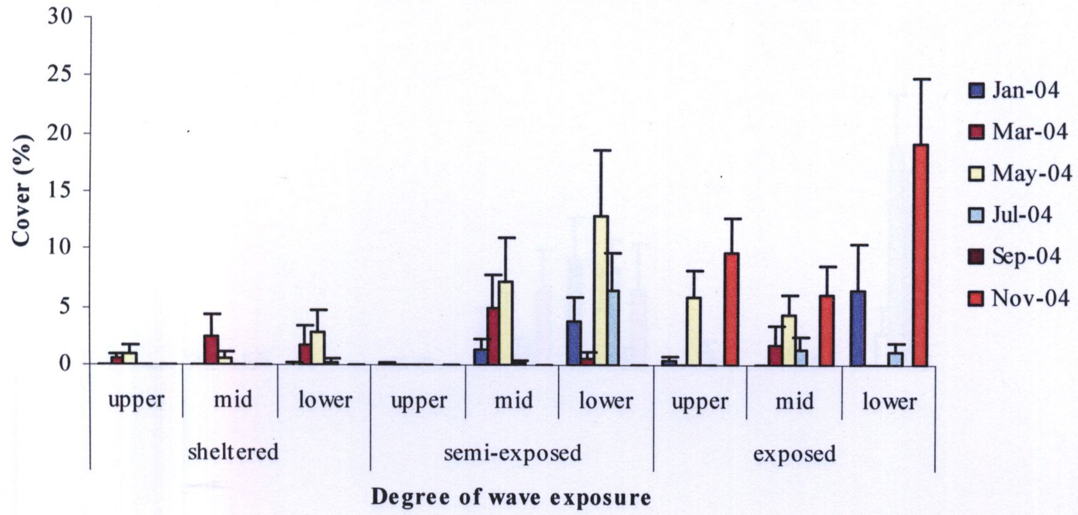




Figure 56. (Continued)

*Ceramium mazatlanense* (e)




*Cladophoropsis sundanensis* (f)

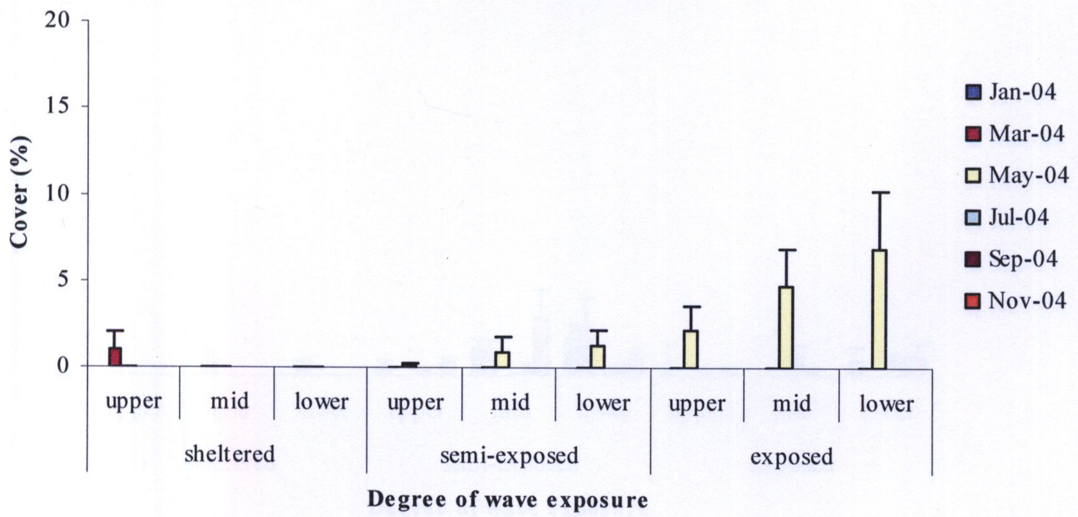
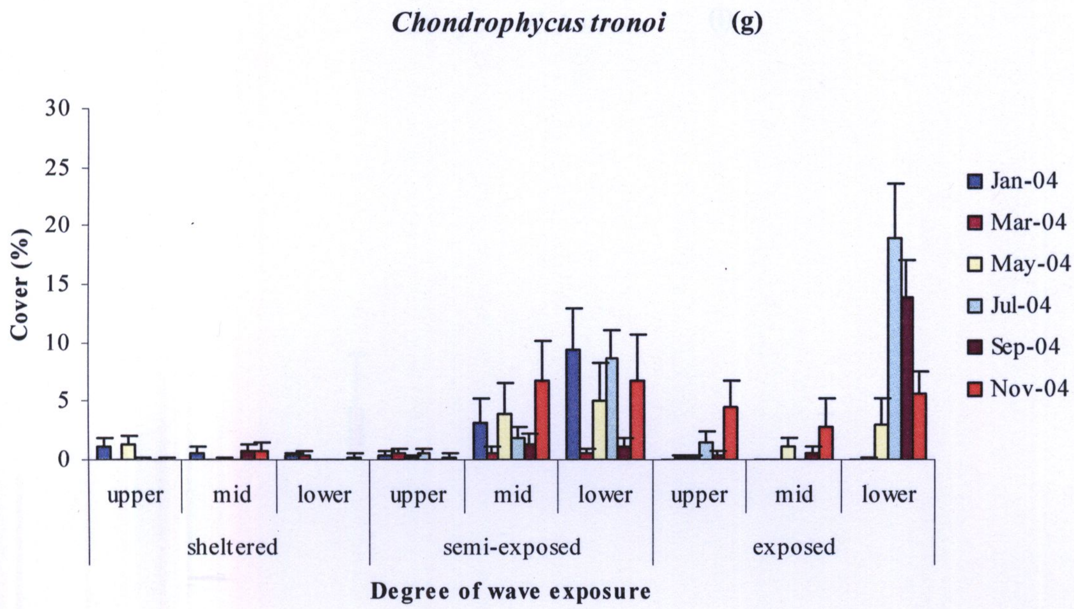



Figure 56. (Continued)



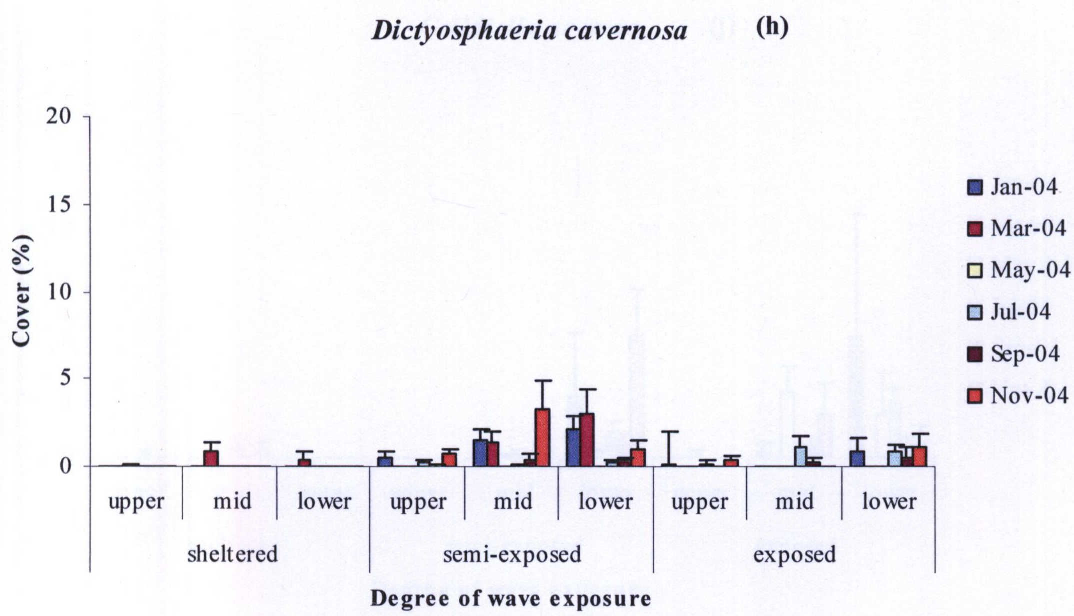
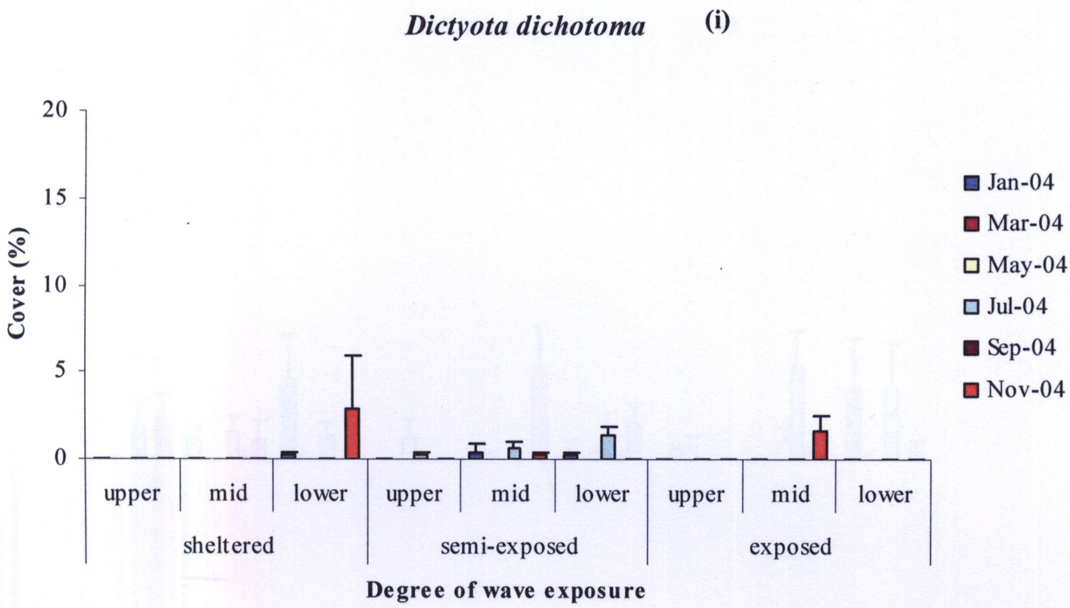




