ORIGINAL PAPER

Effects of Climate Variability on Diversity of Barrel Sponge (*Xestospongia testudinaria*) Associated Fungi in Coral Community from Underwater Pinnacle, Rayong Province

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Abstract. Climate change and coastal development in Rayong Province, Thailand, have led to rising sea temperatures, impacting marine ecosystems. This study investigated the effect of seasonal temperature variation on the diversity of marine fungi associated with the barrel sponge (*Xestospongia testudinaria*) at depths of 10, 15, and 20 meters around the Hin Phloeng underwater pinnacle. Samples were collected during three seasons: summer (April 2023), rainy season (September 2023), and winter (February 2024). A total of 848 fungal isolates were obtained and identified through morphological and molecular analysis. Eight fungal taxa were recorded, with the dominant species being *Aspergillus flavus* and *Penicillium* spp. The abundance of these species decreased with lower seawater temperatures, while *Emericella* spp. and *Cladosporium* sp. increased in cooler conditions. These results suggest that specific marine fungal taxa associated with *X. testudinaria* may serve as potential bioindicators of seawater temperature changes. This study provides a valuable baseline for marine fungal diversity in Thai coral ecosystems and supports the use of sponge-associated fungi in environmental monitoring.

Keywords: Climate variability, Diversity, *Xestospongia testudinaria*, Marine fungi, Underwater pinnacle

1. Introduction

The coastal development in Rayong Province has led to the establishment of industrial zones, and coupled with the ongoing global climate change, rising sea temperatures, and increasing severity of environmental shifts, this has significantly impacted marine ecosystems both directly and indirectly. One key approach to managing and conserving the eastern coastline is actively monitoring and assessing marine environmental quality, ensuring timely awareness of changes and prompt responses to emerging issues. In addition to sediment and seawater quality analysis, marine organisms used in environmental health assessment also play an important role in ecosystem monitoring. The filter-feeder marine organisms are particularly effective in accumulating pollutants, which can later be extracted and examined. Marine sponges, organisms of invertebrates, are well suited for this purpose. Their porous body structure allows water to circulate, filtering organic matter, plankton, and microorganisms. Since they are sessile, meaning they remain attached to surfaces on the seabed, they provide stable indicators of environmental changes. Monitoring environmental quality using marine sponges as bioindicators can be especially beneficial in underwater pinnacles such as "Hin Phloeng" in Rayong Province. These underwater pinnacle reefs, located far from the coastline and at greater depths, experience minimal disturbance from coastal development. As a result, they maintain favorable conditions for biodiversity, including soft corals, gorgonians, sea anemones, various coral species, and marine sponges, making them ideal sites for environmental assessment (Yeemin et al., 1999; 2001; Sutthacheep et al., 2023; 2024; Suebpala et al., 2025).

Marine sponges are invertebrates belonging to the phylum Porifera. They are sessile organisms, fixed in place, and filter feeders. Sponges can be found in various aquatic ecosystems, including oceans worldwide, polar seas, temperate regions, and tropical waters. Microorganisms make up approximately 40% of the sponge's biomass.

These microorganisms live within the sponge in a symbiotic relationship, "holobionts." The major microorganisms associated with sponges include autotrophic bacteria, heterotrophic bacteria, archaea, fungi, unicellular algae, and, as research has indicated, viruses (Batista et al., 2018). Sponges also can accumulate contaminants such as heavy metals, making them valuable as biological monitoring organisms (biomonitoring) for marine ecosystems (Rodríguez and Morales, 2020). Additionally, they play a significant ecological role by serving as micro-habitats for other organisms and as reservoirs for microorganisms, particularly fungi. Marine microorganisms within sponges are an important source of natural bioactive compounds with potential applications in chemistry, medicine, pharmaceuticals, and dietary supplements.

Marine fungal communities, being highly sensitive to ecological shifts, are particularly susceptible to temperature, salinity, pH, and nutrient levels; they can significantly influence the structure and diversity of fungal communities. Rising temperatures generally stimulate the proliferation of the fungi typically found in warmer waters, while also potentially intensifying the eutrophication process, which in turn can lead to shifts in fungal community composition. Furthermore, temperature variations may influence the degradation capacity of fungi, thereby affecting water quality and nutrient cycling dynamics (Gao et al., 2024). This study aims to investigate the effects of climate variability on the diversity of sponge-associated fungi may serve as potential bioindicators of seawater temperature changes and environmental monitoring.

2. Materials and Methods

2.1 Location of study site and sample collection

The underwater pinnacle (Hin Phloeng; Alhambra Rock; 12°25'44.20" N, 101°39'58.43" E) is located in Rayong Province, in the Eastern Gulf of Thailand. The study site is situated approximately 24 kilometers from the mainland and has a depth of about 20-25 meters (Figure 1). Marine sponge (*Xestospongia testudinaria*) was collected by SCUBA diving at depths of 10, 15, and 20 meters in the coral community from the underwater pinnacle, Rayong Province, in April 2023 – February 2024 (Figure 2A-2C and Figure 3A). Sponge samples were collected during each season, 3 colonies at each depth, 3 samples per colony, and sponges were collected in duplicate from the same colony. A sample photograph was taken with a waterproof digital camera, and a label with a sample number and location was placed on waterproof paper. The labeled sample was then placed in a polyethylene bag containing seawater. Finally, the sample was placed in an icebox for one night before isolation and was immediately transported to the laboratory (Figure 3B) (Longmatcha et al., 2022; Buaruang et al., 2023).

