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Species diversity, taxon structure and distribution of the macroalgae in Con Co Special Administrative Region, Vietnam

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ABSTRACT

This study presents the results of seaweed investigations conducted at four transects in the Con Co Special Administrative Region from 1994 to 2025. A total of 101 macroalgal species were recorded, belonging to four phyla. Among these, Cyanophyta comprised 5 species (4.9%), Rhodophyta 40 species (39.6%), Ochrophyta (Phaeophyta) 36 species (35.6%), and Chlorophyta 20 species (20.5%). We classified these species into 23 orders, 38 families, and 49 genera, indicating a mixed algal flora. Species richness across the studied transects ranged from 51 species (transect I) to 76 species (transect IV), with an average of 63.8 species per transect. The similarity coefficient among transects varied from 52.63 (between transects I and IV) to 78.14 (between transects IV and V), with an average value of 67.64, reflecting a moderate to high degree of similarity in species composition. In terms of ecological distribution, 20 species (19.8%) were found exclusively in the intertidal zone, 44 species (43.6%) occurred only in the subtidal zone, and 37 species (36.6%) were distributed across both zones. Most species were concentrated from the lower intertidal zone to the upper subtidal zone, highlighting this transitional area as a key habitat for macroalgal diversity. Taxonomic structure varied considerably among phyla. Rhodophyta exhibited the highest diversity, with 12 orders, 17 families, 23 genera, and 40 species, while Cyanophyta showed the lowest diversity. On average, each phylum included 5.75 orders, each order contained 9.5 families, and each phylum comprised approximately 12.25 genera and 25.25 species. Several genera contained only a single species, whereas others, such as *Sargassum* (10 species), *Lobophora* (9 species), and *Caulerpa* (5 species), showed higher species richness. Similarly, some families included only one genus, while others contained multiple genera. The distribution of the 23 recorded orders was uneven among the four phyla, with Rhodophyta accounting for the highest proportion (52.1%). Notably, several recorded species belong to economically important genera such as *Porphyra*, *Grateloupia*, and *Sargassum*, which have applications in food, pharmaceuticals, and cosmetics.

Keywords: Con Co Island, intertidal and subtidal zones, macroalgae diversity, taxonomic structure.

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Introduction

Seaweed is a group of lower plants living in the sea; it is an important component of marine resources. Industries use seaweed as a raw material to process high-value products, such as agar, alginate, carrageenan, and biological compounds (amino acids, growth hormones), which are widely used in the food, pharmaceutical, and cosmetic industries. In Vietnam, 826 species of seaweed have been discovered [1], many of which are being exploited and used, such as *Gracilaria, Hypnea, Sargassum, Laurencia* and *Eucheuma, Kappaphycus* [2, 3], etc. which farmers and industries currently target for wide cultivation to serve domestic and export needs.Con Co Special Administrative Region is a small island belonging to Quang Tri province, located off the coast of Central Vietnam, with an area of approximately 2.3 km². Geologically and geomorphologically, the island has a volcanic origin, creating a characteristic basalt bedrock that supports a diverse marine ecosystem in the island's coastal waters. The Con Co marine ecosystem includes coral reefs, seaweed beds, and benthic communities, with brown and red algae abundant and playing an important role in the nutrient cycle and protecting the island's coastline. In the current development orientation, Con Co is identified as a priority area for marine ecological conservation combined with small-scale ecotourism, marine scientific research, and sustainable marine economic development, rather than developing according to the model of a concentrated special economic zone.

This seaweed system not only plays an ecological role (stabilizing the seabed, reducing erosion, maintaining food webs) but also has potential for research on marine biological resources and biopharmaceutical applications. To date, researchers have published several studies on Con Co seaweed, but mainly on species composition and distribution [3–11].

The results of this study will provide a scientific basis for the management, conservation, sustainable exploitation, and development of seaweed resources in the Con Co Special Administrative Region.

Materials and methods

Materials

Materials used for this research were collected from several projects implemented in Con Co Special Administrative Region from 1994 to 2025, at six transects within the region.

