Diversity, Species Composition and Habitat of the Genus *Dictyota* J.V. Lamour. and *Canistrocarpus* De Paula & De Clerck in the Peninsular Thailand

Anuchit Darakrai

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Ecology (International Program)

Prince of Songkla University

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Author	Mr. Anuchit Darakrai
Major Program	Ecology (International Program)

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(Prof. Dr. Amornrat Phongdara**)**
Dean of Graduate School

ชื่อวิทยานิพนธ์	ความหลากหลาย องค์ประกอบชนิด และแหล่งอาศัยของสาหร่ายทะเลสีน้ำตาลในสกุล *Dictyota* J.V. Lamour. และสกุล *Canistrocarpus* De Paula & De Clerck ในคาบสมุทรของประเทศไทย
ผู้เขียน	นายอนุชิต ดาราไกร
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ปีการศึกษา	2554

บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อสำรวจความหลากหลาย องค์ประกอบชนิด และแหล่งอาศัยของสาหร่ายทะเลขนาดใหญ่ในสกุล *Dictyota* J.V. Lamour. และสกุล *Canistrocarpus* De Paula & De Clerck ในคาบสมุทรของไทย ผลการศึกษาความหลากหลาย พบสาหร่ายทั้งสองสกุลจำนวนทั้งสิ้น 8 ชนิด อยู่ในสกุล *Dictyota* จำนวน 6 ชนิด คือ *D. bartayresiana* J.V. Lamour., *D. ceylanica* Kütz., *D. ciliolata* Sonder ex Kütz., *D. friabilis* Setch., *D. grossedentata* De Clerck & Coppejans และ *D. stolonifera* E.Y. Dawson และอยู่ในสกุล *Canistrocarpus* จำนวน 2 ชนิด คือ *C. cervicornis* (Kütz.) De Paula & De Clerck และ *C. crispatus* (J.V. Lamour.) De Paula & De Clerck โดยเป็นสาหร่ายที่มีการรายงานเป็นครั้งแรกในประเทศไทยจำนวน 2 ชนิด คือ *D. grossedentata* และ *D. stolonifera* สาหร่ายชนิดที่มีการแพร่กระจายสูงสุดในการศึกษาครั้งนี้ คือ *C. cervicornis* อุทยานแห่งชาติหาดขนอม – หมู่เกาะทะเลใต้เป็นพื้นที่ที่มีความหลากหลายของสาหร่าย *Dictyota* และ *Canistrocarpus* สูงสุดและพบทุกชนิดที่เคยมีการรายงานในทะเลอ่าวไทย เกาะลันตาใหญ่และเกาะตะลิบงเป็นพื้นที่ที่มีความหลากหลายของสาหร่าย *Dictyota* และ *Canistrocarpus* สูงที่สุดของชายฝั่งตะวันตกและมีชนิดที่พบเหมือนกัน องค์ประกอบชนิดของสาหร่าย *Dictyota* และ *Canistrocarpus* ที่พบในชายฝั่งตะวันออกและชายฝั่งตะวันตกของคาบสมุทรของไทยมีความคล้ายคลึงกัน 85.71% การศึกษาครั้งนี้พบสาหร่าย *Dictyota* และ *Canistrocarpus* อาศัยในแนวปะการัง แนวหาดหินและแหล่งหญ้าทะเล โดยจำนวนชนิดที่พบในแต่ละแหล่งจะมีความแตกต่างกันขึ้นกับแนวเขตของแนวปะการัง การเปิดรับคลื่นของหาดหินและแหล่งหญ้าทะเล ซึ่งสามารถแบ่งออกได้เป็นแหล่งอาศัยที่ต่างกัน 5 แบบ ได้แก่ บริเวณปะการังแนวราบ บริเวณปะการังแนวลาดชัน หาดหินรับคลื่น หาดหินอับคลื่น และแหล่งหญ้าทะเล องค์ประกอบชนิดของสาหร่ายในแต่ละแหล่งอาศัยสามารถแบ่งได้เป็น 2 กลุ่มที่มีสมาชิกไม่ซ้ำกัน และแตกต่างกันอย่างมีนัยสำคัญทางสถิติ โดยการถูกกินจากสัตว์กินพืชและความแรงของ

กระแสน้ำน่าจะเป็นสองปัจจัยหลักที่ควบคุมและรักษาความแตกต่างขององค์ประกอบชนิดในแต่ละแหล่งอาศัย มีแนวโน้มว่าคาบสมุทรไทยน่าจะเป็นตัวขัดขวางการแพร่กระจายของสาหร่าย *D. grossedentata* และ *D. stolonifera* เข้าสู่ชายฝั่งตะวันออกของคาบสมุทรไทยในช่วงที่ระดับน้ำทะเลเกิดลดต่ำและกลับเพิ่มสูงครั้งล่าสุดในตอนปลายยุคไพลสโตซีน

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ABSTRACT

This study was to investigate diversity, species composition and habitat of marine macroalgae in the genus *Dictyota* J.V. Lamour. and genus *Canistrocarpus* De Paula & De Clerck in the Peninsular Thailand. The results showed a total of 8 species were found in this study. Of these, 6 species belong to *Dictyota*: *D. bartayresiana* J.V. Lamour., *D. ceylanica* Kütz., *D. ciliolata* Sonder ex Kütz., *D. friabilis* Setch., *D. grossedentata* De Clerck & Coppejans and *D. stolonifera* E.Y. Dawson; and 2 species belong to *Canistrocarpus*: *C. cervicornis* (Kütz.) De Paula & De Clerck and *C. crispatus* (J.V. Lamour.) De Paula & De Clerck. This study has added 2 new records to marine flora of Thailand namely *D. grossedentata* De Clerck & Coppejans and *D. stolonifera* E.Y. Dawson. The most common species in this study was *C. cervicornis*. Hat Khanom – Mu Ko Tha Lae Tai National Park had highest species richness of *Dictyota* and *Canistrocarpus* in this study and all species reported in the Gulf of Thailand were found in this area. Both Ko Lanta Yai and Ko Talibong had highest species richness of *Dictyota* and *Canistrocarpus* of the west coast. There was 85.71 % similarity of species composition of *Dictyota* and *Canistrocarpus* between the east coast and the west coast of the Peninsular Thailand. In this study, *Dictyota* and *Canistrocarpus* inhabited in coral reef, rocky shore and seagrass bed with number of species varied along coral reef zonation, degrees of wave exposure in rocky shore and seagrass bed, which were defined as 5 habitats: reef flat, reef slope, wave-exposed rocky shore, wave-sheltered rocky shore and seagrass bed. Species compositions among 5 habitats can be divided into 2 groups with non-overlapping members. Herbivory and water motion might be 2 major factors controlling and maintaining differences in

species compositions. In addition, it was likely that the Peninsular Thailand might act as a barrier obstructed dispersal of *D. grossedentata* and *D. stolonifera* into the east coast of the Peninsular Thailand during sea level transgression in the late Pleistocene.

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My last but never ending thanks is to my family who never understand what I am studying but always give me support. I love you guys always.

Anuchit Darakrai

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CHAPTER 1

INTRODUCTION

Dictyota J.V. Lamour. is a marine brown macroalgal genus. It is one of the most common genera of macroalgae along the tropical to warm temperate shores (De Clerck, 2003). There are 76 species taxonomically accepted worldwide (Guiry & Guiry, 2012). They are common components of marine macrophyte communities. They play ecological important roles in marine ecosystems as producer and shelter for marine life. They are used as model organisms in ecology and eco-physiology studies (Littler, 1980; Littler & Littler, 1980, 1984; Hay, 1981a, b; Taylor and Hay, 1984; Kuhlenkamp et al., 2001; Haring & Carpenter, 2007), phylogeny (Draisma et al., 2001; Lee & Bae, 2002; De Clerck et al., 2006) and pharmaceutical and health sciences (Albuquerque et al., 2004; Cavalcanti et al., 2011).

Apparently, a revised classification of the tribe Dictyoteae (Dictyotaceae, Phaeophyceae) using rbcL and 26S ribosomal DNA sequence provided 2 new genera to science: *Canistrocarpus* De Paula & De Clerck and *Rugulopteryx* De Clerck & Coppejans (De Clerck et al., 2006). Three species of *Dictyota* were transferred to *Canistrocarpus*: *D. cervicornis*, *D. crispata* and *D. magneana*. Two species of *Dictyota* were transferred to *Rugulopteryx*: *D. radicans* and *D. suhrii*. However, these 3 genera remain monophyletic under tribe Dictyoteae and their gross morphologies look very similar and they still share most of morphological characters and habitats.

Members of *Dictyota* are benthophyte in which mainly attach onto hard substrata, but they can also grow on other marine macrophytes such as seagrasses species and seaweeds. They are commonly found from shallow intertidal to the outermost edge of both mainland or islands, from air-exposed to always submerged underwater and from still water in the sheltered bay to high wave impact in headland wave-exposed rocky shore (Hay, 1981a, b; Littler & Littler, 1984; De Clerck, 2003; Haring & Carpenter, 2007). These wide ranges of distribution along spatial gradients reflect their capability and flexibility to live in various environmental conditions.

The functional-form model (Littler & Littler, 1980) hypothetically concerned about adaptive features of algal structure and function. As diverse features of algal morphology resulting from adaptive responses against fluctuating environments or selective factors based on costs-benefits approach. Later studies supported this model by discovering correlation among thalli forms, photosynthetic efficiency and allocation of materials to photosynthetic or structural tissues (Littler, 1980; Hay 1981a, b; Littler & Littler, 1984; Taylor & Hay, 1984; Hanisak et al., 1988; Haring & Carpenter, 2007); and morphological suitability on particular physical or biotic factors such for environmental tolerance or resistance to predation (Hay 1981a, b; Littler & Littler, 1984; Taylor & Hay, 1984; Hanisak et al., 1988; Haring & Carpenter, 2007; Sotka & Hay, 2009).

In Thailand, there are 7 species of *Dictyota* and *Canistrocarpus* reported: *D. bartayresiana*. *D. ceylanica*, *D. ciliolata*, *D. dichotoma*, *D. friabilis*, *C. cervicornis* and *C. crispatus* reported (Lewmanomont and Ogawa, 1995; Lewmanomont et al., 1995; De Clerck, 2003; Lewmanomont et al., 2007a, b; Coppejans et al., 2010; Guiry & Guiry, 2012). However, most studies were carried out from the Gulf of Thailand and it still lacks of information from the Andaman Sea. There are only 3 species yet reported from the Andaman Sea namely *D. bartayresiana*, *D. dichotoma* and *C. crispatus*, which were reported from Ko Phayam, Ranong Province, Ko Surin, Phangnga Province and Ko Pling, Phuket Province (Lewmanomont et al., 1995; Aungtonya & Liao, 2002; De Clerck, 2003; Thongroy, 2006). It is likely that there will be more species of *Dictyota* and *Canistrocarpus* in the Andaman Sea since De Clerck (2003) reported 21 species distributed in the Indian Ocean; as well as in the Gulf of Thailand, which there are 21 species recorded for Southeast Asia in algaebase.org (Guiry & Guiry, 2012).

This study covered 2 genera of the tribe Dictyoteae: *Dictyota* and *Canistrocarpus*, as they are monophyletic group and they also share morphological characters and habitat. This study was to 1) establish number of species of *Dictyota* and *Canistrocarpus* in the Peninsular Thailand, 2) to generate key to species of *Dictyota* and *Canistrocarpus* in the Peninsular Thailand and 3) to investigate species compositions of *Dictyota* and *Canistrocarpus* among different habitats in the Peninsular Thailand.

Review of Literatures

Classification (after Guiry & Guiry, 2012)

Kingdom	Chromista
Phylum	Ochrophyta
Class	Phaeophyceae
Order	Dictyotales
Family	Dictyotaceae
Genera	***Dictyota* J.V. Lamour.**
	***Canistrocarpus* De Paula & De Clerck**
	***Rugulopteryx* De Clerck & Coppejans**

The name *Dictyota* derived from the Greek word, means net or a network. Jean Vincent Félix Lamouroux erected this genus in 1809 for marine algae. Member of Dictyotales in the very beginning comprised of seaweed in Order Dictyotales, Cutleriales and some species of marine red algae (De Clerck, 2003). Recently, it is representative only for seaweed in Tribe Dictyoteae, Family Dictyotaceae, Order Dictyotales.

Revised classification and 2 new erected genera

A revised classification of the tribe Dictyoteae (Dictyotales, Phaeophyceae) using *rbc*L gene and partial 26S rDNA sequence provided 2 new genera: *Canistrocarpus* De Paula & De Clerck and *Rugulopteryx* De Clerck & Coppejans, and led to a merger of *Glossophora*, *Glossophorella* and *Pachydictyon* in *Dictyota*, as shown in Fig. 1 (De Clerck et al., 2006).

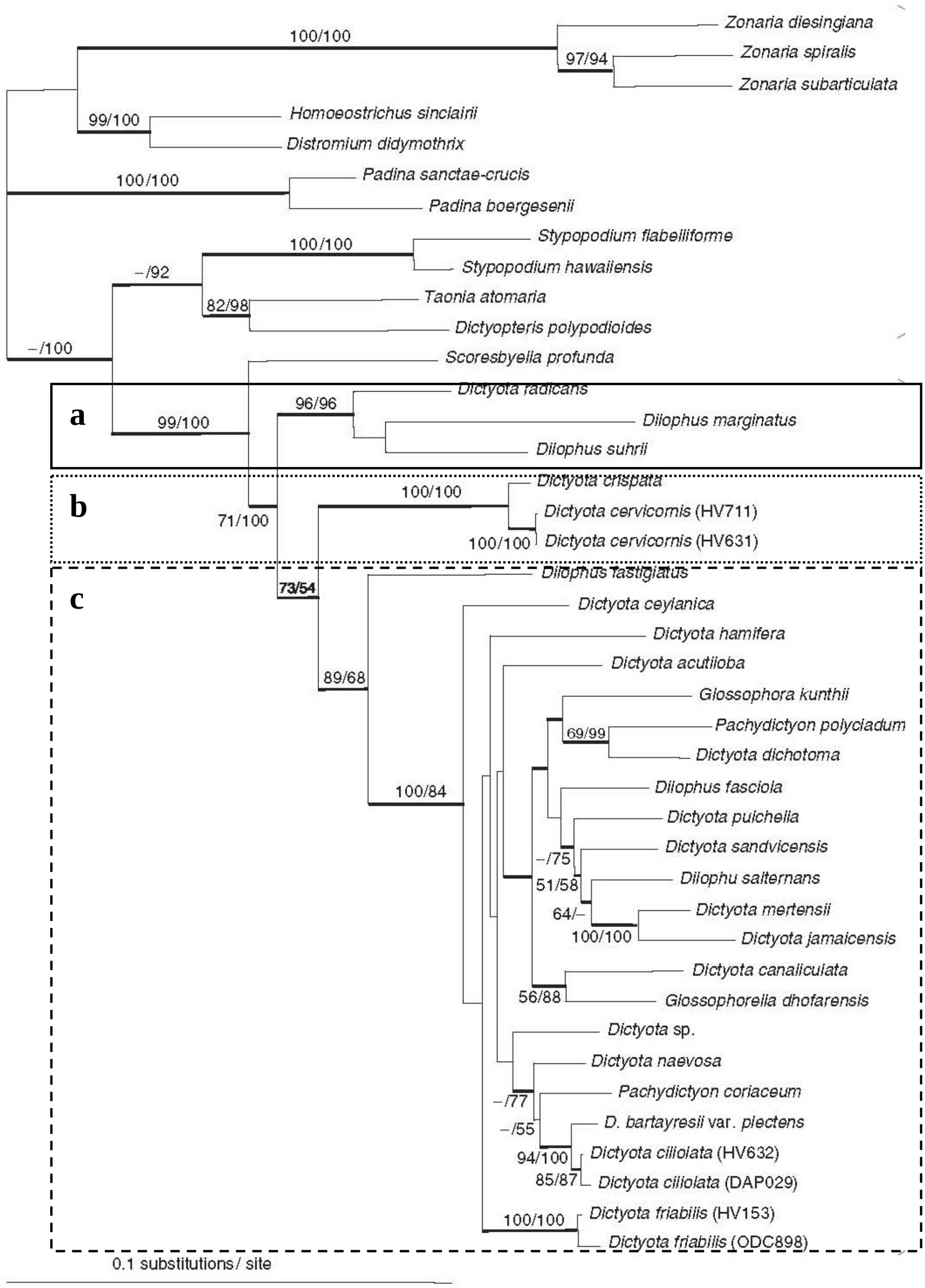

Fig. 1 Phylogram of the maximum likelihood (ML) tree based on *rbc*L and 26S rDNA sequences using a GTR+*I*+*Γ* model: a. *Rugulopteryx* clade, b. *Canistrocarpus* clade and c. *Dictyota* clade (adopted from De Clerck et al., 2006).

Characteristics of *Dictyota* (*sensu lato*)

Dictyota is recognized by its brown flattened straps together with dichotomous branching, growing by a single transversely oriented lenticular apical meristematic cell at the frond apices. The thallus usually consists of 3 layers at least (since merging with other genera, it could be varying), a middle layer or medulla composed of large cells with few or no chloroplasts, surrounded on both sides by a layer of small cells densely packed with chloroplasts called cortex (De Clerck, 2003; Lee, 2008; Fig. 2).

Life history of *Dictyota* is diphasic, with an alternation of isomorphic sporophytes and gametophytes. Sporophyte is diploid, forming unilocular sporangia to produce 4-nonmotile haploid spores (tetraspores). Haploid spores germinate into dioecious gametophytes (male and female plants). Male plants form sori of antheridia to produce uniflagellate sperms. The antheridia sorus is surrounded by elongated sterile paraphyses. Female plants are oogamous, forming sori of oogonia to produce eggs, an egg per oogonium. The egg secretes the pheromone Dictyotene to attract the sperms. A diploid zygote is released after fertilization then germinates into a sporophyte (De Clerck, 2003; Lee, 2008; Fig. 2). Asexual reproduction by fragmentation is commonly found with success in local scale (Beach et al., 2003; Herren et al., 2006).

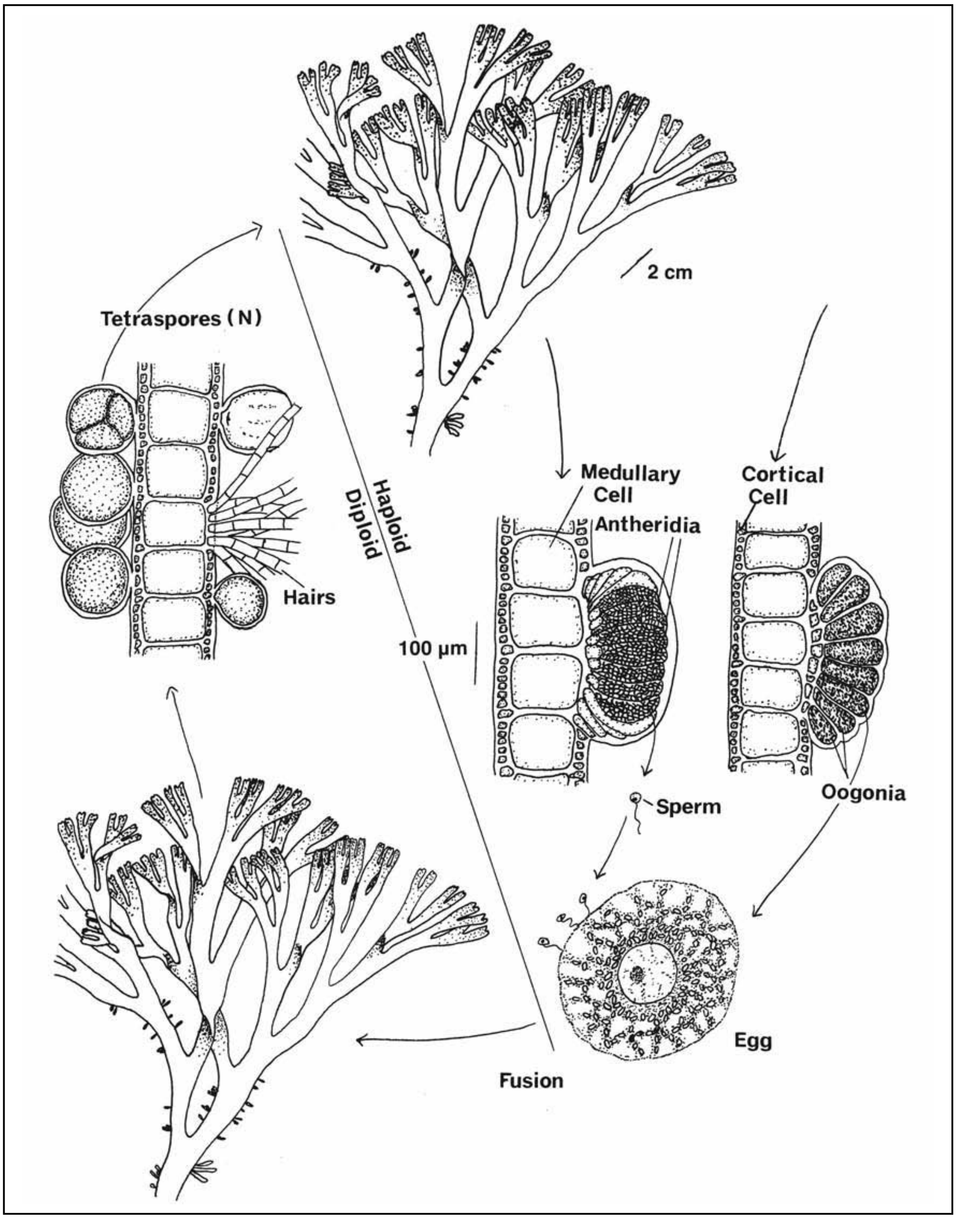

Fig. 2 The life cycle of *Dictyota, sensu lato* (adopted from Lee, 2008).

Vegetative characters

Morphological characters and variables

1. Growth form is defined based on plant habit and number of attachment point. There are species reported in a certain growth form as well as species with variable ones depending on environmental conditions (De Clerck et al., 2001; De Clerck, 2003; Tsuda, 2004). De Clerck (2003) proposed 7 variables of growth forms as the follows:

1.1 Erect: this is used for specimens exhibited only single point of attachment called stupose holdfast, direction of growth is higher up from attachment point. Plants exhibited erect growth form generally growing as spatially separated individual.

1.2 Procumbent: this is used for specimens attached to the substrate over their entire thallus length, direction of growth is sticking onto surface of the substrate and more or less horizontally. Plants exhibited procumbent growth form usually formed dense mats with overlapping, anastomosing layers of straps and individual thallus is difficult to access.

1.3 Repent: this is usually used for epiphytic plants, which attached to the host wherever it is in contact, direction of growth is irregular but normally heading up to light.

1.4 Resupinate: this is used for specimens growing on the vertical substrate and only attached to the substrate by basal part in several points, direction of growth is more or less horizontally.

1.5 Ascending: this is used for specimens attached to the substrate by several basal anastomosing prostrate straps that later formed erect straps higher up, direction of growth is higher up as in erect growth form.

1.6 Pseudo-erect: this is used for specimens that look like erect growth form but attached to the substrate by small entangled mass of straps and usually with dense proliferations as a turfy base.

1.7 Cushion-like: this is used for specimens forming a hemispherical thallus turf or ball-like structure by erect anastomosing straps, direction of growth is in outward direction from basal part of the thallus.

2. Branching is conspicuous morphological character. Most species tend to exhibit a certain pattern whether isotomous and anisotomous dichotomous, but there are also species which exhibited mixed pattern.

3. Interdichotomy (-ies) is a character resulted from branching which its shape affects the whole thallus appearance (slender, short and broad *etc.*) and also used as important morphometric characters (De Clerck, 2003).

4. Divarication angle is other character influencing thallus appearance, usually in a sense of broad or narrow angle.

5. Adventitious branches are also important characteristics using as diagnostic character to determine some species: recurved branch, falcate branch, cervicorn branch and irregular branching.

6. Apices are shape of apical segments which in some species exhibited its typical characteristic such as apiculate apices in *Canistrocarpus crispatus*.

7. Surface is both dorsal and ventral of thallus which usually is smooth together with patches of rhizoids but also exhibited special features in some species such as surface proliferation which developed from cortical cells or germinating sporangia; and undulated thallus in *Rugulopteryx*.

8. Margin is thallus lateral which usually is entire but in several species exhibited some degree of dentations. In some species, marginal teeth can be developed into proliferations.

9. Colour is conspicuous with high variation character depending on species and environments. It can be ranging from light-yellowish or greenish brown to dark brown both fresh and dry specimens. In many species, *in situ* plants exhibited iridescent colours as well as banding pattern (De Clerck, 2003).

Anatomical character and variables

Thallus of *Dictyota* normally comprised of 3 layers of parenchymatous cells: two small cortical cell layers on each surface and a larger medullary cell layer in between. However, Hornig et al. (1992a; in De Clerck, 2003) demonstrated that several species a multilayered medulla can be induced in culture. In addition, multilayered medulla was commonly observed near the basal part of the thallus and in proliferation as well as in cortex (De Clerck, 2003). Detail of variable in numbers of cortex and medulla of *Dictyota* are shown in Fig. 3.

Numbers of cortex and medulla have been used as genera diagnostic characters (Fig. 3). However, since a merger of *Glossophora*, *Glossophorella*, *Pachydictyon* and some species of *Dilophus* in *Dictyota*, these characters are no more than species diagnostic characters, especially to the transferred species.

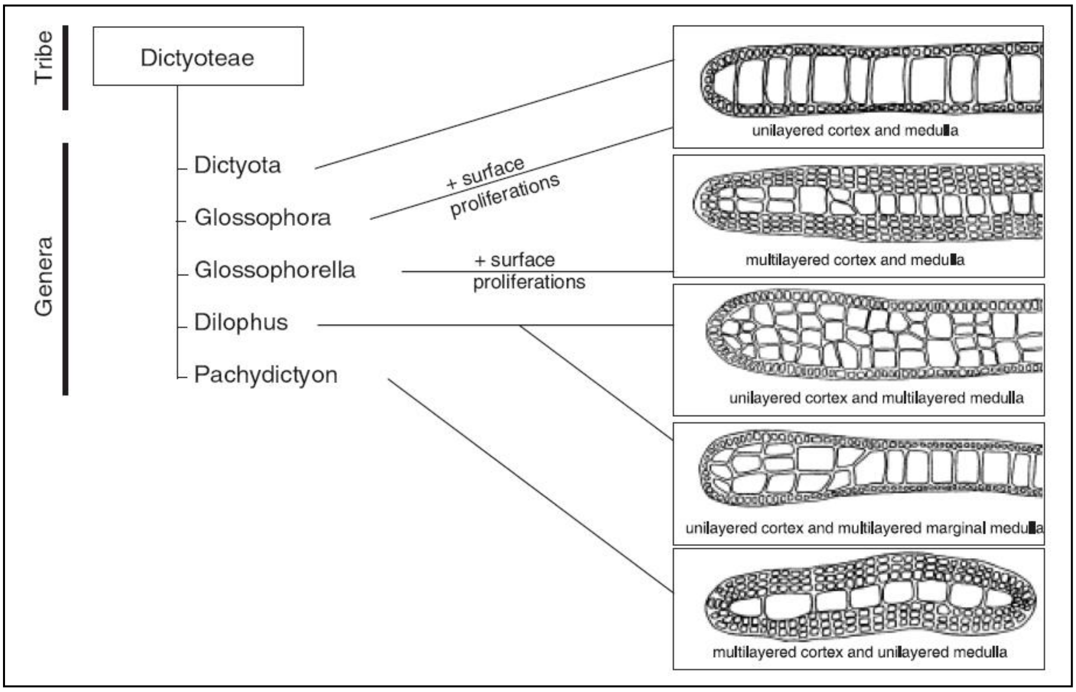

Fig. 3 Details of thallus x-section and numbers of cortex and medulla of *Dictyota* and other genera in the tribe Dictyoteae (adopted from De Clerck et al., 2006).

Reproductive characters

There are three kinds of reproductive organs reported for *Dictyota*: sporangia, antheridia and oogonia. Sporangia are formed on sporophyte (2n) by expansion of cortical cells, mitosis once to form the tetraspore mother cell and the stalk cell(s), tetraspore mother cell later meiosis to produce 4 non-motile spores (haploid spores, Fig. 4; De Clerck, 2003). Sporangia can be formed both as solitary and group as sorus. Male and female gametangia are formed on dioecious gametophytes (n). Male plants form antheridia from cortical cells, which are arranged in ellipsoidal to irregular, whitish, blister-like sori, surrounding by one to several rows of paraphyses. Each antheridium composed of 16-26 tiers consisting 16 loculi. A single loculus contains one uniflagellate spermatozoid. Female plants form oogonia from cortical cells, which are tightly packed in dark brown sori. Each oogonium comprised of one egg, oogonia in central of sori are usually larger than the peripheral ones and are also released after fertilization first. Peripheral oogonia often degenerate (Fig. 4; De Clerck, 2003).