2.2 Data collection

Environmental factors were monitored in the underwater pinnacle from April 2023 to February 2024 at depths of 10, 15, and 20 meters, including seawater temperature, light intensity (Onset-HOBO Data Loggers), electrical conductivity, total dissolved solids (TDS), salinity, dissolved oxygen (DO), and pH (YSI 556-01 Multi Probe), (Figure 2D-2F). The measurement of environmental changes follows seasonal variations, including April 2023 (summer), September 2023 (rainy season), and February 2024 (winter).

2.3 Culture media

Two culture media were used for isolating marine fungi from the sponge namely, (1) Malt Extract Agar (MEA) with 70% seawater containing: malt extract powder 20.0 g, peptone 1.0 g, glucose 20.0 g, agar 15.0 g, seawater 700 ml, and distilled water 300 ml, (2) Yeast Peptone Agar (YPA) containing: yeast extract 1.0 g, peptone 1.0 g, agar 15.0 g, and distilled water 1 L (Add streptomycin sulfate 10 mg/L into both media after autoclaved and decrease temperature for 45-50 °C) (Buaruang et al., 2015; Longmatcha et al., 2022; Buaruang et al., 2023).

2.4 Isolation of marine fungi

The sponge was washed with a 0.06% sodium hypochlorite (NaOCl) solution for 1 minute, followed by rinsing with sterilized seawater three times. The sponge was dried on a sterile filter paper, cut into small pieces (5 x 5 mm), and placed on culture media (MEA with 70% seawater and YPA). It was then incubated at 28°C for 5-7 days. The hyphal tips emerging from the sponge pieces were individually transferred onto MEA with 70% seawater slants and maintained as pure cultures at the Marine Microbe Environment Research Unit (MMERU) of the Division of Environmental Science, Faculty of Science of Ramkhamhaeng University in Bangkok, Thailand (Figure 3C-3H) (Cardona et al., 2021; Buaruang et al., 2023).

2.5 Morphological studies and DNA identification of marine fungi

Marine fungi were identified based on morphological characteristics after incubation for 7 to 14 days at 28 °C on MEA with 70% seawater. Morphological features of the colonies, including growth pattern and texture, were determined. Colony diameters were measured in millimeters, most effectively using transmitted light and from the reverse side. (Manoch et al., 2009; Buaruang et al., 2015; 2023). Colony colors were recorded using the mycological color chart (Rayner, 1970).

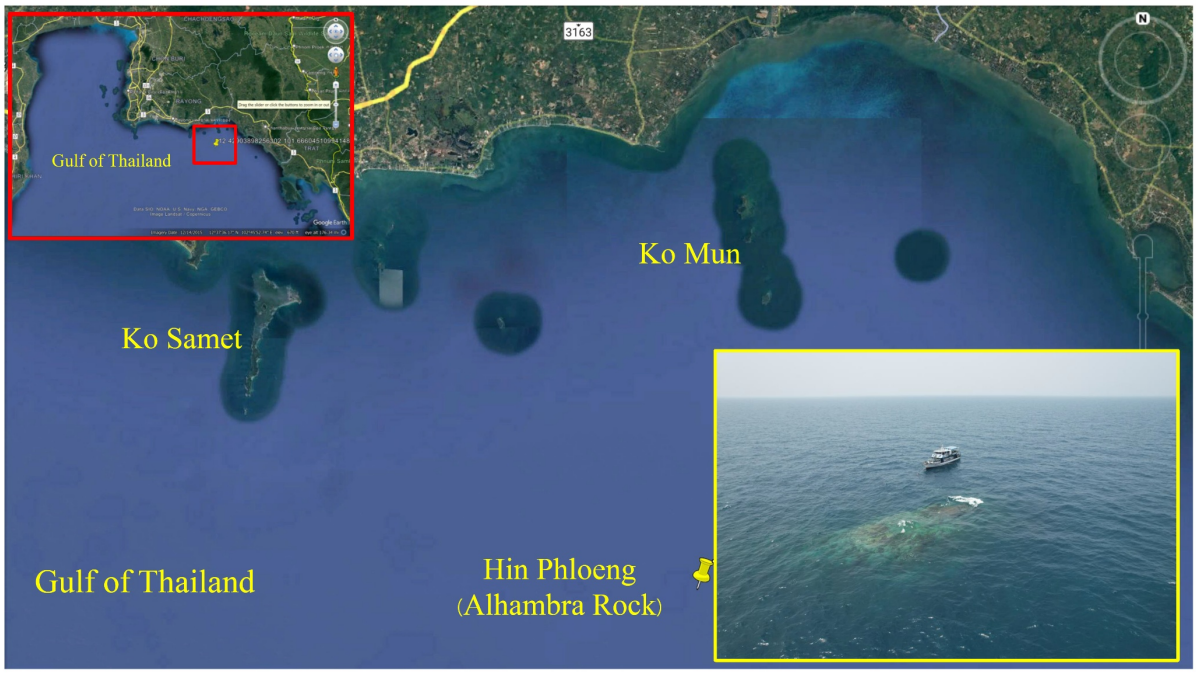

Figure 1. Map of the study site at Hin Phloeng underwater pinnacle, Rayong Province, the Eastern Gulf of Thailand

