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Morphological characteristics of soft coral *Sarcophyton serenei* (Tixier-Durivault, 1958) in Nha Trang Bay

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ABSTRACT

Soft corals are integral components of tropical coral reef ecosystems, contributing significantly to biodiversity and providing substantial economic value as ornamental organisms and sources of bioactive compounds. As such, accurate classification of soft coral species is essential for the sustainable management and exploitation of these resources. Sarcophyton serenei, a soft coral species found in Nha Trang Bay, is commercially important for the marine ornamental trade and the extraction of bioactive substances. This species is characterized by a bright yellow-brown to gray-brown coloration, short and semi-contracted polyps, and a smooth capitulum with numerous folds along the periphery of the disc. The surface of the disc is rough and lacks mucus secretion, distinguishing it from other species in the genus Sarcophyton. The morphological characteristics of the sclerites, including those from the anthocodiae, tentacles, capitulum, and stalk were examined and found to match the descriptions provided by Tixier-Durivault (1958) and Dautova & Savinkin (2013), with some minor differences from the classification key of Verseveldt (1982). Scanning electron microscopy (SEM) was applied to study the surface features of the sclerites, revealing detailed structures such as warts, spines, and granules. Additionally, rDNA ITS2 sequencing was used to identify the coral's algal endosymbionts, which belongs to the genus Symbiodinium, specifically clade C. The nucleotide sequence analysis showed minimal variation among the symbionts, indicating a high degree of similarity within this clade. These findings contribute to the broader understanding of S. serenei and its ecological role in coral reef ecosystems, while also supporting the need for effective conservation and sustainable utilization strategies.

Keywords: Sarcophyton serenei, soft coral, morphological characteristics, sclerite, symbionts clade.

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INTRODUCTION

Soft corals are essential to tropical coral reef ecosystems, enhancing biodiversity and providing economic benefits as ornamental species and bioactive compound sources. Accurate species classification ensures sustainable management. The genus *Sarcophyton* (Anthozoa: Octocorallia: Malacalcyonacea: Sarcophytidae) is found in tropical waters, including the Pacific, Indian Oceans, and the Red Sea [1]. In Nha Trang Bay, Vietnam, the diversity of soft corals is recorded with 76 species belonging to 20 genera and 9 families, including the genus Sarcophyton [2].

Sarcophyton serenei, with a mushroom-shaped morphology, is distinct for its large stalk sclerites with pointed ends [3]. It has been recorded in Nha Trang Bay [3–5], Ly Son island [6] and the Suez Gulf [7]. Previous taxonomic studies on the sclerites of *S. serenei* have only provided descriptions and illustrations based on observations using conventional light microscopy [3, 5]. To date, SEM has not been used to examine *S. serenei*, though it offers detailed observation of sclerite morphology, improving taxonomic clarity [1, 8].

Soft corals host *Symbiodinium* zooxanthellae, divided into seven clades (A–G) based on genetic and physiological traits [9]. Symbiotic clades affect coral adaptation; *Sarcophyton* species typically associate with clade C, but other clades (A, B, D, F) have been reported [10, 11]. No data exist on *S. serenei* symbionts. Therefore, in this study, we conducted genetic sequencing of symbiotic algae in the coral, combined with sclerite morphology analysis using both traditional morphological descriptions and scanning electron microscopy (SEM). This approach aims to clarify the morphological characteristics of the soft coral *Sarcophyton serenei*, provide taxonomic data for this species, and enhance our understanding of its symbiotic relationships.

MATERIALS AND METHODS

Coral morphology analysis by external shape

A total of 210 suspected colonies of *Sarcophyton serenei* were collected by SCUBA diving at depths of 3–8 m at locations around Hon Cut Chim area in Nha Trang Bay, coordinates 12°15’55.9”N - 109°13’29.3”E and 12°17’11.0”N - 109°13’15.0”E. Corals were photographed by using a Ricoh WG-6 waterproof camera. External descriptions of color, colonies shape, polyps, stalks, and capitulums were documented through underwater photographs based on the classification keywords outlined [3, 5, 12]. At the same time, these coral colonies were also separated into subsamples for morphological analysis and genetic analysis of the symbiotic algae group.

Coral morphology analysis by morphology and size of the sclerites

Morphology of sclerites on optical microscope

Sarcophyton coral colonies were collected and preserved in 70% ethanol. To describe the morphology of sclerites, these sclerites were extracted by dissolving tissues in 10% sodium hypochlorite, followed by rinsing with double-distilled water [13]. The sclerites were carefully washed with double-distilled water and examined under an Olympus BX51 optical microscope. Sclerites from different organs, including polyps (tentacles, anthocodia), caps (surface, interior), and stalks (outer layer, interior), were photographed and measured directly under the microscope using software connected to the microscope camera.