Characteristics of involucrum, number of sporangial stalk cells and paraphyses (Fig. 4 and 5) are used as diagnostic characters discriminating *Dictyota*, *Canistrocarpus* and *Rugulopteryx*. *Dictyota* is characterized by absent of involucrum, 1 sporangial stalk cell and hyaline, unicellular pharaphyses; *Canistrocarpus* is characterized by well-developed involucrum of sterile cells, 1 sporangial stalk cell and hyaline, pigmented multicellular pharaphyses; and *Rugulopteryx* is characterized by an inconspicuous involucrum, 2 sporangial stalk cell and hyaline, pigmented multicellular pharaphyses (De Clerck, et al., 2006)

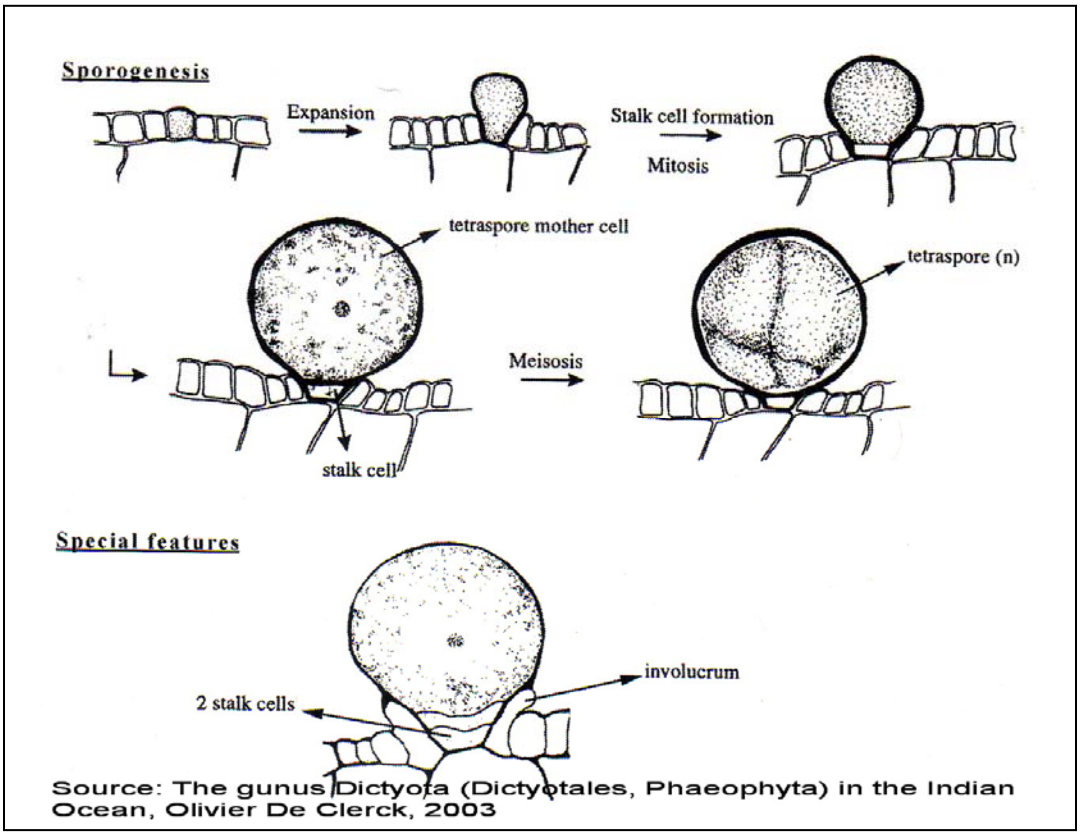

Fig. 4 Sporogenesis and generic diagnostic characters of *Canistrocarpus* (involucrum) and *Rugulopteryx* (2 stalk cells; adopted from De Clerck, 2003).

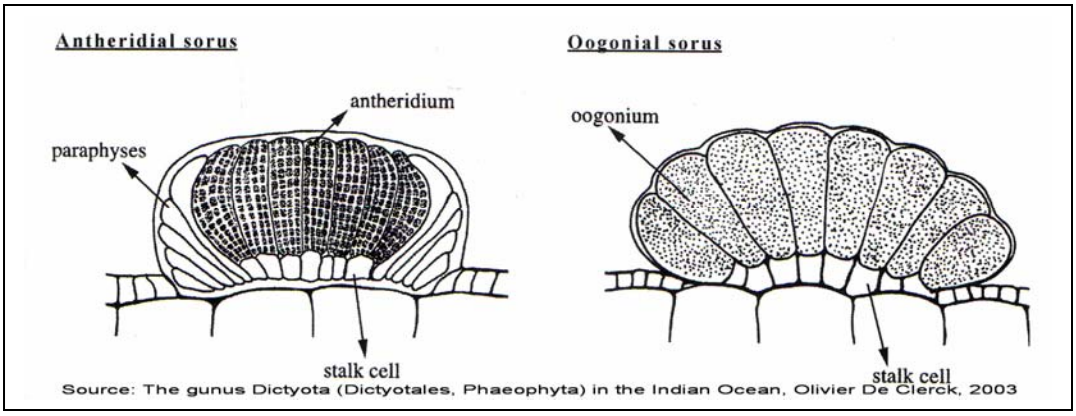

Fig. 5 Characteristics of male and female gametangia (adopted from De Clerck, 2003).

All the above characters can be summarized and compared in Table 1. The generic diagnostic characters among *Dictyota*, *Canistrocarpus* and *Rugulopteryx* are in *italic*.

Table 1 Comparison of vegetative and reproductive characters of *Dictyota*, *Canistrocarpus* and *Rugulopteryx* (adapted from De Clerck et al., 2006)

Character	***Dictyota* J.V. Lamour.**	***Canistrocarpus* De Paula & De Clerck**	***Rugulopteryx* De Clerck & Coppejans**
Thallus	- flattened, ribbon-like.	- flattened, ribbon-like.	- flattened, ribbon-like.
	- erect or prostrate.	- erect or prostrate.	- erect.
	- smooth, dentate, crenulate or ciliate margins.	- smooth margins.	- smooth margins.
Attachment	- by basal rhizoids or marginal rhizoidal processes.	- by basal rhizoids or by marginal rhizoids.	- by rhizoids.
	- scattered along the edges of the thallus or restricted to the base.	- scattered along the thallus.	- restricted to the basal parts of the thallus.
	- stoloniferous holdfasts present or absent.	- stoloniferous holdfasts absent.	- stoloniferous holdfasts present, restricted to the base or emerging from the surface as well as from deformed apices.
Branching	- dichotomous, anisotomous or alternate, rarely falcate.	- dichotomous to anisotomous or alternate or cervicorn or recurved.	- dichotomous to anisotomous.
Apices	- obtuse, rounded, apiculate or acute.	- rounded, apiculate to acute.	- rounded; apical cell protruding to somewhat emarginated.
Hairs and superficial proliferation	- phaeophycean hairs present or absent.	- phaeophycean hairs present.	- phaeophycean hairs present.
	- superficial proliferations present or absent.	- superficial proliferations present.	- surface proliferations present or absent.

Table 1 Continued.

Character	***Dictyota* J.V. Lamour.**	***Canistrocarpus* De Paula & De Clerck**	***Rugulopteryx* De Clerck & Coppejans**
Cortex and medulla	- relative number of layers variable.	- predominantly formed by a single layer of cells. - one or both ‘‘tissues’’ occasionally duplicated in the basal proliferations.	- cortex predominantly unilayered, with occasional duplications in the basal parts. - medulla uniformly unilayered except for the stoloniferous. holdfasts or multilayered near the margins**.**
Sporangia	- isolated, grouped in sori or surrounding a central hair tuft.	- isolated or grouped in sori.	- in small sori or in blocklike patches.
	- lacking a conspicuous involucrum of sterile cells.	*- surrounded by a well-developed involucrum of sterile cells.*	*- surrounded by an inconspicuous involucrum.*
	- subtended by a single stalk cell.	*- borne on a one-celled stalk.*	*- with two stalk cells.*
Antheridia	- arranged in sori.	- in sori.	- in sori.
	- surrounded by hyaline, unicellular paraphyses.	*- surrounded by pigmented multicellular paraphyses.*	*- surrounded by pigmented multicellular paraphyses.*
	- subtended by a single stalk cell.	- subtended by a stalk cell.	- subtended by a stalk cell.
Oogonia	- arranged in sori.	- grouped in sori.	- grouped in sori or small scattered groups.
	- subtended by a stalk cell.	- subtended by a stalk cell.	- subtended by a stalk cell.
Remarks			1. Surface undulating or rugose in mature thalli. 2. Reproductive structures confined to concavities of the thallus surface.

Habitats of *Dictyota* J.V. Lamour.

The genus *Dictyota* is a common component of intertidal and subtidal marine flora in both temperate and tropical regions and almost found in every marine habitat (De Clerck, 2003). Members of this genus have been reported from various locations around the world. The lists of marine ecosystems that reported as habitats of *Dictyota* were summarized in Table 2.

Reports of *Dictyota* J.V. Lamour. in Thailand

The first report of *Dictyota* in Thai waters was Flora of Koh Chang (Schmidt, 1900-1916). There are a total of 7 species of *Dictyota* and *Canistrocarpus* reported in Thai waters and the most frequently reported species in Thailand is *D. dichotoma* as in Table 3. Nomenclatural status of each species in Table 3 has already been updated.

Table 2 Summary of habitats of *Dictyota* and *Canistrocarpus*.

Ecosystems	**Habitat**	**Substrate**	**Distribution & ecology**	**Depth**	**References**
Coral reef	1) Tide pools. 2) Lagoons. 3) Reef flat. 4) Reef slope.	1) Hard substrate: coral skeletons, pebbles, rock outcrops. 2) Soft bottom: sandy bottom. 3) Phorophytes: *Sargassum*, *Turbinaria*, *Halimeda*, coralline red algae.	**Sheltered areas:** plants reported from intertidal tide pools, shallow subtidal lagoon and reef flat; both air-exposed and always submerged; epilithic as well as epiphytic. **Exposed area:** plants reported from surf-exposed back reef to outermost reef slope.	Shallow, down to 30 m. deep.	Womersley, 1987 Lewmanomont, 1988 Trono Jr., 1997 De Clerck, 2003 Trono Jr., 2004 Tsuda, 2004 Ohba et al., 2007 Coppejans et al., 2010
Rocky shore	1) Tide pools. 2) Lagoons. 3) Rock platforms and outcrops. 4) Subtidal cliff.	1) Rocks: surface, crevice, fragment 2) Phorophytes: *Sargassum*, *Turbinaria*, turf coralline algae.	**Sheltered area:** plants reported from intertidal tide pools and shallow subtidal lagoon; both air-exposed and always submerged; epilithic as well as epiphytic. **Exposed area:** plants reported from surf-exposed areas.	Shallow, down to 50 m. deep.	Womersley, 1987 De Clerck, 2003 Tsuda, 2004 De Clerck et al., 2005 Tsutsui et al., 2005 Coppejans et al., 2009 Coppejans et al., 2010

Table 2 Continued.

Ecosystems	Habitat	Substrate	Distribution & ecology	Depth	References
Seagrass bed	1) Seagrass beds	1) Seagrasses species 2) Sand-dwelling seaweed: *Halimeda* spp.	Plants reported from intertidal to shallow subtidal; epiphytic on seagrasses species and sand-dwelling macroalgae.	Shallow, down to few decade meters deep.	Womersley, 1987 De Clerck et al., 2001 De Clerck, 2003 Tsuda, 2004
Mangrove	1) Mangrove channels	1) Soft bottom: sand, mud. 2) Mangrove trees: roots, barks.	Plants reported mostly from tide channels; on bottom to submerged parts of mangrove trees.	Under low water mark to few meters deep.	Lewmanomont, 1976 Womersley, 1987 De Clerck, 2003

Table 3 Summary of *Dictyota* and *Canistrocarpus* species reported in Thailand.

No.	Species	Location	Sea	Literature
1	*Dictyota bartayresiana* J.V. Lamour.	Ko Chang, Trat	Gulf of Thailand	Schmidt, 1900-1916
		unspecified	Thailand	Egerod, 1971
		unspecified	Andaman Sea	Egerod, 1974
		unspecified	Thailand	Lewmanomont, 1988
		unspecified	Thailand	Lewmanomont & Ogawa, 1995
		unspecified	Indian Ocean	Silva et al., 1996
2	*Dictyota ceylanica* Kütz.	Ko Samaesan, Chonburi	Gulf of Thailand	Lewmanomont et al., 2007b
		Hat Khanom – Mu Ko Thale Tai National Park	Gulf of Thailand	Coppejans et al., 2010
3	*Dictyota ciliolata* Sonder ex Kütz.	Hat Khanom – Mu Ko Thale Tai National Park, Surat Thani & Nakhon Si Thammarat	Gulf of Thailand	Coppejans et al., 2010
4	*Dictyota dichotoma* (Huds.) J.V. Lamour.	Ko Chang, Trat	Gulf of Thailand	Schmidt, 1900-1916
		unspecified	Pacific Ocean	Dawson, 1954
		unspecified	Thailand	Egerod, 1971
		unspecified	Andaman Sea	Egerod, 1974
		unspecified	Thailand	Lewmanomont, 1976
		unspecified	Thailand	Lewmanomont, 1978
		unspecified	Thailand	Lewmanomont, 1988
		unspecified	Thailand	Nateewatthana *et al.,* 1981
		unspecified	Thailand	Lewmanomont & Ogawa, 1995
		unspecified	Indian Ocean	Silva et al., 1996
		Ko Surin, Phangnga	Andaman Sea	Aungtonya & Liao, 2002
		Ko Pling, Phuket	Andaman Sea	Thongroy, 2006

Table 3 Continued.

No.	Species	Location	Sea	Researcher & year
5	*Dictyota friabilis* Setch.	unspecified	Thailand	Lewmanomont, 1988
		Ko Samaesan, Chonburi	Gulf of Thailand	Lewmanomont et al., 2007b
6	*Canistrocarpus cervicornis* (Kütz.) De Paula & De Clerck	Ko Chang, Trat	Gulf of Thailand	Schmidt, 1900-1916
		unspecified	Thailand	Lewmanomont, 1976
		unspecified	Thailand	Lewmanomont & Ogawa, 1995
		Ko Samaesan, Chonburi	Gulf of Thailand	Lewmanomont et al., 2007a
		Hat Khanom – Mu Ko Thale Tai National Park, Surat Thani & Nakhon Si Thammarat	Gulf of Thailand	Coppejans et al., 2010
7	*Canistrocarpus crispatus* (J.V. Lamour.) De Paula & De Clerck	Ko Phayam, Ranong	Andaman Sea	De Clerck, 2003

Research questions

1. How many species of *Dictyota* and *Canistrocarpus* in the Peninsular Thailand?

2. Are there any difference of species compositions of *Dictyota* and *Canistrocarpus* among different habitats in the Peninsular Thailand?

Research objectives

1. To establish number of species of *Dictyota* and *Canistrocarpus* in the Peninsular Thailand.

2. To generate a key to species of *Dictyota* and *Canistrocarpus* in the Peninsular Thailand.

3. To investigate species compositions of *Dictyota* and *Canistrocarpus* among different habitats in the Peninsular Thailand

CHAPTER 2

MATERIALS AND METHODS

The study sites

The study sites covered various locations, both in the Gulf of Thailand and in the Andaman Sea (Fig. 6) and conducted from June 2009 to May 2011. Here are the study sites:

1) Chumphon: Ko Khai, Hin Kob and Haad Nha Ladkrabang.

2) Surat Thani: Ko Samui, Ko Taen, Ko Mutsum, Ko Wang Nok, Ko Wang Nai, Ko Rab and Ko Chalarm Lai.

3) Nakhon Si Thammarat: Ko Tharai, Ko Luang Pu Tuad, Haad Nai Plao, Ao Ta Led, Ao Thong Yee and Laem Prathub.

4) Songkhla: Ko Maew and Ko Nu.

5) Phangnga: Mu Ko Surin, Mu Ko Similan, Ao Bang Klee and Kura Buri.

6) Phuket: Ko Pling, Ko Racha Yai and Haad Kalim.

7) Krabi: Ko Lanta Yai, and Ko Phi Phi.

8) Trang: Ko Talibong, Haad Chaomai, Laem Yong Lam, Ko Kradan and Ko Muk.

9) Satun: Ko Lidee Yai, Ko Lidee Lek, Ko Adang, Ko Rawi, Ko Tong, Ko Bulon Mai Phai, Ko Hin-ngam and Ko Tarutao.

Specimens were collected form each site. Habitats and degrees of abundance of each species were carefully observed and documented. There are 3 marine ecosystems encountered in this study: coral reef, rocky shore and seagrass bed. General description of each habitat type could be described as follows:

1) Coral reef: The coral reef in Thailand is a fringing reef, a coral reef which is formed near the shoreline of islands or coasts. Fringing reef comprises of 3 zones: reef flat, reef edge and reef slope as follows:

1.1 **Reef flat:** this is the innermost part of a fringing reef, nearest to the shore and some broad reef flat has a lagoon, close to the shore. The floor is flat and gradually slopes towards the sea. It is the shallowest zone that is exposed to high light intensity, high temperature and desiccation during the low tide. Living corals in a reef flat usually die on its top because of sedimentations from the adjacent shore.

The substrates in a reef flat are dead coral skeletons that are available in many forms, sizes and stabilities. There are also rock outcrops as well as platforms in this zone that are more close to the shore. There are lots of seaweeds in this area.

1.2 **Reef edge**: this is the middle zone between reef flat and reef slope. It is a slope changing point and the highest wave action zone. It typically consists of seaweed line called an algal ridge. There are also living corals in this zone but usually exhibit typical massive or short branching form. Substrate in this zone typically is coral lime stone.

1.3 **Reef slope:** this is the outermost part of fringing reef on the ocean side, farthest from the shore. The slope downward at steep angles, wave action decrease relatively to deep increase as well as light intensity. It is coral abundant zone.

Substrate in reef slope is also coral skeletons as in reef flat but since coral is healthy in this zone, thus available space is scarce.

2) Rocky shore: This study focused on any rock locates in the shoreline, under sea influence as rocky shore. The rocky shore site can be partly submerge or always under sea water. Rocky shore can be divided into 2 categories by 2 degrees of wave exposure: wave-exposed and wave-sheltered rocky shores; and could be described as follows:

2.1 **Wave-exposed rocky shore:** it is rocky shore under severe wave action. This category usually locates at headland of island and coast, as a windward zone. Substrate is always rock.

2.2 **Wave-sheltered rocky shore:** it is rocky shore sheltered from severe wave action. This category usually locates inner in the bay and protected from wave action by headland. Substrate is always rock.

3) Seagrass bed: This study counted the sites that have seagrass species along the shoreline as seagrass bed, but it has to be bigger than 100 square meters.

Number of species of seagrass in the bed was not concerned. Hard substrate in seagrass bed is scarce but soft sandy or mud bottom.

Study sites

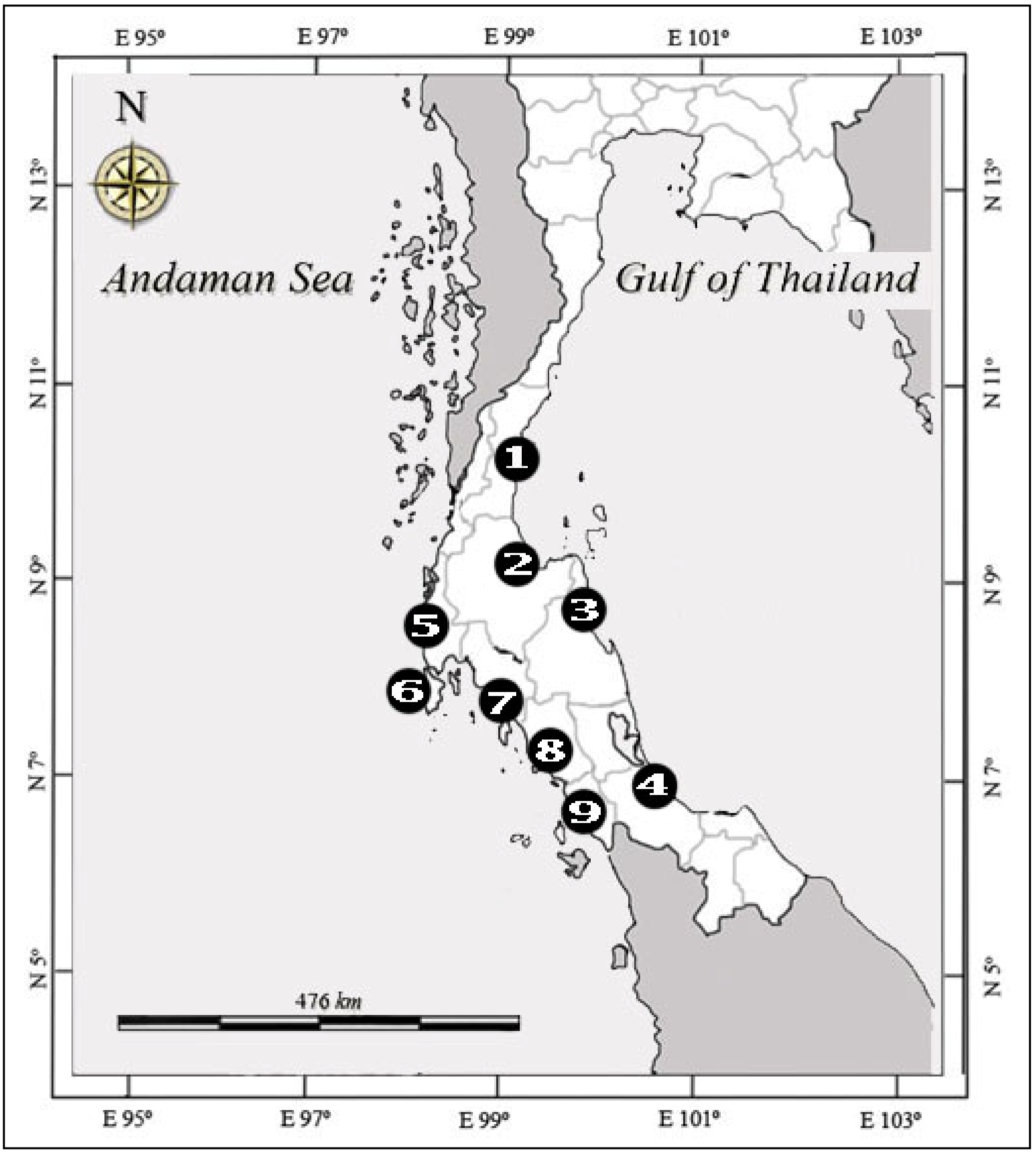

Fig. 6 Map of the sampling sites located in the east coast and the west coast of the Peninsular Thailand; 1) Chumphon , 2) Nakhon Si Thammarat , 3) Surat Thani , 4) Songkhla , 5) Phang-nga , 6) Phuket , 7) Krabi , 8) Trang and 9) Satun.

Specimen collection and laboratory study

Specimens were preserved by 4 methods: 1) dry herbarium sheet for voucher specimen and morphological examination, 2) & 3) wet preserved in 70 % alcohol and 10 % formalin in seawater for anatomical study and 4) absolute dry preserved in silica gel for future molecular study.

In addition, loan specimens from Prince of Songkla University Herbarium (PSU) and Professor Khanjanapaj Lewmanomont, Faculty of Fisheries, Kasetsart University were examined. This was an attempt to cover all the *Dictyota* and *Canistrocarpus* found in Thai waters.

Specimens were identified using aforementioned descriptions from the available taxonomic literatures as follows:

1. Seaweeds of Singapore (Teo & Wee, 1983).
2. The marine benthic flora of southern Australia. Part II. (Womersley, 1987).
3. Seaweed of Panay (Hurtado-Ponce, 1992).
4. Common Seaweeds and Seagrasses of Thailand (Lewmanomont and Ogawa, 1995).
5. Seaweeds of Queensland. A naturalist's guide (Cribb, 1996).
6. Field guide and atlas of the seaweed resources of the Philippines (Trono Jr., 1997).
7. *Dictyota* J.V. Lamour. (De Clerck et al. 2001. In Prud’homme van Reine, W.F. and Trono Jr., G.C. (Eds)).
8. The genus *Dictyota* in the Indian Ocean (De Clerck, 2003).
9. *Dictyota* (Phaeophyceae) from Micronesia (Tsuda, 2004. In Abbott, I.A. and McDermid, K.J. (Eds)).
10. Guide to the seaweeds of KwaZulu-Natal (De Clerck et al, 2005).
11. The common marine plants of southern Vietnam (Tsutsui et al, 2005).
12. Seaweeds of Koh Khram and adjacent islands. (Lewmanomont et al., 2007).
13. Tropical Marine Plants of Palau (Ohba et al. 2007).

14. Sri Lankan Seaweeds. Methodologies and field guide to the dominant species (Coppejans et al., 2009).
15. Seaweeds of Mu Ko Tha Lae Tai (SE Thailand): Methodologies and field guide to the dominant species (Coppejans et al., 2010).

Microscopic freehanded sections were done under the Motic SMZ-168 Stereomicroscope. Anatomical characters were observed and measured under the Olympus CH30 Compound microscope. Morphological and anatomical structures of each species were taken pictures by Olympus C5060 compact digital camera, Olympus C71 Stereomicroscope camera and Olympus C72 Compound microscope camera.

A dichotomous key to species of *Dictyota* and *Canistrocarpus* in the Peninsular Thailand was generated and species descriptions with plates consisted of plates showed plant habits, morphology, anatomy and reproductive organs pictures were prepared based on specimens collections made in this study. Authors of plant species in this thesis were after the International Plant Names Index (IPNI, 2008). All voucher specimens were deposited at Prince of Songkla University Herbarium (PSU).

Morphometrics study

Morphometric characters using in this study were after characters set of De Clerck (2003) as below.

1) **Morphology:** 6 characters were observed and measured once per specimens. (1. growth form, 2. attachment, 3. stoloniferous holdfast, 4. maximum length, 5. thallus width variability and 6. thallus width: Fig. 7)
2) **Interdichotomies:** 4 characters were measured 10 times per specimens (1. length (L), 2. proximal width (Wp), 3. distal width (Wd) and 4. middle width (Wm): Fig. 8). These data were used to calculate for 10 parameters later on (1. average width, 2. average width standard deviation, 3. minimum average width, 4. maximum average width,

5. average proximal width, 6. average distal width, 7. average length, 8. average length standard deviation, 9. minimum average length and 10. maximum average length). Data of each interdichotomy were used to calculate 3 parameters (1. length - width ratio, 2. distal - proximal width ratio and 3. relative width coefficient (RWC)) using these formulas.

Length-width ratio = L/ Wm

Distal - proximal width ratio = Wd / Wp

Relatives width coefficient (RWC) = (Wd *10)/(Wp *L)

3) **Apical segment:** 2 characters were measured 10 times per specimen (1. length (L) and 2. proximal width: Fig. 9). These data were used to calculate for 5 parameters later on (1. average length, 2. average length standard deviation, 3. minimum length, 4. maximum length and 5. average proximal width). Data of each apical segment were used to calculate a length - proximal width ratio using this formula.

Length - proximal width ratio = L/ Wp

4) **Apex shape and apical cell:** 4 characters were observed and documented ten times per specimens, the most frequent variable was selected as a representative for tips shapes and apical cells position (1. apex shape, 2. apiculate tips, 3. spathulate tips and 4. apical cells position: Fig. 10 and 11).
5) **Branching patterns:** each specimen, 4 branching patterns were observed and documented (1. thallus branching pattern, 2. falcate branching, 3. recurved branching and 4. irregular branching: Fig. 11).
6) **Divarication angle:** 10 branching angles were measured per specimens. Average angle, minimum angle, maximum angle and range of the angle per specimens were calculated later on.
7) **Margin, surface and colour:** variables of margin, surface and colour each specimen were observed and documented such as dentate margin, surface proliferation and iridescent colour (Fig. 12).
8) **Anatomical characters:** anatomy of *Dictyota* and *Canistrocarpus* comprises of 2 categories of cell layer (Fig. 13): 1) cortex and 2) medulla. Number of layer of each category was observed and

documented under microscope. Length, width and height of cell in cortex and medulla were measured 10 times each character each specimen. These data were used to calculate 14 parameters later on (1. cortical cells average length, 2. cortical cells minimum length, 3. cortical cells maximum length, 4. cortical cells average width, 5. cortical cells minimum width, 6. cortical cells maximum width, 7. cortical cells average height, 8. medullary cells average length, 9. medullary cells minimum length, 10. medullary cells maximum length, 11. medullary cells average width, 12. medullary cells minimum width, 13. medullary cells maximum width and 14. medullary cells average height) and 4 ratios (1. cortical length - width ratio, 2. medullary length - width ratio, 3. medullary length - cortical length ratio and 4. medullary width - cortical width ratio) were calculated by these formulas (Cl = cortical cell length, Cw = cortical cell width, Ml = cortical cell length and Mw = cortical cell width).