Figure 56. (Continued)



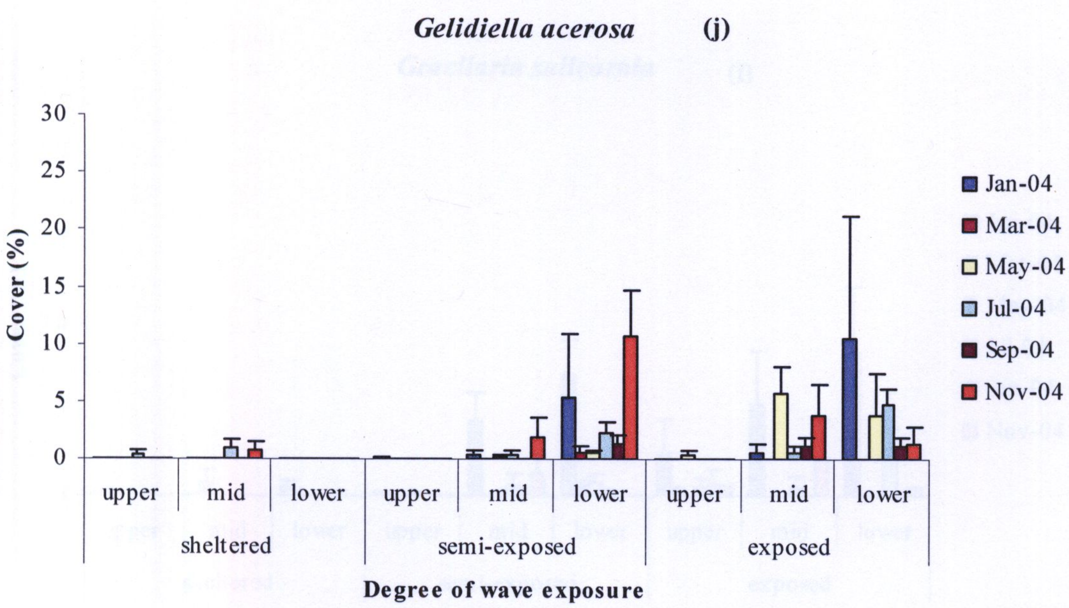
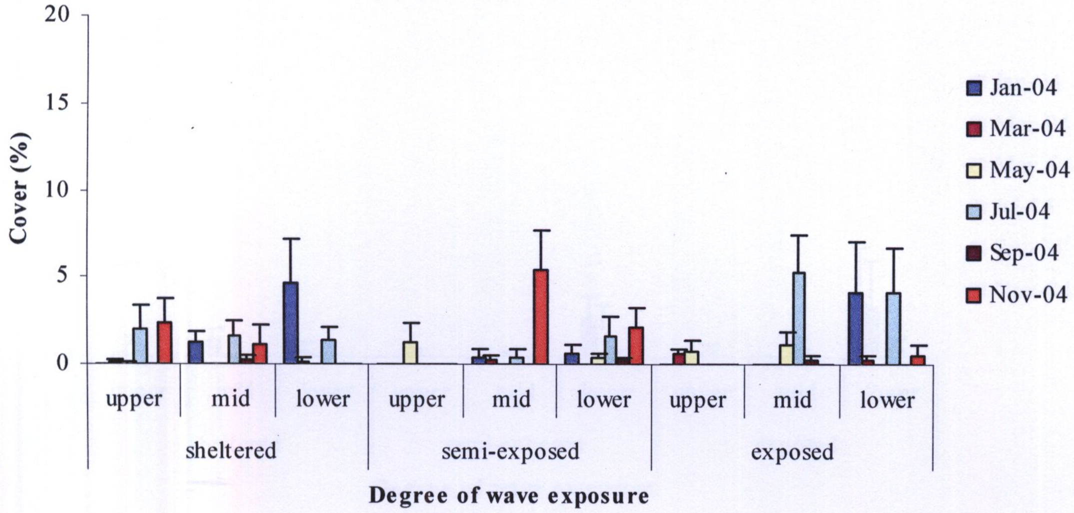




Figure 56. (Continued)

