

# Species diversity of the green macroalgal genus *Caulerpa* (Caulerpaceae, Chlorophyta) in the area of Ko Kut, Ko Chang, and nearby islands, Trat Province

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## Abstract

The preliminary survey of the Project “Species diversity and genetic resources assessment of the genus *Caulerpa* (Caulerpaceae, Chlorophyta) in Thailand for the principal conservation and sustainable utilization” was kicked off in Trat Province as representative of the upper part of the Gulf of Thailand. *Caulerpa*, some other seaweeds and seagrasses were sampled mainly by scuba diving in the area of Ko Kut, Ko Chang, and nearby islands, totaling ten sampling sites from 19–23 December 2022. Unfortunately, it seems like December is not the right season for *Caulerpa* sampling, hence, not many *Caulerpa* were found. Ko Kradad, Ko Khai Hua Ro, and Ko Mak were the only three sites that *Caulerpa* could be collected. Based on morphological characters solely, at least four *Caulerpa* species were identified. For better precision of species diversity in the genus *Caulerpa* in these areas, twenty *Caulerpa* voucher specimens were prepared, and twelve of them were sent for DNA extraction and molecular analysis. The molecular results are pending.

## Keywords

species diversity, *Caulerpa*, Trat, preliminary, Thailand

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## Introduction

The genus *Caulerpa* (Caulerpaceae, Chlorophyta) is one of the most distinctive genera of seaweeds by being identifiable solely based on its habits (Wakey and Bucol, 2014). The thallus, a nonseptate siphonous structure is composed of horizontal stolon anchored by colorless rhizoids, bearing erect photosynthetic fronds (assimilators) of extremely diverse morphology including thread-like, blade-like, pinnate, spongy and vesicular structures. *Caulerpa* contains more than 100 accepted species and is found throughout tropical and subtropical seas around the world (Guiry and Guiry, 2024). Many of them exhibit polymorphism, showing different growth forms in different habitats which makes them difficult to identify.

*Caulerpa* is among the most prolific and widespread group of seaweed. Some *Caulerpa* species, *C. taxifolia* for example, have invaded some marine waters such as in the Mediterranean, Australia, USA, and Europe due to the aquarium trade and caused ecological

and economic loss (Klein and Verlaque, 2008; Zubia *et al.*, 2020). On the other hand, some species of *Caulerpa* such as *C. lentillifera* and *C. racemosa* are farmed, consumed, and also exported to many countries, Philippines and Thailand, for instance. Regarding species diversity of the genus *Caulerpa* in Thailand, approximately 15 species were reported from both the Andaman Sea and Gulf of Thailand (Coppejans *et al.*, 2017).

The Trat site is located at the coastal zone of Trat Province in the Gulf of Thailand, bordering Cambodia. The province is the easternmost part of the country, covering 2,819 km<sup>2</sup> of land-area and 7,257 km<sup>2</sup> of sea-area with 165.5 km coastline. Trat is has been regarded as one of the richest coastal ecosystems in Thailand due to its high abundances of mangroves, coral reefs, as well as number of small and big islands (Munprasit *et al.*, 2020). Among those islands, Ko Kut and Ko Chang are the biggest two.

This is the preliminary survey of the “Species diversity and genetic resources assessment of the genus *Caulerpa* (Caulerpaceae, Chlorophyta) in Thailand for the principal conservation and sustainable utilization Project”. Ko Kut, Ko Chang, and some nearby islands were selected as the representatives of the upper Gulf of Thailand sites.

## Materials and Methods

### Field work

Collecting was carried out in Ao Salat, Ao Klong Chao, northwest of Ko Kut, Ko Rad and east of Ko Kut from 19–20 December 2022 and in Ko Klum, Ko Lao Ya, Ko Kradad, Ko Khai Hua Ro, and Ko Mak from 22–23 December 2022, totaling ten sites (Figure 1). The collection was done by SCUBA-diving in 3–7 m depth. *Caulerpa* and some other seaweeds and seagrasses specimens were collected, rinsed with seawater and stored in plastic bags by adding some salt to protect the plants from fouling. Small pieces of selected *Caulerpa* were kept in silica gel for DNA extraction and molecular analysis. Underwater photographs were taken if needed.