Cortical length - width ratio = Cl/Cw

Medulla length - width ratio = Ml/Mw

Medulla length - cortical length ratio = Ml/Cl

Medulla width - cortical width ratio = Mw/Cw

9) **Sporangial characters:** fertile specimens were collected 4 sporangial characters: 1. sori, 2. position on thallus, 3. number of stalk cell and 4. Involucrum (Fig. 14). Width and height of sporangia were measured 10 times each specimen. Average width and height of sporangia were calculated later on.

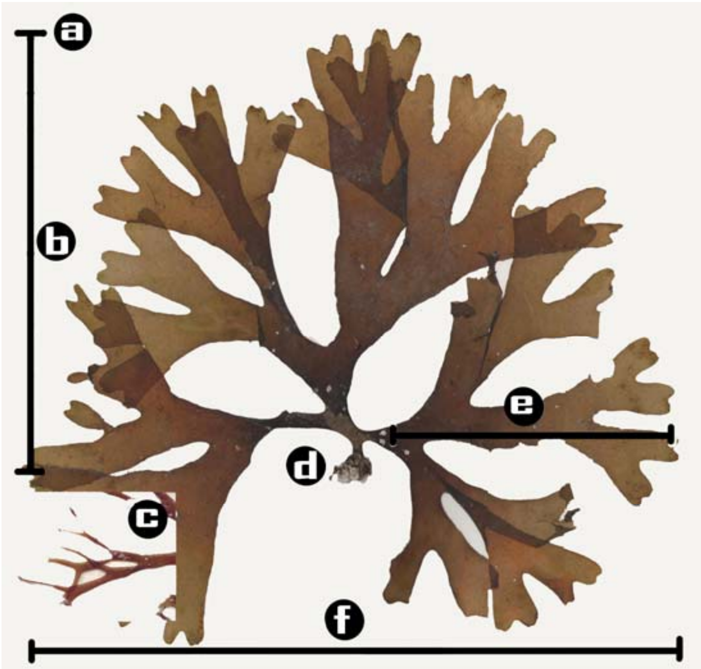

Fig. 7 Morphometric characters: a. growth form, b. maximum length, c. stoloniferous holdfast, d. attachment, e. thallus width variability and f. thallus width.

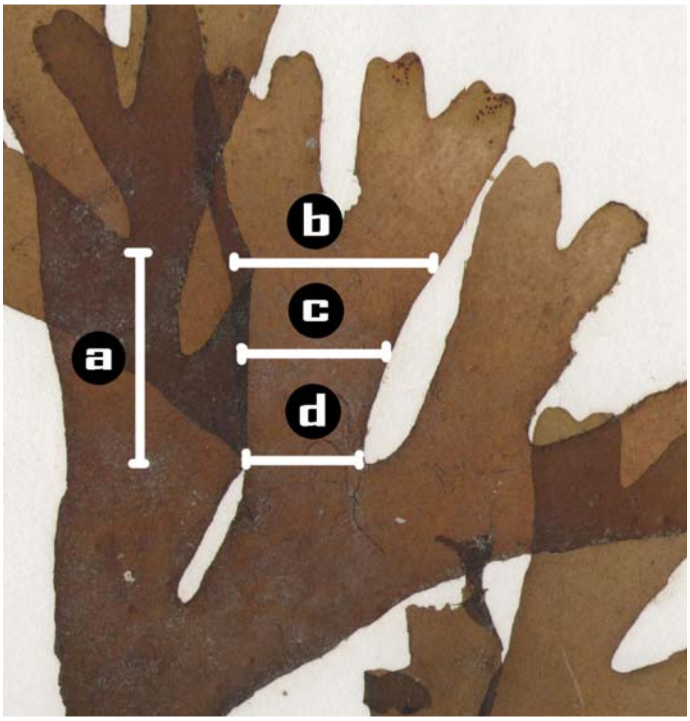

Fig. 8 Morphometric characters: a. length of interdichotomy, b. distal width, c. middle width and d. proximal width.

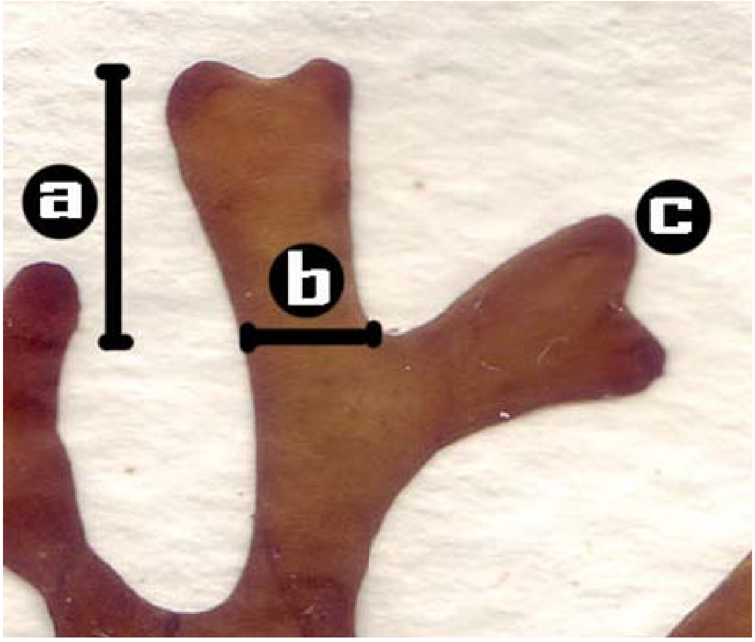

Fig. 9 Morphometric characters: a. length of apical segment, b. proximal width and c. apex shape.

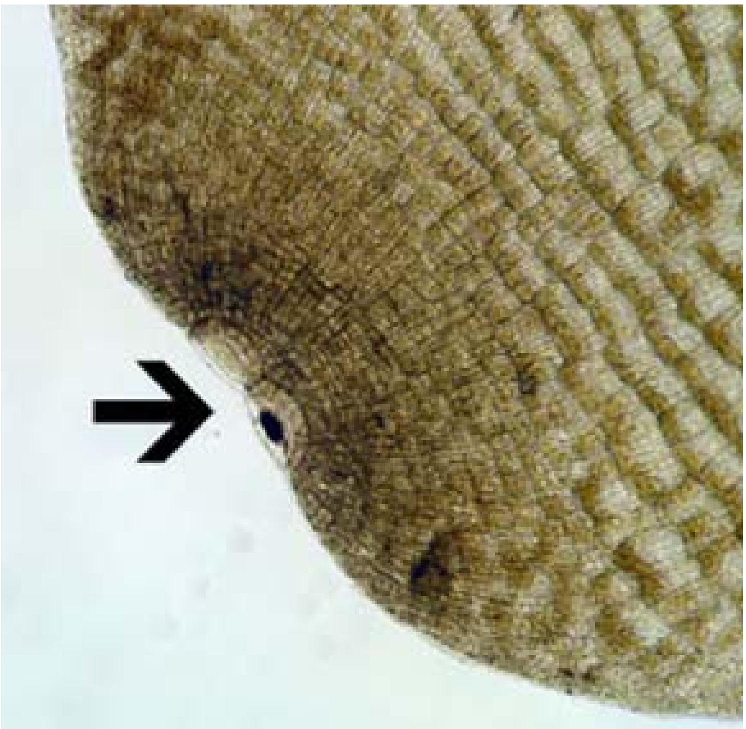

Fig. 10 Morphometric character: shape of apex and apical cells (arrow).

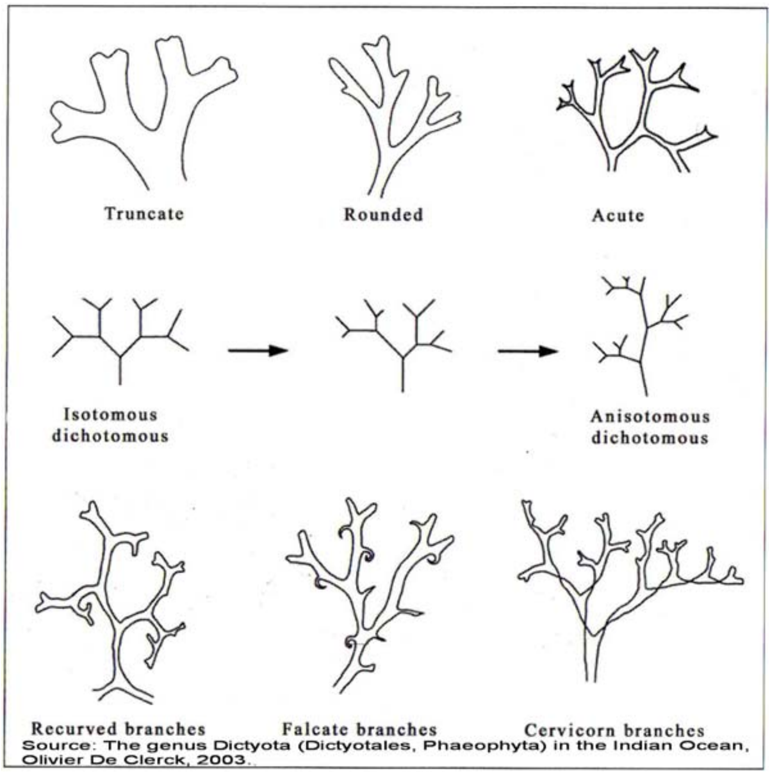

Fig. 11 Morphometric characters: variables of apices, degree dichotomous branching and adventitious branches (adopted from De Clerck, 2003).

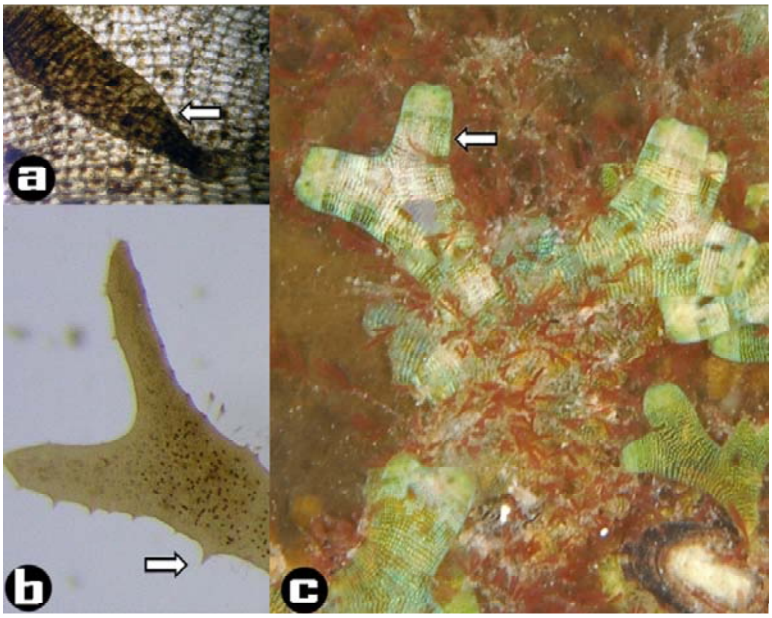

Fig. 12 Morphometric characters: a. surface proliferation, b. dentate margin and c. iridescent colour and banding pattern (Fig. 12c adopted from Coppejans et al., 2010).

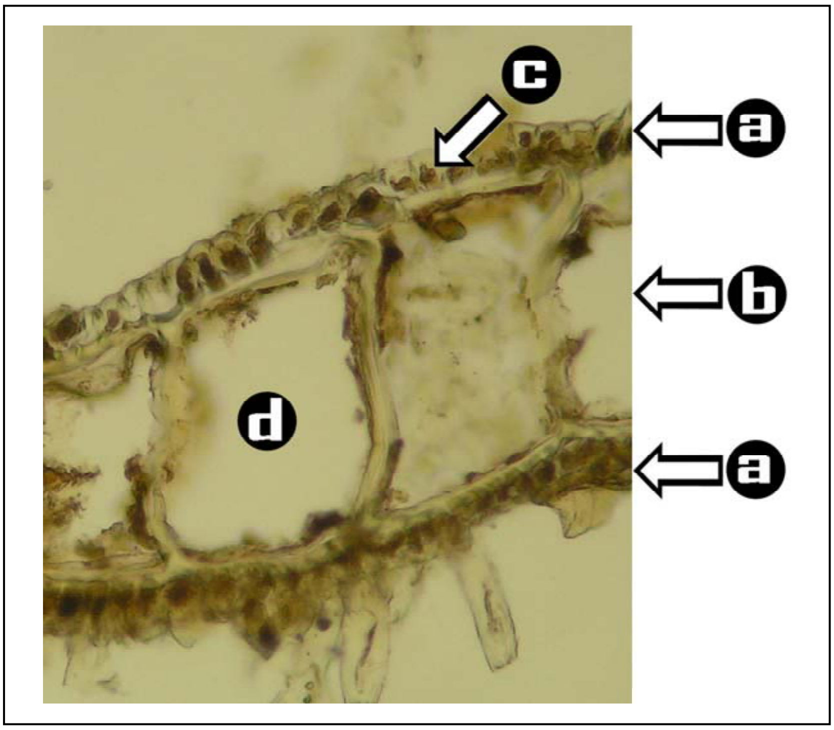

Fig. 13 Morphometric characters: a. cortex, b. medulla, c. cortical cell and d. medullary cell.

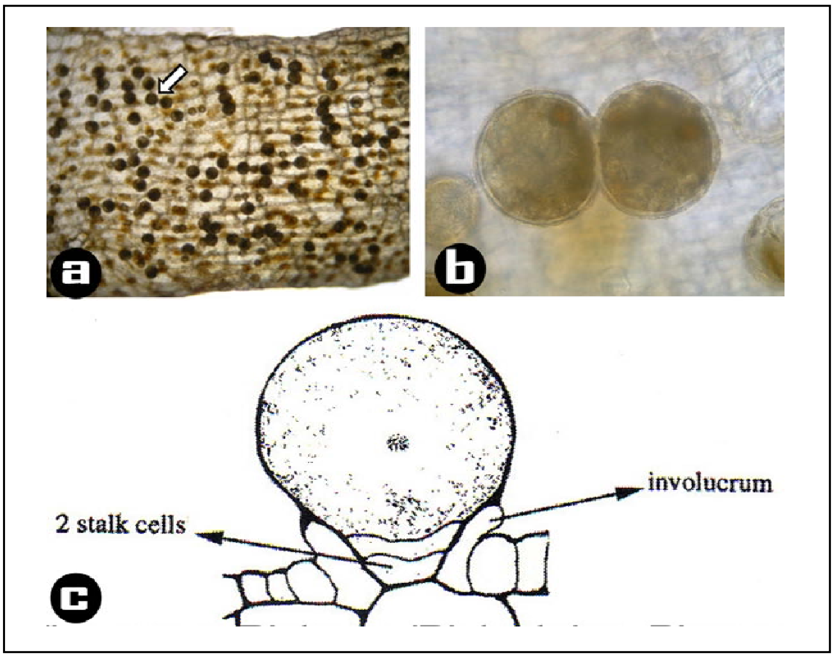

Fig. 14 Morphometric characters: a. solitary sporangia arrangement on thallus surface, b. two adjacent solitary sporangia and c. sporangial structure diagram (Fig. 14c adopted from De Clerck, 2003).

Statistical analyses

Principal Component Analysis (PCA) was performed using PRIMER version 5 on morphometric characters data to reduce morphometric variables into fewer principal components that could be used to define species.

Bray-Curtis Similarity was performed using PRIMER version 5 to test similarity in species compositions between the Gulf of Thailand and the Andaman Sea. Analysis of Similarity (ANOSIM) was performed using PRIMER version 5 to test difference in species composition between the Gulf of Thailand and the Andaman Sea.

Bray-Curtis Similarity was performed using PRIMER version 5 to test similarity in species compositions among study sites; then Cluster Analysis was performed to generate dendrogram of similarity in species composition among the study sites. Analysis of Similarity (ANOSIM) was performed using PRIMER version 5 to test difference in species compositions among study sites.

CHAPTER 3

RESULTS

I. Diversity of *Dictyota* J.V. Lamour. and *Canistrocarpus* De Paula & De Clerck in the Peninsular Thailand.

1.1 Identification using aforementioned description

A total of 194 specimens were examined in this study. Of these, a total 8 species were identified including 6 species of *Dictyota* and 2 species of *Canistrocarpus* as follows: *D. bartayresiana* J.V. Lamour., *D. ceylanica* Kütz., *D. ciliolata* Sonder ex Kütz., *D. friabilis* Setch., *D. grossedentata* De Clerck & Coppejans, *D. stolonifera* E.Y. Dawson, *C. cervicornis* (Kütz.) De Paula & De Clerck and *C. crispatus* (J.V. Lamour.) De Paula & De Clerck (Table 5).

Diversity of *Dictyota* and *Canistrocarpus* in the east coast of the Peninsular Thailand was 6 species whereas 8 species were found in the west coast (Table 5). Compiled with the loan specimens from 1976 to present from this study showed that *Dictyota* and *Canistrocarpus* almost occurred throughout the year except during the monsoons which field collection could not be performed.

Diversity among sites both in the east coast and the west coast of the Peninsular Thailand varied from site to site (Table 6). In the east coast, the highest diversity was found in Hat Khanom – Mu Ko Thale Tai National Park, which covered several islands of Ko Samui District, Surat Thani Province and the coast of Khanom District, Nakhon Si Thammarat Province (Ko Taen, Ko Matsum, Ko Rab, Ko Wang Nok, Ko Wang Nai, Ko Tharai, Ko Luang Pu Tuad, Ao Ta Led, Hat Nai Plao and Ao Thong Yee); and there were 6 species found in the east coast. There were only 1 or 2 species in the other sites in the east coast; 2 species were found in Chumphon Province and only 1 species was found in Songkhla Province. In the west coast of the Peninsular Thailand, the highest diversity was found in 2 sites: Ko Lanta Yai, Krabi Province and Ko Talibong, Trang Province; and there were 5 species found. The second highest diversity was at Ko Rawi, Satun Province, which 3 species found but different in species composition.

Abundances of *Dictyota* and *Canistrocarpus* in the habitat were estimated from their percent cover in the field. There were 3 degrees of abundance: 1) little abundance, 2) moderate abundance and c) high abundance. The low abundance was about 1 – 20 % cover (Fig. 15a), the moderate abundance was about 20 – 50 % cover (Fig. 15b) and the high abundance was over 50 % cover (Fig. 15c). Normally, abundances of *Dictyota* and *Canistrocarpus* were low but only the few sites were high such as at Ko Mutsum, Ko Lanta Yai and some bays of Mu Ko Surin.

There was a blooming phenomenon of *Dictyota friabilis* and *D. grossedentata* which occurred at Ao Phak Kaad and Ao Tao, Mu Ko Surin National Park, Phang-nga Province after coral bleaching phenomena in 2010. These two species grew on skeleton of dead branching coral together with *Halimeda tuna* (J. Ellis & Solander) J.V. Lamour; and occupied over 50 % of the space (Fig. 16).

1.2 Identification using morphometric method

Principal Components Analysis performed on the suite of 26 morphometric characters revealed three orthogonal axes that explained 28.3, 13.6 and 8.6 % of the variance respectively (Table 4). PC1 was characterized by interdichotomies variables (average width, average proximal width, average distal width and minimum average width) and average apical proximal width, variables that describe width of thalli. PC2 was characterized by procumbent growth form and special characters (irregular branching, iridescent and banding colours). PC3 was characterized by two growth forms (resupinate and ascending growth forms) stoloniferous holdfast and surface proliferations. Loadings scores of morphological variables of *Dictyota* and *Canistrocarpus* in this study (72 specimens) were plotted on the first two orthogonal axes to visualize any separation of specimens (Fig. 17). Analysis revealed a separation of specimens into only 2 groups by positive and negative loading scores by PC1 and PC2. This suggested that morphometric method can not be a good tool to identification.

Growth forms such as procumbent, resupinate and ascending, stoloniferous holdfast, irregular branching, iridescence and transverse band showed a very high loading scores (Table 4), suggesting as important diagnostic characters of *Dictyota* and *Canistrocarpus.*

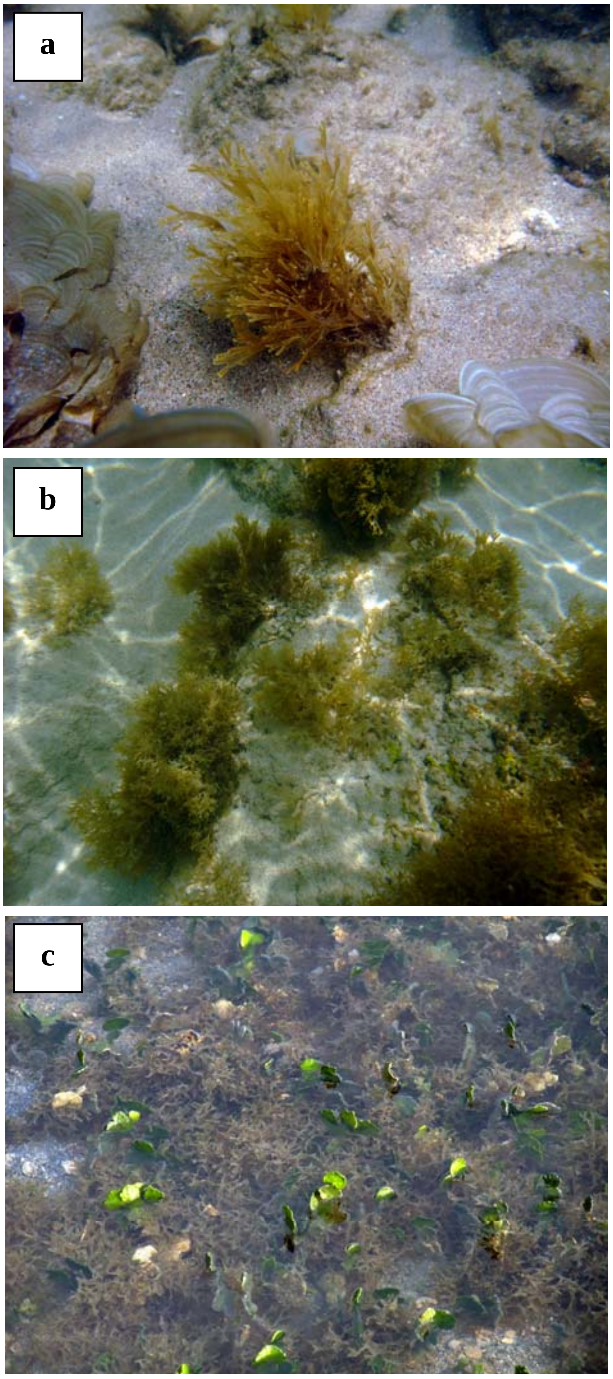

Fig. 15 Degree of abundance of plants in the field: a) low abundance, b) moderate abundance and c) high abundance.

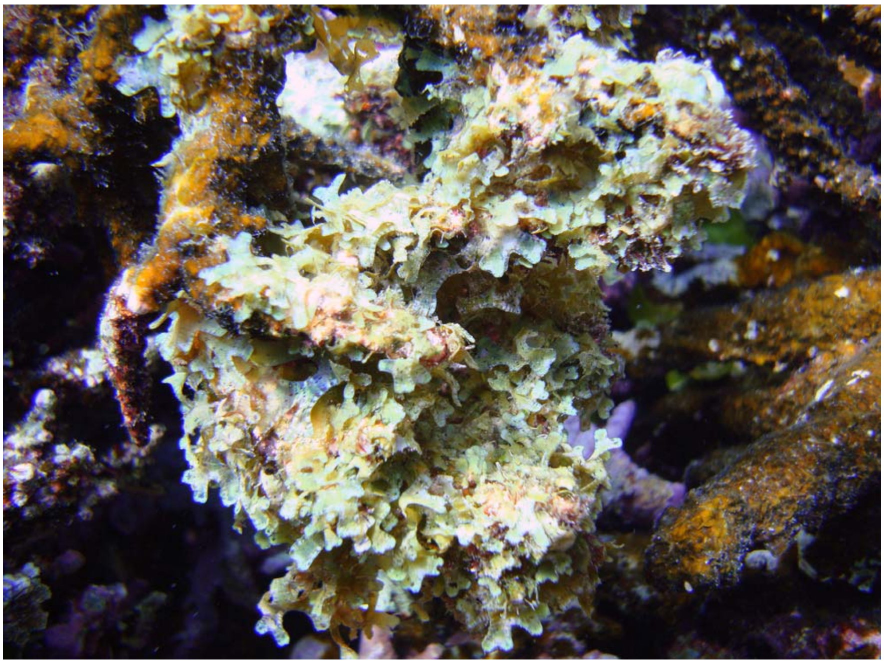

Fig. 16 Blooming of *Dictyota* species after coral bleaching at Mu Ko Surin in 2010.

Table 4 Principal Components Analysis of morphological characters measured on *Dictyota* and *Canistrocarpus* specimens.

Variable	Loading scores		
	PC1	PC2	PC3
Procumbent growth form	0.028	**0.276**	0.081
Resupinate growth form	-0.017	0.102	**-0.297**
Ascending growth form	-0.046	0.011	**-0.299**
Stoloniferous holdfast present	-0.002	-0.019	**-0.337**
Stoloniferous holdfast absent	0.002	0.019	**0.337**
Irregular branching present	0.040	**0.234**	0.065
Irregular branching absent	-0.040	**-0.234**	-0.065
Surface proliferations present	0.031	-0.019	**-0.314**
Surface proliferations absent	-0.031	0.019	**0.314**
Iridescence present	0.011	**0.305**	0.058
Iridescence absent	-0.011	**-0.305**	-0.058
Transverse bands present	0.020	**0.236**	0.061
Transverse bands present	-0.020	**-0.236**	-0.061
Average width	**0.221**	-0.026	0.011
Average proximal width	**0.216**	-0.054	0.042
Average distal width	**0.219**	-0.036	0.012
Minimum average width	**0.218**	-0.008	0.025
Average apical proximal width	**0.214**	0.021	0.024
% Variation	28.30	13.60	8.60
Eigen value	18.09	8.68	5.50

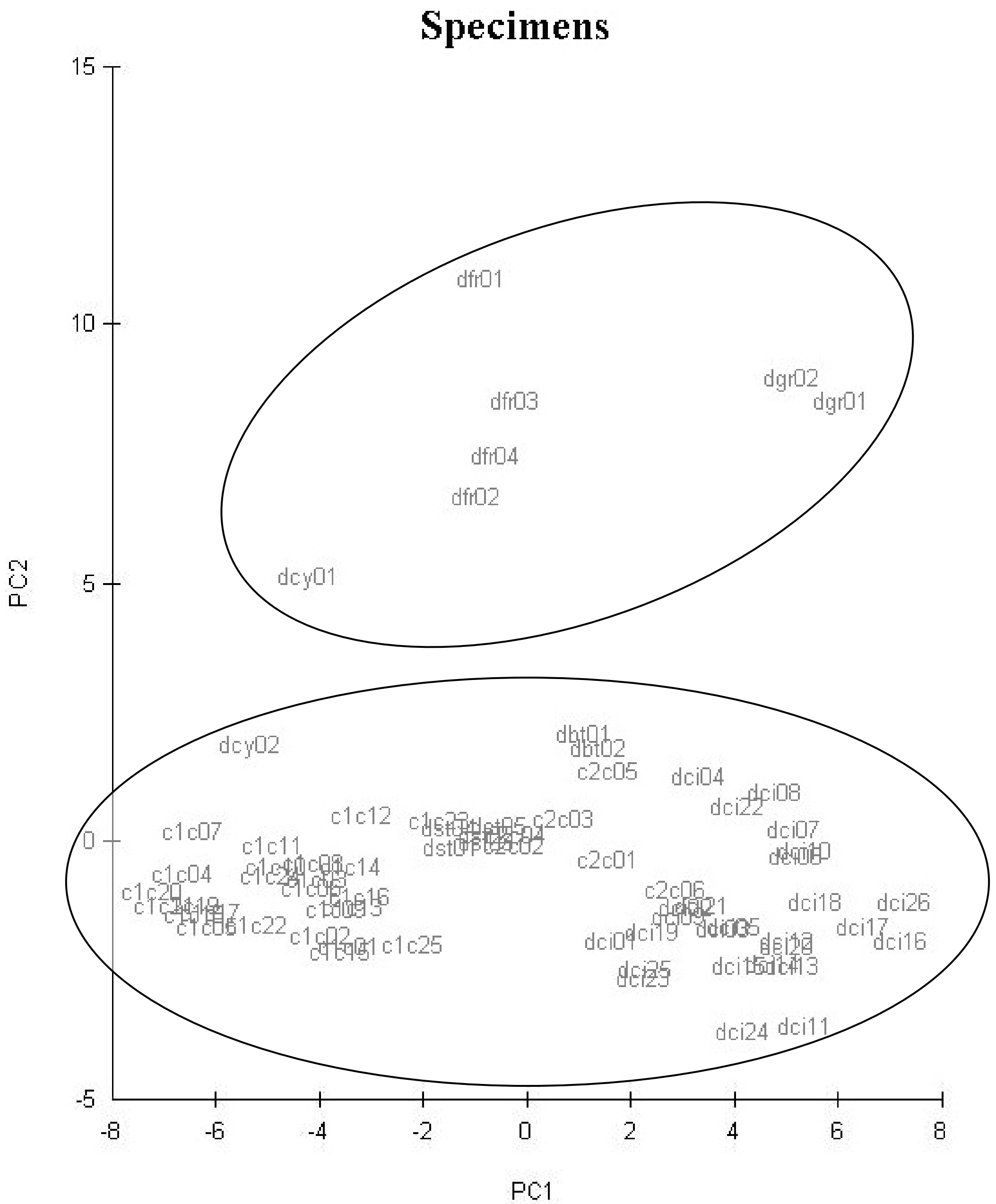

Fig. 17 Plot of PC1 (widths of interdichotomies and apical segments) against PC2 (a growth form and special characters) for specimens of *Dictyota* and *Canistrocarpus* represents by code of specimens: *C. cervicornis* (c1c1-25); *C. crispatus* (c2c1-25); *D. bartayresiana* (dbt01-02); *D. ceylanica* (dcy01-02); *D. ciliolata* (dci01-26); *D. friabilis* (dfr01-04); *D. grossedentata* (dgr01-02); *D. stolonifera* (dst01-05).