***Gelidium pusillum*** **(k)**




***Gracilaria salicornia*** **(l)**

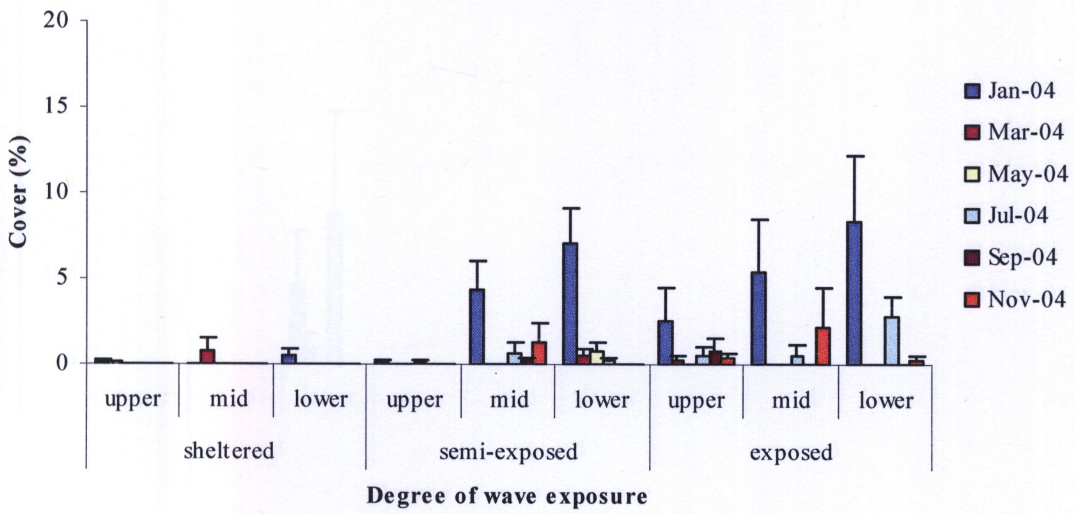
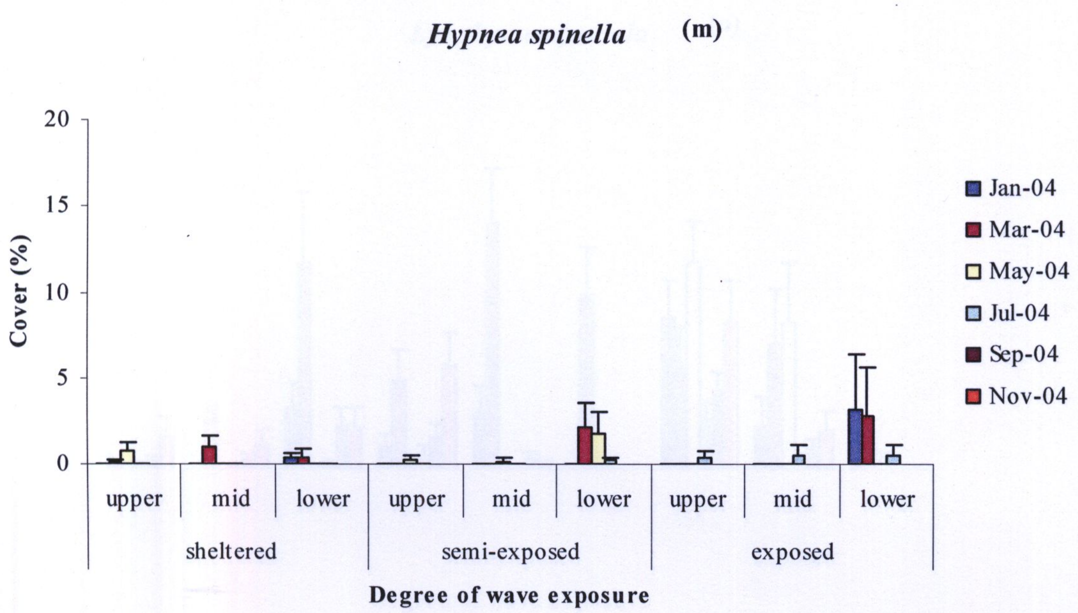



Figure 56. (Continued)



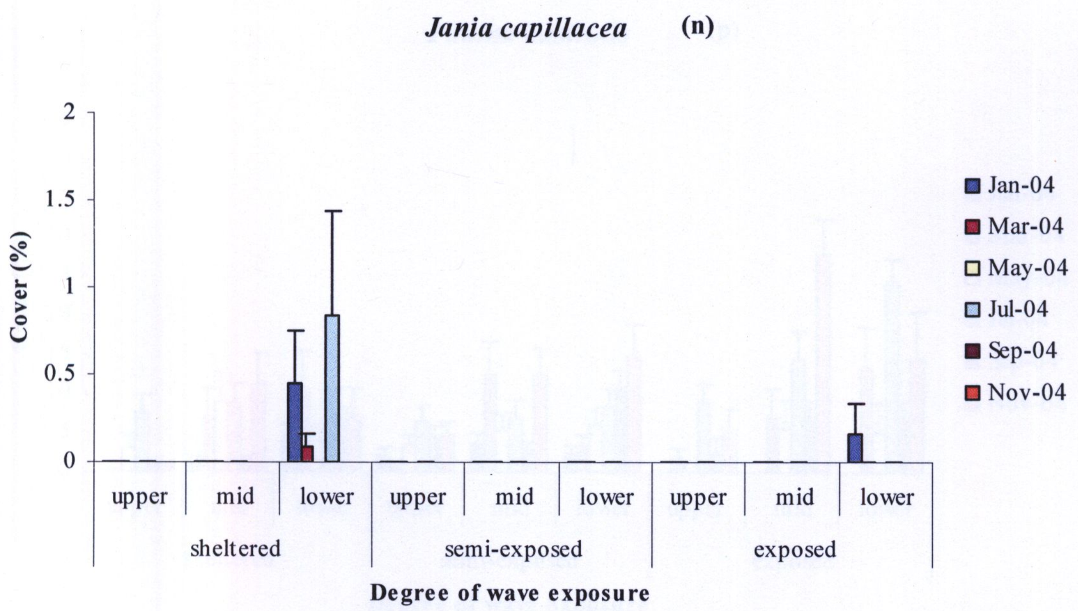
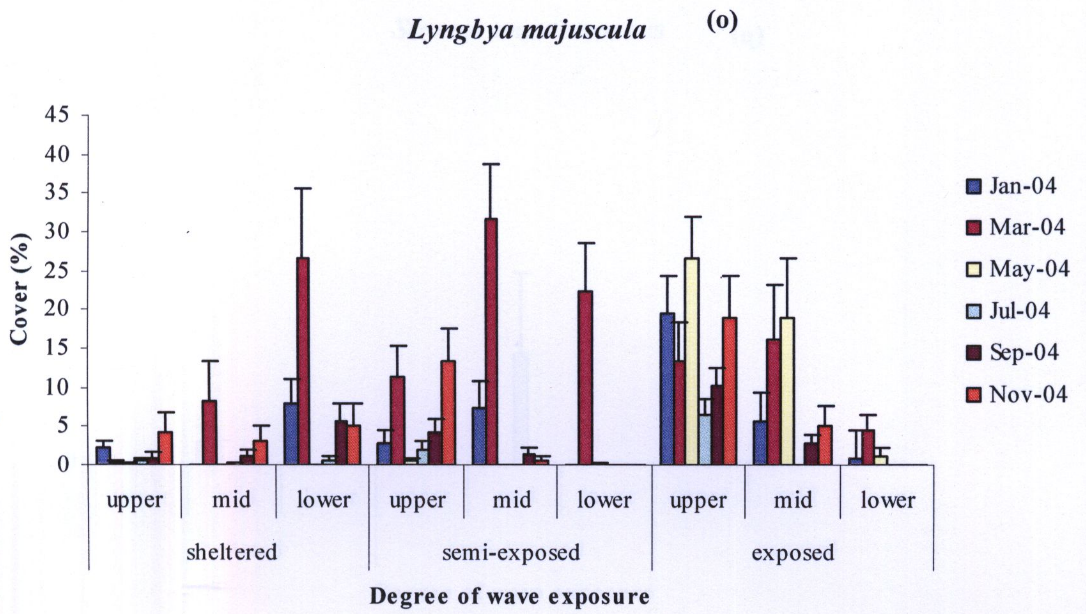
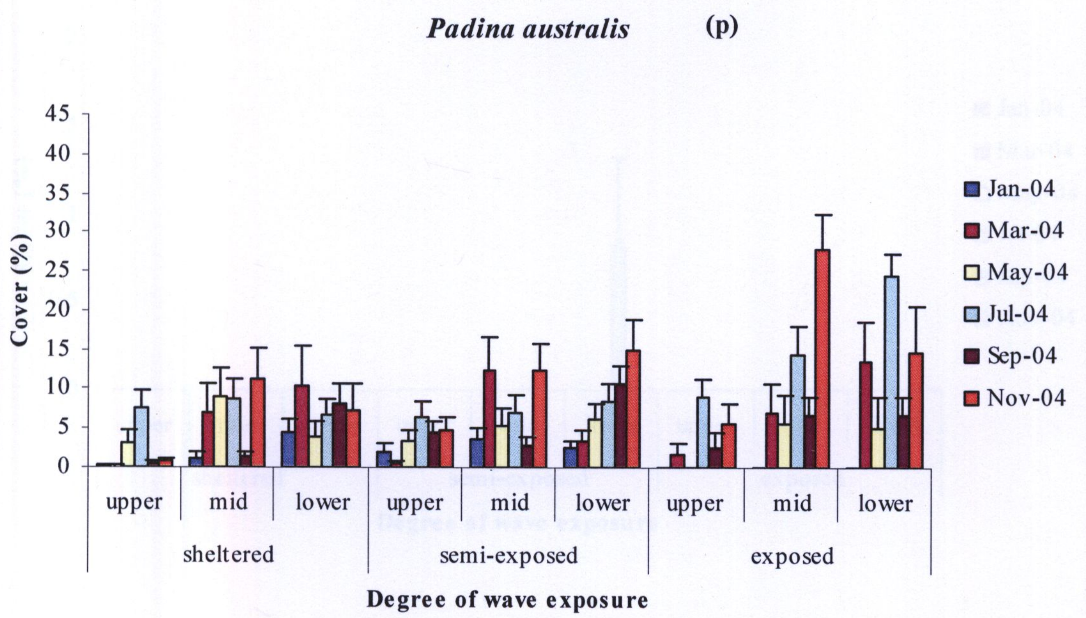