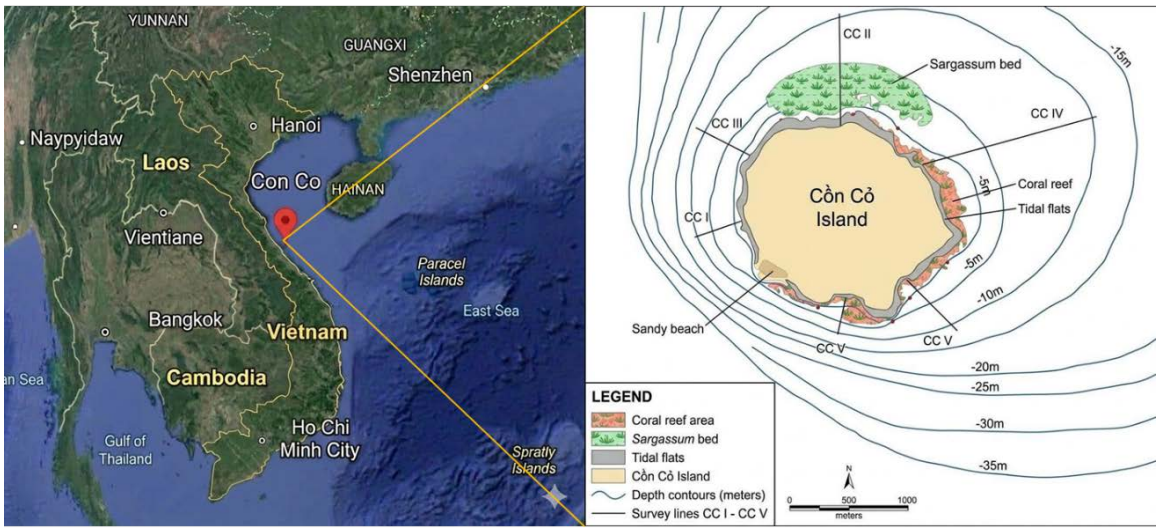

Figure 1. Locations of macroalgae survey transects in Con Co Special Administrative Region

We conducted this study based on the results of a survey at 6 transects. The first point is the coordinates, pulled perpendicular to the edge of the island, to a depth of 18 m, compared to 0 m on the nautical chart. Each transect has points in the intertidal (high tide, mid tide, and low tide) and subtidal zones (upper range: 10 m deep; lower range). At each point, we collected 3 qualitative samples.

Figure 1 and Table 1 show the locations of the macro algae survey transect in Con Co Special Administrative Region.

Table 1. Coordinates of survey transects at Con Co Special Administrative Region

No.	Transects	Coordinates
1	CC1	17°09’22”N - 107°19’07”E
2	CC2	17°09’19”N - 107°19’25”E
3	CC3	17°10’25”N - 107°20’55”E
4	CC4	17°09’28”N - 107°21’36”E
5	CC5	17°08’56”N - 107°21’04”E
6	CC6	17°08’23”N - 107°20’11”E

Methods

Sampling

We collected samples following the Provisional Regulations for Field Survey issued by the State Committee for Science and Technology (Vietnam) in 1981 for the tidal zone [12] and the standard methods by English et al. (1997) [13] for the subtidal zone using SCUBA equipment. We derived water level and tidal data from the tidal regime measured at Son Tra (1994–2025) [14], underwater digital cameras (Sea & Sea, NIKONOS V from Japan, and PENTAX WG 5 from Indonesia), and Olympus TG5 (made in Vietnam with housing). At each survey transect, four North, South, east, and west main transects and some additional transects between the main transects were set up perpendicular to the shoreline and stretched out to the depth without seaweeds (normally at 18 m deep). The depths of sampling sites were determined using SCUBA depth gauges.

We soaked the fresh macroalgal samples in a 5% formaldehyde solution, then placed them on Croki paper, compressed them between blotting papers, dried them naturally, and analyzed them [15].