Morphology of sclerites on scanning electron microscope (SEM)

After the coral samples were examined and identified under an optical microscope, the sclerites from the *Sarcophyton serenei* samples (collected from 5 positions as in the optical microscopy examination method: polyps, caps and stalks) were preserved in 70% ethanol and sent to the Ho Chi Minh City Biotechnology Center for morphological analysis using a scanning electron microscope (SEM).

Identification of the Zooxanthellae symbiotic algae clade on corals

15 coral tissue samples collected from the *S. serenei coral colonies* were fixed in 70%

alcohol. The coral tissue samples were cut into small pieces of about 20 mg and the extracted DNA was extracted using the Qiaprep Spin Miniprep kit (Qiagen, Germany) according to the manufacturer's instructions [11]. After extracting total DNA from the samples, the ITS2 gene segment was amplified using two primer pairs: zITSf (5'-CCGGTGAATTATTCGGACTGACG CAGT-3'); ITS4 (5'-TCCTCCGCTTATTGATATGC-3'), PCR reaction conditions: in the reaction mixture including 5 µL 5X My Taq reaction buffer, 0.5 µL My Taq polymerase; 0.5 µL primer zITSf (5'-CCGGTGAATTATTCGGACTGACG CAGT-3'); 0.5 µL ITS4 (5'-TCCTCCGCTTATTGATA TGC-3'), 2 µL template DNA and 16.5 µL H_2O solution [14, 15]. PCR products were checked for presence and quality of PCR products on agarose gels stained with 1% ethidium bromide in 1X TBE buffer at 100V, 400A and for 30 minutes. Use DNA Marker 100 bp Plus blue 1,500 bp ladder (GeneOn GmbH, Germany) to determine product size. The size of the PCR product amplifying the 16S rDNA gene will give a band of nearly 700 bp. Sequencing results were displayed and processed using Geneious 8.1 software. Species identification was then performed using the BLAST search program (https://blast.ncbi.nlm.nih.gov/Blast.cgi) to compare with the gene source on Genbank of the National Center for Biotechnology Information (NCBI).

Data processing method

Morphological assessment, sclerites size (length and width) of *S. serenei* were determined using ImageJ. Species identification and phylogenetic analysis of the symbiotic algae clade associated with the coral were conducted using Geneious 8.1 and BLAST software.

RESULTS AND DISCUSSION

Morphological characteristics of coral

External morphology of coral

A total of 210 soft coral colony specimens collected from Nha Trang Bay were examined for external morphology and sclerites to classify and identify the species *Sarcophyton serenei*. After comparing and examining the sclerites, 35 colonies were classified with recorded external morphology belonging to the species *S. serenei* (accounting for 16.67%) with 2 different color patterns. Of which, the bright yellow-brown color accounted for the majority at 82.85% and gray-brown color represented 17.14%. The results of the classification of external morphology of *S. serenei* are recorded in Figure 1, Table 1.

Figure 1. Morphology of *S. serenei*. (a) polyps with extension; (b) polyps are not contracted

The external morphology of *S. serenei coral* includes some detailed characteristics according to Table 1. Natural corals are bright yellow-brown or gray-brown, but after being transferred to indoor tanks, they turn brown. This suggests that the coral's color can change according to the living environment. Corals living in tanks with a water level of about 40–50 cm, experience higher light levels compared to the ocean. This difference in light intensity may cause the symbiotic algae to adapt to the new conditions, potentially altering their photosynthesis and chlorophyll content, so the color of corals can be affected.

Table 1. Some external morphological characteristics of soft coral *S. serenei* in studies

Characteristic	Tixier-Durivault (1958) [3]	Verselveldt (1982) [12]	Dautova & Savinkin (2013) [5]	This study
Capitulum diameter (cm)	13–24	18		17–20
Stalk diameter	10 cm			10–12 cm
Distance of autozooids, number of siphonozooids; Cap center	4 mm; 8–10 siphonozoids	2–4 mm; 6–7 siphonozoids	6–8 siphonozoids	2–4 mm; 6–8 siphonozooids (near); 8–10 siphonozooids (distal)
Cap edge	2.0 mm; 1–2 siphonozoid	1.5–2.0 mm; 1–2 siphonozoid	1–3 siphonozoid	1.5–2.0 mm; 1–2 siphonozoid
Color	brown		yellow-gray, the upper part of the polyp is light beige.	Bright yellow brown HEX color # 9c8162, RGB (156,129,98); CMYK (0,17,37,39); gray brown HEX color # b9aba8, RGB (185,171,168)
Polyp characteristics	Almost no retraction inwards	Most do not retraction inward		Short, not fully retracted. Pale white, remaining unexpanded
Polyp height	about 6 mm	about 6 mm		5.76 ± 0.195 mm
Cap features	Smooth in the middle and has little folded at the edge of disc		funnel-shaped, thin disc edges with many folds	not round, there are many folds around the margins
Stalk features	Low, wide			Short and wide stalk with no definite shape