Figure 56. (Continued)

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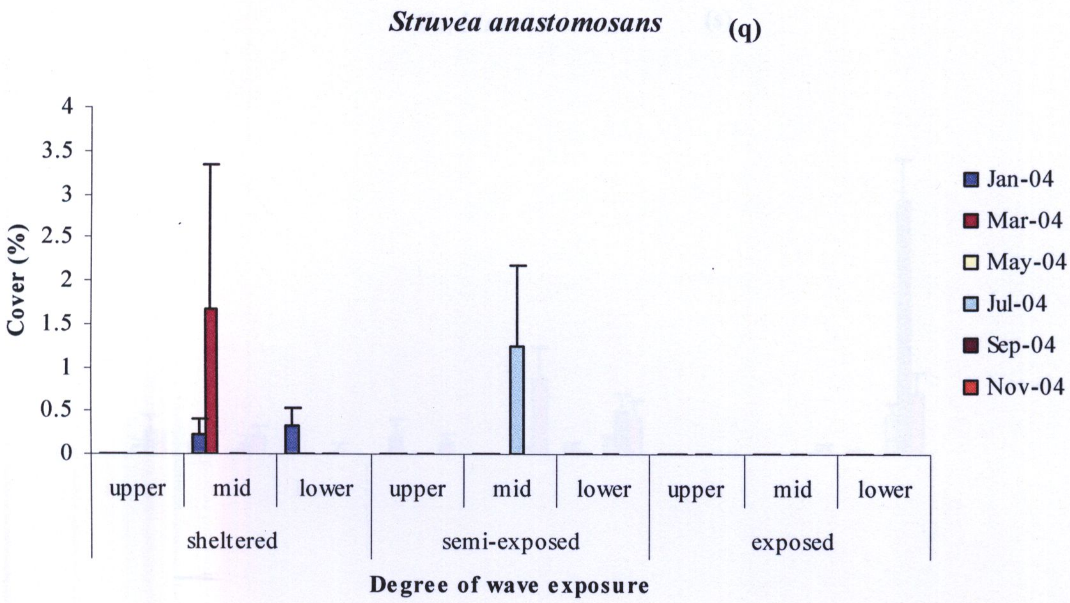


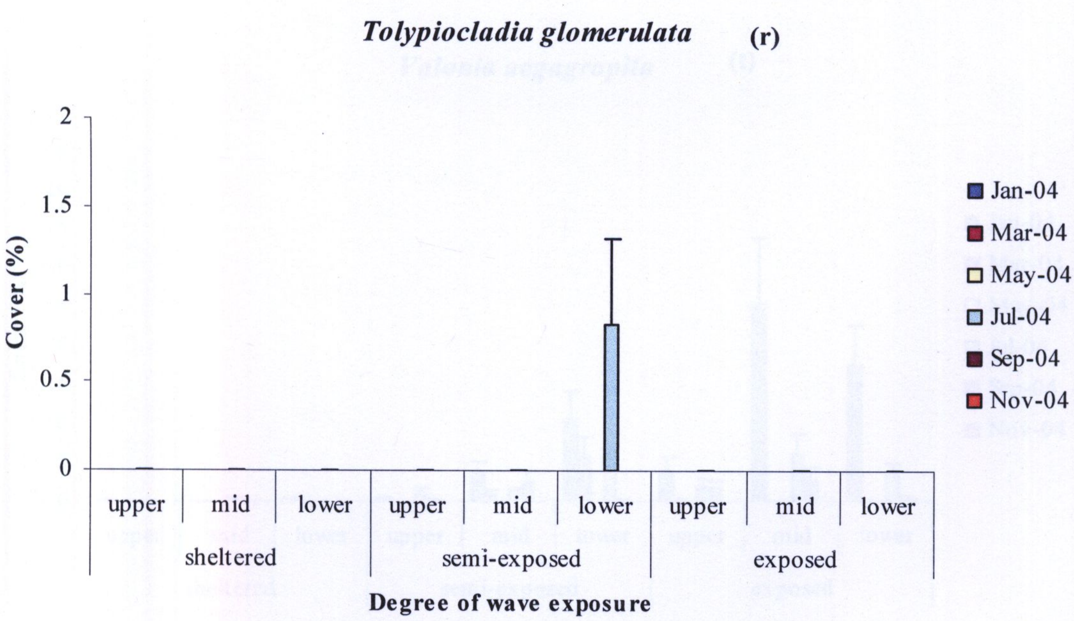


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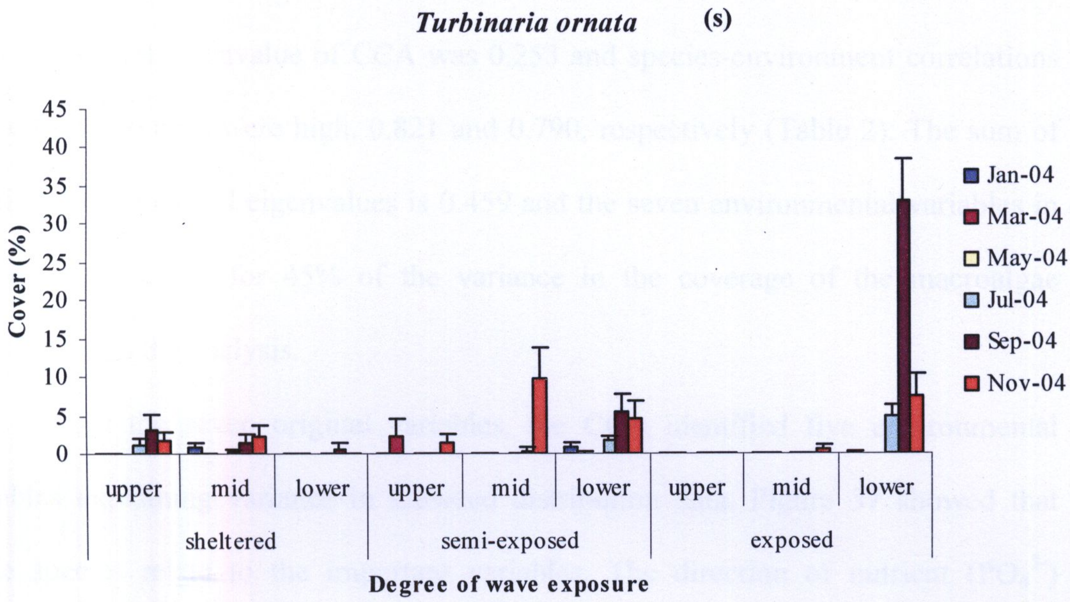


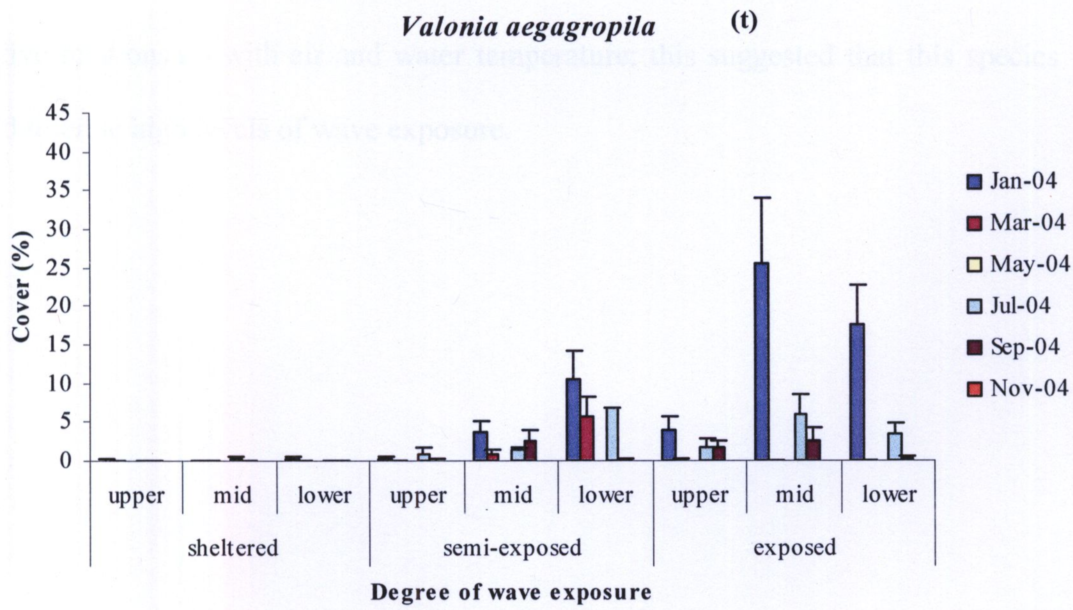




Figure 56. (Continued)