Table 5 Summary of species occurrence of *Dictyota* and *Canistrocarpus* in the east coast and the west coast of the Peninsular Thailand from collections during 1976 – 2011.

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
The east coast	*C. cervicornis*	-	-	/	/	/	-	/	/	-	/	-	-
	C. crispatus	-	-	-	-	-	-	-	/	-	-	-	-
	D. bartayresiana	-	-	-	-	/	-	-	-	-	/	-	-
	D. ceylanica	-	-	/	-	-	-	-	-	-	/	-	-
	D. ciliolata	-	/	/	/	/	-	/	/	-	/	-	-
	D. friabilis	-	-	-	/	-	-	-	-	-	-	-	-
The west coast	*C. cervicornis*	/	/	/	-	-	-	-	-	-	/	/	/
	C. crispatus	/	/	/	/	-	-	-	-	-	/	-	-
	D. bartayresiana	/	-	-	-	-	-	-	-	-	-	-	-
	D. ceylanica	-	/	-	-	-	-	-	-	-	-	-	-
	D. ciliolata	/	/	-	-	-	-	-	-	-	-	-	-
	D. friabilis	-	/	-	-	-	-	-	-	-	-	-	/
	D. grossedentata *	-	/	-	-	-	-	-	-	-	-	-	/
	D. stolonifera *	/	/	-	-	-	-	-	-	/	-	-	-

The legends for table are given as / (found), - (not found), * (new record).

Table 6 Summary of *Dictyota* and *Canistrocarpus* occurrences and abundances from survey sites both the east coast and the west coast of the Peninsular Thailand.

No.	Site	Habitat	*C. cervicornis*	*C. crispatus*	*D. bartayresiana*	*D. ceylanica*	*D. ciliolata*	*D. friabilis*	*D. grossedentata*	*D. stolonifera*
1	Ko Khai, Chumphon	Reef flat	+	-	+	-	-	-	-	-
2	Hat Nha Ladkrabang, Chumphon	Reef flat	-	-	-	-	-	-	-	-
3	Hin Kob, Chumphon	Shelterd rocky shore	+	-	-	-	-	-	-	-
4	Ko Samui, Surat Thani	Reef flat	++	+	-	-	++	-	-	-
5	Ko Taen, Surat Thani	Reef flat	++	-	+	-	++	-	-	-
		Reef slope	-	-	-	-	-	-	-	-
		Exposed rocky shore	-	-	-	+	-	+	-	-
		Seagrass bed	-	-	-	-	-	-	-	-
6	Ko Matsum, Surat Thani	Reef flat	+++	++	-	-	+	-	-	-
7	Ko Rab, Surat Thani	Reef flat	++	-	-	-	++	-	-	-
		Reef slope	-	-	-	-	-	-	-	-
8	Ko Wang Nok, Surat Thani	Reef flat	++	-	-	-	++	-	-	-
		Reef slope	-	-	-	-	-	-	-	-
9	Ko Wang Nai, Surat Thani	Reef flat	++	-	-	-	++	-	-	-
		Reef slope	-	-	-	-	-	-	-	-
10	Ko Chalarm Lai, Surat Thani	Exposed rocky shore	-	-	-	-	-	-	-	-

Table 6 Continued.

No.	Site	Habitat	*C. cervicornis*	*C. crispatus*	*D. bartayresiana*	*D. ceylanica*	*D. ciliolata*	*D. friabilis*	*D. grossedentata*	*D. stolonifera*
11	Ko Luang Pu Tuad, Nakhon Si Thammarat	Shelterd rocky shore	-	-	-	-	+	-	-	-
12	Ao Ta Led, Nakhon Si Thammarat	Shelterd rocky shore	-	-	+	-	-	-	-	-
13	Hat Nai Plao, Nakhon Si Thammarat	Shelterd rocky shore	-	-	+	-	+	-	-	-
14	Ao Thong Yee, Nakhon Si Thammarat	Shelterd rocky shore	+		+	-	+	-	-	-
15	Leam Pra Thap, Nakhon Si Thammarat	Exposed rocky shore	-	-	-	-	-	-	-	-
16	Ko Tharai, Nakhon Si Thammarat	Seagrass bed	+	-	-	-	-	-	-	-
17	Ko Nu, Songkhla	Exposed rocky shore	-	-	-	+	-	-	-	-
18	Ko Maew, Songkhla	Exposed rocky shore	-	-	-	+	-	-	-	-
		Reef flat	-	-	-	-	-	-	-	-
19	Ko Surin, Phang-nga	Reef slope	-	-	-	-	-	+++	+++	-
20	Ko Similan, Phan-gnga	Reef slope	-	-	-	-	-	+	-	-
21	Ao Bang Klee, Phang-nga	X	-	X	-	-	-	-	-	-
22	Kura Buri, Phang-nga	X	-	-	-	-	X	-	-	-
23	Ko Pling, Phuket	Reef flat	+	-	-	-	-	-	-	-
		Shelterd rocky shore	-	-	-	-	-	-	-	-
24	Ko Racha Yai, Phuket	Reef slope	-	-	-	-	-	-	+	-
25	Hat Kalim, Phuket	Shelterd rocky shore	-	X	-	-	-	-	-	-
26	Ko Phi Phi, Krabi	Reef flat	-	-	-	-	-	-	-	-

Table 6 Continued.

No.	Site	Habitat	*C. cervicornis*	*C. crispatus*	*D. bartayresiana*	*D. ceylanica*	*D. ciliolata*	*D. friabilis*	*D. grossedentata*	*D. stolonifera*
27	Ko Lanta Yai, Krabi	Shelterd rocky shore	++	+++	+	-	+++	-	-	++
28	Ko Talibong, Trang	Reef flat	+	+	+	-	+	-	-	+
		Shelterd rocky shore	+	-	-	-	+	-	-	+
		Seagrass bed	-	-	-	-	-	-	-	-
29	Ko Kradan, Trang	Reef flat	-	-	-	-	-	-	-	-
		Reef slope	-	-	-	-	-	-	-	-
		Shelterd rocky shore	-	-	-	-	-	-	-	-
30	Hat Chao Mai, Trang	Shelterd rocky shore	-	-	-	-	+	-	-	-
31	Ko Muk, Trang	Exposed rocky shore	-	-	-	-	-	-	-	-
		Seagrass bed	+	-	-	-	-	-	-	-
32	Leam Yong Lam, Trang	Seagrass bed	-	-	-	-	-	-	-	-
33	Ko Adang, Satun	Reef flat	-	-	-	-	-	-	-	-
		Reef slope	-	-	-	-	-	++	-	-
34	Ko Rawi, Satun	Reef flat	-	-	-	-	-	-	-	-
		Reef slope	-	-	-	+	-	-	+	-
35	Ko Buloan Maiphai, Satun	Reef flat	-	-	-	-	-	-	-	-
		Reef slope	-	-	-	-	-	-	-	-
		Shelterd rocky shore	-	-	-	-	-	-	-	-

Table 6 Continued.

No.	Site	Habitat	*C. cervicornis*	*C. crispatus*	*D. bartayresiana*	*D. ceylanica*	*D. ciliolata*	*D. friabilis*	*D. grossedentata*	*D. stolonifera*
36	Ko Dong, Satun	Reef flat	-	-	-	-	-	-	-	-
37	Ko Tarutao, Satun	Reef flat	-	-	-	-	-	-	-	-
		Reef slope	-	-	-	-	-	-	-	-
		Shelterd rocky shore	-	-	-	-	-	-	-	-
		Seagrass bed	-	-	-	-	-	-	-	-
38	Ko Hin Ngarm, Satun	Reef slope	-	-	-	-	-	-	-	-
39	Ko Lidee Lek, Satun	Seagrass bed	+++	-	-	-	-	-	-	-
% Occurrence relative to number of sites			38	15	18	10	33	13	8	5

The legends for table are given as X (no data), - (not found), + (found); number of + refers to degree of abundance: (+) = little, (++) = moderate and (+++) = high.

II. Distribution of *Dictyota* J.V. Lamour. and *Canistrocarpus* De Paula & De Clerck in the Peninsular Thailand.

There were 8 species of *Dictyota* and *Canistrocarpus* distributed in Thai waters. Of these, there were 6 species distributed in both the east coast and the west coast of the Peninsular Thailand: *D. bartayresiana*, *D. ceylanica*, *D. ciliolata*, *D. friabilis*, *C. cervicornis* and *C. crispatus*, whereas 2 species restricted their distribution only in the west coast of the Peninsular Thailand: *D. grossedentata* and *D. stolonifera*. (Table 5; Fig. 18).

Dictyota and *Canistrocarpus* inhabited in 3 marine ecosystems: coral reef, rocky shore and seagrass bed. Their occurrences showed spatial trends along coral reef zonation, difference of wave exposure and seagrass bed. In coral reef, there were 5 species only occurred in reef flat but absent in reef slope whereas 3 species only occurred in reef slope but absent in reef flat. In rocky shore, there were 5 species only occurred during wave-sheltered period but absent during wave-exposed period whereas 2 species only occurred during wave-exposed period but absent during wave-sheltered period. In seagrass bed, there was only 1 species inhabited and only found in bay site but absent in headland site. In addition, plants size in sheltered area was bigger than in exposed area.

The most common species in this study was *Canistrocarpus cervicornis*. It was the only species that found in all 3 marine ecosystems and had highest possibility to be found (38 %, Table 6). *Dictyota ciliolata* was the second common species by 33 % of possibility to be found (Table 6). The latter 6 species had lower possibilities to be found in the sites (5 – 18 %) and their abundances were much less compared to the 2 former species (Table 6).

There was a species that distributed only in off-shore islands (Table 6). It was *Dictyota grossedentata*. This species was also a species which not found in the east coast of the Peninsular Thailand. In addition, it was found only in reef slope.

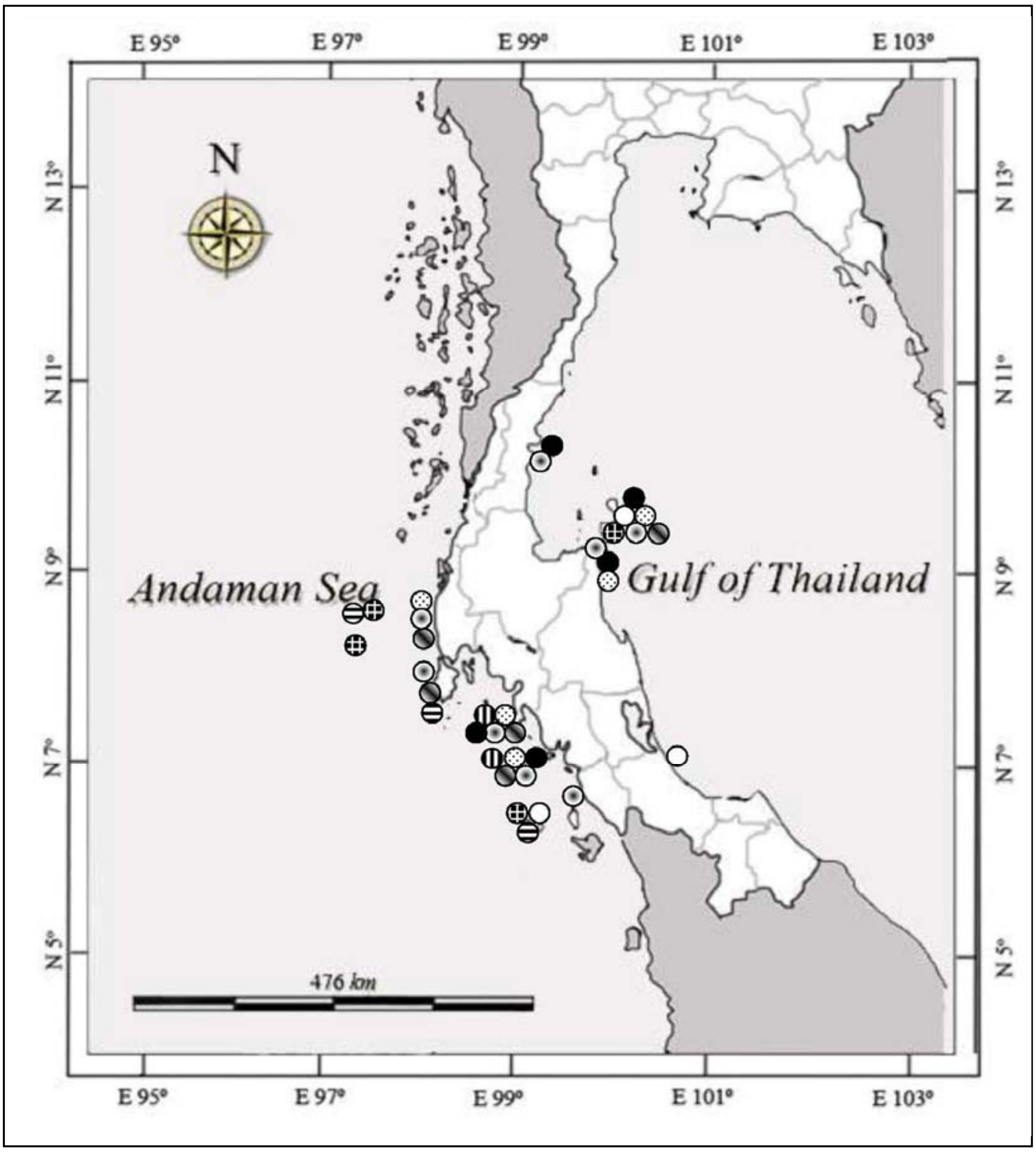

Fig. 18 Distribution map of *Dictyota* J.V. Lamour. and *Canistrocarpus* De Paula & De Clerck in the Peninsular Thailand: ● *D. bartayresiana*, ○ *D. ceylanica*, ◌ *D. ciliolata*, ⊞ *D. friabilis*, ⊜ *D. grossedentata*, ⦶ *D. stolonifera*, ◉ *C. cervicornis* and ◐ *C. crispatus*.

Key to species of *Dictyota* and *Canistrocarpus* in the Peninsular Thailand

1. Plants isotomous dichotomous branching or variable…………………….…..……2

1. Plants anisotomous dichotomous branching……………………………….…..……7

2. Terete stoloniferous fibres at lower part of thallus present...…. ***D. stolonifera***

2. Terete stoloniferous fibres at lower part of thallus absent………..…..……….3

3. Thallus margins coarsely dentate, marginal teeth conspicuous...***D. grossedentata***

3. Thallus margins entirely smooth, or sometimes with sparsely teeth…….………4

4. Plants procumbent, or growing horizontally, often with bluish - purplish iridescent or non-iridescent transverse bands, margins never dentate, branching variable.………………………..…..............…..… ***D. friabilis***

4. Plants upright or nearly so…………………………………………………5

5. Plants grow in dense turf, conspicuous base absent, basal straps prostrate, higher up straps erect and filiform, iridescent blue to yellowish and often together with banding pattern……..…………………...……..…..***D. ceylanica***

5. Thallus straps broad, filiform straps absent…………………….……..…….6

6. A conspicuous holdfast present, length of interdichotomies larger than width several times, marginal teeth usually present……..……………….***D. ciliolata***

6. Conspicuous holdfast absent, length of interdichotomies short and only few times larger than width, marginal teeth rarely found……..…***D. bartayresiana***

7. Branching cervicorn especially at the upper parts of thalli, straps usually spirally twisted, recurved branches present, apices rounded to obtuse.......***C. cervicornis***

7. Paired straps one longer than another, spirally twisted absent, recurved branches absent, apices typically apiculate…………………….…..………***C. crispatus***

Description of the species

1. *Canistrocarpus cervicornis* (Kütz.) De Paula & De Clerck**,** J. Phycol. 42: 1271-1288. 2006. — *Dictyota cervicornis* Kütz., Tabulae phycologicae 9: 11, pl. 24, fig. 2. 1859; Teo, L.W. & Wee, Y.C., Seaweeds of Singapore: 67, fig. 66. 1983; Lewmanomont, K. and Ogawa, H., Common Seaweeds and Seagrasses of Thailand: 70, 1 fig. 1995; Trono Jr., G.C., Field guide and atlas of the seaweed resources of the Philippines: 106, fig. 73. 1997; De Clerck, O., Coppejans, E. and Prud'homme van Reine, W.F. *Dictyota* J.V. Lamour. In Prud'homme van Reine, W.F. and Trono Jr., G.C. (Eds), Plant Resources of South-East Asia No. 15(1). Cryptogams: Algae: 143, figs. 1, 2. 2001; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 42, figs. 11 - 14. 2003; De Clerck, O., Bolton, J.J., Anderson, R.J. & Coppejans, E., Guide to the seaweeds of KwaZulu-Natal: 102, fig. 73. 2005; Lewmanomont, K., Noiraksar, T. and Kaewsuralikhit, C., Seaweeds of Koh Khram and adjacent islands (in Thai): 49, 1 fig. 2007; Coppejans, E., Prathep, A., Leliaert, F., Lewmanomont, K.and De Clerck,O., Seaweeds of Mu Ko Tha Lae Tai (SE Thailand): Methodologies and field guide to the dominant species: 153, fig. 95. 2010. **Fig. 19**

Growth form ascending, repent and resupinate; epilithic specimens typically ascending, attached to the substrate by broad, thick prostrated basal straps, erect part more slender and supple; epiphytic specimens generally lack a conspicuous basal part, characterized as repent growth form, attached to the phorophytes in various points, unattached straps often falling down or clustering in clump; dislodged thallus sometimes formed spherical turf characterized as cushion-like growth form. Attachment by means of turfs of rhizoids especially in the basal parts. Length of the thalli 4-20 cm. long. Color yellow to dark brown, no iridescent and banding, dry specimens apical part pale brown, basal part turn a bit darker. Branching isotomous dichotomous up to the middle parts, apical parts typically cervicorn, recurved branches often with cervicorn; branching angle (30) 60-90 (120). Margins and surface margins smooth and sinoidally curved. Surface proliferation not found, marginal proliferation present. Hair turf common Interdichotomies width of the thallus variable, usually tapering to the apices, hooked-like branch abundant; average width (0.4) 0.9-2.3 (3.9) mm., proximal width (0.5) 0.9-2.4 (3.7) mm., distal width (0.7) 1.4-3.8 (6.5) mm.; length (2.1) 4.5-12.8 (19.9) mm.; Wd/Wp (0.8) 1.4-2.0 (3.0), L/Wm (1.4) 3.1-5.9 (9.9), RWC (0.8) 2.1-4.2 (7.2). Apical segments apices mostly rounded, sometimes acute or truncate, apical cells protruding, sometimes level; average width (0.3) 0.8-1.4 (2.6) mm.; length (0.7) 2.1-3.4 (7.5) mm.; L/Wp (1.2) 2.2-4.3 (9.1). Cortex and medulla unilayered, medullary wall thickening not found; Cl: (25) 35-50 (68) µm, Cw: (10) 13-18 (25) µm, Ch: (10) 13-15 (18) µm; Ml: (63) 160-250 (300) µm, Mw: (48) 58-80 (125) µm, Mh: (53) 58-65 (80) µm; Cl/Cw: (1.33) 2.33-4.00 (6.00), Ml/Mw: (0.78) 2.25-3.32 (4.60), Ml/Cl: (2.08) 3.50-5.31 (8.00), Mw/Cw: (2.67) 3.10-5.83 (6.50). Sporangia. not found. Gametangia. not found.

Habitats.— *Canistrocarpus cervicornis* is a common species in intertidal to shallow subtidal. It grows very well on hard substrates as well as epiphyte on various seaweed and seagrass.

Specimens Examined.— A. Darakrai 6a(PSU), 6b(PSU), 6c(PSU), 6d(PSU), 7(PSU), 8(PSU), 10(PSU), 11(PSU), 13a(PSU), 13b(PSU), 14(PSU), 16a(PSU), 16b(PSU), 17c(PSU), 17d(PSU), 20(PSU), 21(PSU), 23(PSU), 24(PSU), 25(PSU), 26(PSU), 27(PSU), 28(PSU), 29(PSU), 30(PSU), 31(PSU), 32(PSU), 40(PSU), 46a(PSU), 46b(PSU), 46c(PSU), 46d(PSU), 47a(PSU), 77(PSU), 105(PSU), A. Prathep 364(PSU), 172a(PSU), 172b(PSU), 172c(PSU), 172d(PSU), 172e(PSU), 172f(PSU), 172g(PSU), 172h(PSU), 172i(PSU), 277(PSU), 293(PSU), 364a(PSU), 364b(PSU), 364c(PSU), 364d(PSU), 487(PSU), 513(PSU), 1213(PSU), 1214(PSU), 1215(PSU), A 1216(PSU), 1222(PSU), 1227(PSU), 1229(PSU), 1230(PSU), 1231(PSU), 1232(PSU), 1233(PSU), 1234(PSU), 1235(PSU), 1236(PSU), 1237(PSU), 1238(PSU), 1239(PSU), 1240(PSU), 1241(PSU), 1242(PSU), 1243(PSU), 1245(PSU), 1248(PSU), 1249(PSU), 1250(PSU), HEC 16206 E(PSU), 16227 B(PSU), 16227 C(PSU), 16227 D(PSU), 16227 E(PSU), KL 5962, KOKO 007, P. Tantiprapas 09(PSU), 10(PSU), 11(PSU), 19(PSU), 20(PSU), 21(PSU), S. Pongparadon 411(PSU), 433(PSU), 434(PSU), 436 (PSU).

Peninsular Thailand Distributions.— ***The east coast***: Suratthani Province [Ko Samui (Wat Sila-ngu, Had Hua-thanon, Ban Bangkao, Had Watmai), Ko Taen, Ko Matsum], Nakhon Si Thammarat Province [Ko Rab, Ko Wang-nok, Ko Wang-nai];

The west coast: Phuket Province [Had Naiyang: Ko Pling], Trang Province [Ko Talibong], Satun Province [Ko Lidee], Phang-nga Province [Laem Hua-krang].

Remarks.— *Canistrocarpus cervicornis* is easy to recognize by its cervicorn branching and recurved branches. Ascending growth form of this species may look similar to *Dictyota bartayresiana* which is sometimes found together but the latter species has very regular branching and possess short interdichotomies.

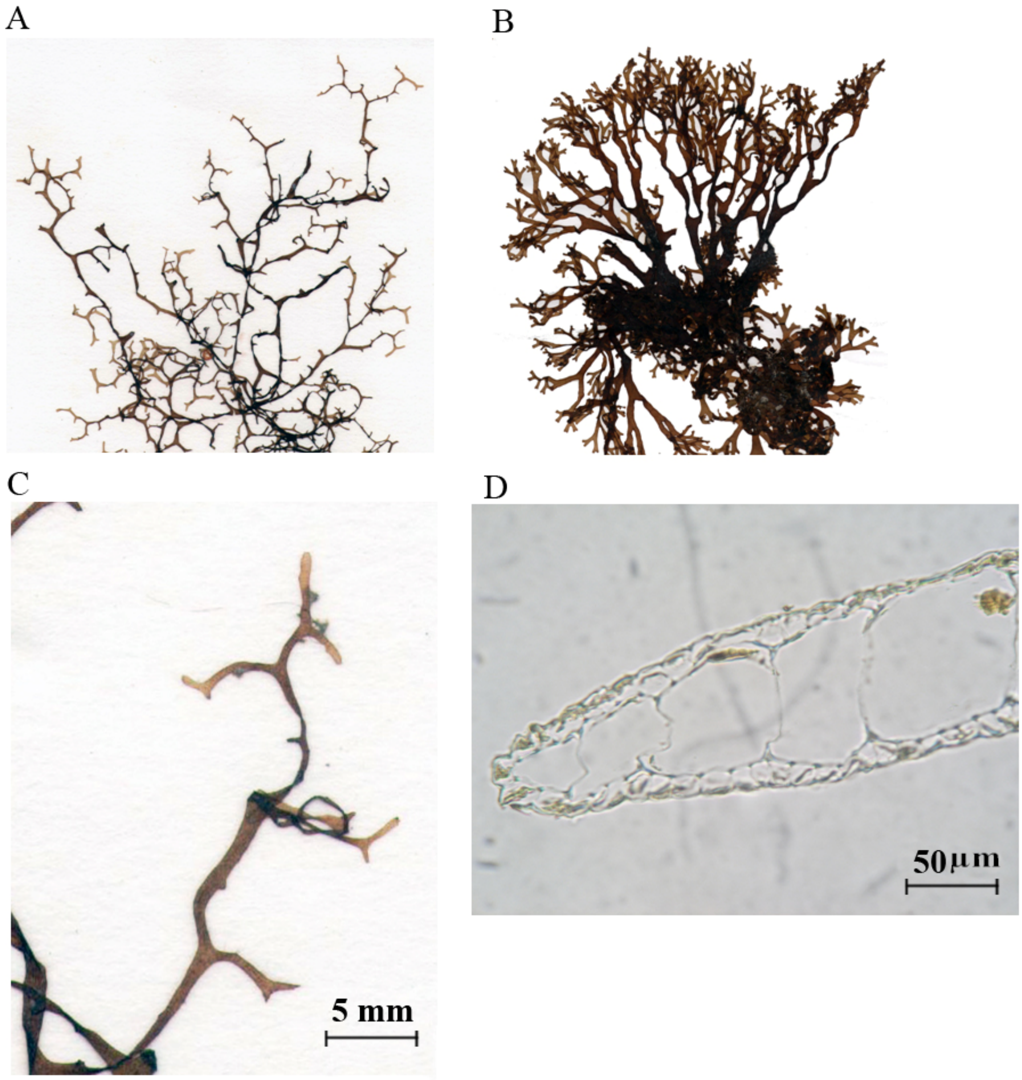

Fig. 19 Diagnostic characters of *Canistrocarpus cervicornis*: A. slender repent growth form, usually found on epiphytic specimens; B. ascending growth form, usually found on epilithic specimens; C. details of recurved branch; D. details of unilayered cortex and medulla: Fig. 19A and 19C from A. Prathep 364d (PSU); 19B from S. Pongparadon 411.