The distance between two autozooids in the center and the edge of the disc was observed (Fig. 2). The distance between the autozooids in the central of the capitulum is 2–4 mm, and the number of siphonozooids varies depending on the criteria used. The nearest and farthest autozooids have 6–8 and 8–10 siphonozooids, respectively. At the cap edge, the distance is only 1–2 siphonozooids. Verselveldt (1982), suggested that the distance between autozooids and the number of siphonozooids near the margin are not taxonomically significant [12]. However, in the central part of the disc, they may serve as a criterion for classification. Additionally, the measurement of the distance between autozooids lacks standardized or consistent guidelines; hence, calculating the number of siphonozooids is always an approximation [12]. According to the classifications by Tixer-Durivault (1958) and Verselveldt (1982), there was a difference in the number of siphonozooids at the center of the disc, with 8–10 siphonozooids [3] and 6–7 siphonozooids [12]. Therefore, we propose that determining the distance between two autozooids should be based on the distance between the two closest autozooids.

The height of the anthocodia of the polyp of *S. serenei* is about 4–6 mm (5.76 ± 0.195 mm), which is significantly shorter than those of the soft coral *Sarcophyton glaucum* (which can be up to 2–3 cm long [12]. Notably, the autozooids do not fully retract and the polyp tentacles are pale white, remaining unexpanded.

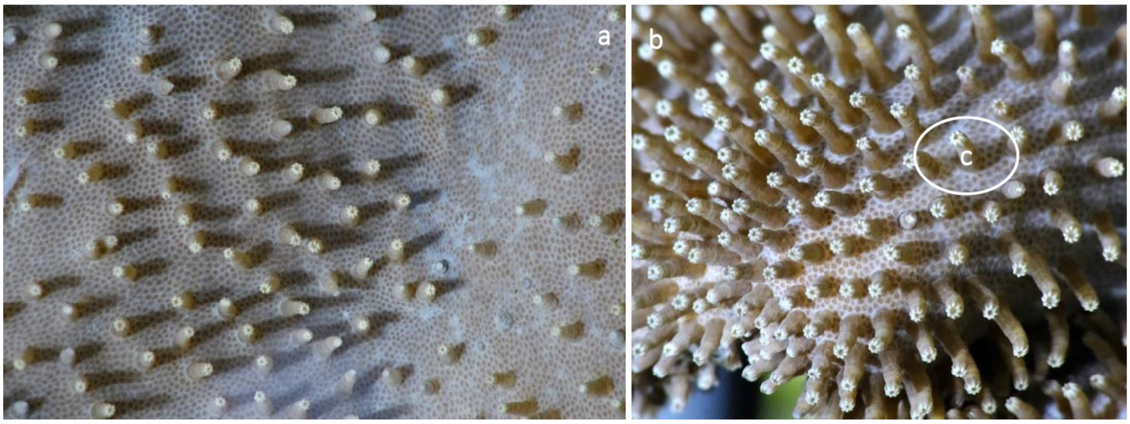

Figure 2. Autozooids and siphozooids at the capitulum margin and center of *S. serenei*. (a) cap center; (b) at the cap margin; (c) anthocodia

In terms of external morphology, color, and polyp characteristics of the coral *S. serenei* in this study are generally similar to the taxonomic features described [3, 5, 12]. However, the number of siphonozooids between autozooids at the center of the coral's disc in the studied varies depending on the method of determination. It may be fewer [5, 12] or more, which would be similar to the Tixier-Durivault's (1958) classification [3].

Characteristics of coral sclerites by optical microscope

Sarcophyton soft corals, sclerites are observed in 05 main positions: the surface layer of the stalk, the stalk interior, the surface of the disc, the disc interior and the polyps. In which, the shape and size of each sclerites at these position are important criteria for classifying species of soft coral, particularly *Sarcophyton serenei*.

The arrangement and size of the sclerites on the coral polyps anthocodia also vary depending on the species. The anthocodia sclerites are rod-shaped and relatively long, reaching up to 0.6 mm, and they are tightly arranged in a V-shaped pattern. Near the polyp tentacles, they become shorter, smoother, and aligned horizontally. The anthocodia sclerites in this study are longer than those described in the Verselveldt's (1982) classification (about 0.4 mm) [12].