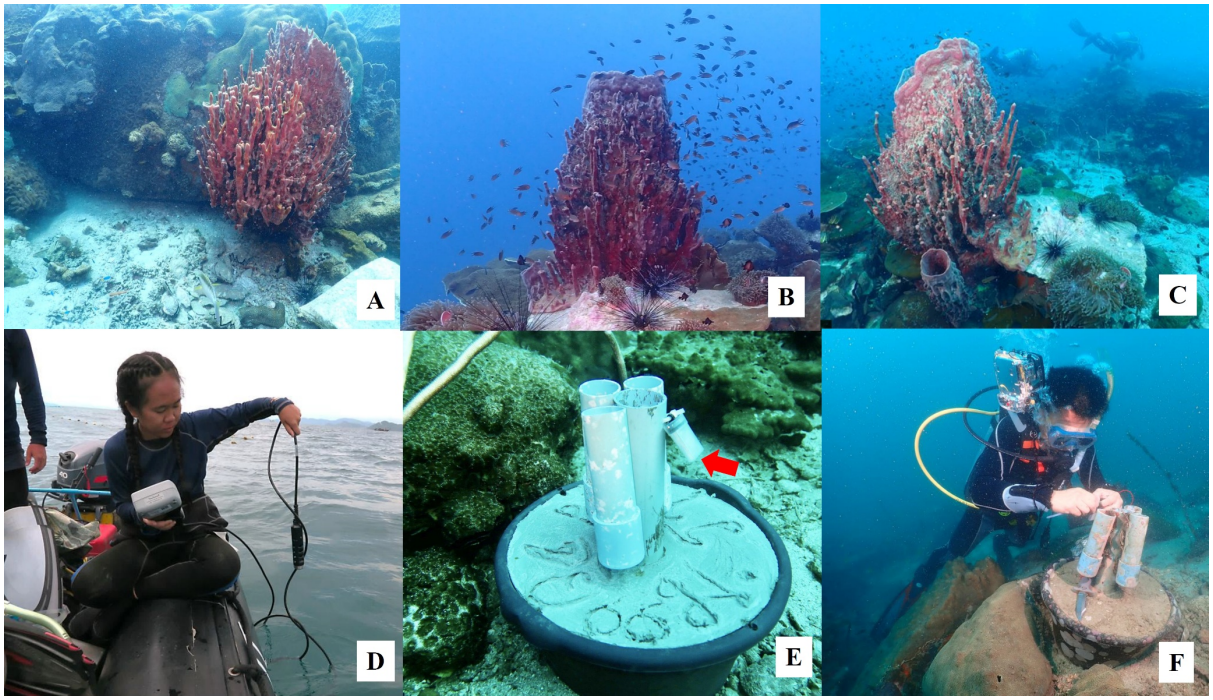

Figure 2. Marine sponge (*X. testudinaria*) at depths of 10 (2A), 15 (2B), and 20 (2C) meters, and the study of environmental factors (2D-2F) in the coral community at Hin Phloeng underwater pinnacle

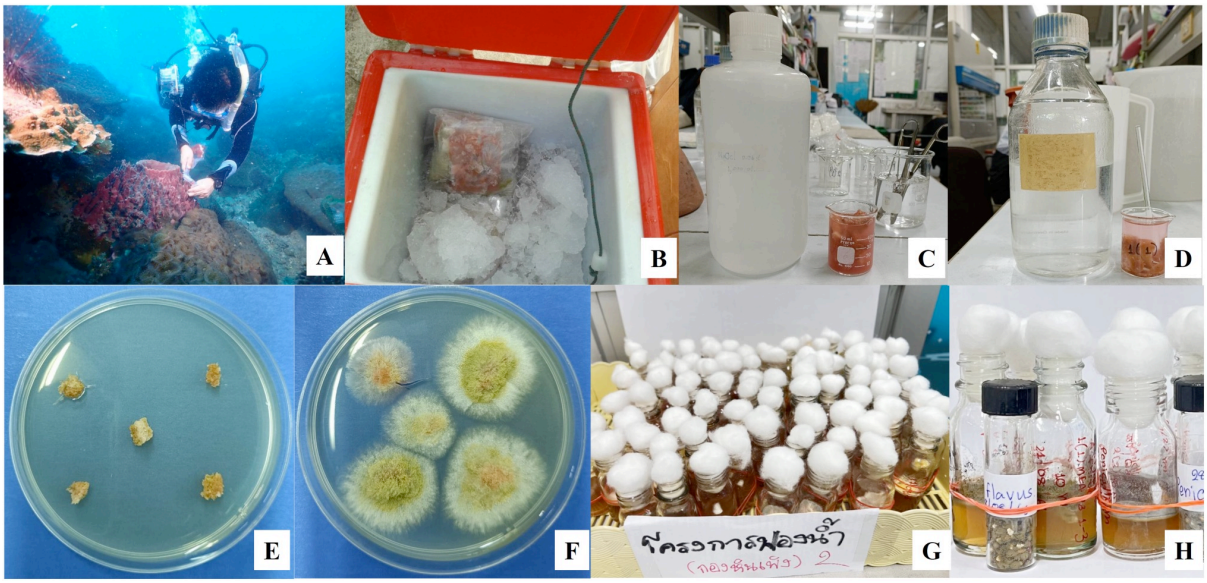

Figure 3. Collection and isolation of marine fungi from sponge (*X. testudinaria*): Collection of samples by SCUBA diving (A), The samples in an ice box transported to the laboratory (B), The sponge washed in 0.06% NaOCl solution for 1 minute (C), followed by rinsing with sterilized seawater three times (D), The sample on a petri dish with MEA with 70% seawater containing (E), Colonies of marine-derived fungi on MEA with 70% seawater, incubated at 28°C for 5-7 days (F), Pure culture of marine-derived fungi on slant MEA with 70% seawater (G) and cereal grain vial (H)