### 3.2.2 The relationships between species distributions and environmental factors.

The first eigenvalue of CCA was 0.253 and species-environment correlations of the first two axes were high, 0.821 and 0.790, respectively (Table 2). The sum of the first two canonical eigenvalues is 0.459 and the seven environmental variables in conjunction account for 45% of the variance in the coverage of the macroalgae investigated in the analysis.

From the seven original variables, the CCA identified five environmental variables explaining variance in seaweed distribution data. Figure 57 showed that some species relate to the important variables. The direction of nutrient ($PO_4^{3-}$) indicated the relative positions of species distributions along the phosphate gradient. Thus, species such as *Ceramium mazatlanense*, *Cladophoropsis sundanensis* and *Enteromorpha flexuosa* were found mainly in sites of high phosphate concentration, while light positively affected *Gracilaria salicornia. Padina australis* showed a positive relationship with air and water temperature; this suggested that this species could tolerate high levels of wave exposure.

Table 2. Axis summary statistics for CCA analysis.

Number of canonical axes : 3

Total variance ("inertia") in the species data : 2.263

| | Axis 1 | Axis 2 | Axis 3 |
|---|---|---|---|
| Eigenvalue | .253 | .206 | .161 |
| Variance in species data | | | |
| % of variance explained | 11.2 | 9.1 | 7.1 |
| Cumulative % explained | 11.2 | 20.2 | 27.4 |
| Pearson Correlation, Spp-Envt* | .821 | .790 | .677 |
| Kendall (Rank) Corr., Spp-Envt | .526 | .487 | .326 |

* Correlation between sample scores for an axis derived from the species data and the sample scores that are linear combinations of the environmental variables. Set to 0.000 if axis is not canonical.

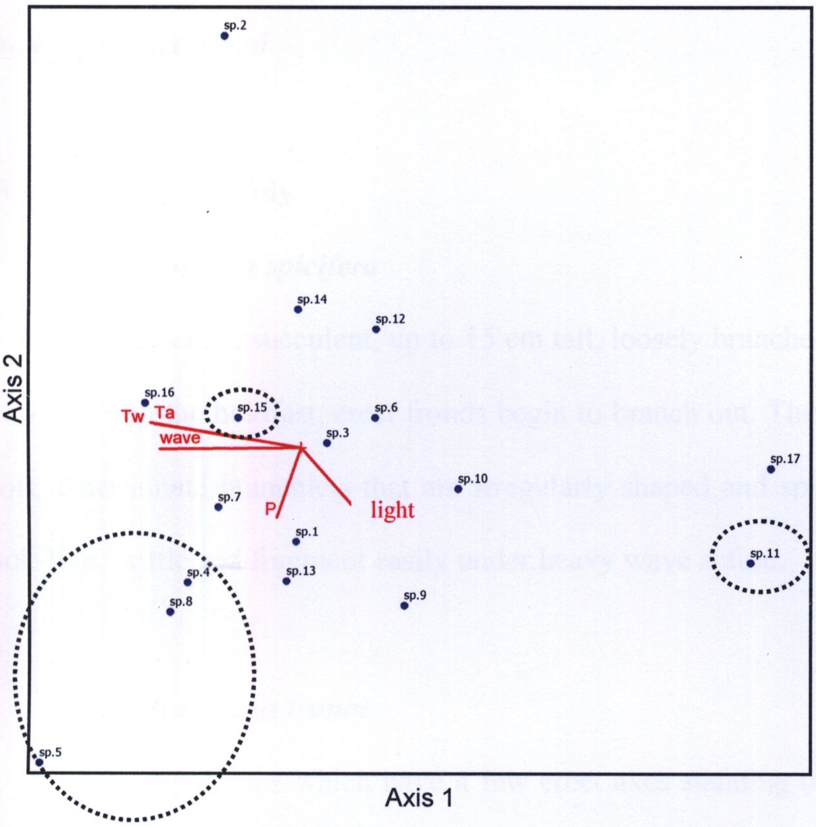



Figure 57. Canonical correspondence analysis ordination of cover data with respect to 7 environmental factors.

light = light

wave = wave motion

Ta = air temperature

Tw = water temperature

sp.1 = *Acanthophora spicifera*

sp.2 = *Lyngbya* sp.

sp.3 = *Boodlea composita*

sp.4 = *Ceramium mazatlanense*

sp.5 = *Cladophoropsis sundanensis*

sp.6 = *Dictyosphaeria cavernosa*

sp.7 = *Dictyota dichotoma*

sp.8 = *Enteromorpha flexuosa* subsp. *paradoxa*

sp.9 = *Gelidiella acerosa*

sp.10 = *Gelidium pusillum*

sp.11 = *Gracilaria salicornia*

sp.12 = *Hypnea spinella*

sp.13 = *Chondrophycus tronoi*

sp.14 = *Lyngbya majuscula*

sp.15 = *Padina australis*

sp.16 = *Turbinaria ornata*

sp.17 = *Valonia aegagropila*

## 3.3 Variations in morphology and reproduction of *Acanthophora spicifera* and *Chondrophycus tronoi*

### 3.3.1 Morphology study

***Acanthophora spicifera***

Thallus erect, succulent, up to 15 cm tall, loosely branched, with small discoid holdfast; from the holdfast, erect fronds begin to branch out. The main branches have short, determinate branchlets that are irregularly shaped and spinose. Branchlets are hook-like, brittle and fragment easily under heavy wave action.

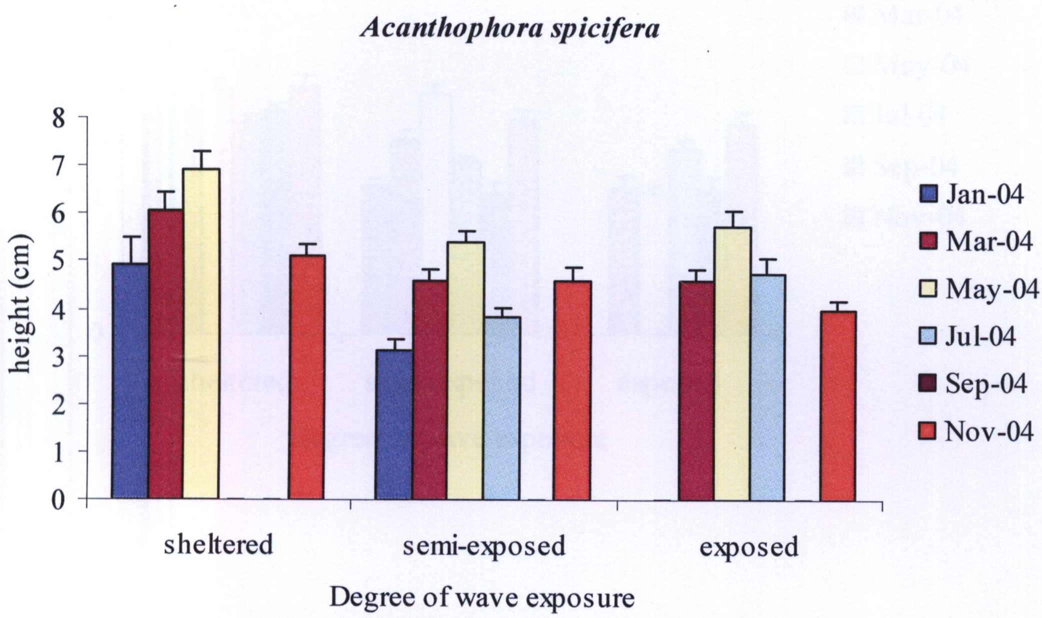
***Chondrophycus tronoi***

Forming clumps which have a few erect axes standing on a discoid holdfast, without stoloniferous basal branches, up to 5 cm high, cartilaginous. Branching alternately or oppositely distichous. Colour brownish purple or somewhat greenish when fresh, changing to black upon drying.