The surface layer of the capitulum contains two types of club-like clerites: Type 1 consists of very small, club-shaped clerites with a constriction at the head and handle of the sclerite, measuring from 0.05–0.098 mm (0.074 ± 0.024 mm), the club heads are not smooth but has a spiny, angular shape that protrudes like a volcanic cone, which is a prominent feature of the coral *S. serenei*. The other type is larger club-like clerites, measuring 0.20 ± 0.035 mm in length, without a constriction in the middle. One end of the club is larger leaf-shaped, while the other end is pointed, featuring flattened, volcanic-shaped parts. The size and shape of the small clubs are quite similar to the Verselveldt's (1982) classification (from 0.06–0.10 mm) [12], however, the large clubs are shorter in length than the classification key (0.38 mm). Inside the cap, the clerites are needles-like, with pointed or slightly curved heads with larger needle, mainly measuring from 0.5–0.6 mm (0.51 ± 0.07 mm). Some are club-shaped with one large end and one pointed end.

The sclerites in the surface layer of the stalk have a shape similar to those in the capitulum surface but are slightly larger (0.12 ± 0.05 mm). The spicules in the stalk are particularly special is a distinguishing feature from other *Sarcophyton* species. These sclerites are straight or curved pointed spindles, very long up to 1.22 ± 0.17 mm (the majority of sclerites are approximately 1.2 mm long) and 0.22 ± 0.00 mm wide. Compared to *S. glaucum*, there are also large in the stalk spicules ranging from 1.3 to 2.3 mm long, up to 2.60 mm, but the width of this spicules is narrower than that of *S. serenei*. Additionally, these sclerites of *S. glaucum* can be branched [12], whereas those of *S. serenei* are thicker and straighter. Moreover, on the surface of *S. serenei* stalk sclerites features shorter and rougher warts than those of *S. glaucum*. Overall, the classification of this coral based on Verselveldt's (1982) description has confirmed the presence of all types of sclerites, however, there are also differences. A newly identified sclerite type was found, characterized by a pointed, elongated body with simple and less rough warty projections. That is, a type of spindles simple warts with little roughness, located at the junction between the covering and the interior of the stalk (0.61 ± 0.04 mm). This sclerite is not described in Verselveldt's (1982) classification [12]. Comparing these sclerite characteristics with those described of Tixer-Durivault (1958) and Dautova & Savinkin (2013) is completely similar. This type of sclerite was mentioned in their works, but its size was not reported [3, 5].

Characteristics of coral sclerites by scanning electron microscopy (SEM)

Similar to observations under a light microscope, SEM imaging also revealed all types of sclerites at the five locations of the coral. In the coral-polyp tentacle, the sclerites have a flattened scale, slightly curved, 0.106 ± 0.029 mm in length (Fig. 3a). In anthocodia, the sclerites are rod-shaped (0.29 ± 0.028 mm) (Fig. 3b - black arrow). These sclerites size are similar to the previous classifications [5, 12].