The fungi were also confirmed by the analysis sequence of the internal transcribed spacer (ITS) gene. Briefly, 2–15 mg of mycelia was ground in liquid nitrogen. DNA was extracted using the DNeasy™ Plant Mini Kit (QIAGEN, Hilden, Germany) according to the manufacturer's instructions. The entire nuclear ITS regions were amplified with the primers: ITS1F-5′ (Gardes and Bruns, 1993) and ITS4-3′ (White et al., 1990). PCR reactions were conducted on a Thermal Cycler and the amplification process consisted of initial denaturation at 95 °C for 5 min, 34 cycles at 95 °C for 1 min (denaturation), at 55 °C for 1 min (annealing), and at 72 °C for 1.5 min (extension), followed by a final extension at 72 °C for 10 min. PCR products were cleaned using QIAquick PCR Purification Kit (QIAGEN, Hilden, Germany), then examined by Agarose gel electrophoresis (1% agarose with 1× TBE buffer) and visualized under UV light after staining with ethidium bromide. DNA sequencing analyses were carried out by Macrogen Inc. (Seoul, South Korea) (Cardona et al., 2021).

2.6 Data analysis

Seasonal variations in environmental factors, including seawater temperature, electrical conductivity, total dissolved solids (TDS), salinity, dissolved oxygen (DO), and pH, were measured at depths of 10, 15, and 20 meters from April 2023 to February 2024. Statistical analysis was conducted using a one-way ANOVA (Microsoft Excel 2021 software) to ascertain differences in these rates among the seasons.

3. Results

3.1 Measurement of environmental factors

The effects of various environmental factors on the diversity of marine fungi were isolated from the sponge *X. testudinaria* in the coral community at Hin Phloeng underwater pinnacle. The study was conducted across different seasons: April 2023 (summer), September 2023 (rainy season), and February 2024 (winter), at varying depths of 10, 15, and 20 meters. The environmental factors were monitored, including seawater temperature, electrical conductivity, total dissolved solids (TDS), salinity, dissolved oxygen (DO), and pH.

The result showed that the average seawater temperatures recorded were 31.459±0.21°C (summer), 30.087±0.12°C (rainy season), and 28.891±0.27°C (winter). The seawater temperature did not vary with depth within the same season but showed significant seasonal differences (One-way ANOVA, $p<0.05$) (Figure 4,5,6,7 and Table 1,2,3). The average electrical conductivity was 51.69±2.30 (summer), 51.13±0.11 (rainy season), and 53.90±3.75 ms/cm (winter). The highest average was found in winter, with no significant difference across the seasons (One-way ANOVA, $p>0.05$). TDS average was 28.42±1.53 (summer), 25.60±0.00 (rainy season), and 31.07±2.92 g/l (winter). At a depth of 20 meters in all seasons, the TDS was the lowest (26.65, 25.60, and 27.70 g/l, respectively). The highest was found in winter, with significant seasonal differences (One-way ANOVA, $p<0.05$). The average salinity was 30.97±2.23 (summer), 30.93±1.60 (rainy season), and 31.18±3.24 ppt (winter). The lowest salinity was recorded in winter at 20 meters (27.44 ppt), while the highest was found in summer at a depth of 15 meters (33.42 ppt). However, the average salinity did not significantly differ between seasons (One-way ANOVA, $p>0.05$). DO average was 7.29±0.20 (summer), 6.93±0.58 (rainy season), and 7.66±0.25 mg/L (winter). The DO did not have significant differences across seasons and depth levels (One-way ANOVA, $p>0.05$). The average pH was 8.17±0.34 (summer), 8.21±0.00 (rainy season), and 8.18±0.00 (winter). The pH did not significantly differ across seasons and depth levels (One-way ANOVA, $p>0.05$) (Table 1, 2, and Table 3). The range of light intensity was 10.8-8,611.2 lux, with the highest in October 2023 and the lowest in August 2023. Light intensity at depths of 10 meters was higher than 15 meters and 15 meters was higher than 20 meters, respectively. The highest light intensity was found between 12:00 and 1:00 PM (Figure 8).