### 3.3.2 Variations in height and diameter

There were significant differences in height and diameter of both *Acanthophora spicifera* (Figure 58) and *Chondrophycus tronoi* (Figure 59) among sites and seasons ($P<0.05$). The height of *C. tronoi* was negatively correlated with the degree of wave exposure($R=-0.360$, $P<0.01$, $N=384$) (Figure 60), suggesting that plants in sheltered area were taller than plants in exposed areas, while there was no significant correlation between degree of wave exposure and height of *A. spicifera*.

Surprisingly, *A. spicifera* were not found in July at sheltered area, and in September at all sites. Then they were found in November, with higher in height and diameter.



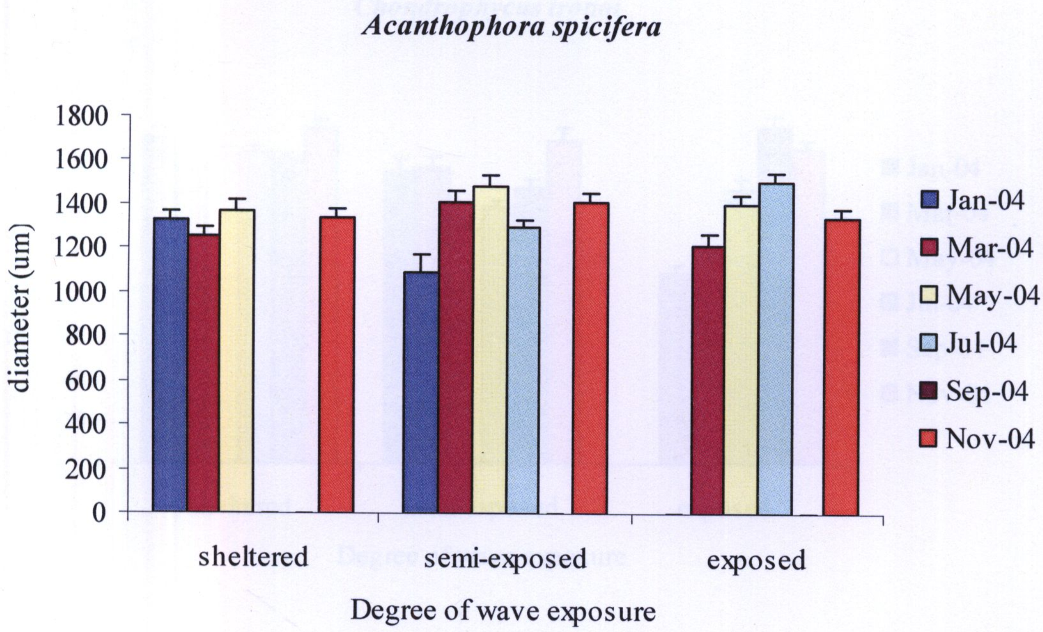
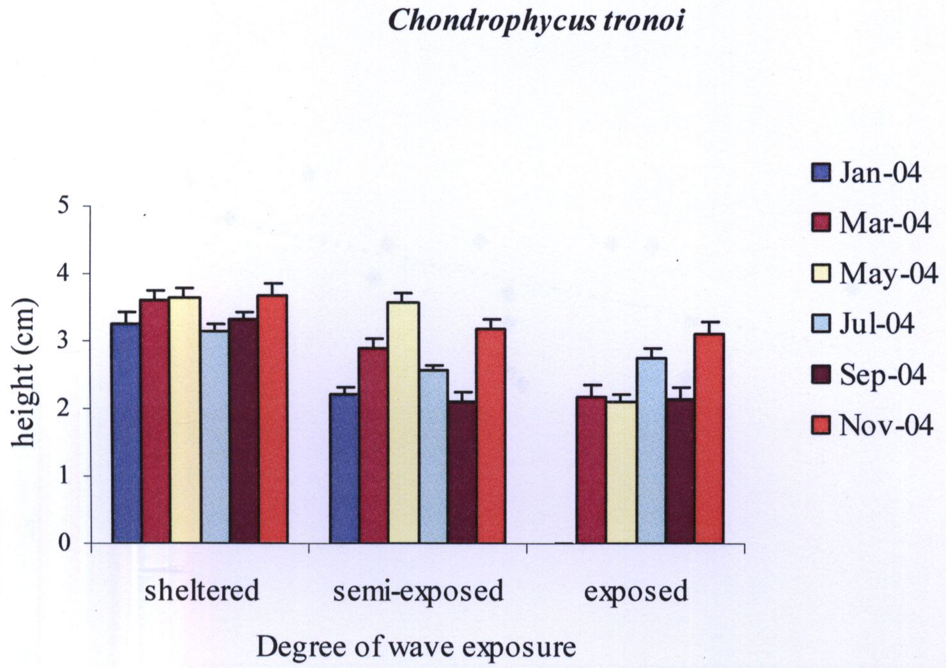




Figure 58. Height and diameter of *Acanthophora spicifera* each season and site.



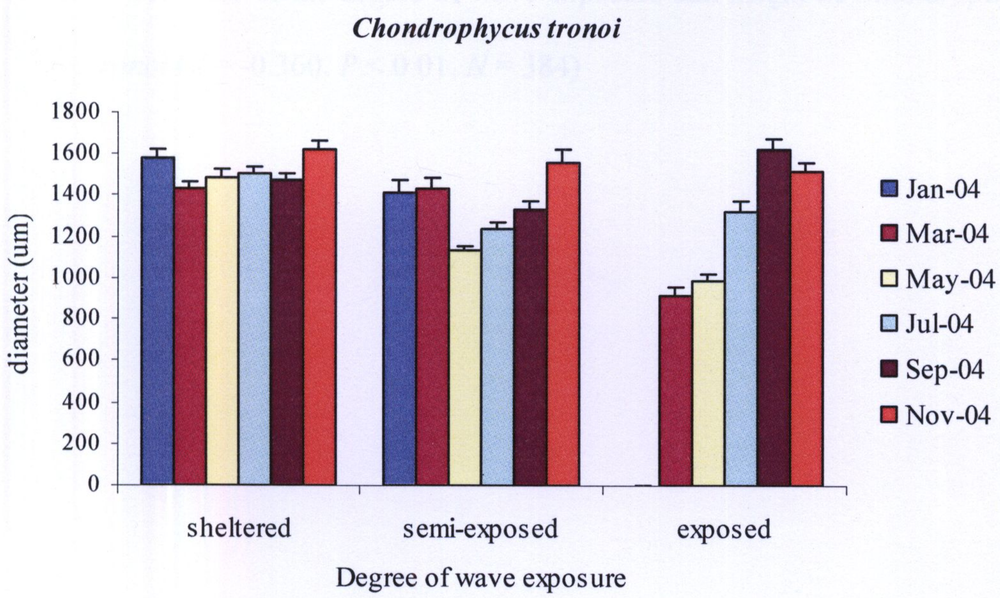




Figure 59. Height and diameter of *Chondrophycus tronoi* each season and site.

