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DIVERSITY AND DISTRIBUTION OF THE BROWN MACROALGAE (Phaeophyceae Kjellman, 1891) IN CHAM ISLANDS, QUANG NAM PROVINCE, VIETNAM

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ABSTRACT

The study investigated the Phaeophyceae during the year 2019 at sixteen sampling sites representative for Cham islands. Specimens were collected by scuba diving, snorkelling and walking at the upper tidal zone in both dry and rainy seasons. Twenty-five species of the Phaeophyceae identified for Cham islands from four orders, four families and eleven genera. The Sargassaceae family is the most abundant species composition, followed by Dictyotaceae, Scytosiphonaceae and Asteronemataceae family. In the six islands surveyed, Hon Lao has the highest diversity with 19 species recorded; Hon Dai, Hon Tai, Hon Kho and Hon Mo island recorded from 10 to 14 species, and the lowest diversity is at the Hon La island with 8 species. Ten species *Canistrocarpus cervicornis*, *Dictyota spinulosa*, *Lobophora obscura*, *Lobophora variegata*, *Pandina minor*, *Sargassum bicorne*, *Sargassum herklotsii*, *Sargassum parvifolium*, *Turbinaria conoides*, *Asteronema breviarticulatum* reported as new records for the marine flora of Cham islands.

Keywords: Brown algae, cham islands, marine protected area, species diversity, Phaeophyceae.

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INTRODUCTION

Marine macroalgae are among the dominant groups of benthic organisms nearshore and essential marine resource of the tropical and subtropical region (Christie et al., 2009). They were used for food, pharmaceuticals, health-related products, nutraceuticals, cosmetics, fine chemicals, feed components, feed additives (Chojnacka et al., 2018). Marine macroalgae are primary producers and play a central role in the coastal ecosystem. They provide ecosystem goods as the hatching ground for many kinds of marine organisms such as fish, crustaceans, molluscs in the coastal zones (Harley et al., 2012; Best et al., 2014; Nabti, 2017). Macroalgae are classified into four groups: brown algae (Phaeophyceae), green algae (Chlorophyta), red algae (Rhodophyta) and blue-green algae (Cyanophyta), and the Phaeophyceae is among the most diversified class, with estimated 1800 species (Algaebase, 2020).

Marine macroalgae diversity of Vietnam stated by Nguyen et al. (2013) with 827 species, in which Rhodophyta is the most abundant taxa with 412 species, followed by Cholorhophyta 180 species, Phaeophyceae 147 species and Cyanophyta 88 species. Seaweed abundance and biodiversity (cover, biomass, species richness, diversity, evenness, and community composition) strongly influenced by tidal height, physical stress, and herbivores (Susan et al., 2013). The species of genus *Sargassum* from Vietnam has divided into northern and southern groups, temperature and sea current may affect the distribution characteristic of these species (Nguyen & Boo, 2020). In the central coast of Vietnam, Marine macroalgae diversity has reported at some locations with similar climatic conditions, such as Ly Son island (Nguyen & Pham, 2001), Nha Trang and its vicinity (Dawson, 1954), and Phu Quy island (Nguyen et al., 2009).

Cham islands constitute a group of 8 small islands which form a part of the Cu Lao Cham Marine Park, a world Biosphere Reserve recognized by UNESCO, in the East Sea of Vietnam. Marine macroalgae diversity in Cham islands previously published by Dinh and Hoang (2010) with 49 species for the flora; the authors have stated the number of species in each phylum rather than report species list of Cham islands. The present study aims to reassess the species composition and examine the distribution characteristic of Phaeophyceae in the Cham islands.

MATERIALS AND METHODS

Study area

The study investigated Phaeophyceae in Hon Lao, Hon Dai, Hon Tai, Hon Mo, Hon La, Hon Kho of Cham islands, Quang Nam province in 2019. Sixteen sampling sites selected are representative of marine algae diversity locations in Cham islands. Six sampling sites in Hon Lao island, three in Hon Dai island, two sampling sites for each of Hon La island, Hon Mo island and Hon Dai island, and one sampling site in Hon Kho island (Fig. 1).