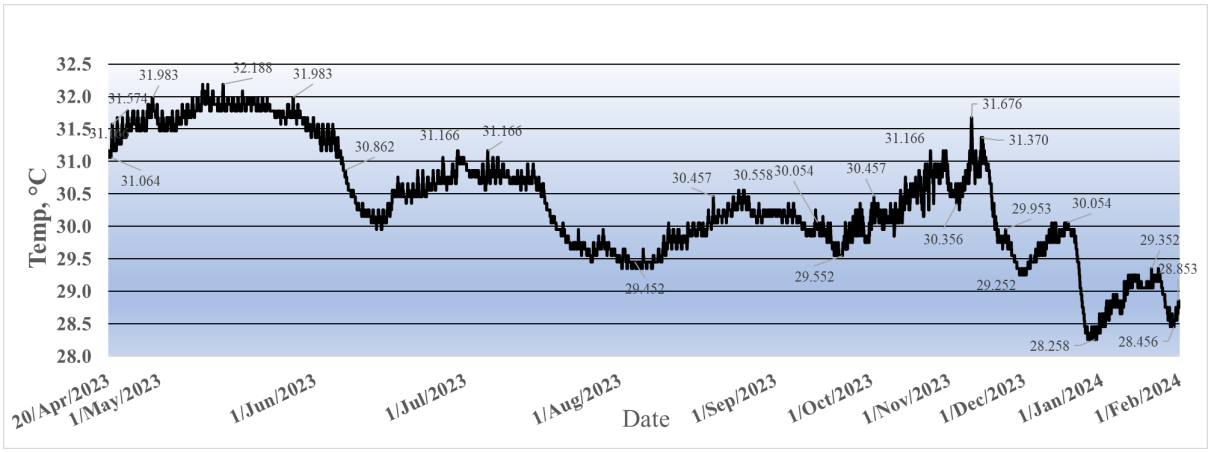

Figure 4. Seawater temperatures as recorded from a data logger at a depth of 10 meters during April 2023 - February 2024

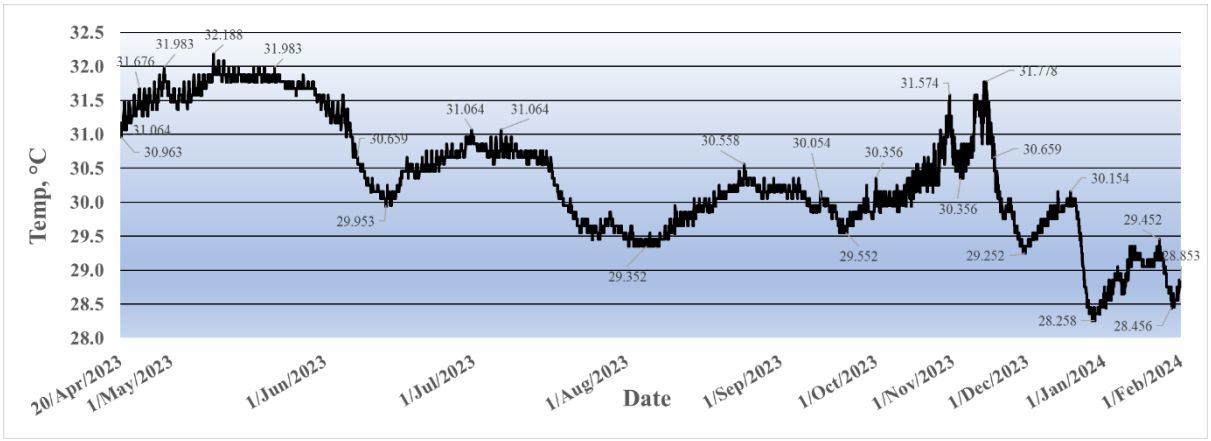

Figure 5. Seawater temperatures as recorded f rom a data logger at a depth of 15 meters during April 2023 - February 2024

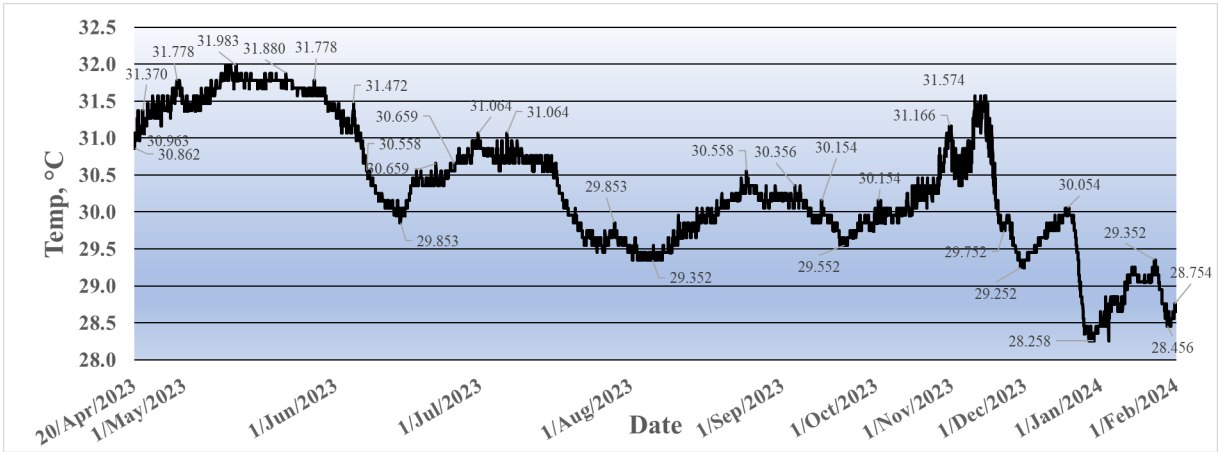

Figure 6. Seawater temperatures as recorded from a data logger at a depth of 20 meters during April 2023 - February 2024