2. *Canistrocarpus crispatus* (J.V. Lamour.) De Paula & De Clerck**,** J. Phycol. 42: 1271-1288. 2006. — *Dictyota crispata* J.V. Lamour., J. Bot. (Desvaux) 2: 44. 1809a; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 66, figs. 20 - 22. 2003; De Clerck, O., Coppejans, E. and Prud'homme van Reine, W.F. *Dictyota* J.V. Lamour. In Prud'homme van Reine, W.F. and Trono Jr., G.C. (Eds), Plant Resources of South-East Asia No. 15(1). Cryptogams: Algae: 143, fig. 6. 2001. **Fig. 20**

Growth form ascending with the small prostrate basal parts attached to the substrate but sometimes form a ball-like thalli after dislodge, straps harsh when touch. Length of the thallus 4-14 cm. long. Color yellow brown, no iridescent and banding, dry specimens pale brown. Branching anisotomous dichotomous, especially in the upper part of the thallus; branching angle (30) 40-70 (90). Margins and surface margins smooth but proliferations can obscure the original appearance, surface proliferation abundant. Interdichotomies straps of the thallus mostly the same width; average width (2.3) 3.0-5.1 (7.2) mm., proximal width (2.3) 3.4-4.4 (6.0) mm., distal width (3.7) 7.0-10.2 (15.1) mm.; length (4.2) 6.6-13.9 (21.3) mm.; Wd/Wp (1.0) 1.7-2.6 (3.3), L/W (1.2) 1.8-3.1 (5.7), RWC (0.9) 1.9-2.8 (4.1). Apical segments typically apiculate, or pointed; proximal width (1.6) 2.2-3.3 (5.5) mm.; length (1.8) 3.5-5.1 (7.7) mm.; L/Wp (0.9) 1.3-1.8 (2.4). Cortex and medulla unilayered, medullary wall thickening not found; Cl: (15) 25-35 (45) µm, Cw: (15) 20-25 (30) µm, Ch: (13) 15-20 (25) µm; Ml: (110) 200-380 (500) µm, Mw: (80) 120-180 (210) µm, Mh: (90) 100-130 (145) µm; Cl/Cw: (0.60)1.30-1.75 (2.50), Ml/Mw: (1.38) 1.60-2.10 (2.38), Ml/Cl: (7.33) 8.00-10.00 (11.11), Mw/Cw: (4.00) 4.50-7.50 (14.00). Sporangia single, scattered over the whole thallus, both surfaces, surrounded by an involucrum, width: (108) 120-170 (183) µm. Gametangia not found.

Habitats.— *Canistrocarpus crispatus* is found only in subtidal zone. They grow on hard substrate and have not been found as an epiphyte.

Specimens Examined.— A. Darakrai 22(PSU), 101(PSU), 106(PSU), 107a(PSU), 107b(PSU), 111(PSU), 112(PSU), 79(PSU), 95(PSU), 97(PSU), 99(PSU), A. Prathep 511(PSU), KL 2907-1, 4783, P. Tantiprapas 4(PSU), 15(PSU).

Peninsular Thailand Distributions.— ***The east coast*****:** Suratthani Province [Ko Samui (Had Hua-thanon)]; ***The west coast*****:** Phang-nga Province [Ao Bang Klee], Phuket Province [Had Kalim], Krabi Province [Ko Lanta Yai], Trang Province [Ko Talibong].

Remarks.— *Canistrocarpus crispatus* is recognized by its typical anisotomous dichotomous and its apices which is typically apiculate or pointed. Another distinct character is its abundant surface proliferation.

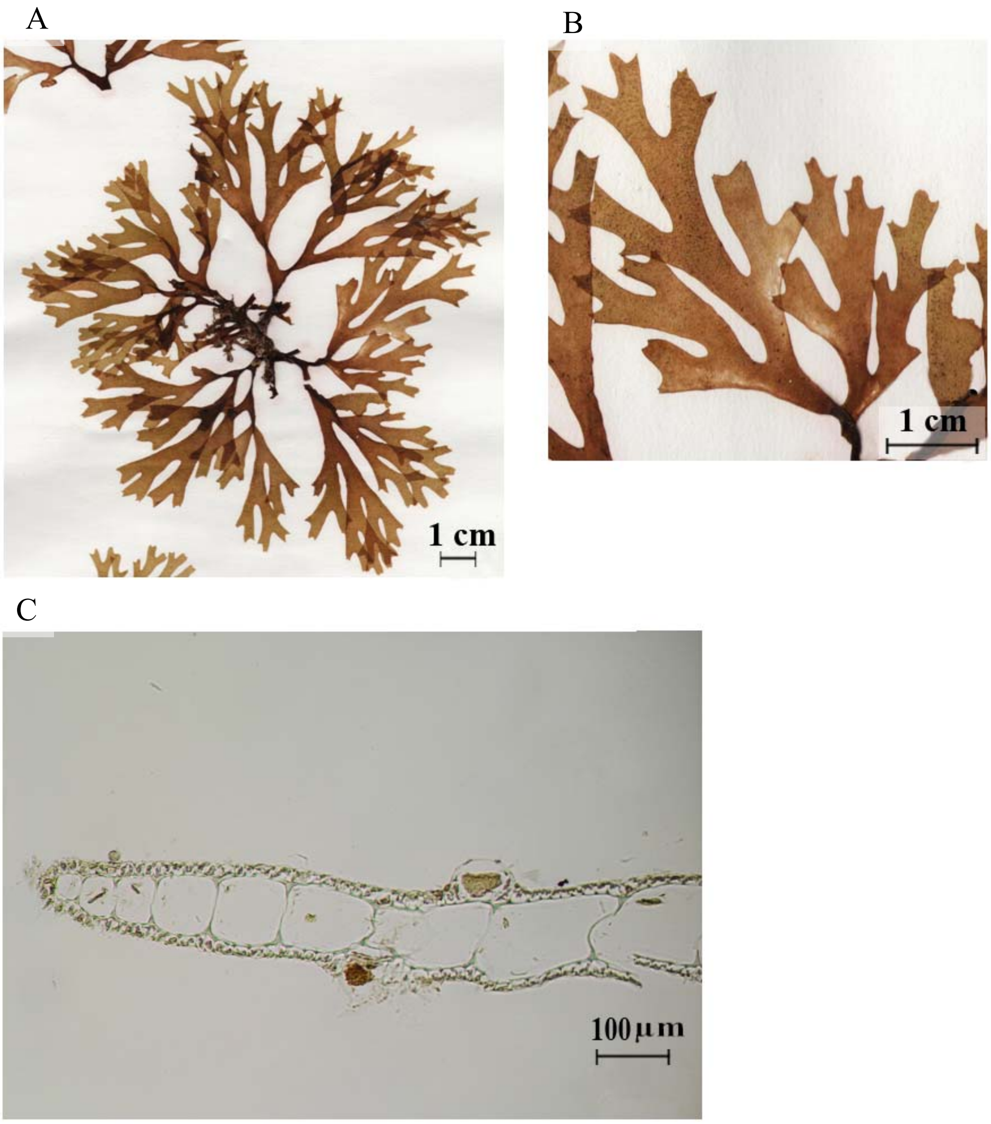

Fig. 20 Diagnostic characters of *Canistrocarpus crispatus*: A. ascending growth form shows anisotomous dichotomous branching; B. details of branching and typically apiculate apices; C. details of unilayered cortex, medulla and sporangium: Fig. 20A, B from A. Darakrai 107b (PSU).

3. ***Dictyota bartayresiana*** J.V. Lamour.**,** J. Bot. (Desvaux) 2: 43. 1809a; Lewmanomont, K. and Ogawa, H., Common Seaweeds and Seagrasses of Thailand: 69, 1 fig. 1995; De Clerck, O., Coppejans, E. and Prud'homme van Reine, W.F. *Dictyota* J.V. Lamour. In Prud'homme van Reine, W.F. and Trono Jr., G.C. (Eds), Plant Resources of South-East Asia No. 15(1). Cryptogams: Algae: 142, 1 fig. 8. 2001; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 37, figs. 9, 10. 2003; Tsuda, R.T., Dictyota (Phaeophyceae) from Micronesia. In Abbott, I.A. and McDermid, K.J. (Eds), Taxonomy of Economic Seaweeds with reference to the Pacific and other locations Volume IX: 46, fig. 3 - 6. 2004; Ohba, H., Victor, S., Golbuu, Y. and Yukihira, H., Tropical Marine Plants of Palau: 73, 4 figs. 2007; — *Dictyota bartayresii* J.V. Lamour., Nouv. Bull. Sci., par la Soc. Philom. *Paris* 1: 331. 1809b; Teo, L.W. & Wee, Y.C., Seaweeds of Singapore: 66, fig. 64. 1983; Cribb, A.B., Seaweeds of Queensland. A naturalist's guide: 43, fig. 2. 1996. **Fig. 21**

Growth form ascending, a conspicuous base disappears when matured, attached to substrate by numerous patches of rhizoids. Length of the thallus 3.5 - 6.0 cm. Color medium brown, no iridescent and banding, specimens turn dark when dry. Interdichotomies the whole thallus of the same width, interdichotomies short and broad, resulting in low length-width ratio; average width (2.7) 3.3-3.9 (5.0) mm., proximal width (2.8) 3.4-4.5 (5.1) mm., distal width (4.6) 5.9-8.5 (9.8) mm.; length (4.2) 5.3-7.4 (8.5) mm.; Wd/Wp (1.6) 1.9-2.5 (2.8), L/W (1.3) 1.6-2.2 (2.5), RWC (2.6) 2.9-3.3 (4.1). Apical segments rounded; proximal width (2.0) 2.3-3.0 (3.4) mm.; length (2.7) 3.2-4.1 (4.6) mm.; L/Wp (1.0) 1.2-1.6 (1.8). Branching isotomous dichotomous; branching angle (35) 60-70 (80). Margins and surface margins smooth, surface proliferation absent, marginal proliferation present. Cortex and medulla unilayered, medullary wall thickening not found; Cl: (15) 30-50 (60) µm, Cw: (10) 15-18 (25) µm, Ch: (10) 13-15 (18) µm; Ml: (140) 200-250 (260) µm, Mw: (70) 100-130 (160) µm, Mh: (50) 58-65 (75) µm; Cl/Cw: (0.86) 2.00-3.60 (5.00), Ml/Mw: (0.94) 1.83-2.50 (3.57), Ml/Cl: (3.53) 400-7.67 (11.00), Mw/Cw: (4.00) 5.00-8.00 (10.40). Sporangia. not found. Gametangia. not found.

Habitats.— *Dictyota bartayresiana* grows on hard substrate in intertidal and shallow subtidal.

Specimens Examined.— A. Darakrai 99, A. Prathep 489, A. Prathep 514, S. Pongparadon 400, S. Pongparadon 435.

Peninsular Thailand Distributions.— ***The east coast***: Suratthani Province [Ko Taen], Nakhon Si Thammarat Province [Ao Ta Led]; ***The west coast***: Krabi Province [Ko Lanta Yai], Trang Province [Ko Talibong]

Remarks.— *Dictyota bartayresiana* is characterized by its short interdichotomies and its regular branching pattern. This species has no conspicuous holdfast, erect straps rise from thick prostrate straps of basal part of thallus. The dry speciemens of *D. bartayresiana* may look similar to *D. ciliolata* but the latter species has much longer interdichotomies.

Fig. 21 Diagnostic characters of *Dictyota bartayresiana*: A. regular pattern of dichomous branching; B. details of unilayered cortex and medulla: Fig. 21A from A. Darakrai 99 (PSU).

4. *Dictyota ceylanica* Kütz., Tabulae phycologicae 9: 11, pl. 25, fig. 1. 1859; De Clerck, O., Coppejans, E. and Prud'homme van Reine, W.F. *Dictyota* J.V. Lamour. In Prud'homme van Reine, W.F. and Trono Jr., G.C. (Eds), Plant Resources of South-East Asia No. 15(1). Cryptogams: Algae: 143. 2001; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 89, fig. 28 - 29. 2003; Tsuda, R.T., *Dictyota* (Phaeophyceae) from Micronesia. In Abbott, I.A. and McDermid, K.J.

(Eds), Taxonomy of Economic Seaweeds with reference to the Pacific and other locations Volume IX: 48, figs. 7, 8. 2004; Ohba, H., Victor, S., Golbuu, Y. and Yukihira, H. Tropical Marine Plants of Palau: 75, 4 figs. 2007; Coppejans, E., Leliaert, F., Dargent, O., Gunasekara, R., & De Clerck, O., Sri Lankan Seaweeds: 134, figs. 23A, 33A, 33D, 108. 2009; Coppejans, E., Prathep, A., Leliaert, F., Lewmanomont, K.and De Clerck,O., Seaweeds of Mu Ko Tha Lae Tai (SE Thailand): Methodologies and field guide to the dominant species: 155, fig. 96. 2010. **Fig. 22**

Growth form procumbent and ascending, conspicuous base absent, basal straps procumbent to repent, higher up of the thallus erect straps; erect straps filiform. Attachment by means of rhizoids, attached to the substrate mostly by the basal part. Length of the thallus approximately 3 cm. Color medium to pale brown, greenish to yellowish iridescent with patch-like banding pattern, dry specimens retain the same color. Branching isotomous dichotomous. Branching angle: (55-) 70 – 80 (-90). Margins and surface margins smooth, sometime sinoidally curved occurred in the slender erect parts of the thallus. Surface proliferation absent; marginal proliferation not observed. Hair turf common. Interdichotomies width of the thallus variable, basal straps often broad and tapering gradually or abruptly to the filiform apical straps; average width: (0.2-) 0.7 – 0.9 (-1.2) mm., proximal width: (0.2-) 0.6 – 0.8 (-1.0) mm., distal width: (0.4-) 1.0 – 1.3 (-1.6) mm.; Wd/Wp: (1.1-) 1.3 – 1.9 (-2.2); length: (1.4-) 2.7 – 5.2 (-6.5) mm.; L/W: (1.9-) 4.5 – 9.7 (-12.4); RWC: (1.7-) 4.6 – 7.4 (-13.2). Apical segments apices of the filiform straps acute, sometimes tips elongated, broad basal straps rounded to obtuse; apical cells protruding; proximal width: (0.3-) 0.6 – 0.8 (-1.0) mm.; length: (0.9-) 1.5 – 2.0 (-3.2) mm.; L/W: (1.4-) 2.1 – 3.5 (-4.3). Cortex and medulla unilayered; Cl: 15 – 35 µm., Cw: 8 – 15 µm.; Ml: 88 – 112 µm., Mw: 50 – 75 µm.; Cl/Cw: 1.2 – 4.0; Ml/Mw: 1.5 – 2.0; Ml/Cl: 3.7 – 6.4; Mw/Cw: 3.3 – 8.3. Sporangia single, scattered on one surface, mainly in the middle and subapical parts of the thallus. Gametangia not found.

Habitats.— *Dictyota ceylanica* was found just under lower water limit on extremely exposed rocky shores and in deep sub tidal coral reef of an off-shore island [Ko Rawi]. They grew on hard substrate as well as epiphyte on coralline algae.

Specimens Examined.— S. Pongparadon 327(PSU).

Peninsular Thailand Distributions.— ***The east coast***: Suratthani Province [Ko Taen]; ***The west coast***: Satun Province [Ko Rawi].

Remarks.— *Dictyota ceylanica* is characterized by its typical ascending filiform straps, growing in dense tuft without conspicuous base. This species is the smallest species found in this study.

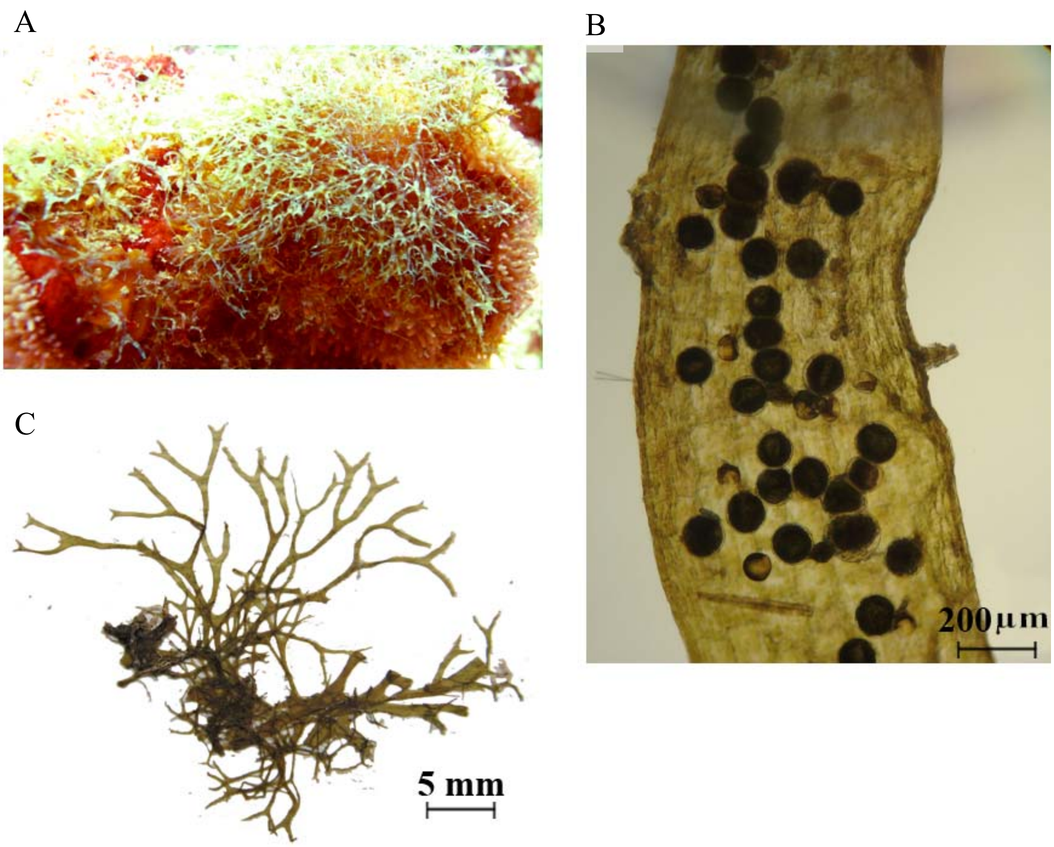

Fig. 22 Diagnostic characters of *Dictyota ceylanica*: A. dense turf forming of in situ specimens; B. details of filiform ascending straps; C. details of sporangia scattering on thallus surface: Fig. 22A, B, C from S. Pongparadon 327(PSU).

5. *Dictyota ciliolata* Sonder ex Kütz.**,** Tabulae phycologicae 9: 12, pl. 27, fig. 1. 1859; Teo, L.W. & Wee, Y.C., Seaweeds of Singapore: 66, fig. 65. 1983; De Clerck, O., Coppejans, E. and Prud'homme van Reine, W.F. *Dictyota* J.V. Lamour. In Prud'homme van Reine, W.F. and Trono Jr., G.C. (Eds), Plant Resources of South-East Asia No. 15(1). Cryptogams: Algae: 143, figs. 9, 10. 2001; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 58. figs. 17 - 19. 2003; De Clerck, O., Bolton, J.J., Anderson, R.J. & Coppejans, E., Guide to the seaweeds of KwaZulu-Natal: 102, fig. 74. 2005; Coppejans, E., Leliaert, F., Dargent, O., Gunasekara, R., & De Clerck, O., Sri Lankan Seaweeds: 136, fig. 109, 2009; Coppejans, E., Prathep, A., Leliaert, F., Lewmanomont, K.and De Clerck,O., Seaweeds of Mu Ko Tha Lae Tai (SE Thailand): Methodologies and field guide to the dominant species: 157, fig. 97. 2010. **Fig. 23**

Growth form erect and occasionally ascending, attached to substrate by stupose holdfast. Length of the thallus 4.5 - 12 cm. Color medium to dark brown, no iridescent and banding, dry specimens retain the same color. Interdichotomies the whole thallus totally the same width, gradually widening to the apices; average width: (2.6) 3.8-5.1 (9.9) mm., proximal width: (1.8) 4.6-10.0 (18.2) mm., distal width: (4.0) 6.6-9.1 (19.3) mm.; length: (9.5) 13.3-28.5 (32.2) mm.; Wd/Wp (0.3) 2.1-2.6 (3.8), L/W (2.2) 3.0-4.6 (7.0), RWC (0.2) 0.9-1.6 (2.3). Apical segments rounded or truncate, sometimes acute; apical cells protruding; proximal width: (1.5) 2.0-2.5 (4.7) mm.; length: (2.6) 4.2-7.3 (12.0) mm.; L/Wp: (1.3) 2.0-3.0 (3.4). Branching isotomous dichotomous, sometimes slightly anisotomous dichotomous; branching angle (25) 40-80 (135). Margins and surface margin smooth or sparsely dentate, marginal proliferation common. Cortex and medulla unilayered, medullary wall thickening not found; Cl: (28) 40-65 (93) µm, Cw: (13) 15-25 (33) µm, Ch: (13) 18-20 (30) µm; Ml: (120) 200-320 (350) µm, Mw: (80) 100-140 (170) µm, Mh: (103) 113-125 (133) µm; Cl/Cw: (1.10) 2.00-3.43 (5.29), Ml/Mw: (1.09) 1.75-2.75 (3.50), Ml/Cl: (2.29) 3.54-7.00 (10.55), Mw/Cw: (3.08) 4.00-8.00 (11.33). Sporangia single, scattered over the whole thallus on one surface, not surrounded by involucrum, width: (123) 128-130 (135) µm**.** Gametangia not found.

Habitats.— *Dictyota ciliolata* is a common species in subtital to shallow subtidal zone. It grows on any kind of hard substrate, sometimes also grows on coralline red algae.

Specimens Examined.— A. Darakrai 9a(PSU), 9b(PSU), 9c(PSU), 9d(PSU), 12a(PSU), 12b(PSU), 15a(PSU), 15b(PSU), 15c(PSU), 16c(PSU), 17a(PSU), 17b(PSU), 18a(PSU), 19a(PSU), 19b(PSU), 19c(PSU), A. Intarapim 1(PSU), A. Prathep 1226(PSU), 1246(PSU), 1247(PSU), R. Sriwoon 4(PSU), 588 a(PSU), 588 b(PSU), 157(PSU), 263(PSU), 515a(PSU), 515b(PSU), 516(PSU), 531(PSU), 532(PSU), 533(PSU), 538(PSU), 539(PSU), 540(PSU), 573(PSU), J. Inuthai 357a(PSU), 357b(PSU), K. Nuwongsri 1(PSU), KL 2333-3, 6110, 7018, P. Tantiprapas 5(PSU), 6(PSU), 7(PSU), 8(PSU), 16(PSU), 17(PSU), S. Pongparadon 409(PSU), 412(PSU), S. 413(PSU), S. 414(PSU).

Peninsular Thailand Distributions.— ***The east coast***: Suratthani Province [Ko Samui (Wat Sila-ngu, Ban Pang-ga, Had Taling-ngam), Ko Taen], Nakhon Si Thammarat Province [Ao Khanom, Ko Rab, Ko Wang-nok, Ko Wang-nai]; ***The west coast***: Phang-nga Province [Kura Buri District], Trang Province [Ko Talibong, Had Chao-mai, Palian District], Krabi Province [Ko Lanta Yai].

Remarks.— *Dictyota ciliolata* is easy to recognize by its conspicuous stupose holdfast, as well as its long interdichotomies. This species has largest thallus than all other species in this study.

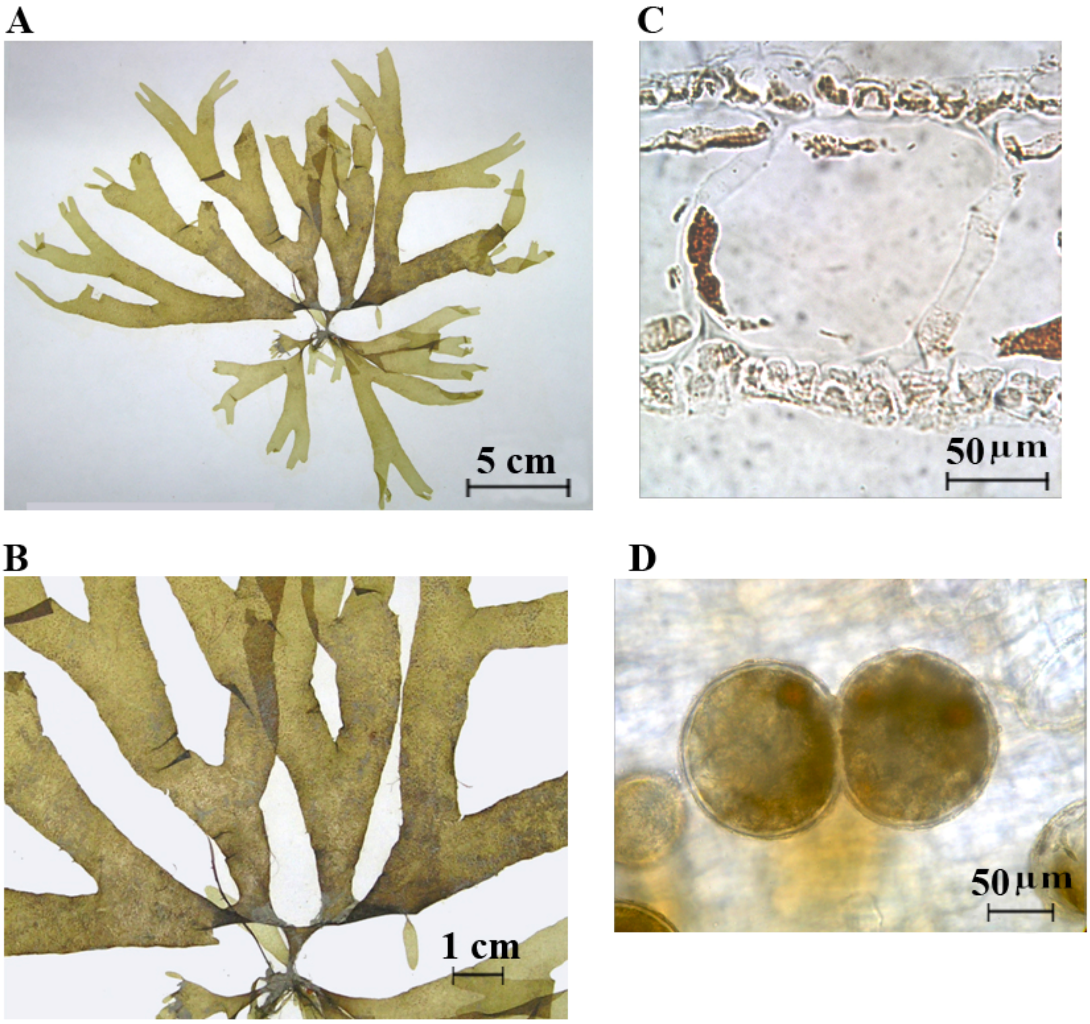

Fig. 23 Diagnostic characters of *Dictyota ciliolata*: A. an erect growth form with a stupose holdfast; B. details of stupose holdfast, long interdichotomies, sparsely teeth on the margins and marginal proliferations; C. details of unilayered cortex and medulla; D. two sporangia closely originated on the surface: Fig. 23A, B from KL 6110.