Sampling technique

The specimens collected follow three perpendicular transects and two parallel transects to the shoreline at each study site. Each perpendicular transects laid a distance of 100 m to others, and parallel transects spread a distance of 20 m and 60 m to the shoreline. Scuba diving and snorkelling applied to collect underwater specimens. Phaeophyceae images were taken by camera Nikon Coolpix W300 (Japan), and coordinates of sampling sites recorded by the GPS Garmin 76CSX.

Sample Identification and Species distribution

The seaweeds were classified based on morphological characteristics of the thallus, holdfast, stipe, branch, leaves, the structure of reproductive organs and vegetative cells. The

taxonomic keys from the Pham (1969, 1985), Nguyen et al. (1993), Tsutsui Isao et al. (2005), Nguyen (2013) and AlgaeBase (2020) were employed to identify the taxonomic system of each species. The images of reproductive organs and vegetative cells produced by BX41 optical microscope (Olympus, Japan) used to classify specimens within a genus.

Species distribution identified base on the coordinate information collected during sampling work. The Bray-Curtis similarity index used to evaluate the similarity of species composition among surveyed islands. The biodiversity in the brown algae biome was analyzed through biodiversity indices, the Shannon-Weiner diversity index (H ') and the Margalef index (d).

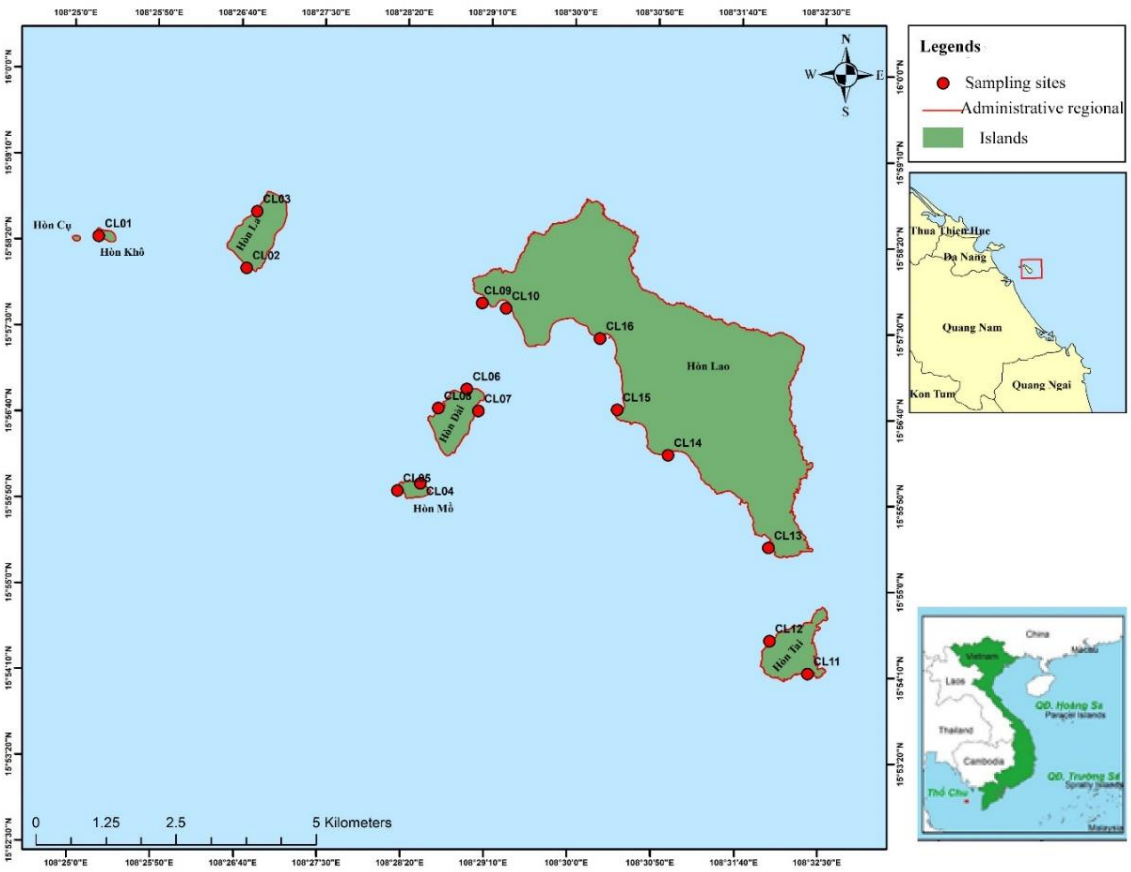

Figure 1. Sixteen sampling sites in Cham Islands

RESULTS

Species diversity

The study identified 25 species of Phaeophyceae in Cham islands from four orders, four families and eleven genera. The family Sargassaceae obtained the highest with 11 species, followed by the family Dictyotaceae with 9 species, the family Scytosiphonaceae with 4 species and the family Asteronemataceae 1 species. Species composition in Cham islands is presented in Table 1.

The representative specimens for morphological analysis of some species of class Phaeophyceae showed in Figure 2.

Table 1. The species composition of Phaeophyceae in Cham islands