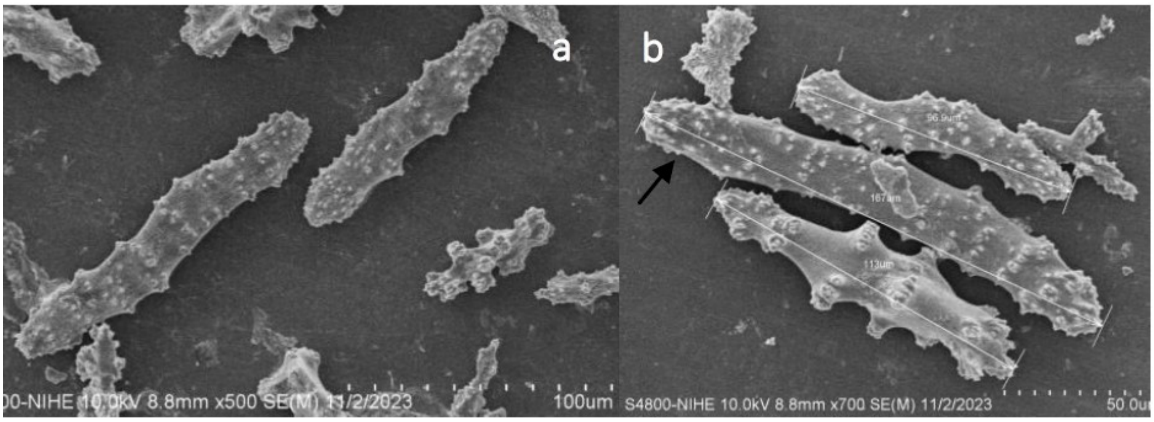

Figure 3. Sclerites in *S. serenei* polyps. (a) in tentacles; (b) in anthocodia

In the descriptions by Verseveldt (1982), the coral disc surface contains two types of of club-shaped sclerites, one end was leaf-shaped, with a rough, volcanic surface and the other end was smoother [12]. SEM images also reveal the same two types of spicules on the disc surface, consistent with the findings observed under the light microscope. The longer club without a constriction, with a non-smooth shaft and warts at the head were clearly observed in the SEM images (Figs. 4a, 4b). The small club-shaped sclerites measure approximately 0.089 ± 0.011 mm in length, while the larger club-shaped spicules have a length of 0.24 ± 0.05 mm. The small club were approximately 0.089 ± 0.011 mm in length, while the larger club were 0.24 ± 0.05 mm in length. The interior of the capitulum, the sclerites are straight or slightly curved, taking the form of rods and needles. Most are straight needle sclerites (0.4–0.5 mm). However, we recorded some needle with lengths reaching up to approximately 0.6 mm (Fig. 4c). This is quite similar to the Tixier-Durivault's (1958) and Verselveldt's (1982) descriptions, which reported lengths of 0.4 mm and 0.5 mm, respectively.

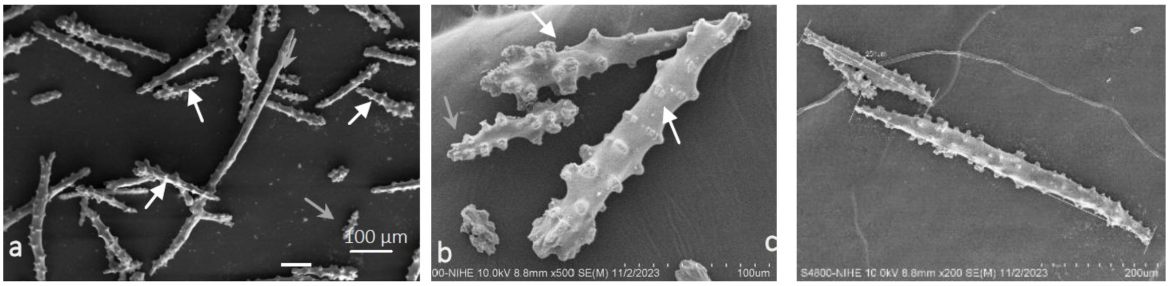

Figure 4: SEM images of sclerites on the disc surface of *S. serenei* coral. a, b: small club (black arrow) and large club (white arrow); c: inside the coral capitulum

In the outer layer of the stalk, the sclerites are club-shaped with a constriction in the middle and with warts on the surface (similar to those found in the cap surface), with a length of 0.15 ± 0.08 (Fig. 5a, black arrow). Compared to other description, these sclerites are quite similar to this result (0.06–0.16 mm and up to 0.23 mm long) [12]. However, according to Dautova & Savinkin (2013), these club-shaped sclerites can be up to 0.45 mm long [5].

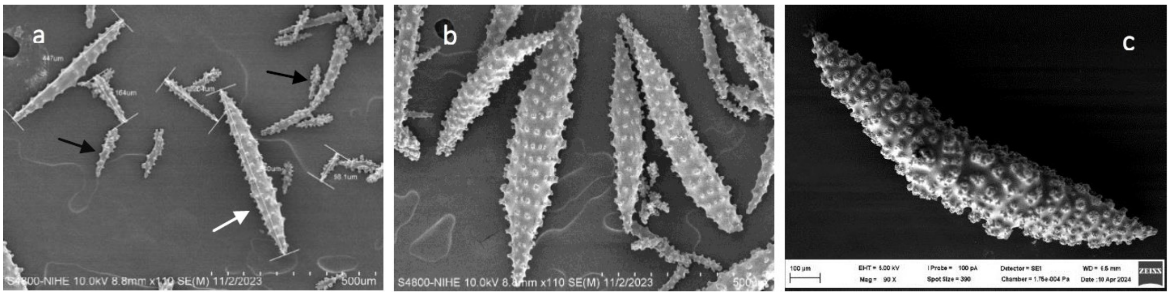

Figure 5. Sclerites in coral stalk. (a) club-shaped sclerites in the stalk outer layer (black arrow), spindles at the junction between the covering and the interior (white arrow); (b, c) in the stalk

The sclerites inside the stalk are quite distinct from those at other locations (Figs. 5b, 5c). These are pointed, straight, or slightly curved spindles, approximately 1.20 mm long (99.41 ± 15.82 µm), 0.28 ± 0.31 mm in width, and covered with small, irregular warts (Fig. 5c). Compared to other classifications of *S. serenei*, these spindles were described up to 1.7 mm [12] and 1.5 mm long [5], and 0.32 mm wide, but in our study we did not observe spindles reaching these lengths. However, the results of sclerites analysis in this study align with Tixier-Durivault's (1958) findings, indicating that sclerites within the stalk measure approximately 1.2 mm long and 0.26 mm wide [3]. Additionally, besides the distinctive large sclerites within the coral stalk, pointed, elongated spindles with less rough warts were also found, as described in the light microscopy analysis. As mentioned, these sclerite were not included in the taxonomic Verselveldt's (1982) description [12], but previous classifications have described this type of sclerite, providing descriptions but without specifying exact dimensions [3, 5]. SEM imaging revealed that these sclerite (0.68 ± 0.08 mm) and located at the junction between the stalk's surface layer and its interior (Fig. 5a, white arrow). The bumps on these sclerites are sharp and less rugged compared to those on the sclerites found deeper within the stalk.