6. *Dictyota friabilis* Setch., Univ. of Calif. Publ. in Bot. 12: 91, pl. 13: figs 4 - 7; pl. 20: fig. 1. 1926; Trono Jr., G.C., Field guide and atlas of the seaweed resources of the Philippines: 109, fig. 75. 1997; De Clerck, O., Coppejans, E. and Prud'homme van Reine, W.F. *Dictyota* J.V. Lamour. In Prud'homme van Reine, W.F. and Trono Jr., G.C. (Eds), Plant Resources of South-East Asia No. 15(1). Cryptogams: Algae: 144, figs. 3. 2001; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 89, fig. 28, 29. 2003; Tsuda, R.T., Dictyota (Phaeophyceae) from Micronesia. In Abbott, I.A. and McDermid, K.J. (Eds), Taxonomy of Economic Seaweeds with reference to the Pacific and other locations Volume IX: 50, fig. 10. 2004; De Clerck, O., Bolton, J.J., Anderson, R.J. & Coppejans, E., Guide to the seaweeds of KwaZulu-Natal: 104, fig. 75. 2005; Tsutsui, I., Huybh, Q.N., Nguyên, H.D., Arai, S. & Yoshida, T., The common marine plants of southern Vietnam: 83, 3 figs. 2005; Ohba, H., Victor, S., Golbuu, Y. and Yukihira, H., Tropical Marine Plants of Palau: 75, 4 figs. 2007. Lewmanomont, K., Noiraksar, T. and Kaewsuralikhit, C., Seaweeds of Koh Khram and adjacent islands (in Thai): 50, fig. 2007. Coppejans, E., Leliaert, F., Dargent, O., Gunasekara, R., & De Clerck, O., Sri Lankan Seaweeds: 136, figs. 32D, 33C, 110. 2009; Coppejans, E., Prathep, A., Leliaert, F., Lewmanomont, K.and De Clerck,O., Seaweeds of Mu Ko Tha Lae Tai (SE Thailand): Methodologies and field guide to the dominant species: 159, fig. 98. 2010. **Fig. 24**

Growth form completely procumbent, forming imbricate mat on the substrates, individual thalli approximately 3.5 cm. Attachment by marginal bundles of rhizoids along thallus length. Color pale brown, bluish to purplish iridescent with no banding pattern; dry specimens turn a bit darker to somewhat greenish color. Branching variable, ranging from isotomous to anisotomous dichotomous or irregular; branching angle (45-) 70 - 80 (-90). Margins and surface margin entirely smooth, never dentate, surface proliferation absent, marginal proliferation present. Hair turf common. Interdichotomies the whole thallus of the same width, usually widening toward the apices, with typical short and broad interdichotomies, resulting in a low length width ratio; average width: (1.9-) 2.3 – 3.3 (-4.1) mm., proximal width: (1.5-) 1.8 – 2.9 (-3.6) mm., distal width: (2.6-) 3.2 – 5.2 (-6.5) mm.; Wd/Wp: (1.2-) 1.5 – 2.1 (-3.1); length (2.7-) 3.2 – 4.6 (-5.6) mm.; L/W: (1.0-) 1.3 – 1.8 (-2.6); RWC: (2.8-) 3.4 – 5.2 (-6.4). Apical segments apices rounded, obtuse or truncate; apical cells protruding; proximal width: (1.1-) 1.8 – 2.4 (-3.1); length: (1.6-) 2.6 – 4.5 (-7.5); L/Wp: (0.8-) 1.2 – 2.0 (-3.3). Cortex and medulla unilayered; Cl: (25-) 25 – 48 (-60) µm., Cw: (15-) 18 – 22 (-25) µm., Ch: 13 – 18 (-20) µm.; Ml: (63-) 62 – 101 (-120) µm., Mw: 43 – 53 µm., Mh: 47 – 50 µm. Sporangia Single, scattered on one surface; absent from apical segment; not surrounded by an involucrum; sporangia with a single pedicel; width: 75 – 113 µm., height: 50 – 63 µm. Gametangia not found.

Habitats.— *Dictyota friabilis* is found in outer reef slopes. It was a species succession on coral branching after the coral bleaching phenomena in 2010. This species can grow on various kind of hard substrate even on small pebbles. This species is not found on reef flat habitat.

Specimens Examined.— S. Pongparadon 136(PSU), 158(PSU), 225(PSU), 315(PSU).

Peninsular Thailand Distributions.— ***The east coast***: Suratthani Province [Ko Samui, Ko Taen; ***The west coast***: Phang-nga Province [Mu Ko Surin, Mu Ko Similan]; Satun Province [Ko Adang, Ko Rawi].

Remarks.— *Dictyota friabilis* is characterized by its completely procumbent growth form and its short interdichotomies. This species sometimes share habitat with *D. grossedentata*; another procumbent species, but these two species have different margins characters.

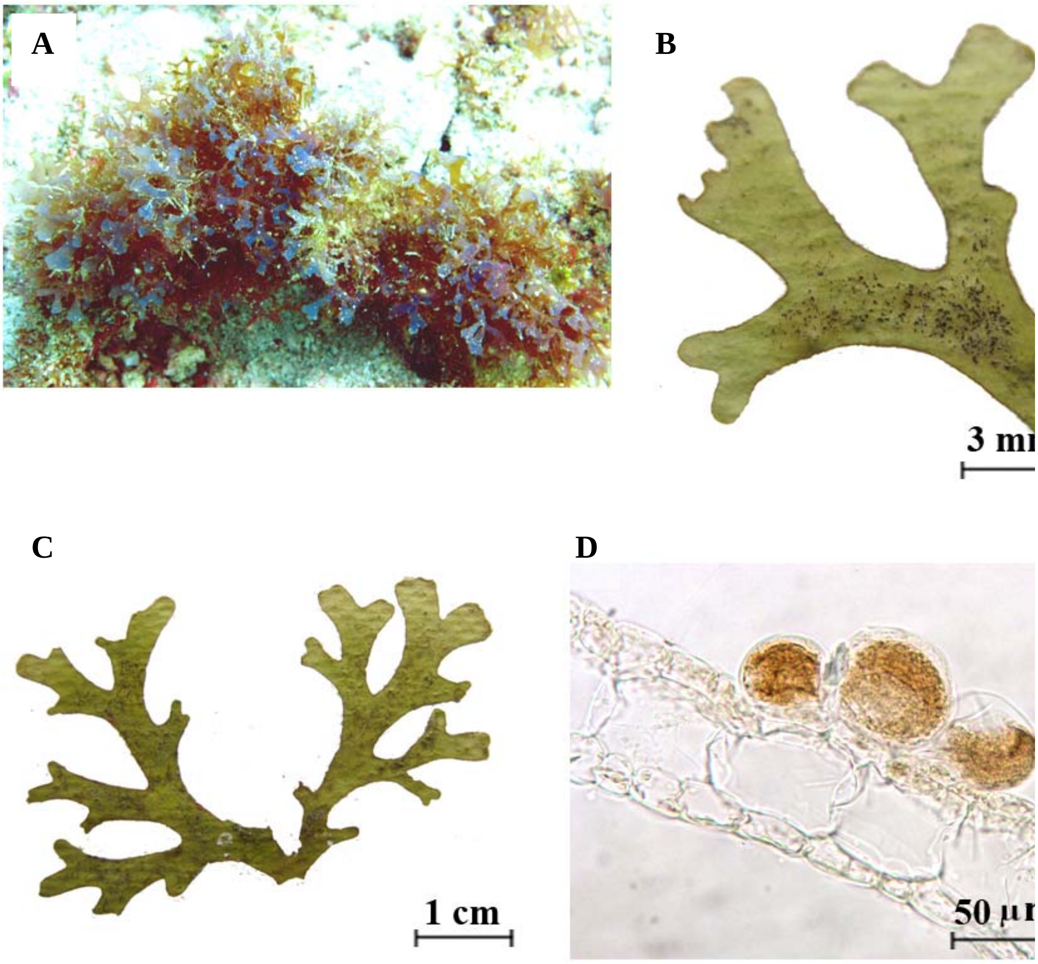

Fig. 24 Diagnostic characters of *Dictyota friabilis*: A. procumbent growth form of in situ specimens showing bluish iridescent; B. details of individual thallus showing irregular pattern of branching; C. details of sporangia scattering on thallus surface (black spots); D. details of unilayered cortex, medulla and sporangia: Fig. 24B, C from S. Pongparadon 255 (PSU).

7. ***Dictyota grossedentata*** De Clerck & Coppejans**,** Phycologia 38 (3): 185-189, figs 1-9. 1999; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 97, fig. 31, 32. 2003. **Fig. 25**

Growth form procumbent, attached to the substrate by means of patches of rhizoids, length of the thallus 4 - 6 cm. Color pale brown, pale bluish to grey iridescent with transverse banding; dry specimens medium brown. Branching commonly isotomous dichotomous but seemed to be slightly anisotomous dichotomous when normal branching obstructed; branching angle (40) 70-90 (90). Margins and surface margins coarsely dentate, marginal teeth triangle: base (86) 257-428 (642) µm, high (107) 235-428 (492) µm, proliferation not found. Interdichotomies straps of thallus totally the same width; average width: (3.6) 4.5-5.5 (6.5) mm., proximal width: (3.6) 4.2-4.8 (5.4) mm., distal width: (5.6) 9.6-10.6 (13.1) mm.; length: (7.0) 9.5-12.1 (14.6) mm.; Wd/Wp: (1.4) 2.1-2.3 (2.8), L/W: (1.5) 2.0-2.6 (3.2), RWC: (1.3) 1.9-2.4 (3.0). Apical segments rounded to truncate, sometimes elongate; apical cells protruding; proximal width: (2.6) 3.6-4.5 (5.4) mm.; length: (7.1) 9.0-10.9 (12.8) mm., L/Wp: (1.8) 2.5-3.1 (3.8). Cortex and medulla unilayered; Cl: (53) 60-68 (83) µm, Cw: 18-25 µm, Ch: 15-20 µm; Ml: (220) 250-300 (330) µm, Mw: (75) 83-93 (118) µm, Mh: (88) 90-110 (140) µm; Cl/Cw: (2.00) 3.00-3.57 (4.71), Ml/Mw: (2.47) 2.81-3.24 (3.57), Ml/Cl: (3.15) 4.00-5.00 (5.74), Mw/Cw: (3.00) 3.70-5.29 (6.71).Sporangia single, scattered on single surface, absent in apical segment, not surrounded by an involucrum, spore on single stalk cell, width: (68) 70-75 (98) µm, height: (68) 75 (78) µm. Gametangia not found.

Habitats.— *Dictyota grossedentata* is found only in the off-shore island and only in the west coast of the Peninsular Thailand. It grew on hard substrate such as dead coral.

Specimens Examined.— A. Prathep 383(PSU), 383(PSU), S. Pongparadon 112a(PSU), 112b(PSU), 112c(PSU), S. Pongparadon 224(PSU), 260(PSU), 304(PSU), 336a(PSU), 336b(PSU).

Peninsular Thailand Distributions.— ***The east coast***: not found; ***The west coast***: Phang Nga Province [Mu Ko Surin], Phuket Province [Ko Racha Yai], Satun Province [Ko Rawi].

Remarks.— *Dictyota grossedentata* was easy to recognize in this study because it is the only species that possess coarsely dentate margins and obviously conspicuous teeth.

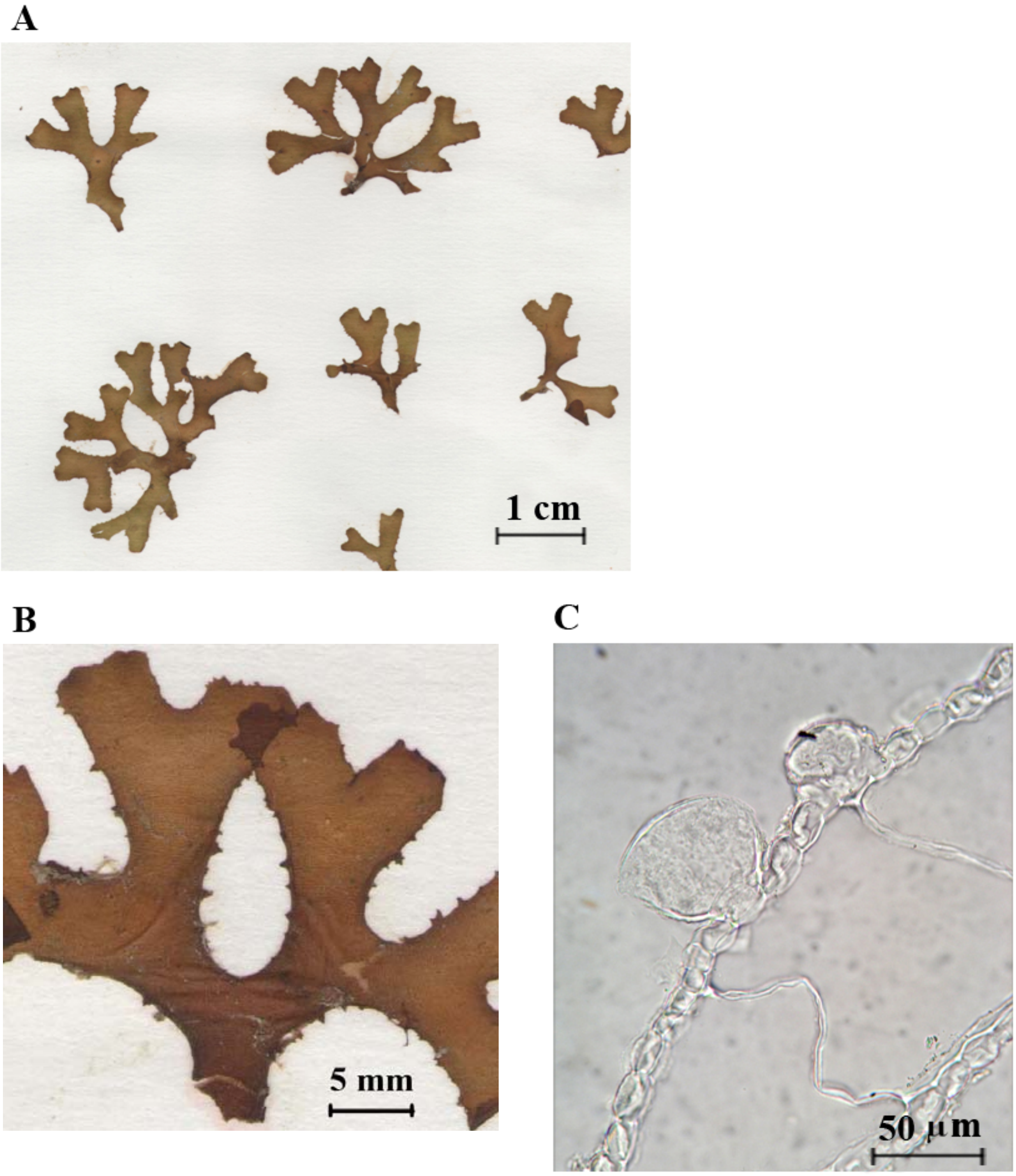

Fig. 25 Diagnostic characters of *Dictyota grossedentata*: A. habit of individual specimens; B. details of coarsely dentate margins; C. details of unilayered cortex, medulla and sporangia: Fig. 25A, B from S. Pongparadon 224 (PSU).

8. *Dictyota stolonifera* E.Y. Dawson, Pacific Naturalist 3: 392, pl. 5. fig. A. 1962; De Clerck, O., The genus *Dictyota* in the Indian Ocean: 136, fig. 51, 52. 2003. **Fig. 26**

Growth form ascending and resupinate, attached to the substrate by means of stoloniferous fibers, originating from lower parts of thallus. Length of the thallus 5-7 cm. Color medium to dark brown with golden apices, no iridescent and banding; dry specimens turn dark color. Branching isotomous dichotomous but elongate apical segments may obscure the pattern; branching angle (45) 60-70 (105). Margins and surface margins smooth, surface proliferation present, marginal proliferation present. Hair turf common. Interdichotomies width of the straps constant, except for the apical segment to form stoloniferous fibers; average width: (1.3) 2.0-3.1 (3.8) mm., proximal width: (1.3) 1.7-2.9 (4.0) mm., distal width: (2.4) 3.2-6.8 (8.6) mm.; length: (4.6) 5.7-10.1 (12.3) mm.; Wd/Wp: (1.2) 1.8-2.5 (3.4), L/W: (1.4) 2.1-5.0 (6.4), RWC: (1.5) 2.4-3.4 (4.7). Apical segments rounded, slender straps acute, apex usually elongate to form stoloniferous holdfast, apical cells protruding; proximal width (0.7) 1.3-2.1 (2.7) mm.; length (2.0) 2.8-4.3 (7.4) mm.; L/Wp (1.2) 2.2-3.3 (8.5). Cortex and medulla unilayered cortex, double layered of medulla near stoloniferous fibers; Cl: (33) 38-43 (48) µm, Cw: (13) 15-23 (25) µm, Ch: 13-20 µm; Ml: (60) 70-90 (120) µm, Mw: 40-60 µm, Mh: 38-50 µm; Cl/Cw: (1.44) 1.5-3.00 (3.40), Ml/Mw: (1.20) 1.40-2.75 (3.00), Ml/Cl: (1.41) 1.60-2.90 (3.20), Mw/Cw: (2.22) 2.30-3.00 (4.00). Sporangia single, scattered on single surface. Gametangia not found.

Habitats.— *Dictyota stolonifera* grows in shallow subtidal on hard substrate such as rock. This species is found only in the west coast of the Peninsular Thailand.

Specimens Examined.— A. Darakrai 66(PSU), 97a(PSU), 97b(PSU), 99a(PSU), 99b(PSU), A. Prathep 512(PSU), 252(PSU), 253(PSU), 346a(PSU), 346b(PSU), P. Tantiprapas 18(PSU).

Peninsular Thailand Distributions.— *The east coast*: not found; ***The west***: Krabi Province [Ko Lanta Yai], Trang Province [Ko Talibong].

Remarks.— *Dictyota stolonifera* is easy to recognize because of its stoloniferous fibers.

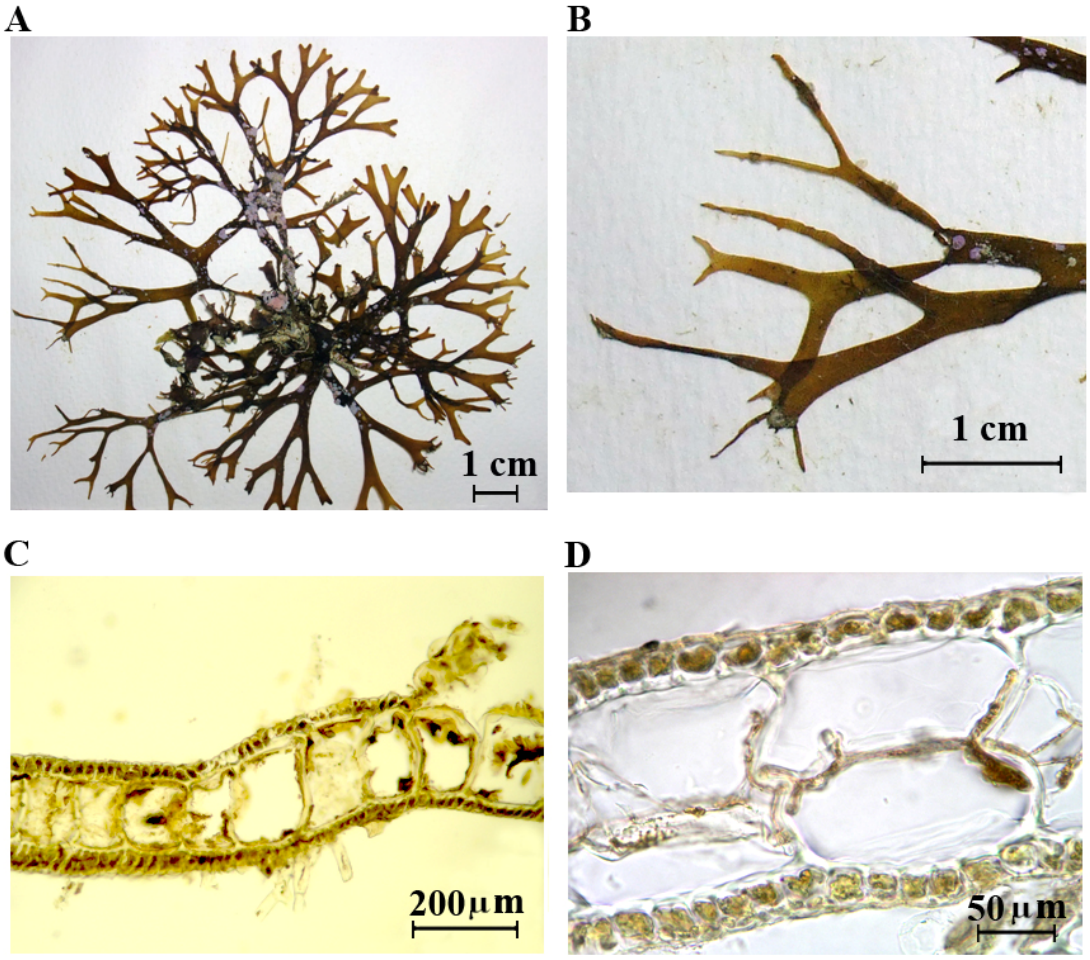

Fig. 26 Diagnostic characters of *Dictyota stolonifera*: A. habit of individual specimens; B. details of apical segments forming stoloniferous fibers; C. details of unilayered cortex and medulla; D. details of double layers medulla of straps near stoloniferous fiber: Fig. 26A, B, C, D from A. Prathep 512 (PSU).

III. Habitat of *Dictyota* J.V. Lamour. and *Canistrocarpus* De Paula & De Clerck

Dictyota and *Canistrocarpus* were found in coral reef, rocky shore and seagrass bed sites. There were 8 species in coral reef, 7 species in rocky shore and only 1 species in seagrass bed. Coral reef can be divided into 2 areas: reef flat and reef slope. Rocky shore can be divided into 2 areas: wave-exposed and wave-sheltered rocky shore. There were 5 species in reef flat which were the same species as in wave-sheltered rocky shore. There were 3 species in reef slope which were completely different from reef flat. There were 2 species in wave-exposed rocky shore which were completely different to wave-sheltered rocky shore. There was only 1 species in seagrass bed (Table 7). More details of habitats and ecology were described as below.

Table 7 Summary of *Dictyota* and *Canistrocarpus* and their habitats.

Species	**Reef flat**	**Reef slope**	**Wave-sheltered rocky shore**	**Wave-exposed rocky shore**	**Seagrass bed**
Canistrocarpus cervicornis	/	-	/	-	/
Canistrocarpus crispatus	/	-	/	-	-
Dictyota bartayresiana	/	-	/	-	-
Dictyota ceylanica	-	/	-	/	-
Dictyota ciliolata	/	-	/	-	-
Dictyota friabilis	-	/	-	/	-
Dictyota grossedentata	-	/	-	-	-
Dictyota stolonifera	/	-	/	-	-
Total	5	3	5	2	1

The legends for table are given as / (found), - (not found).

1) Coral reef

Dictyota and *Canistrocarpus* were in reef flat (Fig. 27a) and reef slope (Fig. 27b) but absent in reef edge. Plants mainly grew on hard substrate which is coral skeletons, but some grew on other macroalgae such as *Sargassum* spp., *Turbinaria* spp. and *Amphiroa* sp. Coral skeletons in reef flat mostly are small coral head or patch (Fig. 27a) whereas coral skeleton in reef slope mostly is dead branching corals (Fig. 27b). Sedimentation in reef flat is higher than in reef slope. Depth in reef flat is shallower than in reef slope, 1-3 m and 1-10 m respectively. Water velocity causing by wave action and tidal change in reef flat is weaker than in reef slope, according to depth difference. In this study, *Dictyota* and *Canistrocarpus* in coral reef were not in intertidal zone but always submerge even during the lowest tide.

Occurrences of *Dictyota* and *Canistrocarpus* in reef flat showed seasonal trend (Table 5), even though, field collection cannot be performed during monsoon but no plant was found in the late non-monsoon collection. Their sensitivity to strong wave action can be seen in the absence of plants in reef edge which is the wave-hitting zone. Abundance of plants in reef flat was limited by many species of marine macroalgae in reef flat such as *Padina* spp., *Sargassum* spp., *Actinotrichia* sp., *Gelidiella* sp., *Avrainvillea* sp., *etc*. *Dictyota* and *Canistrocarpus* were inferior space-competitors to these species resulted in 1 - 30 % cover (little - moderate abundance). Whereas, occurrence of *Dictyota* in reef slope (no *Canistrocarpus* found in this zone) showed no seasonal trend. Because reef slope normally dominated by living corals thus plants hardly were observed.

There were 5 species of *Dictyota* and *Canistrocarpus* found in reef flat: *D. bartayresiana*, *D. ciliolata*, *D. stolonifera*, *C. cervicornis* and *C. crispatus* and they were never found in reef slope in this study (Table 7). There were 3 species found in reef slope: *D. ceylanica*, *D. friabilis* and *D. grossedentata* and they were never found in reef flat in this study (Table 7). In addition, species in reef flat were bigger and exhibited upright forms: erect, ascending and repent growth forms (Fig. 28a); whereas species in reef slope were smaller and exhibited prostrate form: procumbent growth form (Fig. 28b). These differences of species compositions, thallus size and growth forms between reef flat and reef slope were summarized (Fig. 29).

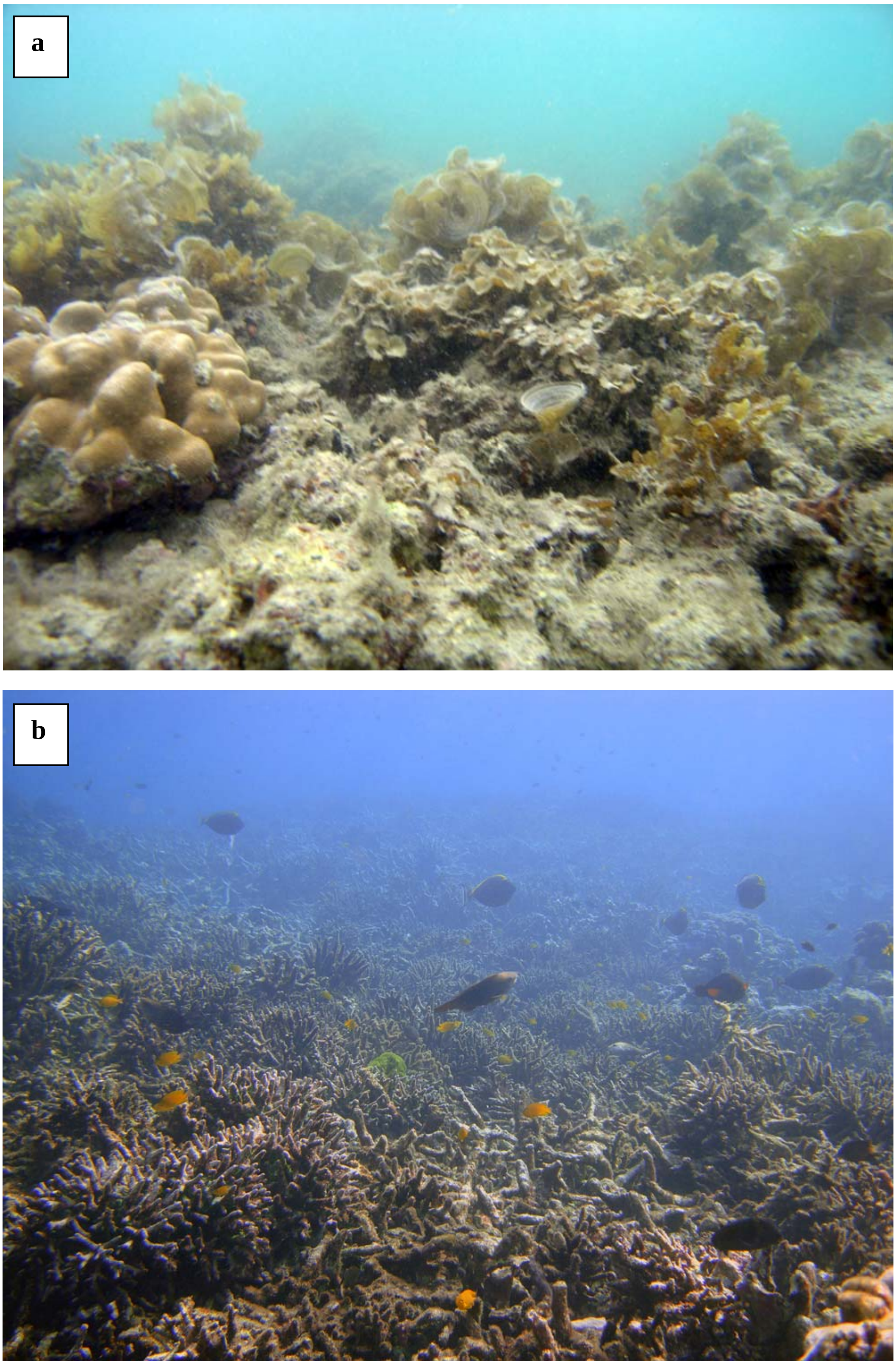

Fig. 27 Characteristics of coral reef: a. reef flat, b. reef slope.