No	Scientific name	Hon Kho	Hon La	Hon Mo	Hon Dai	Hon Tai	Hon Lao
	PHAEOPHYCEAE						
	Order Dictyotales						
	Family Dictyotaceae						
1	**Canistrocarpus cervicornis* (Kützing) De Paula & De Clerck			+	+		
2	*Dictyota dichotoma* (Hudson) J.V.Lamouroux	+					+
3	*Dictyota implexa* (Desfontaines) Lamouroux						+
4	**Dictyota spinulosa* J. D. Hooker & Arnott						+
5	**Lobophora obscura* (Dickie) C. W. Vieira, De Clerck & Payri		+	+	+	+	+
6	**L. variegata* (Lamouroux) Womersley ex E. C. Oliveira		+	+	+	+	+
7	*Padina australis* Hauck		+			+	+
8	*P. boryana* Thivy	+	+	+	+		+
9	**P. minor* Yamada	+	+	+	+		+
	Order Ectocarpales						
	Family Scytosiphonaceae						
10	*Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier	+	+			+	+
11	*Hydroclathrus clathratus* (C.Agardh) M.Howe					+	
12	*Pseudochnoospora implexa (*J. Agardh*)* Santiañez, G. Y. Cho & Kogame	+		+	+	+	+
13	*Rosenvingea intricata* (J. Agardh) Børgesen				+		
	Order Fucales						
	Family Sargassaceae						
14	*Sargassum aquifolium* (Turner) C. Agardh	+	+	+	+		+
15	**S. bicorne* J. Agardh					+	
16	*S. feldmannii* Pham-Hoang Ho	+		+	+		+
17	**S. herklotsii* Setchell					+	
18	*S. ilicifolium* (Turner) C. Agardh			+	+	+	+
19	*S. mcclurei* Setchell	+				+	+
20	*S. microcystum* (Turner) C. Agardh						+
21	*S. oligocystum* Montagne	+			+	+	+
22	**S. parvifolium* (Turner) C. Agardh						+
23	**Turbinaria conoides* (J. Agardh) Kützing				+	+	+
24	*T. ornata* (Turner) J. Agardh	+	+	+	+	+	+
	Order Scytothamnales						
	Family Asteronemataceae						
25	**Asteronema breviarticulatum* (J. Agardh) Ouriques & Bouzon				+		
Total		10	8	10	14	13	19

Note: *: New record for Cham islands.

Figure 2. Morphology of some species of Phaeophyceae in Cham islands

Distribution of Phaeophyceae in Cham islands

The distribution of Phaeophyceae was a significant difference among islands. In Hon Lao there were 19 species recorded belong to 7 genera, in Hon Dai 14 species recorded belong to 8 genera, in Hon Tai were 13 species belong to 7 genera, in Hon Kho were 10 species belong to 6 genera, in Hon Mo were 10 species belong to 6 genera, and Hon La were 8 species belong to 5 genera (Table 1).