Species identification

The macroalgae specimens were analyzed at the Marine Botanical Ecology and Resources Department laboratory, Institute of Marine Environment and Resources (Vietnam Academy of Science and Technology).

We classified specimens based on morphological and anatomical criteria under a LEICA microscope. The scientific names used follow the conventions of national and international authors [16–34].

Distribution study

** Geographical distribution*

We expressed the geographical distribution of marine macroalgae using a similarity index (Sorensen Similarity Index) that is calculated according to the formula $S = 2C/(A + B)$, where A and B are the numbers of species in sampling transect A and B, respectively; C is the number of species shared by the two sampling transects (A and B). In the range from 0 (zero) to 1 (one), when the coefficient (S) value approaches one (1), these sampling sites show a strong similarity; and when the coefficient value gets down to zero (0), these sampling transects are less similar [35].

** Vertical distribution*

Determining the vertical distribution of marine macroalgae is based on the principle of tidal zone partitioning (zonation) as used by Feldmann (1937) [36]. Under this scheme, the coastal zone is arbitrarily partitioned into many areas, depending on tidal levels such as high tide, mid-tide, and low tide. Water level and tidal data were derived from the tidal regime measured at Hon Dau.

The spatial distribution data were processed using Excel to obtain the final values.

We sourced additional information from the documents of Nguyen Van Tu and colleagues (2013) [1].

Results and discussion

Species composition

Based on the analysis results from marine macroalgae surveyed samples in Con Co Special Administrative Region and references, we have discovered 101 species of seaweed belonging to 4 phyla, in which Cyanobacteria (blue-green algae) are included in this study due to their ecological similarity and functional role comparable to macroalgae in coastal ecosystems, despite being taxonomically classified as prokaryotes. The results show that Cyanophyta comprised 5 species (4.9% of the total), while Rhodophyta, Ochrophyta (Phaeophyta), and Chlorophyta accounted for 40 (39.6%), 36 (35.6%), and 20 species (20.5%), respectively (Table 2).

Table 2. Species composition and distribution of macroalgae in Con Co Special Administrative Region

No.	The name of the taxa	Geographical distribution						Vertical distribution	
		I	II	III	IV	V	VI	TZ	STZ
	CYANOPHYTA								
	Order Oscillatoriales								
	Family Oscillatoriaceae								
1	*Lyngbia aestuarii* (Mert.) Liebm.	+	+	+	+	+	+	+	
2	*L. lutea* (C. Ag.) Gom	+			+			+	
3	*L. martensiana* Menegh.	+						+	
4	*Microcoleus chthonoplaste* Thur. et *Gom*	+	+	+	+	+	+	+	
5	*Symploca hydnoides* Kuetz. ex Gom.	+	+	+	+			+	
	RHODOPHYTA								
	Order Bangiales								
	Family Bangiaceae								
6	*Porphyra suborticulata* Kjellm.			+	+			+	
	Order Nemaliales								
	Family Liagoraceae Kuetz.								
7	*Liagora divaricatat* Tseng	+	+	+	+			+	+
8	*L. caenomyce* Dcne.		+	+	+		+	+	+
9	*L. orientalis* J. Ag.	+		+	+		+		+
	Family Galaxauraceae								
10	*Galaxaura fastigiata* Decne		+	+	+	+	+		+
11	*G. rugosa* (J. Ellis *et* Solander) J.V. Lamouroux		+	+	+	+	+		+
12	*G. obtusata* (Ell. et Sol.) Lamx.						+		+
13	*Actinotrichia fragilis* (Forsk.) Boerg.	+						+	+
	Family Gelidiellaceae								
14	*Gelidiella acerosa* (Forsk.) Feld. & Ham.	+	+	+	+	+	+	+	
15	G. *lubrica* (Kuetz.) Feldm. Et Ham.	+	+	+	+	+		+	
	Order Gelidiales								
	Family Gelidiaceae								
16	*Gelidium crinale* (Turn.) Lamx.		+			+	+	+	
17	*G. lithophila* Boerg.	+	+	+	+	+	+	+	
18	*G. pulchellum* (Turn.) Kuetz.		+	+	+	+	+	+	
	Order Peyssonneliales								
	Family Peyssonneliaceae								
19	*Peyssonnelia gunniana* J. Ag.			+	+			+	+
	Order Corallinales								