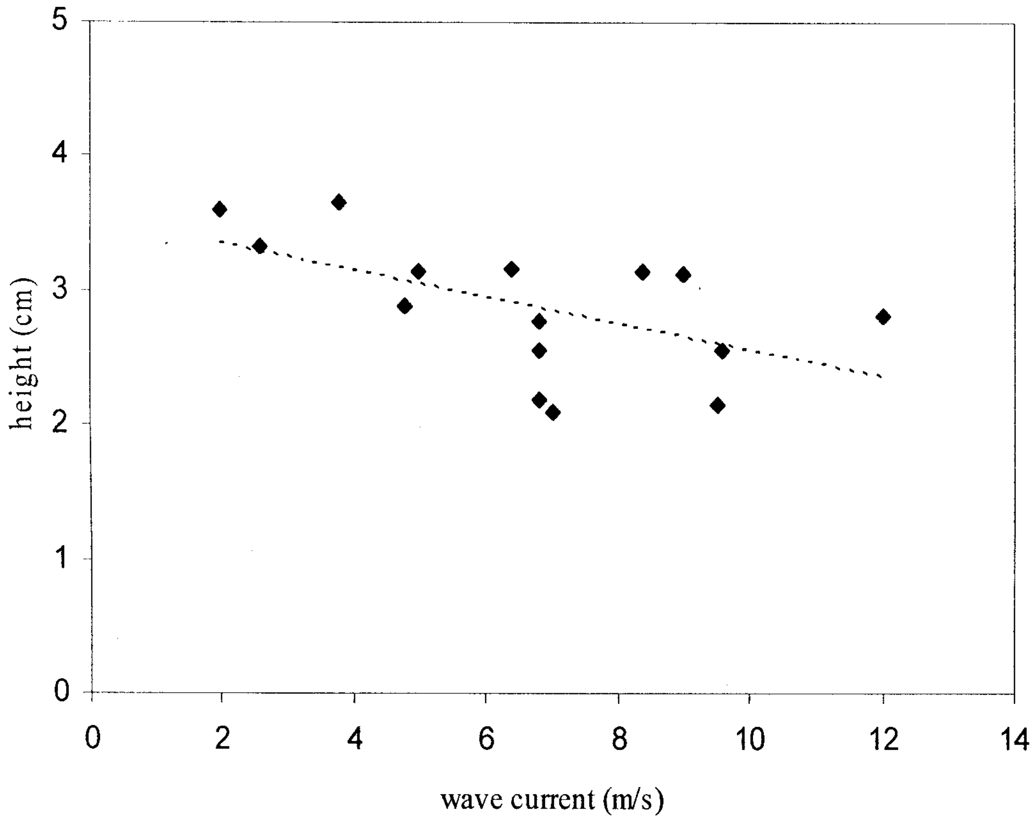



Figure 60. Correlations of the degree of wave exposure and height of *Chondrophycus tronoi* ($R$ = -0.360, $P < 0.01$, $N$ = 384)

### 3.3.3 Branching pattern of *Acanthophora spicifera* and *Chondrophycus tronoi* at the sites.

The number of primary and secondary branches of *Acanthophora spicifera* and *Chondrophycus tronoi* were similar at all sites, branching patterns of plants from all 3 sites had the same series. Comparisons of numbers of branches showed that there were no significant differences among sites in numbers of primary ($P$=0.75) and secondary branches ($P$=0.56) of *A. spicifera*, and there were no significant differences among sites in numbers of primary ($P$=0.69) and secondary branches ($P$=0.51) of *C. tronoi.*

### 3.3.4 Variations in reproduction of *Acanthophora spicifera* and *Chondrophycus tronoi* at the site.

The reproduction of both *Acanthophora spicifera* and *Chondrophycus tronoi* were investigated, total of 540 plants were examined throughout the study. There was no reproductive structures of these two species were found during this study.

### 3.4 Physical factors study

The physical factors were recorded bimonthly: January and March represent the dry season, whilst May, July, September and November represent the rainy season.

There were significant variations in temperature, salinity and wave current among sites ($P<0.01$, $N=15$). The average water temperature was 30.75- 31.33 °C during the dry season and 31.27- 33.16 °C during the rainy season, whilst average air temperature was 28.1- 29.8 °C during the dry season and 30.33- 32.44 °C during the rainy season. Average salinity during the dry season was 32.94- 34.55 psu, and 32.67-33 psu during the rainy season, which were in the narrow range.

The average wave current was 3.5±0.28, 7.2±0.21 and 9.4±0.7 m/s in sheltered, semi-exposed and exposed area, respectively during the dry season while the average wave current was 4.9±0.4, 6.7±0.2 and 8.4±0.54 m/s during the rainy season.

There were no significant variations in nutrients ($PO_4^{3-}$, $NO_3^-$) among sites ($P>0.05$). The phosphate and nitrate concentration were 1.4 and 0.9 mg/l during dry season, 0.03 and 2.83 mg/l during rainy season.

# 4. DISCUSSION

## 4.1 Diversity study

Thirty-seven genera with 52 species were found in this study. These account for 15.6% of the total number of marine algae recorded in Thailand. Twenty-two species of Rhodophyta, 16 species of Chlorophyta, 9 species of the Class Phaeophyceae and 5 species of Cyanobacteria were collected. The highest diversity belonged to the Rhodophyta, characteristically diverse and abundant in the tropics (Taylor, 1960; Trono, 1997; Littler and Littler, 2003). More than 4,000 species of rhodophytes have been described and they are known to have greater diversity in the tropics than in the temperate regions. Although marine red algae occur at all latitudes, there is a marked shift in their diversity and abundance from the equator to colder sea (Lee, 1999).

Thirteen percent higher diversity of macroalgae were found at the site, as compared to the study of Sakuntab (1976), in which only 46 species were reported throughout Phuket province. Only 22 genera were reported from Sirinat Marine National Park, 40% fewer than in this study. In addition, the number of species of macroalgae in this study was two times greater than the report of Prathep (2005). Only two field collections were made in those previous studies as compared to the six field collections in this study. Thus, the number of visits field collection could be important for appraising species diversity. In addition, this suggested that there was temporal variation in diversity of macroalgae at the sites.

Of the total number, 9 species are believed to be new records for the Thai marine flora. There are only few studies published in Thailand such as a series of taxonomical studies on red algae, *Gracilaria* (Lewmanomont, 1994, 1995; Lewmanomont and Chirapart, 2004). *Gracilaria* seems to be the only red algae genus which has been well studied. Some of the new records found in this study such as *Acetabularia*, *Polysiphonia* and *Corallophila* are rather small in size. These, therefore, could be hidden or covered by other algae or substrates when collected the specimens, while *Gelidiopsis* and *Wurdemannia* are conspicuous and easy to collect in the field. *Chondrophycus, Sargassum* and *Hypnea* have been studied by a few scientists both globally and regionally. Also, revisions of these genera are still ongoing e.g. *Chondrophycus* and *Laurencia* (Nam, 1999); *Sargassum* (Yoshida, 1988; Trono, 1992; Tseng and Baoren, 1997) and *Hypnea* (Chiang, 1997; Yamagishi and Masuda, 1997). Therefore, many more new records of macroalgae are likely to be found with increasing of research.

More of algae taxonomists are needed in Thailand, the taxonomy study could provide basic information for further study in biology and ecology of macroalgae. Many macroalgae become more of ecological problems in marine ecosystem. For example, some species such as *Padina* can grow rather fast and occupy very large area, inhibited recruitment and cause death to coral in Surin island (Liddle and Phongsuwan, 2004). However, the taxonomical knowledge and reproductive biology of *Padina* is still little known. *Ulva*, a causing green-tide bloom species in many marine habitats including Patong beach, Phuket. Its taxonomy has been little studied. Just recently, there are revisions of *Enteromorpha* and *Ulva*, they both now belong into a same genus, *Ulva* (Tan *et al.,* 1999).

**4.2 Abundance and distribution study**

The highest number and percent cover of macroalgae were found at the semi-exposed site, which might be due to better nutrient and gas exchange as well as more efficient removal of waste products (Díez *et al.*, 2003). In contrast, fewer species and less abundance were characteristic of the exposed and sheltered shores. On the sheltered shore, macroalgae could be exposed to stress due to limited circulations of nutrients and gas exchange. While, exposed shores have better circulation due to wave action, but such wave motion also wash and snaps off the larger fronds of *Turbinaria* (Stewart, 2004). The results indicated that fragile algae such as *Boodlea composita* and the filamentous forms, had greater abundance on the sheltered shore. *Boodlea's* leaf-like thallus is more intact on the sheltered shore than on the semi-exposed or the exposed shore where some thalli were easily broken and frayed (Prathep, 2005).