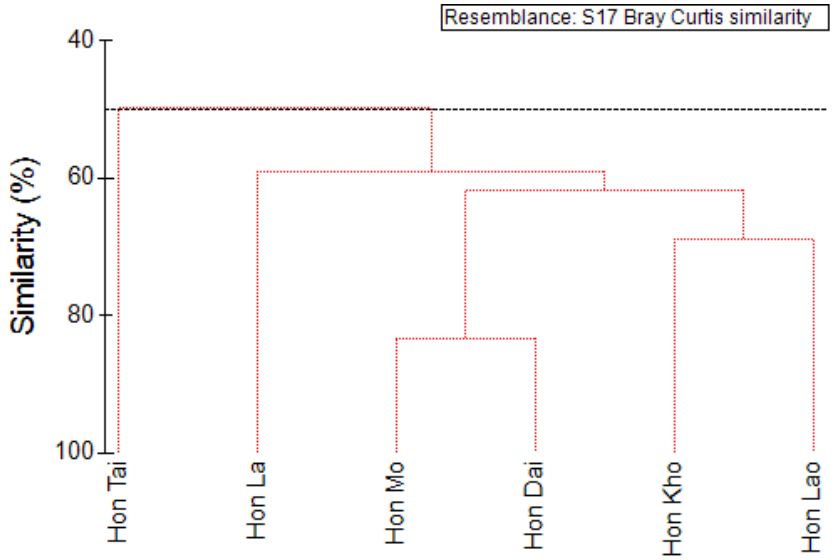

Figure 3. Cluster analysis distribution of Phaeophyceae in Cham islands

The distribution characteristic of Phaeophyceae among islands has been analysed by the Bray Curtis similarity index. The species composition of Hon Mo and Hon Dai was the highest with 83.3% of the similarity, follows Hon Kho and Hon Lao were 69% of the similarity. The Hon La and Hon Tai revealed the distinction to the other four islands (Fig. 3).

The biodiversity indices of Phaeophycea of Cham islands supports additional information about the distribution of each island. The Shannon-Weiner (H') diversity index and Margalef (d) abundance index showed a high value in Cham islands. The value of Shannon-Weiner (H') and Margalef (d) of each island reported the same order among the Cham islands (Table 2).

Table 2. Shannon-Weiner (H') and Margalef (d) index of Cham islands

Islands	Shannon-Weiner (H')	Margalef (d)
Hon Kho	3,32	3,91
Hon La	3,00	3,37
Hon Mo	3,32	3,91
Hon Dai	3,81	4,93
Hon Tai	3,70	4,68
Hon Lao	4,25	6,11

DISCUSSION

Phaeophyceae plays a vital role in the marine ecosystem, especially in the intertidal zones, where marine algae were forming nursery habitats for other aquatic creatures (Nguyen & Boo 2020). The species of genus *Sargassum* in Cham island were an essential marine plant community with nine taxa reported, this community however abundant than the *Sargassum* community of Tho Chu islands in the South - Western Sea of Vietnam (Nguyen, 2020), Phu Quy island in the South Central of Vietnam (Nguyen et al., 2009) and Ha Long Bay in the North of Vietnam (Nguyen, 1996). Three species in the genus *Dictyota* of Cham islands were sparse and uncommonly distributed; conversely, the species of genus *Pandina* more common among the islands, the species of these two genera naturally living in the shallow area and moderate wave action in the Cham islands.

The number of taxa identified in this study 10 species higher than reported by Dinh and Hoang (2010), this disparity probably due to the difference in sampling efforts and surveying area. In comparison to other islands in the Centre of Vietnam, the Phaeophyceae in Cham islands graded at a high diversity level (Table 3).

Table 3. Phaeophyceae taxa in some islands of Vietnam

No	Name of Island	Number of Taxa	Reference documents
1	Con Co (Quang Tri province)	14	Le, 1996
2	Nam Yet, Son Ca, Song Tu Tay, Sinh Ton (Spratly islands)	20	Dam et al., 2016
3	Dung Quat Economic Zone (Quang Ngai province)	18	Vu et al., 2013
4	Ly Son (Quang Ngai province)	21	Nguyen & Pham, 2001
5	Phu Quy (Binh Thuan province)	26	Nguyen et al., 2009
6	Cu Lao Cham (Quang Nam province)	15	Dinh & Hoang, 2010
7	Cu Lao Cham (Quang Nam province)	25	Present study