No.	The name of the taxa	Geographical distribution						Vertical distribution	
		I	II	III	IV	V	VI	TZ	STZ
	Family Corallinaceae								
20	*Coralina officinalis* L.	+		+			+		+
21	*Jania capillacea* Harv.		+		+	+			+
22	*J. pumila* Yendo		+	+		+			+
	Family Lithophyllaceae								
23	*Amphiroa achigoensis* Yendo		+			+			+
24	*A. zonata* Yendo			+		+			+
	Order Halymeniales								
	Family Halymeniaceae								
25	*Grateloupia taiwanensis* S.-M.Lin & H.Y.Liang			+	+		+		+
	Order Acrochaetiales								
	Family Acrochaetiaceae								
26	*Acrochaetium thuretti* (Bornet) F.S.Collins & Hervey			+					+
	Order Gigartinales								
	Family Hypneaceae								
27	*Hypnea boergesenii* Tanaka		+	+	+				+
28	*H. esperi* Bory		+	+	+				+
29	*H. flagelliformis* Grev.		+		+		+	+	+
30	*H. japonica* Tanaka			+			+	+	+
31	*H. nidulans* Secth			+		+		+	+
	Order Gracilariales								
	Family Gracilariaceae								
32	*Gracilaria arcuata* Zan.	+	+	+	+	+			+
33	*G. salicornia* (C. Ag.) Daws.	+	+		+	+			+
	Family Gigartinaceae								
34	*Gigartina intermedia* Sur.	+	+		+			+	
	Family Phyllophoraceae								
35	*Ahnfeltiopsis griffithsiae* (Turn.) Mart.	+	+	+	+	+	+	+	
	Order Bonnemaisoniales								
	Family Bonnemaisoniaceae								
36	*Asparagopsis taxiformis* (Del) Coll. et Harv.	+		+	+		+		+
	Order Ceramiales								
	Family Rhodomelaceae								
37	*Polyshiphonia nhatrangense* Phamhoang H.		+	+	+	+	+	+	+
38	*P. sertularioides* (Grot.) J. Ag.	+	+	+	+	+	+	+	+
39	*P. subtilissima* Mont.	+		+				+	+
40	*P. sphaerocarpa* Boerg.		+		+			+	+
41	*Laurencia obtusa* (Huds.) Lamx.			+	+		+		+
42	*Acanthophora muscoides* (L.) Bory	+		+		+	+	+	+
43	*A. spicifera I(Vall.) Boerg.*			+		+	+	+	+
44	*Leveillea jungermanioides* (Harv. & Mart.) Harv.		+	+	+	+	+	+	+
45	*Acrocystis nana* Zan,		+	+	+	+	+	+	+
	Order Rhodymeniales								
	Family Rhodymeniaceae								
46	*Ceratodiction spongiosum* Zanard.		+	+	+	+	+		+
	OCHROPHYTA (PHAEOPHYTA)								