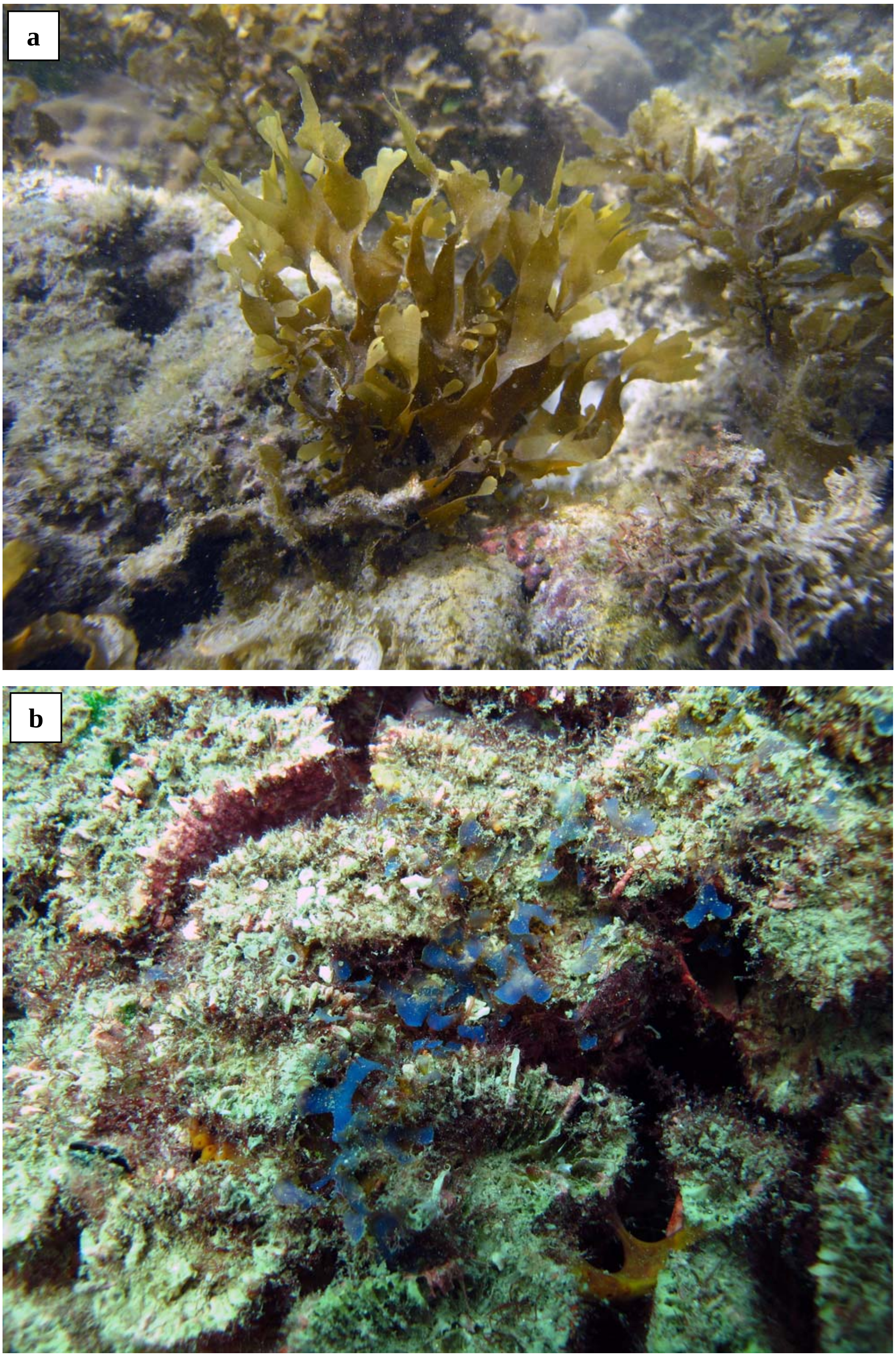

Fig. 28 Details of typical plant habits in coral reef: a. habit of the plant in reef flat, b. habit of the plant in reef slope.

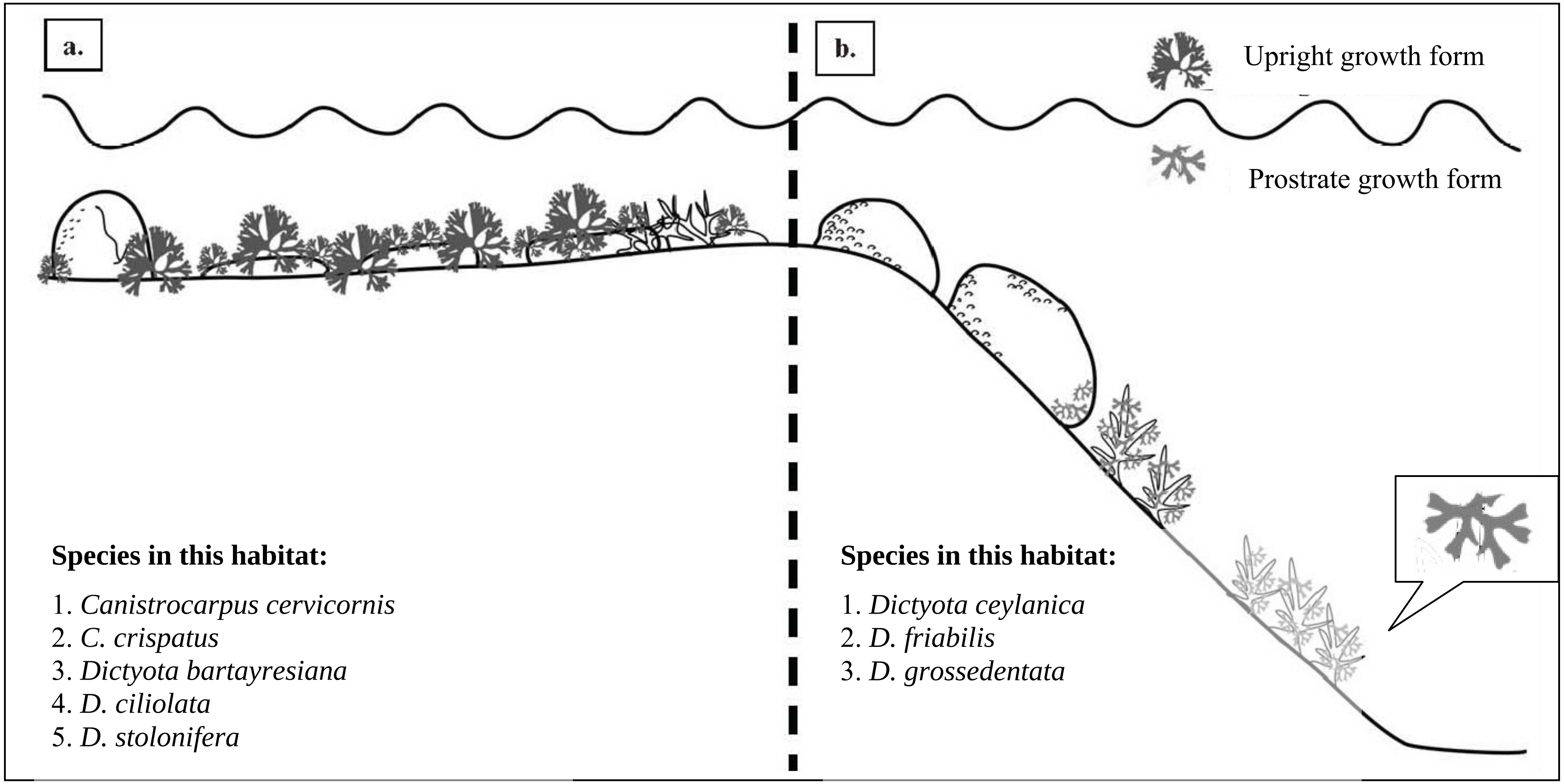

Fig. 29 Summary of differences of species composition, thallus size and growth forms of plants between (a) reef flat and (b) reef slope.

2) Rocky shore

Dictyota and *Canistrocarpus* in rocky shore were under 2 conditions: wave-sheltered periods (Fig. 30a) and wave-exposed period (Fig. 30b). Plants mainly grew on rock but some grew on other macroalgae especially coralline red algal turfs such as *Amphiroa* spp. Plants grew on 2 different kinds of rock surface: smooth and slippery surface and coarse surface but absent from shellfish-growing surface. Sedimentation on plants in wave-sheltered rocky shore is higher than in wave-exposed rocky shore. Depth in rocky shore sites were 1-2 m. Water velocity causing by wave action in wave-sheltered rocky shore is much weaker than in wave-exposed rocky shore due to wave energy. *Dictyota* and *Canistrocarpus* in rocky shore were not in intertidal zone but always submerge even during the lowest tide. In some location, the plants were found just lower water mark.

Occurrence of *Dictyota* and *Canistrocarpus* in wave-sheltered rocky shore also showed seasonal trends (Table 5). Plants disappeared from the sites they used to live in the early non-monsoonal collection. Abundance of plants in wave-sheltered rocky shore was limited by many coexisting species of marine macroalgae such as *Padina* spp., *Sargassum* spp., *Galaxuara* spp., *Caulerpa* spp., *etc*. *Dictyota* and *Canistrocarpus* were inferior space-competitors to these species resulted in 1 - 30 % cover (little - moderate abundance) but sometimes, their abundances were over 50 % cover. Plants occurred as individual on rough surface of rock (Fig. 31a). Whereas, occurrence of *Dictyota* (no *Canistrocarpus* found in this zone) in wave-exposed rocky shore yet showed no seasonal trend. Because specimen's collection from this kind of habitat is yet insufficient and further information is needed. Abundance of plants in wave-exposed rocky shore was very little, usually not more than 10 % cover. Plants occurred in small dense patches on smooth-slippery surface of rock (Fig. 31b).

There were 5 species of *Dictyota* and *Canistrocarpus* in wave-sheltered rocky shore: *D. bartayresiana*, *D. ciliolata*, *D. stolonifera*, *C. cervicornis* and *C. crispatus* and they were never found in wave-exposed rocky shore in this study. There were 2 species in wave-exposed rocky shore: *D. ceylanica* and *D. friabilis* and they were never found in wave-sheltered rocky shore in this study (Table 7). In addition, species found in wave-sheltered rocky shore were bigger and exhibited upright forms: erect, ascending and resupinate growth forms (Fig. 31a); whereas species found in wave-exposed rocky shore were smaller and exhibited prostrate form: procumbent growth form (Fig. 31b). These differences in species compositions, thallus size and growth forms were summarized (Fig. 32).

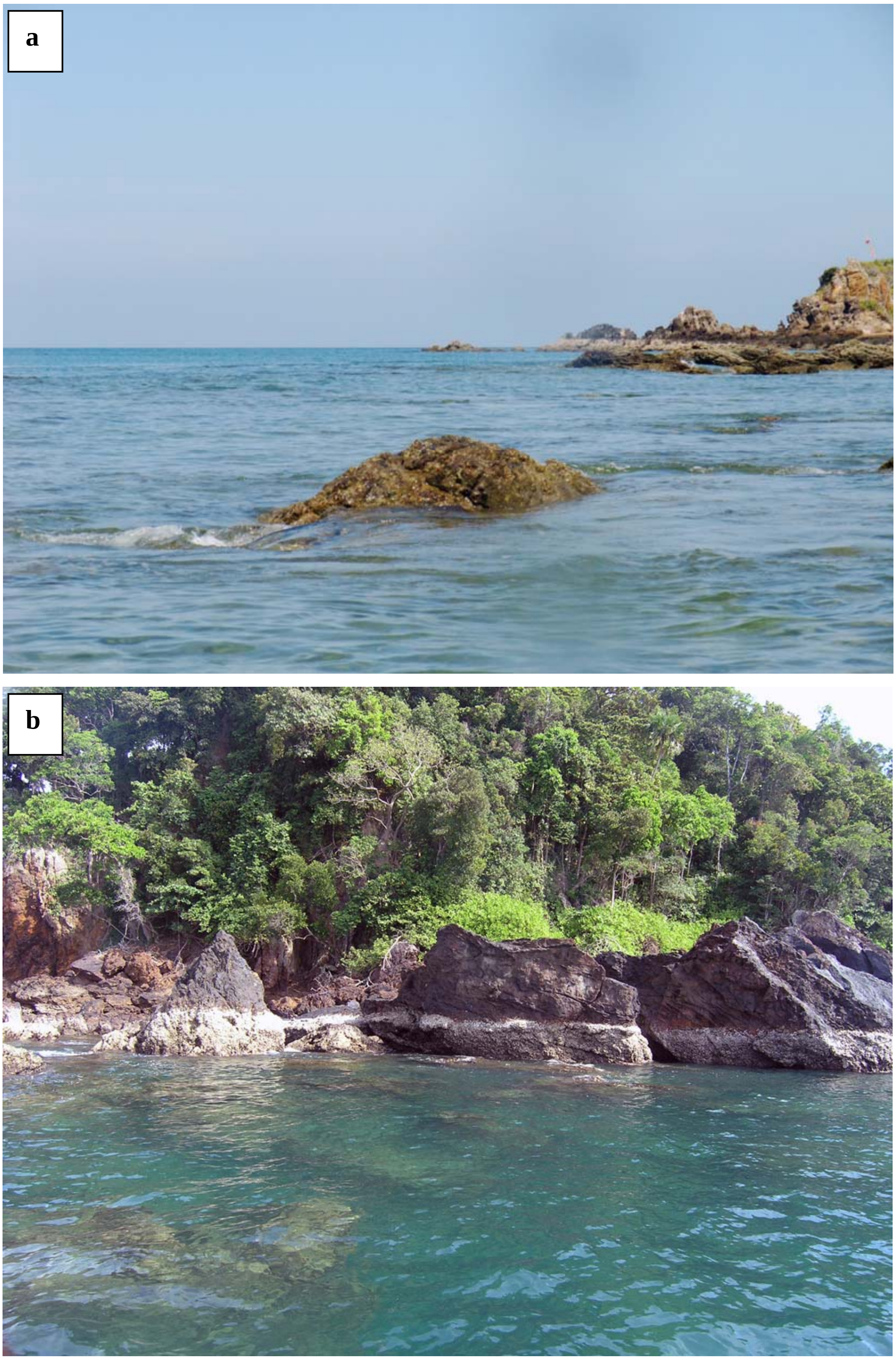

Fig. 30 Characteristics of rocky shore: a. wave-sheltered rocky shore, b. wave-exposed rocky shore.

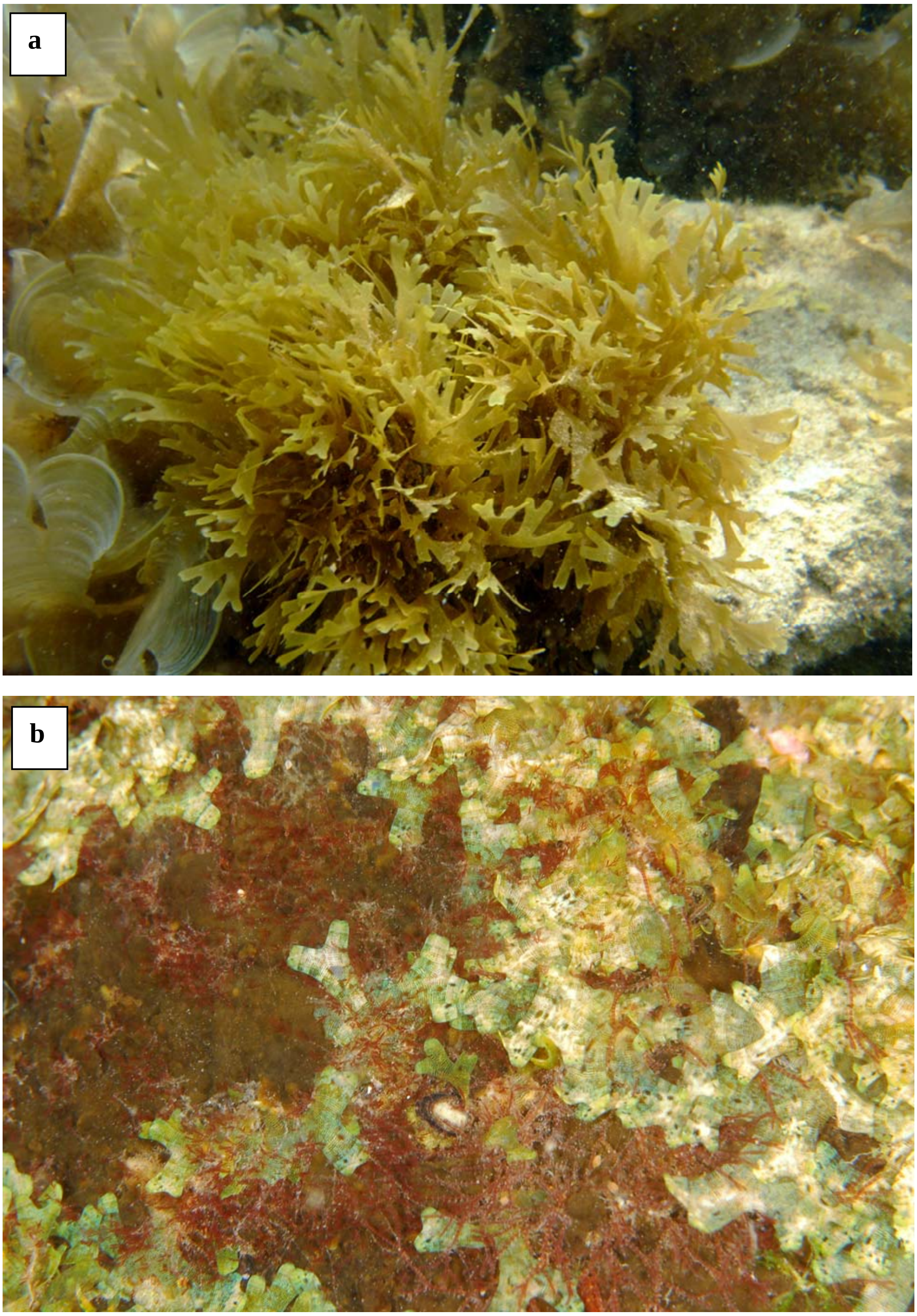

Fig. 31 Details of typical plant habits in rocky shores: a. habit of the plant in wave-sheltered rocky shore, b. habit of the plant in wave-exposed rocky shore (Fig. 31b adopted from Coppejans et al., 2010).

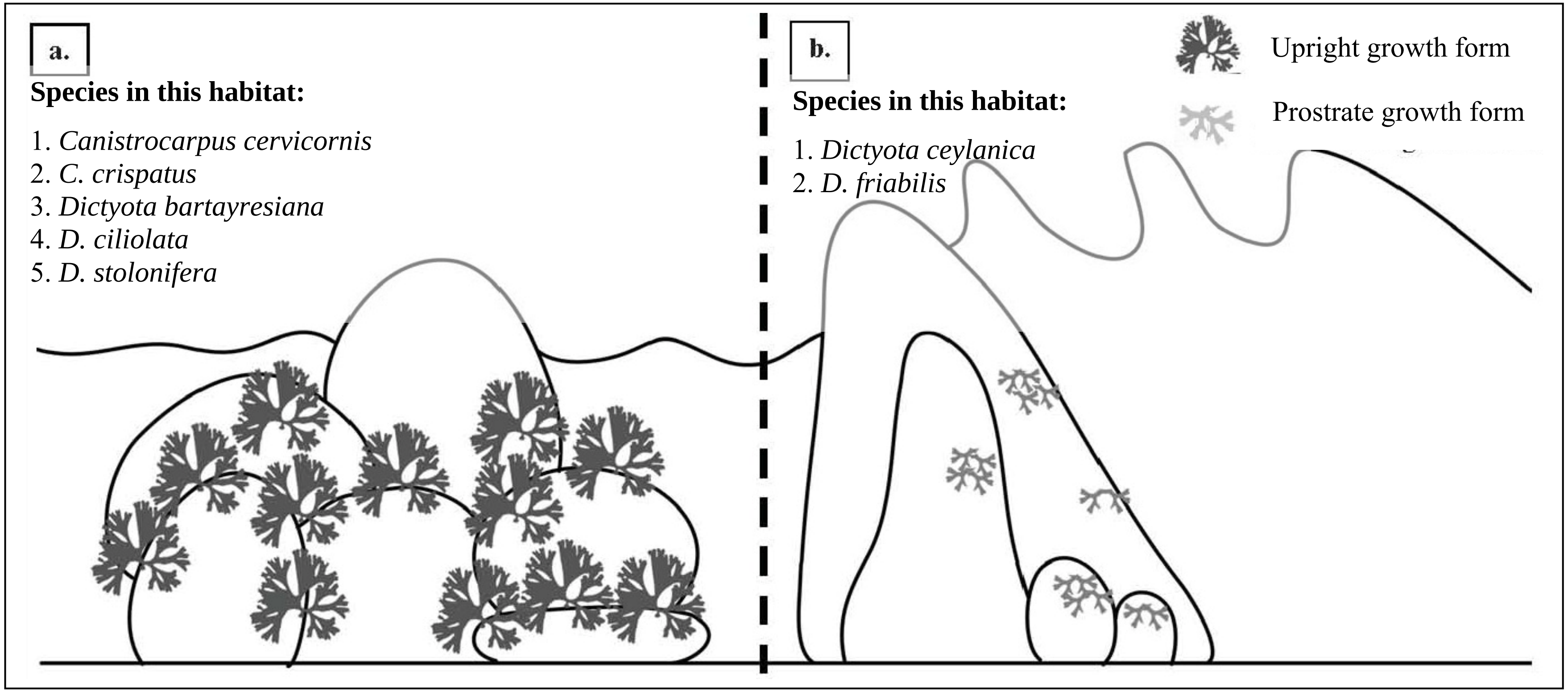

Fig. 32 Summary of differences of species composition, thallus size and growth forms of plants between (a) wave-sheltered rocky shore and (b) wave-exposed rocky shore.

3) Seagrass bed

Seagrass bed provides different condition from coral reef and rocky shore. It lacks hard substrate which is a basic requirement for *Dictyota* and *Canistrocarpus*. Seagrass bed is naturally located in sheltered area and being sediment-trapping location (Fig. 33). Principle substrate in seagrass bed is soft bottom such as sand or mud which both *Dictyota* and *Canistrocarpus* are incapable to grow on (Fig. 33). Hence, the species in seagrass bed was found only as epiphyte on seagrasses species (Fig. 34a) and other sand-grower macroalgae (Fig. 34b). The species in seagrass bed was in intertidal zone and exposed to air during the lowest tide (Fig. 34b).

There was only 1 species found in seagrass bed. It was *Canistrocarpus cervicornis*. The plants grew on any parts of seagrass such as leaf-blades and exposed rhizomes (Fig. 33a). In addition, sand-grower species in seagrass bed was also the phorophyte such as *Halimeda macroloba* Decne (Fig. 33b). Occurrence of *C. cervicornis* in seagrass bed was rather in bay site but absent in the headland site. No seasonal trend yet was found because insufficient data but a site at Ko Lidee Lek, Satun Province seemed to be throughout the year. Abundance of the plants in seagrass bed varied from site to site. It can be very low or up to over 50 % cover (Fig. 15c).

Fig. 33 Details of seagrass bed during high tide.

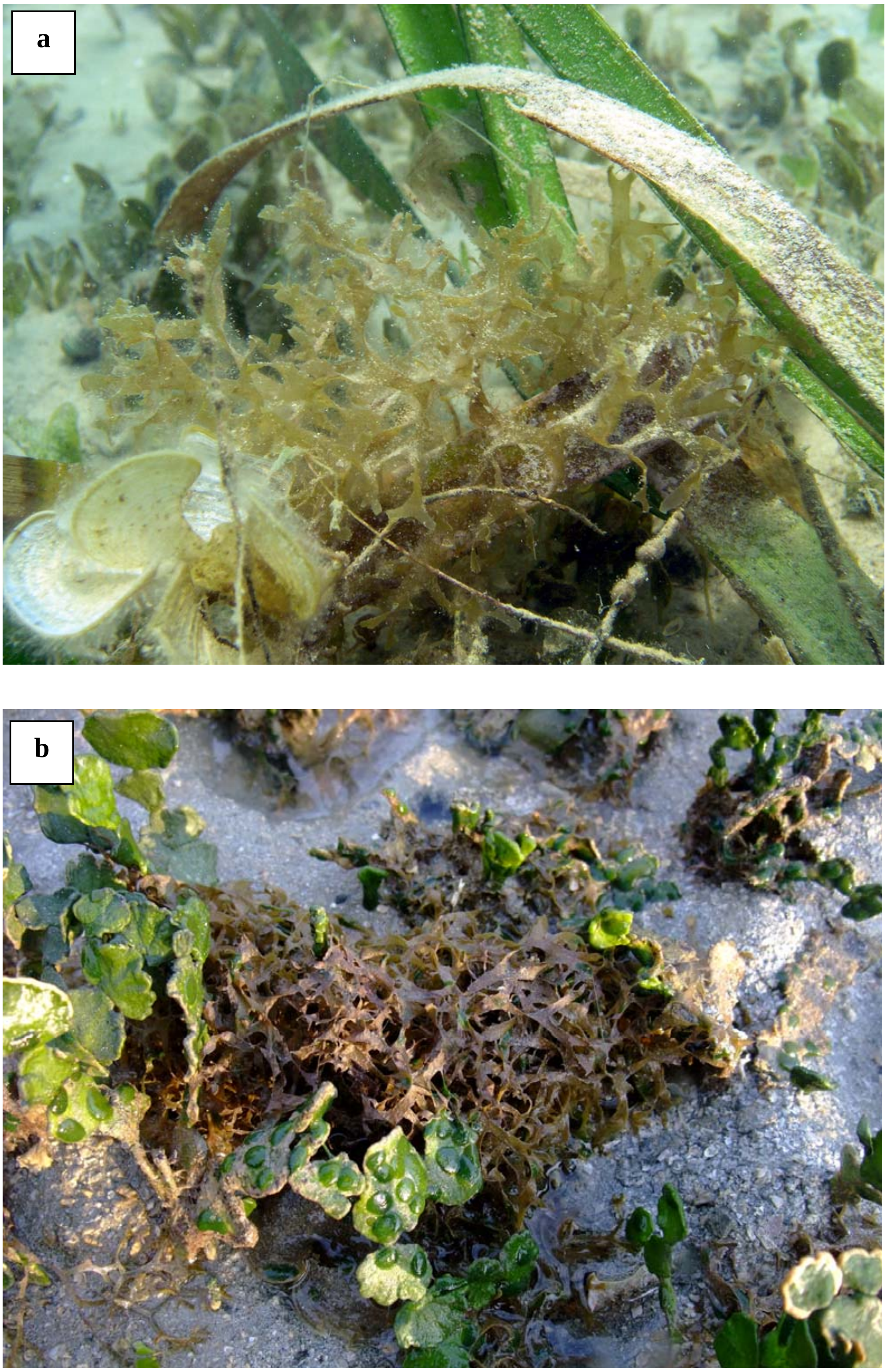

Fig. 34 Habits of plants in seagrass bed: a. epiphytic on *Enhalus acoroides*' leaf fibres, b. epiphytic on *Halimeda macroloba* in seagrass bed.

IV. Species compositions of *Dictyota* J.V. Lamour. and *Canistrocarpus* De Paula & De Clerck

Species composition of the east coast of the Peninsular Thailand was *D. bartayresiana*, *D. ceylanica*, *D. ciliolata*, *D. friabilis*, *C. cervicornis* and *C. crispatus*. Species composition of the west coast of the Peninsular Thailand was *D. bartayresiana*, *D. ceylanica*, *D. ciliolata*, *D. friabilis*, *D. grossedentata*, *D. stolonifera*, *C. cervicornis* and *C. crispatus* (Table 5). Bray-Curtis similarity matrix performed on species compositions of the east coast and the west coast of the Peninsular Thailand indicated that species compositions of these 2 seas were similar to each other by 85.71 % (Table 8). One-way Analysis of Similarity (One-way ANOSIM) indicated that difference of species compositions between the east coast and the west coast of the Peninsular Thailand by the absence of *D. grossedentata* and *D. stolonifera* in the east coast of the Peninsular Thailand was not statistically different.

Species composition of reef flat was *D. bartayresiana*, *D. ciliolata*, *D. stolonifera C. cervicornis* and *C. crispatus*. Species composition of reef slope was *D. ceylanica*, *D. friabilis* and *D. grossedentata*. Species composition of wave-exposed rocky shore was *D. ceylanica* and *D. friabilis*. Species composition of wave-sheltered rocky shore was *D. bartayresiana*, *D. ciliolata*, *D. stolonifera C. cervicornis* and *C. crispatus*. Species composition of seagrass bed was *C. cervicornis* (Table 5). Bray-Curtis similarity matrix performed on species compositions among 5 habitats: reef flat, reef slope, wave-exposed rocky shore, wave-sheltered rocky shore and seagrass bed, indicated that species composition of reef flat was 100 % similar to wave-sheltered rocky shore, 33.33 % similar to seagrass bed and completely different to reef slope and wave-exposed rocky shore; species composition of reef slope was 80 % similar to wave-exposed rocky shore and completely different to wave-sheltered rocky shore and seagrass bed; species composition of wave-sheltered rocky shore was 33 % similar to seagrass bed and completely different to wave-exposed rocky shore; species composition of wave-exposed rocky shore was completely different to seagrass bed (Table 9). Two-way nested Analysis of Similarity (Two-way nested ANOSIM) indicated that difference of species compositions among reef flat, reef slope, wave-exposed rocky shore, wave-sheltered rocky shore and seagrass bed was significantly different ($p < 0.05$; Global R = 0.774).