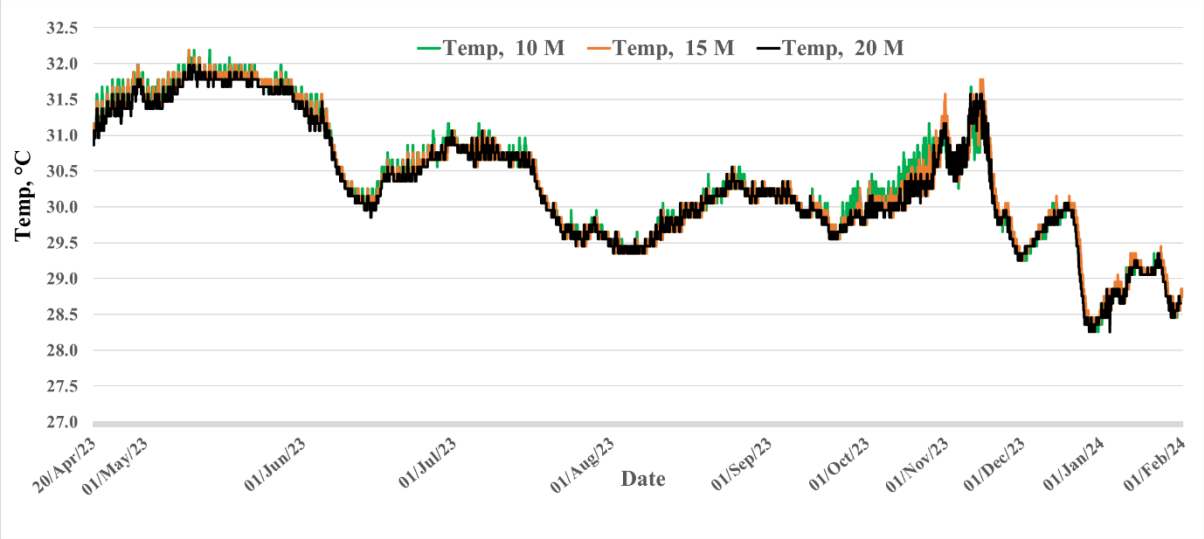

Figure 7. Seawater temperatures as recorded from a data logger at depths of 10, 15, and 20 meters during April 2023 - February 2024

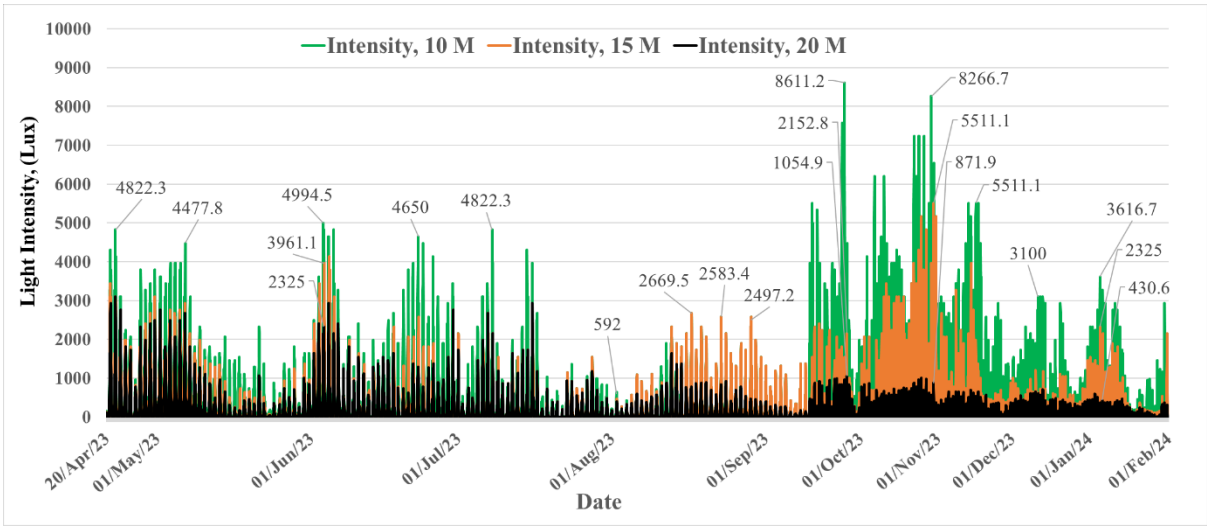

Figure 8. Light intensity as recorded from a data logger at depths of 10, 15, and 20 meters during April 2023 - February 2024

Table 1 Environmental factors at Hin Phloeng underwater pinnacle at depths of 10, 15, and 20 meters in April 2023 (summer)

Environmental factors	Depths (meter)			Averages
	10	15	20	
Average temp. (°C)	31.528±0.20	31.463±0.20	31.386±0.19	31.459±0.21
Minimum temp. (°C)	31.064	30.963	30.862	-
Maximum temp. (°C)	31.983	31.983	31.778	-
Conductivity (ms/cm)	50.24	54.35	50.50	51.69±2.30
TDS (g/l)	29.34	29.27	26.65	28.42±1.53
Salinity (ppt)	29.03	33.42	30.47	30.97±2.23
DO (mg/l)	7.53	7.16	7.19	7.29±0.20
pH	8.13	8.19	8.19	8.17±0.34