No.	The name of the taxa	Geographical distribution						Vertical distribution	
		I	II	III	IV	V	VI	TZ	STZ
	Order Ectocarpales								
	Family Ectocarpacea								
47	*Feldmannia irregularis* (Kuetz.) Ham.	+	+	+	+	+	+	+	+
	Family Scytosiphonaceae								
48	*Colpomenia sinuosa* (Roth.) Derb. et Sol.	+	+	+	+	+	+	+	+
	Family Chnoosporaceae								
49	*Chnoospora minima* (Her.) Papenf.		+	+	+	+			+
50	*Ch. implexa* (Hering) J. Ag.		+	+	+	+			+
	Family Scytosiphonaceae								
51	*Hydroclathrus clathratus* (Bory) Howe.		+	+			+	+	+
	Family Chordariaceae								
52	*Nemacystus decipiens* (Sun.) Kack.	+		+				+	+
	Order Ralfsiales								
	Family Ralfsiaceae								
53	*Ralfsia verrucosa* (Aresch.) J. Ag.		+	+	+	+		+	
	Order Sphacelariales								
	Family Sphacelariaceae								
54	*Sphacelaria variabilis* Sauv.		+					+	
55	*S. rigidula* Kützing		+	+	+	+	+	+	
	Order Dictyotales								
	Family Dictyotaceae								
56	*Dictyota adnata* Zanardini	+		+	+	+	+		+
57	*D. divaricata* Lamx.		+	+	+	+	+		+
58	*D. ceylanica* var. *anastromosans* Ta.		+	+	+	+	+		+
59	*D. patens* J. Ag.	+	+	+				+	+
58	*Padina australis* Hauck.	+	+	+	+	+	+	+	+
59	*P. boryana* Thivy	+	+	+	+				+
60	*P. crassa* Yam.	+			+	+			+
61	*P. tetrastroma* Hauck.	+	+	+	+		+	+	+
62	*Lobophora variegata* (Lamx.) Wom.	+	+	+	+	+	+	+	+
63	*L. asiatica* Z.Sun, Ji. Tanaka & H.Kawai	+							+
64	*L. boussoleae* C.W.Vieira & Payri		+	+		+			+
65	*L. lamourouxii* C.W.Vieira & Payri								+
66	*L. obscura* (Dickie) C.W.Vieira, De Clerck & Payri	+			+	+	+		+
67	*L. pachyventera* Z. Sun, P. E. Lim, Ji. Tanaka & H. Kawai		+	+					+
68	*L. thailandensis* A. M. Klomjit and C. W. Vieira	+			+		+		+
69	*L. quangtriensis* D.T.Dam, M.L.Nguyen et C.W.Vieira		+	+	+				+
70	*L. vietnamensis* D.T.Dam, M.L.Nguyen et C.W.Vieira			+	+	+			+
	Order Fucales								
	Family Sargassaceae								
71	*Sargassum aquifolium* (Turner) C. Agardh						+		+
72	*S. duplicatum* J. Ag.						+		+
73	*S. echinocarpum* I. Ag.	+			+	+		+	+
74	*S. glaucescens* J. Ag.	+			+	+	+	+	+
75	*S. gracillimum* Rbd.				+	+		+	+
76	*S. kuetzingii* Setch.			+	+	+		+	+

No.	The name of the taxa	Geographical distribution						Vertical distribution	
		I	II	III	IV	V	VI	TZ	STZ
77	*S. paniculatum* J. Ag.	+			+	+	+	+	+
78	*S. polycystum* C. Ag.	+			+	+		+	+
79	*S. polyporum* Mont.	+		+	+	+		+	+
80	*Sargassum siliquosum* J. Ag.	+			+		+		+
81	*Turbinaria gracilis* Sond.	+	+	+	+	+	+		+
	CHLOROPHYTA								
	Order Ulvales								
	Family Ulvaceae								
82	*Ulva clathrata* (Roth.) Grev.	+	+	+	+	+	+	+	
83	*Ulva flexuosa* (Wult.) J.	+	+	+	+	+	+	+	
	Order Cladophorales								
	Family Anadyomenaceae								
84	*Anadymene wrightii* Harv.		+	+	+			+	
	Family Boodleaceae								
85	*Boodlea siamensis* Reinb		+	+	+	+	+	+	+
	Family Cladophoraceae								
86	*Chaetomorphaantennina* (Boerg.) Kuetz.			+				+	
87	*Chaetomorpha crassa* (C. Ag.) Kuetz.		+		+			+	
88	*Rhizoclonium riparium* (Roth.) Harv.	+	+			+		+	+
	Order Bryopsidales								
	Family Bryopsidaceae								
89	*Bryopsis pennata* Lamx.	+	+	+	+	+	+		+
	Order Caulerpales								
	Family Caulerpaceae								
90	*Caulerpa. lentiliffera* J. Ag.			+	+	+			+
91	*Caulerpa peltata* Lamx. var. *Typica* W. V. Bosse	+	+	+	+	+	+		+
92	*Caulerpa serrulata* (Forsk.) J. Ag.	+	+	+	+	+	+		+
93	*Caulerpa racemosa* (Forsk.) J. Ag.	+	+	+	+	+	+		+
94	*Caulerpa. taxifolia* (Vahl.) C. Ag.		+	+	+		+		+
	Order Codiales								
	Family Codiaceae								
95	*Codium arabicum* Kuetz.		+	+	+	+	+	+	+
96	*Codium tenue* Kuetz.		+	+	+	+	+		+
	Order Bryopsidales								
	Family Halimedaceae								
97	*Halimeda macroloba* Decn.	+	+	+	+	+	+		+
	Họ Udoteaceae								
98	*Chlorodesmis hildebrandtii* Aet. E. S. Gepp.				+		+	+	
	Order Dasycladales								
	Family Dasiacladaceae								
99	*Neomeris annunata* Dich.	+	+	+	+		+	+	+
100	*Neomeris Vanbosseae* Howe	+		+		+		+	+
	Family Polyphysaceae								
101	*Acetabularia parvula* Solms-Laubach	+	+	+	+	+	+	+	+
Total: 101 species		51	63	75	76	61	57	58	81