Cluster analysis revealed three separate groups: the first group is the Phaeophyceae of Hon Tai, the second group is the Phaeophyceae of Hon La and the third group is the Phaeophyceae of Hon Mo, Hon Dai, Hon Kho and Hon Lao. The distinct species distribution in Cham islands probably driven by the characteristic of the bottom substrate, current, wave regime and environmental conditions (Best et al., 2014; Nguyen, 2014). The appearance of numerous species in a narrow area or particular island such as *Dictyota implexa, D. spinulosa, S. microcystum, S. parvifolium* in Hon Lao, *Hydroclathrus clathratus, S. bicorne, S. herklotsii* in Hon Tai, *Rosenvingea intricata, Asteronema breviarticulatum* in Hon Dai one again confirmed the importance of survey effort to the insight of how seaweed diversity in a study area. The Shannon-Weiner (H') diversity index and Margalef (d) abundance index showed the ranking from high to low diversity in Cham islands were Hon Lao, Hon Dai, Hon Tai, Hon Mo, Hon Kho and Hon La, these indexes congruent with variation in species composition among the islands.

Turbinaria ornata popular found in Cham islands; this species appearance endorses the wide distribution along the coast of Vietnam (Nguyen, 2013). Besides common species in Cham islands were *Lobophora obscura, L. variegata, Padina boryana, Pseudochnoospora implexa, Sargassum aquifolium*. However, only two species *Padina boryana* and *Sargassum aquifolium*, popularly reported for the Centre of Vietnam (Dam et al., 2016; Nguyen et al., 2009; Vu et al., 2013). The *Padina australis, Sargassum aquifolium, S. feldmanni, S. ilicifolium, S. mcclurei, S. oligocystum,* and *Turbinaria ornata* recognized as potential economic species in Cham island due to promising biochemical compounds and large biomass (Nguyen & De Clerk, 2013; Yu et al., 2019).

CONCLUSION

The Phaeophyceae of Cham islands comprised of 25 species from four orders, four families and eleven genera. Spatial distribution of these species clustered by three groups of the islands. However, species distributed unevenly among islands.

One-third are common species popularly found in Cham islands, and eight species were rare species that only found on a single island.

The study has contributed ten new records for Cham islands marine flora. An assessment of species variation and spatial distribution of Phaeophyceae in Cham islands after ten years will help to know how species changes in a study location over time.

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REFERENCE

Best R. J., Chaudoin, Bracken M. E, Graham M. H, Stachowicz J. J., 2014. Plant-animal diversity relationships in a rocky intertidal system depend on invertebrate body size and algal cover. *Ecology*, 95(5): 1308−1322.

Christie H., Norderhaug K. M., Fredriksen S., 2009. Macrophytes as habitat for fauna. *Mar. Ecol. Prog. Ser.,* 396: 221–33.

Chojnacka K., Wieczorek P. P., Schroeder G., Michalak I., 2018. Algae biomass: characteristics and applications. Springer, pp. 146.

Dawson E. Y., 1954. Marine plants in the Vicinity of the Institute Oceanography of Nha Trang. *Pacific Science*, 8: 373−471.

Dam Duc Tien, 2003. Species composition and distribution of seaweeds in Spratly archipelago (Truong Sa islands). *Journal of Marine Science and Technology*, 3: 54−63. (in Vietnamese with English summary).

Dam Duc Tien, 1999. Species composition and distribution of Chlorohophyta in Spratly islands (Truong Sa islands). 4th National Marine Science and Technology Congress. Science and Technical

Publishing House, Hanoi, pp. 988−992. (in Vietnamese with English summary).

Dam Duc Tien, Do Huy Cuong, 2016. Species composition and distribution of seaweeds from some small islands (Nam Yet, Son Ca, Song Tu Tay, Sinh Ton) of Truong Sa archipelago. *Vietnam Journal of Marine Science and Technology*, 16(3): 297−305. (in Vietnamese with English summary).