**Figure 1.** Research area.

### DNA extraction and molecular analysis

Silica gel specimens were sent to the Faculty of Fisheries, Kasetsart University for DNA extraction and amplification. PCR products were purified and subjected to commercial sequencing. The *tufA* gene (a partial section, ~ 950 bp) was chosen as it has been shown to have sufficient species-level resolution in the Bryopsidales, including *Caulerpa* (Kazi *et al.*, 2013; Vieira *et al.*, 2016; Darmawan *et al.*, 2021).

Individual sequences obtained in this study were compared to additional sequences retrieved from GenBank in order to produce the phylogeny of *Caulerpa*. *Caulerpella ambigua* was used as an outgroup as it was found to be the most basal taxon to all the *Caulerpa* species. A maximum likelihood (ML) tree was constructed by the bootstrap resampling method.

### Reference materials

After arrival in the laboratory, specimens were sorted and prepared as reference herbarium specimens. Seaweed and seagrass vouchers were deposited in the collection of the Thailand Natural History Museum (THNHM).

### Results and Discussion

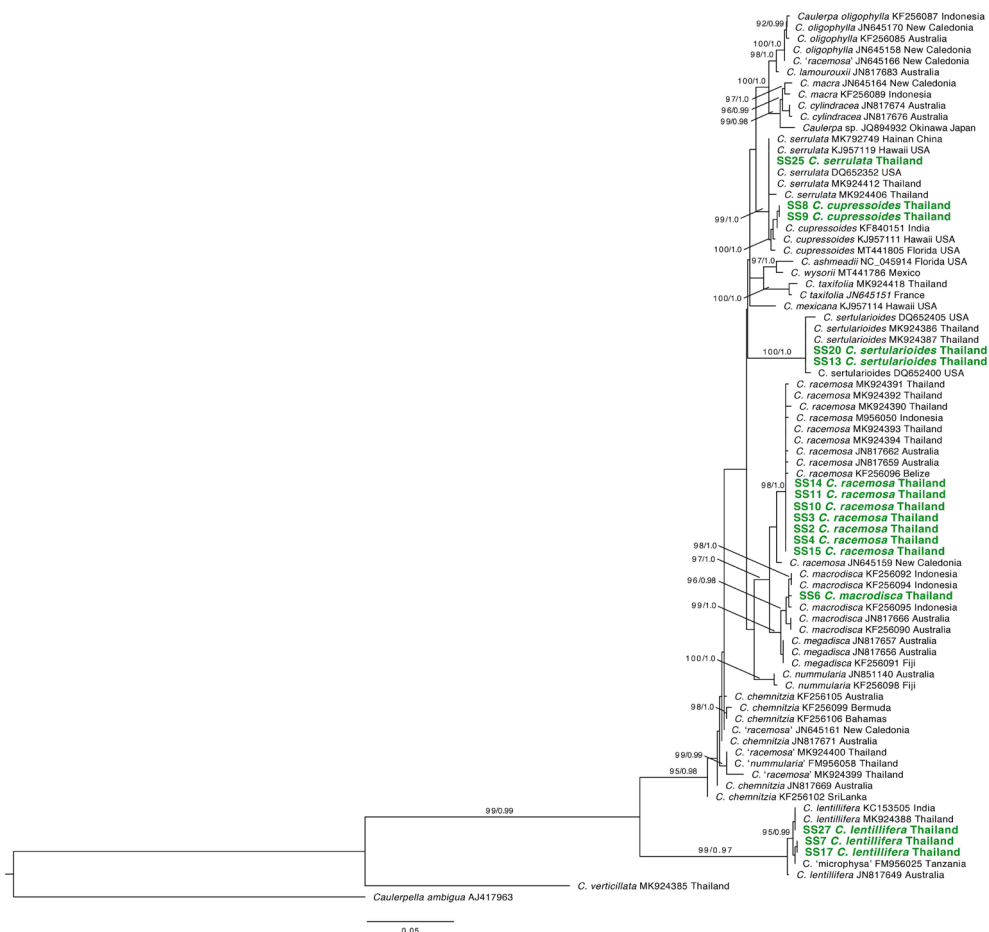
Regarding ten sampling sites (Figure 1), *Caulerpa* were found only in three sites: Ko Kradad, Ko Khai Hua Ro, and Ko Mak at the 3–5 m depth. Ko Kradad, Ko Khai and Ko Mak share common characteristics of the sites such as sandy seabeds with rocks and dead corals mainly occupied by brown seaweeds. *Caulerpa* species are known to occupy a range of environmental niches. Most of them are intertidal species. They attach to a hard substrate but can also grow in unconsolidated sand using their rhizoids (Zubia *et al.*, 2020; Darmawan *et al.*, 2021).