Notes: The numbers 1–6 are the survey transect numbers; TZ: tidal zone; STZ: subtidal zone.

Taxon structure

In terms of structure, the results of the research in Table 2 show that, overall, the number of orders of taxa of the phyla ranges from 1 (Cyanophyta) to 12 (Rhodophyta) and averages 5.75 orders/phylum. Similarly, the number of family taxa ranges from 1 (Cyanophyta) to 17 (Rhodophyta) and 9.5 family/order. The number of genus taxa, from 3 (Cyanophyta) to 23 (Rhodophyta), and 12.25 genus/family. The number of species taxa ranges from 5 (Cyanophyta) to 40 (Rhodophyta), and 25.25 species/genus.

Although the average number of species/genus is quite large (25.25), some genera have only one species (*Porphyra, Hydroclathrus, Anadymene,* etc.) and some others have a larger number of species (*Sargassum:* 10 species*; Lobophora:* 9, *Hypnea*: 5 species; *Caulerpa:* 5, etc.). Among families, several families consist of only one genus (Peyssonneliaceae, Ralfsiaceae, Boodleaceae, etc.) but others have more than one (Dictyotaceae: 5, Boodleaceae: 4, Sargassaceae: 2).

A total of 23 orders were recorded across the four phyla (Cyanophyta, Rhodophyta, Ochrophyta, and Chlorophyta). Rhodophyta accounted for the largest proportion with 12 orders (52.1%), followed by Ochrophyta with 7 orders (30.4%), Chlorophyta with 3 orders (13.2%), and Cyanophyta with 1 order (4.3%) (Table 3).

Table 3. The taxon structure of macroalgae in Con Co Special Administrative Region

Phyllum	Order		Family		Genus		Species	
	Quan-tity	Ratio (%)	Quan-tity	Ratio (%)	Quan-tity	Ratio (%)	Quan-tity	Ratio (%)
Cyanophyta	1	4.4	1	2.6	3	6.1	5	5.00
Rhodophyta	12	52.2	17	44.7	23	45.1	40	39.60
Ochrophyta	7	30.4	9	23.7	12	24.4	36	35.60
Chlorophyta	3	13.0	11	29.0	12	24.4	20	19.80
Total	23	100	38	100	50	100	101	100