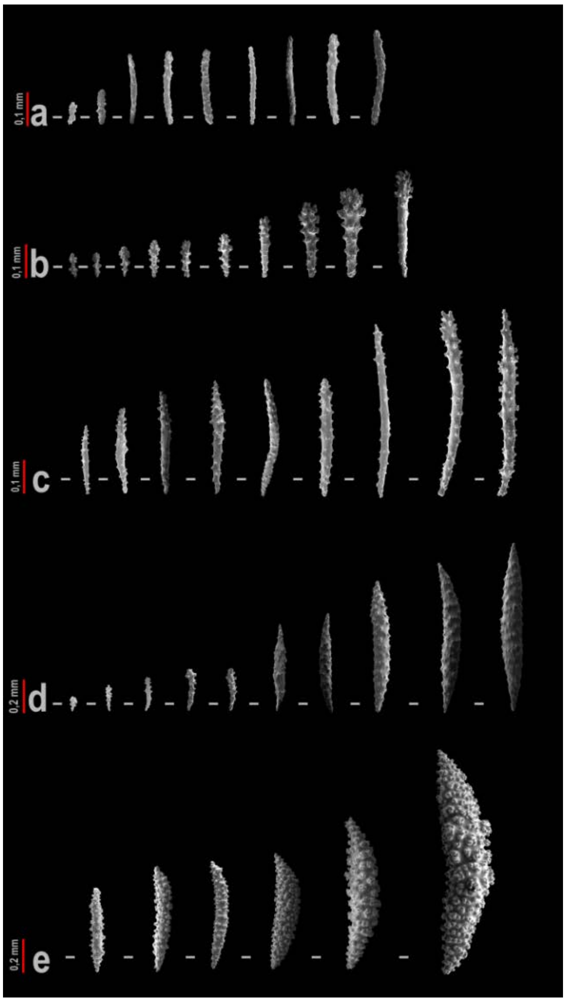

Figure 6. Sarcophyton serenei sclerites imaged by scanning electron microscopy-SEM. (a) sclerites in the tentacles, anthocodia of poplyp; (b) disc surface; (c) interior the disc; (d) stalk outer layer; (e) stalk interior

Through the examination and analysis of over 210 samples of the soft coral *Sarcophyton*, the classification of *S. serenei* has been compiled, with a description of its sclerites under scanning electron microscopy (SEM), as shown in Figure 6. This is the first data on the classification of *S. serenei* at the SEM image level, contributing a small part to the coral species classification information data. Overall, the sclerites samples of *S. serenei* in this study have some common observations regarding the quantity and morphology consistent with the classifications [3, 5, 12]. Notably, the morphological characteristics of *S. serenei* sclerites identified in this study closely resemble those described in previous research [3, 5], with minor differences from the other classification [12].

Symbiotic algae layer with soft coral *S. serenei*

S. serenei coral samples identified through morphological examination were sent for sequencing of the symbiotic algae gene segment to identify the group of algae symbiotic with this coral. Through analysis using Geneious 8.1 software and species identification using the BLAST program (https://blast.ncbi.nlm.nih.gov/Blast.cgi), the symbiotic algae gene sequences on NCBI's Genbank were compared and a phylogenetic tree of the symbiotic algae on the soft coral *S. serenei* was constructed (Fig. 7).

Phylogenetic analysis of the symbiotic algal samples showed that the NTS1, NTS2 and NTS3 symbiotic algal samples had 100% genome homology with each other, while the NTS9–NTS13 and NTS8–NTS10 pairs also showed 100% homology. In general, the NTS1 to NTS15 symbiotic algal samples had almost identical ITS2 gene sequences, differing only a few nucleotide pairs, with homology ranging from 98.24–99.80%. The obtained gene sequences were identified as belonging to the *Symbiodinium* clade C group. In particular, the NTS1-NTS3 samples had 100% homology with the *Symbiodinium* sp. C90 strain (AF427469) isolated from the hard coral *Montipora verrucosa* [20]. In addition, samples NTS8 and NTS10 had 99.80% similarity with C90 (AF427469) and 99.61% similarity with *Symbiodinium* sp. C90 (EU828670) isolated from foraminifera [22]. The sequencing results in this study are consistent with studies on coral species of the genus *Sarcophyton* from various geographical regions, where the majority of symbiotic algae were identified as belonging to clade C [23–30]. However, studies on *S. glaucum* have detected the presence of symbiotic algae belonging to clades B, C, D, E [11] or clade A [10, 31].