Exposed shores are known to be occupied by fewer marine organisms (Stephenson and Stephenson, 1972). Some algae, however, are well-adapted to the exposed shore such as *Chondrophycus* spp., *Gelidiella acerosa, Gracilaria salicornia,* and *Hypnea spinella.* These algae form clumps of turf, decreasing the area exposed to strong wave motion, and help them to resist desiccation when the tide is out (Hay, 1981). Individual fronds of *Chondrophycus* spp. and *G. salicornia,* for example, aggregate together, decreasing the area exposed to strong wave action. Also, the red crustose algae, another dominant alga on the exposed shore, accumulate calcium carbonate and encrust onto the rock. These algae are tougher and their flat form is less affected by strong wave action. They, therefore, can better withstand the strong forces of the waves (Prathep, 2005).

Statistical analyses indicated that shore elevation does not influence the macroalgal population significantly. The shore elevation at this study is not very steep, thus the exposed hours during the low tide was short, only 4-5 hours differences during the spring tide. Thus, desiccation and temperature might not play crucial role on this shore, this is rather different from the temperate zone where shore zonation is rather well-defined (Littler, 1973; Kapraun, 1974; Kim *et al.*, 1996; Boaventura *et al.*, 2002). Also, biological interactions such as herbivory, competition and predation are known to play important roles on community structure (Lubchenco and Gaines, 1981; Paine, 1984), such studies are still very scarce. The combination of such study could give a better understanding of diversity and abundance of macroalgae community on the shore.

*Lyngbya* and *Padina* are the most common genera found at all sites in all seasons. They also had greater percentage cover on the shore, 31.66% and 27.77%, respectively, which are 20 times greater than others. *Lyngbya* are known to have secondary metabolites which make them unpalatable for herbivores (Bager, 1987; Nagle and Paul, 1999; Paul *et al.*, 2005). They can form mat and bloom in tropical area. With decreasing desiccation, they can occur from sheltered to exposed and from upper to lower shores. The success of *Lyngbya* occurs in various shore (Whitton and Potts, 2000; Thacker *et al.*, 2001; Boaventura *et al.*, 2002; Mayakun and Prathep, 2005). Similar to *Lyngbya, Padina* forms dense patches, with funnel-shaped blade, help to maintain water at low tide out. Also, *Padina* reproduction was observed throughout the year with very high number of spores (Lewmanomont, 1980; Liddle and Phongsuwan, 2004). This allows for high recruitment rates and population success. Such abundance is characteristic of the shores of other sites in Thailand such as at Ko Samui, Surat Thani Province (Mayakun and Prathep, 2005), Talibong, Trang Province (Prathep and Tantiprapas, in press) and Tang Khen Bay, Phuket Province. In addition, *Padina* accumulates calcium carbonate ($CaCO_3$) in the thallus, this could help them to withstand the high wave exposure; and also they are known to produce phenol with unflavored for herbivores (Shaikh *et al.*, 1991; El-Masry *et al.*, 1995).

Community grouping with 45% of the variance in the coverage of the macroalgae investigated in the CCA analysis. The CCA showed that some filamentous algae such as *Ceramium mazatlanense*, *Cladophoropsis sundanensis* and *Enteromorpha flexuosa* were influenced by phosphate ($PO_4^{3-}$) concentration. The highest phosphate ($PO_4^{3-}$) and nitrate ($NO_3^-$) concentrations were 4 mg/l and 8.8 mg/l, respectively, in this study. It seems that the algae use the nutrients efficiently, and there were no nutrient limitation effects in this study. These concentrations were high, and suitable for macroalgae. Fluctuations of salinity, water and air temperature in this study site were low; and the conditions found in this study were suitable for growth and reproduction of macroalgae (Subbaraju *et al.*, 1982). However, further investigations are needed for a better understanding of $PO_4^{3-}$ on those species, wave motion on *Padina australis* and light on *Gracilaria salicornia.*

### 4.3 Variations in morphology and reproduction of *Acanthophora spicifera* and *Chondrophycus tronoi*

There was variation in height among sites and seasons of *Acanthophora spicifera*. The highest plants were found at the sheltered area in May. Smaller plants were found in July and November concomitant with lesser abundance. The shorter plants might be due to their having been snapped off by strong wave action. There were, however, no reproductive organs observed throughout the year in this study. Fragmentation, therefore, might be an adaptation for asexual reproduction of *A. spicifera* in this area. This also could increase the ability in dispersal and distribution of plants in many areas throughout the world as for example at Galeta Point, Panama (Kilar and McLachlan, 1986b) and Taranto, Southern Italy (Cecere *et al.,* 2000; Cecere and Perrone, 2002). The disappearance of *A. spicifera* in September might have been because of high sedimentation in July and September which covered the plants (Mayakun, 2006). Higher plants were found later in November when sediment was washed away.

Macroalgae are known to adapt to withstand the greater wave motion such as shorter fronds, forming turfs or even encrusting to the substrate (Norton, 1991). Kilar and McLachlan (1986a) found that in the fore-reef, where *Acanthophora spicifera* plants were exposed to intense wave action, the plants had fewer branches compared to the sheltered area. There was, however, no significant correlation between height and degree of wave exposure in *A. spicifera* plants in this study. However, it is noteworthy that the number of primary branches in sheltered area was slightly higher than those in exposed and semi-exposed area during wet season, this suggested that stronger waves during the wet season could also slightly influence branching patterns of *A. spicifera* by snapping the branch off.

*Chondrophycus tronoi* in sheltered areas were also taller and larger than plants in exposed area, similar to the pattern in *Acanthophora spicifera.* In contrast, however, slightly greater branching of *C. tronoi* was observed on the exposed shore, as suggested in Kilar and McLachlan (1986a). They found that *Laurencia papillosa* (transfer to *Chondrophycus papillos*us at present) on the fore-reef area had shorter fronds, with greater branching, forming a dense patch to protect themselves from wave action and desiccation.

The reproductive stages of *Chondrophycus tronoi* were not found in this study. *C. tronoi* is a perennial plant (Cecere *et al.,* 2000; Cecere and Perrone, 2002), during our study plant could be in juvenile stage, thus no reproductive organs were found in this study. However, the disappearance of sexual reproduction is a common phenomenon of a red alga forming turf; and vegetative propagation seems to be an asexual reproduction for this turf (Guiry and Womersly, 1993). Increasing of young *C. tronoi* turfs also noticed in this study. Further investigation would be useful to understand the phenomenon of the red algae reproduction.

# CONCLUSIONS

1. Total of 52 species, 9 species are believed to be new records for Thai marine flora; they are

*Acetabularia pusilla* (Howe) Collins

*Chondrophycus tronoi* (Ganzon-Fortes) Nam

*Chondrophycus dotyi* (Saito) Nam

*Polysiphonia sphaerocarpa* Børgesen

*Gelidiopsis variabilis* (J. Agardh) F. Schmitz

*Wurdemannia miniata* (Sprengel) J. Feldmann & G. Hamel

*Hypnea spinella* (C. Agardh) Kützing

*Sargassum cristaefolium* C. Agardh

2. Wave motion influenced diversity, abundance and distribution of macroalgae at Sirinat Marine National park. The greatest diversity was found on the semi-exposed area.

3. *Lyngbya majuscula* and *Padina australis* were the dominant species and common at all sites throughout the study with the greatest percentage cover of 31.66% in semi-exposed area at mid shore level during March 2004 and 27.77% in exposed area at mid shore level during November 2004, respectively.

4. Wave motion affected height and diameter of *Acanthophora spicifera* and *Chondrophycus tronoi*. On the other hand, branching patterns of both species was not influenced by wave motion.

5. There were no sexual reproduction of either *Acanthophora spicifera* and *Chondrophycus tronoi* found in this study.

# RECOMMENDATIONS

1. An acute shortage of taxonomists is a worldwide problem and occurs in many fields of study, including taxonomy of macroalgae study, more taxonomists are urgently needed.

2. Further study in relationships between species distributions and environmental factors are needed for better understanding at community level.

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**List of Publication and Proceeding**

Prathep, A., Wichachucherd, B. and Thongroy, P. Spatial and temporal variations in density and biological characteristics of *Turbinaria ornata* in Thailand. (In revision: Aquatic Botany)

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