The results presented in Table 2 indicate that the order *Ectocarpales* contains the highest number of families (5), while the family *Rhodomelaceae* includes the greatest number of genera (5). The genus *Sargassum* exhibits the highest species richness, with 10 recorded species. Several orders contain only a single family, such as *Bonnemaisoniales*, *Gracilariales*, and *Halymeniales* (Rhodophyta), as well as *Dictyotales*, *Ectocarpales*, and *Fucales* (Ochrophyta). Similarly, some families comprise only one genus, including *Bangiaceae*, *Gelidiellaceae*, and *Gelidiaceae* (Rhodophyta); *Ectocarpaceae*, *Scytosiphonaceae*, and *Chnoosporaceae* (Ochrophyta); and *Ulvaceae*, *Anadyomenaceae*, and *Bryopsidaceae* (Chlorophyta). At the genus level, several taxa are represented by a single species, such as *Microcoleus* and *Symploca* (Cyanophyta); *Peyssonnelia*, *Gigartina*, and *Asparagopsis* (Rhodophyta); *Nemacystus*, *Ralfsia*, and *Turbinaria* (Ochrophyta); and *Anadyomene*, *Boodlea*, and *Bryopsis* (Chlorophyta).

Geographical distribution

The number of species of macroalgae at six stations ranged from 51 sp. (transect I) to 76 (transect IV) and averaged 63.8 species/transect. The lowest species richness recorded at transect I can be attributed primarily to the narrow intertidal zone and the predominance of sandy substrates in the subtidal area, which are unfavorable for seaweed growth and development. Transect IV recorded the highest number of species (76), owing to its large tidal area and hard subtidal bottom, both of which are highly favorable for seaweed growth.

The Sorensen Similarity Index (SSI) of marine macroalgae at six different transects ranged from 52.63 (between transect I and II) to 78.14 (between transect III and IV), averaging 67.64

(Table 4). This can be explained by the differences in physical conditions and bottom structure of the different transects (Table 4).

Table 4. Matrix of Sorensen Similarity Index values at surveyed transects

Transects	I	II	III	IV	V	VI
VI	57,40	65,00	69,69	72,18	66,10	
V	58,92	70,96	72,05	74,45		
IV	64,56	77,69	78,14			
III	57,14	76,81				
II	52,63					
I						

Vertical distribution

In the Con Co Special Administrative Region, there are two substrate types related to the vertical distribution. They are rocky intertidal areas (mostly dead and original rock) and soft-bottom intertidal areas (mainly coarse sandy bottom with other foreign objects such as shells, empty cans). The soft substrate type with less macro algae is distributed mainly in the subtidal areas of transect number six. As such, macroalgae vertical distribution is mainly surveyed and studied in the rocky intertidal and subtidal transects.

Based on tidal level data (from 1994 to 2025) at Cua Tung, among 101 species recorded in Con Co, we found 20 species (accounting for 19.8% of total species) in the intertidal zone only; 44 species (43.6%) in the subtidal zone; and 37 species (36.6%) recorded in both intertidal and subtidal zones.

On hard bottoms at sea, macroalgae are abundant and common, with most species identified in the study transects (Table 5).

Table 5. Distribution of macro algae in transects of the rocky Con Co Special Administrative Region (*Source:* Con Co regime, from 1994 to 2025)

On the tide		There is no seaweed The average value of the tropical spring tide 1.3 m
Tidal area	High tide belt	*Lyngbia aestuarii, Ralfsia verrucosa, Ulva clathrata,* etc. The average value of the equator spring tide 1.0 m
	Middle tide belt	*Microcoleus chthonoplaste, Porphyra suborticulata, Gigartina intermedia,* etc. The average value of the equator neap tide 0.7 m
	Low tide belt	*Gelidiella acerosa, Gelidium crinale, Gigartina intermedia,* etc. The average value of the tropical neap tide 0 m
Subtidal tide area	High belt	*Hypnea boergesenii, Gracilaria arcuata, Ceratodictyon spongiosum,* etc. -10.0 m
	Low belt	*Galaxaura rugosa*, *Peyssonnelia gunniana, Jania capillacea,* etc.

Most transects of the Con Co Special Administrative Region are often small in size, narrow in intertidal areas, and structured with tidal sandy substrates, which are not favorable for seaweed growth. Meanwhile, large subtidal areas (especially in shallow waters or submerged islands) with hard bottoms and clear water are ideal for seaweed growth. That is why Chlorophytes grow mainly in the subtidal areas of the Con Co Special Administrative Region.