Table 2 Environmental factors at Hin Phloeng underwater pinnacle at depths of 10, 15, and 20 meters in September 2023 (rainy season)

Environmental factors	Depths (meter)			Averages
	10	15	20	
Average temp. (°C)	30.093±0.12	30.084±0.12	30.084±0.12	30.087±0.12
Minimum temp. (°C)	29.853	29.853	29.853	-
Maximum temp. (°C)	30.356	30.356	30.356	-
Conductivity (ms/cm)	51.20	51.20	51.00	51.13±0.11
TDS (g/l)	25.60	25.60	25.60	25.60±0.00
Salinity (ppt)	30.61	32.68	29.52	30.93±1.60
DO (mg/l)	7.55	6.38	6.87	6.93±0.58
pH	8.21	8.21	8.21	8.21±0.00

Table 3 Environmental factors at Hin Phloeng underwater pinnacle at depths of 10, 15, and 20 meters in February 2024 (winter)

Environmental factors	Depths (meter)			Averages
	10	15	20	
Average temp. (°C)	28.917±0.27	28.886±0.26	28.871±0.27	28.891±0.27
Minimum temp. (°C)	28.456	28.456	28.456	-
Maximum temp. (°C)	29.452	29.352	29.352	-
Conductivity (ms/cm)	54.20	57.50	50.00	53.90±3.75
TDS (g/l)	32.58	32.93	27.70	31.07±2.92
Salinity (ppt)	32.87	33.24	27.44	31.18±3.24
DO (mg/l)	7.50	7.95	7.53	7.66±0.25
pH	8.18	8.18	8.18	8.18±0.00

3.2 Diversity of marine fungi

The study on the diversity of marine fungi associated with the barrel sponge (*X. testudinaria*) in the coral community at Hin Phloeng underwater pinnacle, Rayong Province was studied during April (summer), September (rainy season) of 2023, and February (winter) of 2024 at depths of 10, 15, and 20 meters.

The result showed that the diversity of marine fungi in the summer consists of 357 isolates identified into 5 species: *A. flavus*, *Aspergillus* spp., *Emericella* sp., *Penicillium* spp., *T. harzianum,* and sterile mycelium. During the rainy season, 311 marine fungal isolates were found, identified into 8 species: *A. flavus*, *A. hiratsukae*, *A. unguis*, *Aspergillus* spp., *Cladosporium* sp., *Emericella* spp., *Penicillium* spp., *T. harzianum*, and sterile mycelium. In winter, 180 marine fungal isolates were identified into 5 species: *A. flavus*, *Aspergillus* spp., *Cladosporium* sp., *Emericella* spp., *Penicillium* spp., and sterile mycelium. The result showed that the diversity of marine fungi associated with the sponge *X. testudinaria* for 3 seasons identified 8 species: *A. flavus*, *A. hiratsukae*, *A. unguis*, *Aspergillus* spp., *Cladosporium* sp., *Emericella* spp., *Penicillium* spp., *T. harzianum*, and sterile mycelium (Figure 9 and Table 4).

3.3 Morphological and DNA Identification

The result showed that the morphological characteristics of marine fungi associated with the sponge *X. testudinaria* can be identified into 8 species: *A. flavus*, *A. hiratsukae*, *A. unguis*, *Aspergillus* spp., (Figure 10), *Cladosporium* sp., *Emericella* spp., *Penicillium* spp. and *T. harzianum* (Figure 11). DNA identification based on analysis, a BLAST search of ITS gene sequences was determined and the results search were shown in Table 5.

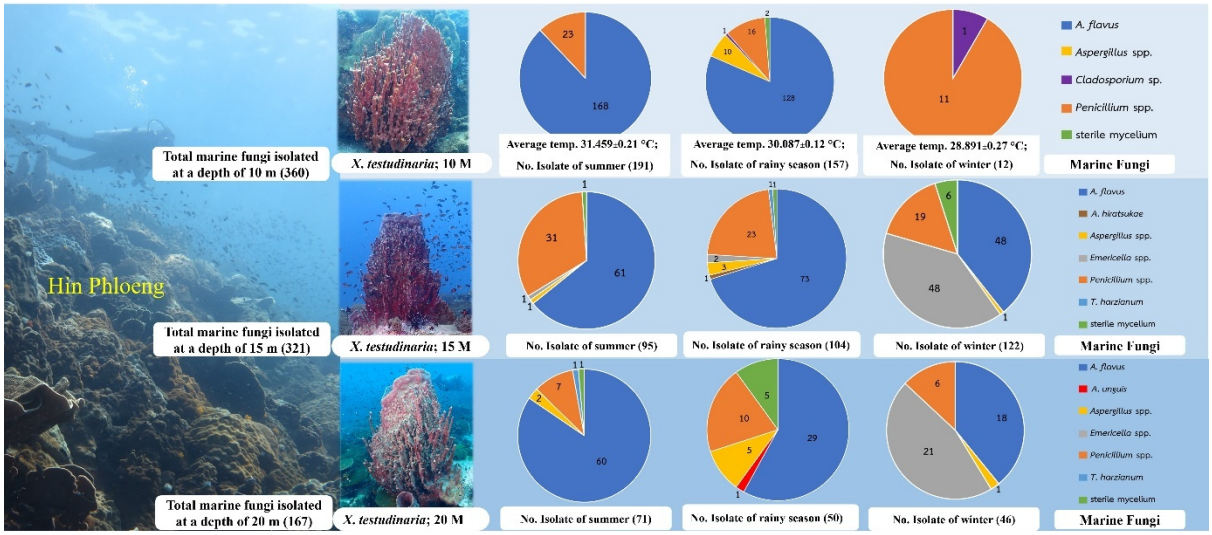

Figure 9. Illustrations of the number of isolates and species of marine fungi isolated from sponge (*X. testudinaria*) according to seasonal variations at Hin Phloeng underwater pinnacle, at depths of 10, 15, and 20 meters