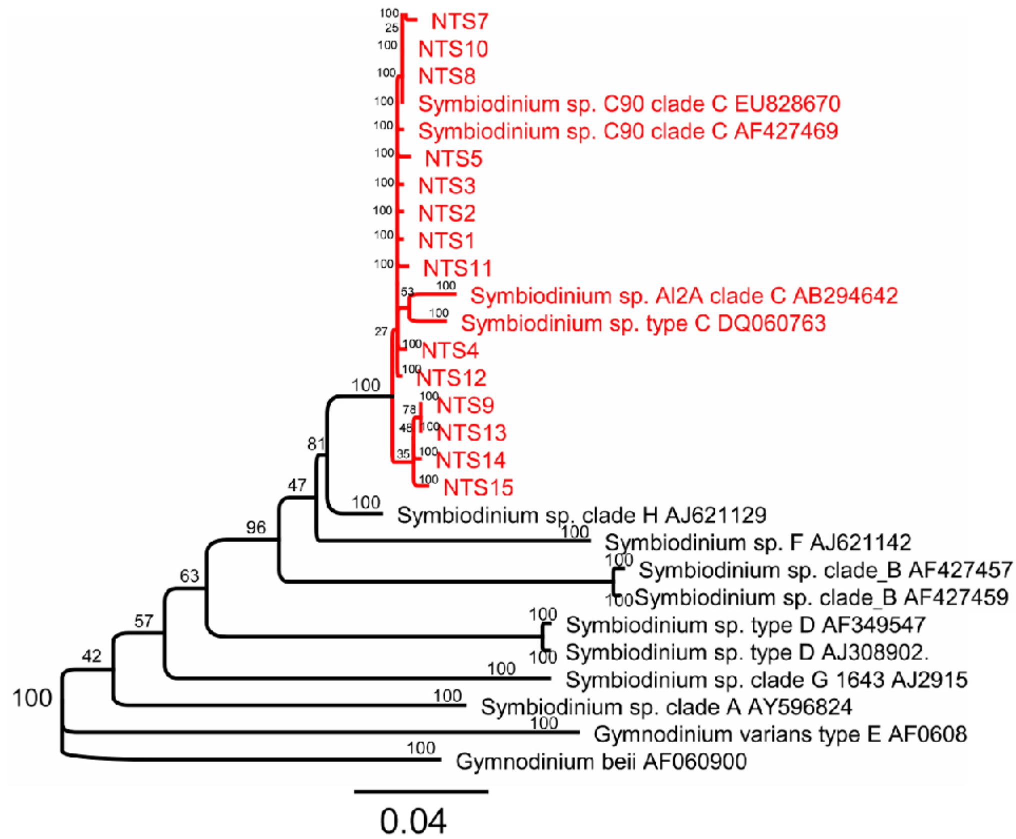

Figure 7. Phylogenetic diagram constructed by the Maximum Likelihood-ML method based on the rDNA ITS2 of Symbiodinium strains. The reference branches belong to the AH clade [16–21] and an outgroup organism (*Gymnodinium beii*) was used as the outgroup in the analysis (GenBank accession number is shown in the figure). Numbers at the nodes represent bootstrap values from 100 replicates and Bayesian posterior probabilities (in percentages). Species shown in bold red are the samples sequenced in this study

The results of the study using the ITS2 gene in this study showed that symbiotic algae belonging to the *Symbiodinium* clade C group were dominant in coral samples collected from Nha Trang sea. Compared to previous studies, clade C was also commonly recorded on coral reefs in other tropical seas such as the Pacific, Indian Ocean and Caribbean Sea when using the ITS2 marker [27, 32]. However, other molecular markers such as 18S rRNA, cp23S, or psbA have also been widely used to assess the diversity and phylogenetic relationships of *Symbiodinium*. The 18S rRNA marker was used to identify *S. goreaui* in Cu Lao Cham, giving similar results on the dominance of clade C on soft corals [33]. In addition, cp23S and psbA markers, commonly used to study the physiological properties and thermal tolerance of symbiotic algae, have shown that some subspecies of clade C, such as C3 and C15, are more heat tolerant when compared to other algal groups [34, 35]. This adds further evidence for the adaptive role of clade C under tropical environmental conditions and climate change. In other tropical regions such as the Great Barrier Reef, shift of symbionts from clade C to clade D under high temperature conditions using ITS2 and cp23S as markers

[36]. This is an important demonstration of the adaptive capacity of corals through disturbance of symbiotic algal communities. The results of this study in Nha Trang waters, combined with studies using various markers, further clarify the prevalence of clade C and its role in the environmental adaptability of corals.