**Figure 2.** Underwater photographs of some *Caulerpa* species. **a)** *Caulerpa lentillifera* at Ko Kradad; **b)** *Caulerpa racemosa* at Ko Kradad; **c)** *Caulerpa serrulata* at Ko Khai Hua Ro; **d.** *Caulerpa sertularioides* at Ko Khai Hua Ro.

**Table 1.** Selected silica gel samples handling to DNA extraction and molecular analysis.

No.	Field Number	Catalog Number	Genus	Specific Epithet	Date Collected	Locality	District	Remarks
1	s408	THNHM-P-2022-0072	<i>Caulerpa</i>	<i>serrulata</i>	23 December 2022	Ko Kradad	Ko Chang	
2	s409	THNHM-P-2022-0073	<i>Caulerpa</i>	<i>lentillifera</i>	23 December 2022	Ko Kradad	Ko Chang	<i>tufA</i>
3	s409	THNHM-P-2022-0074	<i>Caulerpa</i>	<i>lentillifera</i>	23 December 2022	Ko Kradad	Ko Chang	
4	s410	THNHM-P-2022-0075	<i>Caulerpa</i>	sp.	23 December 2022	Ko Kradad	Ko Chang	
5	s421	THNHM-P-2022-0087	<i>Caulerpa</i>	<i>racemosa</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	<i>tufA</i>
6	s422	THNHM-P-2022-0088	<i>Caulerpa</i>	<i>racemosa</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	<i>tufA</i>
7	s423	THNHM-P-2022-0089	<i>Caulerpa</i>	<i>racemosa</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
8	s424	THNHM-P-2022-0090	<i>Caulerpa</i>	<i>serrulata</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
9	s425	THNHM-P-2022-0091	<i>Caulerpa</i>	<i>serrulata</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
10	s426	THNHM-P-2022-0092	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
11	s426	THNHM-P-2022-0093	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
12	s426	THNHM-P-2022-0094	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
13	s439	THNHM-P-2022-0105	<i>Caulerpa</i>	<i>serrulata</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
14	s440	THNHM-P-2022-0106	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
15	s441	THNHM-P-2022-0107	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Khai Hua Ro	Ko Chang	
16	s448	THNHM-P-2022-0114	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Mak	Ko Chang	<i>tufA</i>
17	s449	THNHM-P-2022-0115	<i>Caulerpa</i>	<i>serrulata</i>	23 December 2022	Ko Mak	Ko Chang	<i>tufA</i>
18	s450	THNHM-P-2022-0116	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Mak	Ko Chang	
19	s450	THNHM-P-2022-0117	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Mak	Ko Chang	
20	s450	THNHM-P-2022-0118	<i>Caulerpa</i>	<i>sertularioides</i>	23 December 2022	Ko Mak	Ko Chang	