Dinh Thi Phuong Anh, Hoang Thi Ngoc Hieu, 2010. A survey on the species composition and distribution of seaweeds in Cu Lao Cham-Quang Nam. *Journal of Science and Technology (JST-UD)*, 5 (40): 1−8. (in Vietnamese with English summary).

Harley C. D. G., Anderson K. M., Demes K. W., Jorve J. P., Kordas R. L., Coyle T. A., Graham M. H., 2012. Effects of climate change on global seaweed communities. *J Phycol.*, 48: 1064–78.

Le Thi Thanh, 1996. Seaweed composition of Con Co island. *Vietnamese Collection of Marine Research Works* 7: 235−241. (in Vietnamese with English summary).

Nabti E., (Ed), 2017. Biotechnological applications of seaweeds. Nova science publishers, New York, pp. 119.

Nguyen Huu Dinh, Huynh Quang Nang, Tran Ngoc But, Nguyen Van Tien, 1993. Marine algae of North Vietnam. Technical and Science Publishing House, pp. 344. (in Vietnamese).

Nguyen Huu Dai, Pham Huu Tri, Nguyen Xuan Vy, 2009. Species composition and resources of seaweed and seagrass of Phu Quy island, Binh Thuan province. *Vietnamese Collection of Marine Research Works*, 16: 225−243. (in Vietnamese with English summary).

Nguyen Huu Dai and Pham Huu Tri, 2001. The seaweed resources of Ly son islands. *Vietnamese Collection of Marine Research Works*, 11: 121−134. (in Vietnamese with English summary).

Nguyen Van Tien 1996. Seaweed of Halong Bay. *Vietnamese Collection of Marine Research Works*, 7: 184−193. (in Vietnamese with English summary).

Nguyen V. T., Le N. H., Lin S. M., Steen F. and Olivier D. C., 2013. The checklist of the marine macroalgae of Vietnam. *Botanica Marina*, 56(3): 207−227.

Nguyen Van Tu, Olivier De Clerck, 2013. Diversity and distribution characteristics of economically potential seaweed in Vietnam. Proc. 1st VAST-IRD workshop on Marine Science. Hai Phong – Vietnam, pp. 350–357.

Nguyen Van Tu, 2014. Seaweed diversity in Vietnam, with an emphasis on the brown algal genus *Sargassum*. Ghent University, pp. 196.

Nguyen Van Tu, 2020. Diversity of the genus *Sargassum* (Fucales: Sargassaceae) in Tho Chu Archipelago, Kien Giang province. *Academia Journal of Biology*, 42(2): 123–130.

Nguyen V. T., Boo S. M., 2020. Distribution patterns and biogeography of Sargassum (Fucales, Phaeophyceae) along the coast of Vietnam. *Botanica Marina*, 63(3): 463−468.

Pham Hoang Ho, 1969. Marine algae of South Vietnam. Sai Gon study Center - Ministry of Education and Youth, pp. 558. (in Vietnamese).

Pham Hoang Ho, 1985. The plant of Phu Quoc islands. Ho Chi Minh publishing house, pp. 188. (in Vietnamese).

Susan L. W., Bracken M. E., Jones E., 2013. Additive effects of physical stress and herbivores on intertidal seaweed biodiversity. *Ecology*, 94 (5): 1089–1101.

Tsutsui I., Huynh Q. N., Nguyen H. D., Arai S., Yoshida T., 2005. The common marine plants of southern Vietnam. Japan. Seaweed Association, Kochi, Japan, pp. 250.

Vu Thanh Ca, Pham Van Hieu, Mai Kien Dinh, Dam Duc Tien, 2013. Species composition, distribution and biomass of seaweeds at Dung Quat Economic Zone, Quang Ngai Province, Vietnam. *Vietnam*

Journal of Marine Science and Technology, 13(4): 342−348. (in Vietnamese with English summary).

Yu K-X, Norhisham S. N., Ng C. H., 2019. Antimicrobial potential of *Pandida Australis* and *Sargassum polycystum* against respiratory infections causing bacteria. *International Journal of Medical Toxicology & Legal Medicine*, 22(1-2): 138−141.

https://www.algaebase.org/ [accessed on December 15th, 2020].