In order to accurately determine the phylogenetic relationships of *Symbiodinium symbiotic algal lineages* in addition to the ITS2 marker, it is necessary to combine other molecular markers such as the 18S rRNA gene and cp23S from the chloroplast genome to classify and clarify the evolutionary relationships at the clade and species levels. Markers such as psbA and rbcL have also been proven effective in studying ecological adaptation and distinguishing symbiotic algal lineages under different environmental conditions. In addition, whole genome sequencing (WGS) and RNA-seq studies will provide comprehensive information on the genome and functional gene expression, thereby improving the resolution of the phylogenetic tree. In addition, the application of microsatellite markers can help assess genetic diversity at the lineage level within the same symbiotic algal clade. Combining Bayesian and Maximum Likelihood (ML) analysis with various markers will improve the reliability of phylogenetic analysis. Finally, studies of adaptive gene expression under environmental stress conditions such as high temperature or high light will shed light on the evolutionary role and adaptive capacity of *Symbiodinium* lineages, contributing to a better understanding of the symbiotic relationship between algae and corals.

The results of this study have important implications for the conservation of corals and tropical marine ecosystems. The identification of symbiotic algal strains belonging to clade C and the high level of similarity between samples contribute to a better understanding of the genetic diversity of *Symbiodinium* in Nha Trang waters. This provides a scientific basis for assessing the adaptive capacity of coral communities to the pressures of climate change, especially temperature increases and coral bleaching. Specifically, symbiotic algal clades such as clade C are able to adapt to different temperature and light ranges, while clade D shows better heat tolerance, helping corals survive in harsh environmental conditions. Therefore, detecting and monitoring the presence of heat-sensitive and heat-tolerant symbiotic algal groups can help predict the resilience of local coral reefs when heat stress occurs. In addition, the genetic information obtained from this study can be used to develop conservation strategies such as breeding coral species that are able to live with heat-tolerant algae, thereby increasing the resilience of coral reefs. At the same time, expanding the study with other molecular markers and combining it with metagenomics technology will further clarify the relationship between corals and symbiotic algae, supporting coral reef restoration programs and sustainable conservation of marine biodiversity.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The soft coral *Sarcophyton serenei* in this study has some external morphological characteristics, such as bright yellow-brown to gray-brown, with the cap having numerous folds at the periphery and smooth at the center. The surface of the cap is rough and does not secrete mucus. The distance between the autozooids in the central region is 2–4 mm, and the number of siphonozooids varies depending on the criteria used. The nearest and farthest autozooids have 6–8 and 8–10 siphonozooids, respectively. At the capitulum edge, the distance is 1–2 siphonozooids. The coral polyp is short (4–6 mm) and does not fully retract. The morphological characteristics of sclerites, according to the classification methods of Tixier-Durivault (1958), Verselveldt (1982) and Dautova & Savinkin (2013) have identified various types of sclerites across five organs, providing clearer images and descriptions of the species under optical microscopy and the first scanning electron microscope (SEM) images. The main diagnostic feature of *S. serenei* is the straight spindles in the stalk, which are large in both length and width (over 1.2 mm long and over 0.3 mm wide), small warts on the sclerites's surface. Additionally, SEM images of sclerite at the junction between the outer layer and in the stalk, which was missing in Verselveldt's (1982) classification.

The rDNA-ITS2 sequences of the symbiotic algae have been identified as *Symbiodinium* sp., showing similarities belonging to clade C.

Recommendations

Currently, the classification of the soft coral *Sarcophyton serenei* still relies on traditional morphological taxonomy, which may be outdated. Additionally, potential morphological variations of this species could lead to misidentification. Therefore, genomic sequencing studies are necessary to achieve a more accurate and efficient classification of this coral species. Furthermore, research on the morphological characteristics of *S. serenei* in different geographic regions should be conducted to better understand its adaptability and morphological variations.

In further research, it is recommended to combine the use of ITS2 marker and many other types of molecular markers such as 18S rRNA gene and cp23S, psbA and rbcL or other methods (whole genome sequencing (WGS) and RNA-seq) to classify and clarify the evolutionary relationship at the branch level and comprehensive information on the genome and functional gene expression, thereby improving the resolution of the phylogenetic tree. At the same time, it is a modern tool to warn about the health status of coral reefs as well as in the restoration and conservation of marine biodiversity.

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