**Figure 3.** ML tree based on *tufA* sequence data.

Morphological characters and molecular analysis (Figures 2–3, Table 1) support four *Caulerpa* species including *Caulerpa lentillifera*, *Caulerpa racemosa*, *Caulerpa serrulate*, and *Caulerpa sertularioides* from Trat. Basically, most *Caulerpa* were identified by the differences in gross morphology of fronds, stolons, and rhizoids with the form and size of ramuli. Within the *Caulerpa*, the most taxonomically troublesome taxa are those currently associated with *C. racemosa* (Belton *et al.*, 2014). However, only four specimens initially identified as *C. racemosa* were collected with solely *tufA* (plastid elongation factor) sequence data support. *tufA* has been selected as the DNA barcode marker for the genus *Caulerpa* (Belton *et al.*, 2014; Darmawan *et al.*, 2021). However, *tufA* alone is not variable enough to resolve all *Caulerpa* species relationships. Rubisco large subunit (*rbcL*) is the other marker purposed for *Caulerpa* species identification. The *rbcL* result of this preliminary survey is pending.

According to personal interviews from local people in Ko Kut and Ko Chang, *Caulerpa* can be found nearby at all sites selected especially in the hot season or between March to April. Hence, December is not the right season for *Caulerpa* sampling. For better understanding regarding species diversity of the genus *Caulerpa* in Thailand, more sampling sites covering both the Gulf of Thailand and Andaman Sea are necessary. Moreover, molecular analysis using appropriate *Caulerpa* DNA markers is needed.

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## References

- Belton, G.S., W.F. Prud'homme van Reine, J.M. Huisman, S.G.A. Draisma C.F.D. Gurgel. 2014. Resolving phenotypic plasticity and species designation in the morphological challenging *Caulerpa racemose-peltata* complex (Chlorophyta, Caulerpaceae). **Journal of Phycology** 50: 32–54.
- Coppejans, E., A. Prathep, K. Lewmanomont, K. Hayashizaki, O. De Clerck, F. Leliaert and R. Terada. 2017. **Seaweeds and Seagrasses of the Southern Andaman Sea coast of Thailand**. The Kagoshima University Museum. Japan. pp. 244.
- Darmawan, M., N.P. Zamani, H.E. Irianto and H. Madduppa. 2021. Molecular Characterization of *Caulerpa racemosa* (Caulerpales, Chlorophyta) from Indonesia Based on the Plastid *tufA* Gene. **SQUALEN BULLETIN** 16(3): 101–109.
- Guiry, M.D. and G.M. Guiry. 2023. **AlgaeBase. World-wide electronic publication, National University of Ireland, Galway**. Downloaded from <http://www.algaebase.org>; searched on 23 December 2023.
- Kazi, M.A., C.R.K. Reddy and B. Jha. 2013. Molecular Phylogeny and Barcoding of *Caulerpa* (Bryopsidales) Based on the *tufA*, *rbcl*, *18S rDNA* and *ITS rDNA* Genes. **PLOS ONE** 8(12): 1–13.
- Klein, J. and M. Verlaque. 2008. The *Caulerpa racemosa* invasion: A critical review. **Marine Pollution Bulletin** 56: 205–225.
- Munprasit, R., P. Nootmorn and K. Loychuen. 2020. **Technical Report Fisheries Refugia Profile for Thailand: Trat**. Department of Fisheries. Thailand. pp. 37.
- Vieira, H.H., I.L. Bagatini, C.M. Guinart and A.A.H. Vieira. 2016. *tufA* gene as molecular marker for freshwater Chlorophyceae. **Algae** 31(2): 155–165.
- Wagey, B.T. and A.A. Bucol. 2014. A Brief Note of Lato (*Caulerpa racemosa*) Harvest at Solong-on, Siquijor, Philippines. **Journal Budidaya Perairan** 2 (1): 46–51.
- Zubia, M., S.G.A. Draisma, K.L. Morrissey, E. Varela-Álvarez and O.De. Clerck. 2020. Concise Review of the genus *Caulerpa* J.V. Lamouroux. **Journal of Applied Phycology** 32: 23–39.