The results in Table 5 show that in the intertidal zone, the high tidal range often encounters *Hydrocoryne enteromorphoides*, *Lyngbya majuscula*, *Ceramium deslongchampsii*, etc.; middle tidal range: *Lyngbya majuscula*, *Centroceras clavulatum*, *Acanthophora muscoides*, etc.; low tide range: *Gelidiella acerosa*, *Gelidium pusillum*, *Colpomenia sinuosa*, etc.; In the subtidal zone, the upper band is commonly found: *Hypnea pannosa*, *Chondracanthus intermedius*, *Ceratodictyon spongiosum*, etc. and the lower band is *Galaxaura rugosa*, *Peyssonnelia calcea*, *Peyssonnelia rubra,* etc.

The algal flora

The results presented in Table 2 show that 40 species of red algae (Rhodophyta), 36 species

of brown algae (Ochrophyta/Phaeophyta), and 20 species of green algae (Chlorophyta) were recorded in the Con Co Special Administrative Region. According to Cheney's ratio, calculated as (Rhodophyta + Chlorophyta)/Ochrophyta = (40 + 20)/36 = 1.66, the algal flora can be characterized as a mixed system. This value falls within the range indicating a transitional composition between tropical and temperate algal assemblages.

Discussion

Although Con Co is a relatively small island and the surveyed transects are geographically close to one another, considerable variation in macroalgal species richness was observed, ranging from 51 species at transect I to 76 species at transect IV. This difference can primarily be attributed to variations in substrate type and geomorphological structure rather than to spatial distance.

At transect IV, the intertidal zone is narrow and underlain by exposed bedrock, while the subtidal zone is relatively steep with a predominance of sandy substrate. Such conditions are generally less favorable for macroalgal settlement and growth, as sandy bottoms are unstable and provide limited attachment surfaces for algae. The steep slope further restricts habitat availability, reducing both species diversity and abundance.

In contrast, transect II features wide and relatively flat intertidal and subtidal zones, with bedrock as the dominant substrate. Hard substrates such as bedrock provide stable attachment surfaces, which are essential for the establishment and persistence of macroalgae. The gentle topography also enhances light availability and reduces physical stress, thereby supporting higher species richness and more diverse algal communities.

More broadly, large areas around Con Co Island consist of extensive flat bedrock platforms extending across both intertidal and subtidal zones. These conditions are highly conducive to macroalgal development and may support a greater diversity of species than currently recorded. Therefore, the present study likely underestimates the full macroalgal diversity of the area. Further comprehensive surveys, particularly in less accessible or previously unexplored habitats, are expected to reveal additional species and provide a more complete understanding of the algal flora in this region.

Conclusion

A total of 101 seaweed species were recorded from the surveyed transects in the Con Co Special Administrative Region, belonging to four phyla. Cyanophyta comprised 5 species (4.9%), Rhodophyta 40 species (39.6%), Ochrophyta (Phaeophyta) 36 species (35.6%), and Chlorophyta 20 species (20.5%). The Sørensen Similarity Index (SSI) among transects ranged from 52.63 to 78.14, with an average of 67.64, indicating a moderate to high similarity in species composition and reflecting a mixed algal flora. Species richness ranged from 51 to 76 per transect, averaging 63.8. Of the total recorded species, 19.8% were restricted to the intertidal zone, 43.6% to the subtidal zone, and 36.6% occurred in both zones, with most species concentrated from the lower intertidal to the upper subtidal zone. Taxonomic structure showed clear variation among phyla, with a total of 23 orders identified; Rhodophyta contributed the largest proportion (52.1%), followed by Ochrophyta (30.4%), Chlorophyta (13.2%), and Cyanophyta (4.3%). On average, there were 5.75 orders per phylum, 9.5 families per order, 12.25 genera per phylum, and 25.15 species per phylum. Notably, several species belong to economically important genera such as *Porphyra*, *Grateloupia*, and *Sargassum*, highlighting their potential applications in food, pharmaceuticals, and cosmetics.

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