Cluster Analysis performed on the difference of species compositions among reef flat, reef slope, wave-exposed rocky shore, wave-sheltered rocky shore and seagrass bed, revealed 2 groups of habitats with 0 % similar of species compositions (Fig. 35). The first group comprised of the sites of reef slope and wave-exposed rocky shore and shared composition of these 3 species: *D. ceylanica*, *D. friabilis* and *D. grossedentata*. The second group comprised of the sites of reef flat, wave-sheltered rocky shore and seagrass bed, and shared composition of these 5 species: *D. bartayresiana*, *D. ciliolata*, *D. stolonifera*, *C. cervicornis* and *C. crispatus*.

Table 8 Bray-Curtis similarity matrix of species compositions between the east coast and the west coast of the Peninsular Thailand.

	The east coast	**The west coast**
The east coast		
The west coast	**85.71**	

Table 9 Bray-Curtis similarity matrix of species compositions among reef flat, reef slope, wave-sheltered rocky shore, wave-exposed rocky shore and seagrass bed.

	Reef flat	**Reef slope**	**Wave-sheltered rocky shore**	**Wave-exposed rocky shore**	**Seagrass bed**
Reef flat					
Reef slope	**0**				
Wave-sheltered rocky shore	**100**	**0**			
Wave-exposed rocky shore	**0**	**80**	**0**		
Seagrass bed	**33.33**	**0**	**33.33**	**0**	

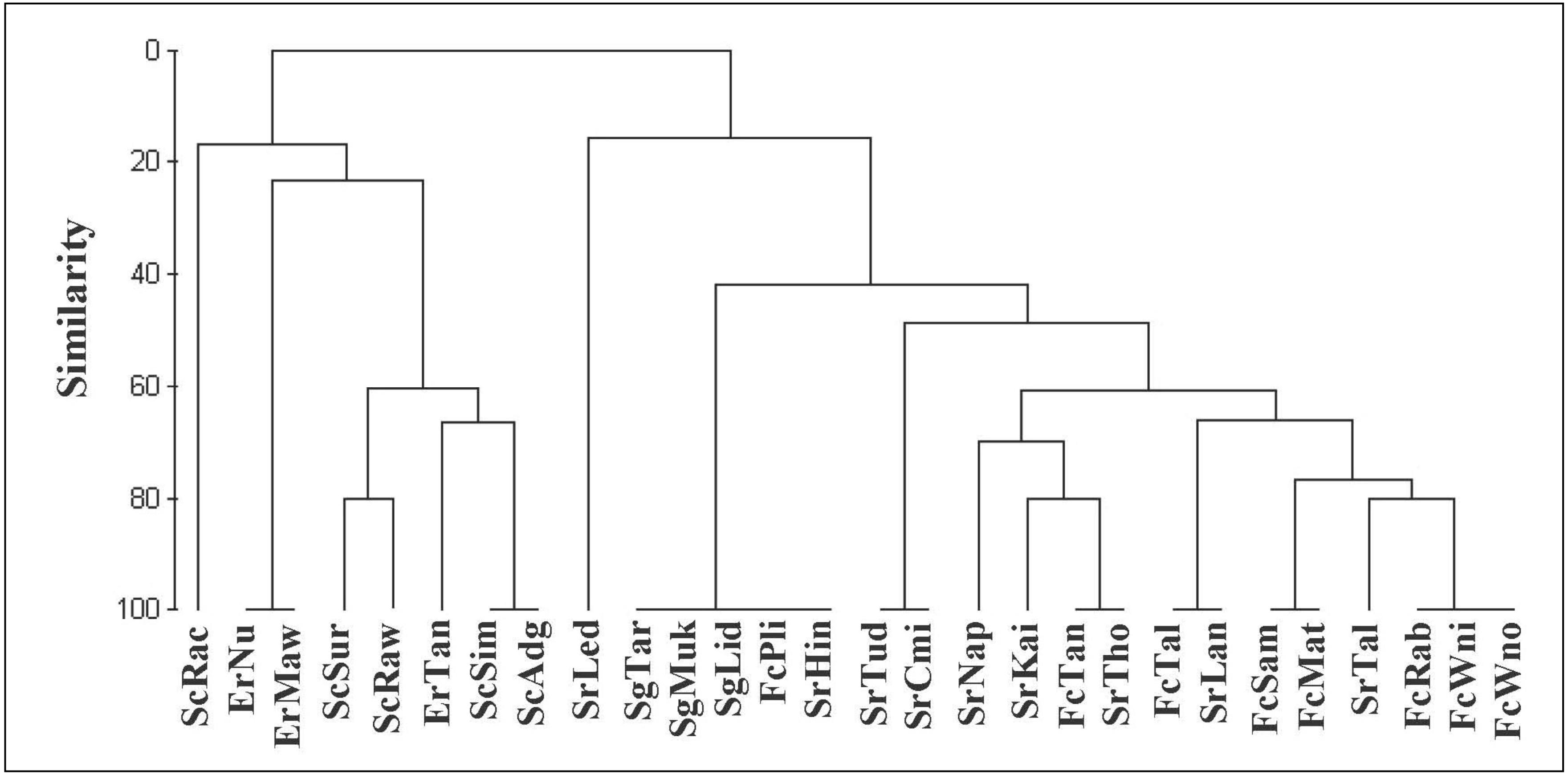

Fig. 35 Cluster Analysis of study sites based on their similarities in species compositions: ScRac = reef slope Ko Racha Yai; ErNu = exposed rocky shore Ko Nu; ErMaw = exposed rocky shore Ko Maw; ScSur = reef slope Ko Surin; ScRaw = reef slope Ko Rawi; ErTan = exposed rocky shore Ko Taen; ScSim = reef slope Ko Similan; ScAdg = reef slope Ko Adang; SrLed = sheltered rocky shore Ao Ta Led; SgTar = seagrass bed Ko Tharai; SgMuk = seagrass bed Ko Muk; SgLid = seagrass bed Ko Lidee; FcPli = reef flat Ko Pling; SrHin = sheltered rocky shore Hinkob; SrTud = sheltered rocky shore Ko Luang Pu Tuad; SrCmi = sheltered rocky shore Had Chao Mai; SrNai = sheltered rocky shore Had Nai Plao; SrKai = sheltered rocky shore Ko Khai; FcTan = reef flat Ko Taen; SrTho = sheltered rocky shore Ao Thong Yee; FcTal = reef flat Ko Talibong; SrLan = sheltered rocky shore Ko Lanta Yai; FcSam = reef flat Ko Samui; FcMat = reef flat Ko Matsum; SrTal = sheltered rocky shore Ko Talibong; FcRab = reef flat Ko Rab; FcWni = reef flat Ko Wang Nai; FcWno = reef flat Ko Wang Nok.

Chapter 4
Discussion

Species Diversity

There were 8 species of *Dictyota* and *Canistrocarpus* in this study: *D. bartayresiana* J.V. Lamour., *D. ceylanica* Kütz., *D. ciliolata* Sonder ex Kütz., *D. friabilis* Setch., *D. grossedentata* De Clerck & Coppejans, *D. stolonifera* E.Y. Dawson, *C. cervicornis* (Kütz.) De Paula & De Clerck and *C. crispatus* (J.V. Lamour.) De Paula & De Clerck. It was accounted for 38 % and 10 % of the diversity of *Dictyota* and *Canistrocarpus* in Southeast Asia (21 species) and in the world (79 species) respectively (Guiry & Guiry, 2012).

This study provided 2 new records of *Dictyota* to Thai macroalgal flora: *D. grossedentata* and *D. stolonifera*. This study also provided areas of high species richness both *Dictyota* and *Canistrocarpus*: Hat Khanom – Mu Ko Thale Tai National Park (6 species), Ko Lanta Yai and Ko Talibong (5 species).

There was 1 species reported in previous studies but absent in this study: *Dictyota dichotoma* (Huds.) J.V. Lamour. *Dictyota dichotoma* is the most frequently reported species in Thailand and it is also a cosmopolitan species (De Clerck, 2003). Schnetter et al. (1987 in Tronholm et al., 2008) proposed limit of distribution range of *D. dichotoma* should be restricted to the European Atlantic coast and the Mediterranean Sea. De Clerck (2003) suggested that records of *D. dichotoma* outside the European Atlantic coast and the Mediterranean Sea are consistently misinterpreted of the authors. However, the existence of *D. dichotoma* in Thailand remains unclear since no voucher specimens to be examined; and have not found in this study.

Diversity difference and role of the Peninsular Thailand

Difference in species compositions between the east coast and the west coast of the Peninsular Thailand caused by 2 species, which restricted their distribution only in the west coast: *Dictyota grossedentata* and *D. stolonifera*. The Peninsular Thailand could be a barrier limiting the dispersals of both species to the east coast of the Peninsular Thailand. This event might occur since the late Pleistocene Epoch (21 ka BP; Sathiamurthy and Voris, 2006) when most part of Southeast Asia including the east coast and the west coast of the Peninsular Thailand or part of the Sunda Shelf was dry according to low sea level. The sea level came up to the present level in the 15,000 year later (6 ka BP). The source of sea water in the east coast is from the South China Sea whereas the source of sea water in the west coast is from the Indian Ocean (Sathiamurthy and Voris, 2006; Fig. 36). These 2 species have never been reported in the South China Sea until now and also reported from outside of the Wallace's line (Table 10) but there were reported in the Indian Ocean (De Clerck, 2003) whereas, the other 6 species were reported in both the South China Sea and the Indian Ocean (De Clerck, 2003; Guiry & Guiry, 2012). Hence, the existence of the Peninsular Thailand during sea level transgression might limit distribution of diversity of *Dictyota* and *Canistrocarpus* between the east coast and the west coast of the Peninsular Thailand. Furthermore, the sea level transgression during the late Pleistocene Epoch might cause phylogeographic breaks among marine faunal populations in the Coral Triangle (Sunda Shelf) by provided barriers according to low sea level (Carpenter et al., 2011; Fig. 37).

a
b
c

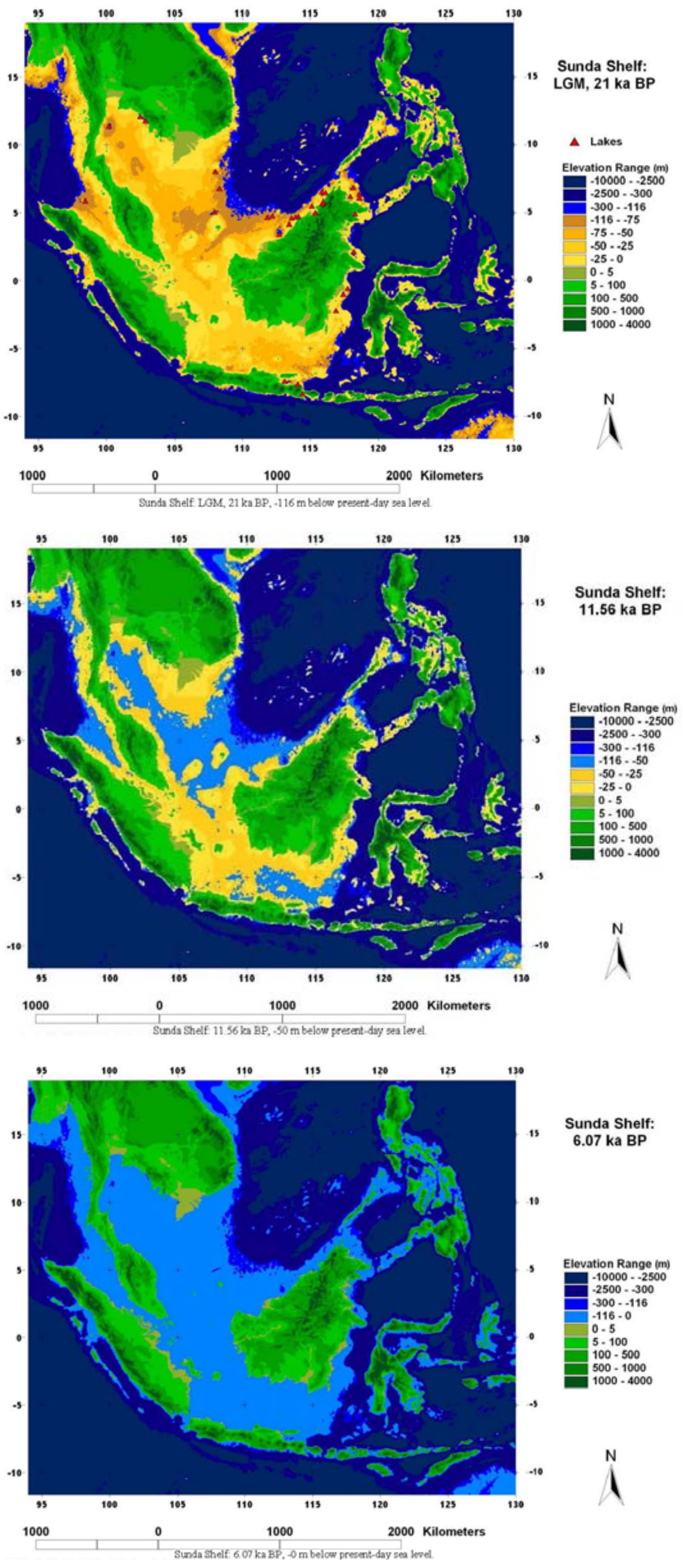

Fig. 36 Sea level after the late Pleistocene Epoch: a. 21 ka BP; b. 11.56 ka BP; c. 6.07 ka BP (after Sathiamurthy and Voris, 2006).

Table 10 Distribution of *Dictyota* J.V. Lamour. and *Canistrocarpus* De Paula & De Clerck in Southeast Asia and adjacent areas, adapted from Guiry & Guiry, 2012.

No.	Species	Thailand	Malaysia	Singapore	Vietnam	Myanmar	Indonesia	Philippines	China	Taiwan	Hong Kong	Australasia
1	*Dictyota bartayresiana* J.V.Lamour.	/	/	/	/	-	/	/	/	/	-	/
2	*Dictyota ceylanica* Kütz.	/	-	-	-	-	-	/	-	/	-	/
3	*Dictyota ciliolata* Sonder ex Kütz.	/	/	/	/	-	/	/	-	-	-	/
4	*Dictyota friabilis* Setch.	/	/		/	-	-	/	/	/	-	/
5	*Dictyota stolonifera* E.Y. Dawson	/	-	-	-	-	-	/	-	-	-	-
6	*Dictyota grossedentata* De Clerck & Coppejans	/	-	-	-	-	-	-	-	-	-	/
7	*Canistrocarpus cervicornis* (Kütz.) De Paula & De Clerck	/	/	/	/	-	/	/	/	-	-	/
8	*Canistrocarpus crispatus* (J.V.Lamour.) De Paula & De Clerck	/	-	/	/	-	-	/	-	-	-	/
9	*Dictyota adnata* Zanardini	-	-	/	/	-	/	-	-	-	-	/
10	*Dictyota canaliculata* De Clerck & Coppejans	-	-	-	-	-	-	/	-	-	-	/
11	*Dictyota ceylanica* var. *anastomosans* Yamada	-	-	-	/	-	-	-	-	-	-	-
12	*Dictyota crenulata* J. Agardh	-	-	-	-	-	/	/	-	-	-	-
13	*Dictyota dichotoma* (Huds.) J.V.Lamour.	/	/	/	/	/	/	/	/	/	/	/
14	*Dictyota fasciola* (Roth) J.V.Lamour.	-	-	-	-	-	/	-	-	-	-	-
15	*Dictyota hauckiana* Nizam.	-	-	/	-	-	-	-	-	-	-	-
16	*Dictyota implexa* (Desf.) J.V.Lamour.	-	/	/	/	-	/	/	/	/	-	/

Table 10 continued.

No.	Species	Thailand	Malaysia	Singapore	Vietnam	Myanmar	Indonesia	Philippines	China	Taiwan	Hong Kong	Australasia
17	*Dictyota intermedia* Zanardini	-	-	-	-	-	/	-	-	-	-	/
18	*Dictyota lata* J.V.Lamour.	-	-	/	-	-	-	/	-	/	-	/
19	*Dictyota major* W.R. Taylor	-	-	-	-	-	-	/	-	-	-	-
20	*Dictyota mertensii* (Mart.) Kütz.	-	-	-	/	-	-	/	-	-	-	/
21	*Dictyota spinulosa* Hook.f. & H.J. Arn.	-	-	-	/	-	-	-	-	/	-	-
	Total	9	6	9	11	1	9	14	5	7	1	14

The legends for table are given as / (found), - (not found).

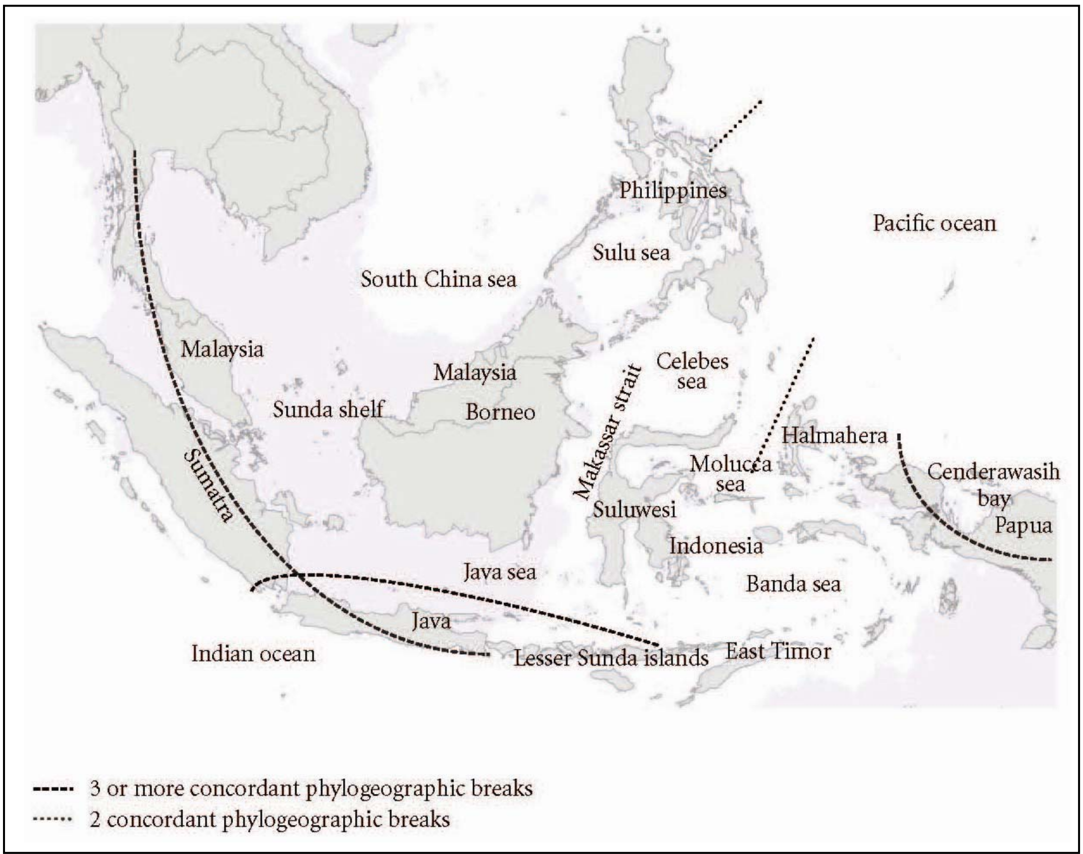

Fig. 37 Phylogeographic breaks among marine faunal populations in the Coral Triangle according to the sea level transgression during the last glaciations (Carpenter et al., 2011).

Effect of environmental factors on difference of species compositions

In this study, species compositions of *Dictyota* and *Canistrocarpus* were significantly different among their habitats and divided into 2 groups. Surprisingly, none overlapping species was found between these 2 groups and each group had different growth form. The first group contained species found in reef slope and wave-exposed rocky shore which exhibited prostrate growth form and the second group contained species found in reef flat, wave-sheltered rocky shore and seagrass bed which exhibited upright growth form. Advantages and disadvantages of each growth form to environmental factors might determine difference of species compositions among 5 habitats.

In coral reef, herbivory might be main driving force controls and maintains difference of species composition of *Dictyota* and *Canistrocarpus* between reef flat and reef slope. Herbivores were scarce in reef flat but commonly abundant in reef slope (Hay 1981a, b). The species in reef flat had upright habit with erect fronds, loosely-lax branching and growing as spatially separated individual. These characters allowed effective photosynthesis because of low self-shading and high nutrients diffusion rate according to high surface area per volume ratio (Littler, 1980; Hay, 1981b; Taylor & Hay, 1984; Hanisak et al., 1988). These advantages allowed high growth rate because of high nutrition. However, herbivores preferred high nutritional food (Littler & Littler, 1980, 1984; Sotka & Hay, 2009). Thus, this group might be excluded from reef slope through herbivores food preference. The species in reef slope had prostrate habit with fronds lying down, often superimposed and usually growing as dense turfs or mats but firmly attached to the substrate. These characters might disadvantage to photosynthesis and nutrients diffusion rate as they usually exhibited smaller thallus. However, Hay (1981b) reported that this kind of habit lost less biomass to herbivores.

In rocky shore, water motion might be main driving force controls and maintains difference of species composition of *Dictyota* and *Canistrocarpus*. The species in low wave impact rocky shore had upright habit with erect fronds, loosely-lax branching and growing as spatially separated individual. Haring & Carpenter (2007) reported that loosely-lax branching experienced 50% higher of water drag force than the compact one. Strong water motion can tear off fronds or dislodge the whole plants (Haring & Carpenter, 2007; Yñiguez et al., 2010). Thus, this group might be excluded from high wave impact rocky shore through dislodgement by strong water motion. Whereas, the species in high wave impact rocky shore had prostrate habit with fronds lying down, often superimposed and usually growing as dense turfs or mats but firmly attached to the substrate and these characters were lesser against water motion.

In seagrass bed, lacking of hard substrate might be main driving force limits existence of most species of *Dictyota* and *Canistrocarpus*. Attachment by rhizoidal system of *Dictyota* and *Canistrocarpus* might be incapable to grow on soft bottom such as in seagrass bed. However, there was only *C. cervicornis* in seagrass bed. This species was also the most common and abundant species in this study. Plasticity of growth form or habit of this species might play an important role to support its existence in seagrass bed as well as its wide distribution and high abundance. *Canistrocarpus cervicornis* has 2 distinct growth forms: ascending and repent growth forms. The ascending growth form has good attachment on hard substrate or seagrass rhizomes by several anastomosing prostrate straps and the repent growth form has recurved branchlets and hook-like structure to improve attachment as epiphyte. This shift between 2 growth forms was not found in other species in this study.

Canistrocarpus cervicornis was a well-adapted species. In coral reef, under strong water motion as just behind a reef edge, attachment part of this species expanded while free-floating straps shortened to somewhat mat-like patch; under low water motion as in the inner reef flat, the free-floating part extended in length with extremely spirally twisted and smaller attachment part. The epiphytic habit was abundant in sheltered area with narrow straps, recurved branchlets and hook-like structure which probably turn form the torn-off straps. In rocky shore, the plants exhibited a compact hemispherical bush in strong water motion but exhibited loosely-lax branching in sheltered area; the epiphytic habit was rarely observed but a cushion-like form was found which might develop from the dislodged hemispherical thalli.

Morphometric and identification to species of *Dictyota* and *Canistrocarpus*

Morphometric method cannot discriminate any species in this study. The specimens were divided into 2 groups. Each group differed by size of interdichotomies and presence-absence of qualitative characters. In addition, each group has the same species as in 2 groups of habitat with different species composition. This somewhat indicated a connection between different morphological characters and different habitats.

Identification by morphometric method for *Dictyota* and *Canistrocarpus* might be limited because they have limited characters valuable to use as diagnostic characters (De Clerck, 2003) and have long been known as a difficult genus to identify because most descriptions of *Dictyota* species were often not discriminating and highly uninformative (De Clerck, 2003). More importantly, the high morphological plasticity in some species confused many researchers and leading to misidentified: in Europe, more than 60 names were described for high polymorphic species *D. dichotoma* (De Clerck, 2003); all voucher specimens from Indonesia reported as *D. crenulata* by Verheij & Prud'homme van Reine (1993 in De Clerck, 2003) belong to other species: *C. cervicornis*, *D. bartayresiana* and *D. ciliolata* (De Clerck, 2003); and Tsuda (1972a, in Tsuda, 2004) misidentified 2 ecomorphs of *D. bartayresiana* as *C. cervicornis* and *D. friabilis*. (De Clerck, 2003; Tsuda, 2004). Some of morphological resemble entities along geographic variations have been proved to be separated species: *D. dichotoma* vs. *D. menstrualis*, by breeding barrier and chromosome number; *D. dichotoma* vs. *D. pulchella*, by breeding barrier (De Clerck, 2003); *D. ciliolata* vs. *D. cyanoloma*, by phylogenetic relationship study using 6 genes: partial LSU rDNA, *rbc*L, *psb*A, *cox*1, *cox*3 and *nad*1 (Tronholm et al., 2010). This taxonomic problem is mainly caused by environmental influence; as in this study, a prostrate-like thallus of *C. cervicronis* in surf-exposed reef flat was very similar to *D. bartayresiana* which is difficult to discriminate. Recently, advanced in molecular genetic brought us a new character which less affected by environment and would be useful as diagnostic character to solve notoriously difficult species and species complex caused by geographic isolation.

Further study

Population genetics of *Dictyota* and *Canistrocarpus* between the Gulf of Thailand and the Andaman Sea, and also in Southeast Asia such as in the Coral Triangle should be carried out in order to better understand population dynamics of *Dictyota* and *Canistrocarpus* in this region through the role of geographical changing.

Chapter 5

Conclusion

1. There are six species of *Dictyota* J.V. Lamour. in this study:

    Dictyota bartayresiana J.V. Lamour.

    D. ceylanica Kütz.

    D. ciliolata Sonder ex Kütz.

    D. friabilis Setch.

    D. grossedentata De Clerck & Coppejans

    D. stolonifera E.Y. Dawson

2. There are two species of *Canistrocarpus* De Paula & De Clerck in this study:

    Canistrocarpus cervicornis (Kütz.) De Paula & De Clerck

    C. crispatus (J.V. Lamour.) De Paula & De Clerck

3. This study has added two new records of Thai marine flora, namely *Dictyota grossedentata* and *D. stolonifera*.
4. There are six species found in both the east coast and the west coast of the Peninsular Thailand: *Dictyota bartayresiana, D. ceylanica, D. ciliolata, D. friabilis, Canistrocarpus cervicornis* and *C. crispatus.*
5. There are two species only found in the west coast of the Peninsular Thailand: *Dictyota grossedentata* and *D. stolonifera*.
6. *Canistrocarpus cervicornis* is the most common and abundant species in the Peninsular Thailand coasts.
7. There was a significant difference in species compositions among 5 habitats: reef flat, reef slope, wave-exposed rocky shore, wave-sheltered rocky shore and seagrass bed.

    7.1 Reef flat is habitat of *Dictyota bartayresiana*, *D. ciliolata*, *D. stolonifera*, *Canistrocarpus cervicornis* and *C. crispatus*, as well as wave-sheltered rocky shore.

    7.2 Reef slope is habitat of *Dictyota ceylanica*, *D. friabilis* and *D. grossedentata*.

7.3 Wave-exposed rocky shore is habitat of *Dictyota ceylanica* and *D. friabilis*.

7.4 Seagrass bed is habitat only of *Canistrocarpus cervicornis*.

8. Herbivory might be a major factor, controlling and maintaining compositions of species of *Dictyota* and *Canistrocarpus* in coral reef, between reef flat and reef slope.
9. Water motion might be a major factor, controlling and maintaining compositions of species of *Dictyota* and *Canistrocarpus* in rocky shore, between wave-exposed and wave-sheltered rocky shore.
10. It is likely that the Peninsular Thailand might act as a barrier limited dispersal of *Dictyota grossedentata* and *D. stolonifera* into the Gulf of Thailand during sea level transgression in the last glaciations.

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