Table 4 The number of isolates and species of marine fungi isolated from sponge (*X. testudinaria*) according to seasonal variations at Hin Phloeng underwater pinnacle, at depths of 10, 15, and 20 meters

Marine Fungi	April 2023 (summer) (31.459±0.21 °C)			September 2023 (rainy season) (30.087±0.12 °C)			February 2024 (winter) (28.891±0.27 °C)		
	Depths (meter)			Depths (meter))			Depths (meter)		
	10	15	20	10	15	20	10	15	20
	No. Isolate								
A. flavus	168	61	60	128	73	29	-	48	18
A. hiratsukae	-	-	-	-	1	-	-	-	-
A. unguis	-	-	-	-	-	1	-	-	-
Aspergillus spp.	-	1	2	10	3	5	-	1	1
Cladosporium sp.	-	-	-	1	-	-	1	-	-
Emericella spp.	-	1	-	-	2	-	-	48	21
Penicillium spp.	23	31	7	16	23	10	11	19	6
T. harzianum	-	-	1	-	1	-	-	-	-
sterile mycelium	-	1	1	2	1	5	-	6	-
Total number of isolates by depth level	191	95	71	157	104	50	12	122	46
Total number of isolates by season	357			311			180		

4. Discussion

The present study shows the diversity of marine fungi associated with the sponge *X. testudinaria* at depths of 10, 15, and 20 meters across different seasons: April 2023 (summer), September 2023 (rainy season), and February 2024 (winter). A total of 357, 311, and 180 fungal isolates were found, respectively. The average seawater temperature at each depth was recorded as 31.459±0.21°C, 30.087±0.12°C, and 28.891±0.27°C, respectively. Analyzing the relationship between average seawater temperature and the diversity of marine fungi, it was found that the number of isolates of *A. flavus* and *Penicillium* spp. showed a decrease in April, September, and February. The number of isolates recorded was 289, 230, and 66 for *A. flavus*, respectively, and 61, 49, and 36 for *Penicillium* spp., respectively. Thus, the number of isolates of *A. flavus* and *Penicillium* spp. showed a decrease as seawater temperature decreased. In contrast, *Emericella* spp. exhibited an increase in the number of isolates across April 2023, September 2023, and February 2024, with recorded counts of 1, 2, and 69 isolates, respectively. For *Cladosporium*

sp., 1 isolate was found in September and another in February. *T. harzianum* was detected with 1 isolate in April and another in September. Thus, the number of isolates of *Emericella* spp. and *Cladosporium* spp. showed an increasing trend as seawater temperature decreased.

Lesser et al. (2016) reported that the combined effects of thermal stress and ocean acidification on the sponge *Xestospongia muta*, found in Caribbean coral reefs, indicated that increased ocean acidification and elevated seawater temperatures impact the microbiome within the sponge. Climate change affecting marine sponges is primarily influenced by two key factors: ocean warming (OW) and ocean acidification (OA). Heat stress associated with global warming is likely to have the greatest impact on the sponge itself, leading to alterations in the microbial

communities within the sponge (Carballo and Bell, 2017). OW has a more negative effect on sponges than OA, and sponges influence seawater temperatures that are higher than normal. This also affects the microorganisms living in sponges due to sponge stress (Bell et al., 2018). Medina et al. (2015) reported that the concentration of carbon dioxide (CO_2) and temperature affect the growth of *Fusarium graminearum* and *F. verticillioides*. Under incubation conditions with a CO_2 concentration of 1000 ppm and a temperature of 30°C, the growth rate of *F. graminearum* was significantly reduced. Venkatachalam et al., (2019) reported that the influence of salinity on the biomass of the fungus *Talaromyces albobiverticillius* 30548 by cultivating in PDB medium supplemented with sea salt at the ratios of 0% (T1), 3.65% (T2), 6% (T3), and 9% (T4) (wt/wt water content of salt) and pH 4.0, the biomass of *T. albobiverticillius* 30548 was found to be higher with increasing salinity. Pang et al. (2020) reported *Aspergillus terreus* NTOU4989 was the only fungus that showed growth at 45 °C, pH 3, and 30% salinity, and might be active near the vents and also carried out a transcriptome analysis to understand the molecular adaptations of *A. terreus* NTOU4989 under these extreme conditions.

The present study environmental factors that may be affected by the number of marine fungal isolates include total dissolved solids (TDS). The highest average TDS was observed in February, coinciding with an increase of *Emericella* spp. isolates. Another influencing factor was light intensity. According to the measurements at different depths, light intensity was highest at 10 meters, followed by 15 meters, and lowest at 20 meters. The total number of marine fungal isolates recorded at depths of 10, 15, and 20 meters were 360, 321, and 167 isolates, respectively (Figure 8 and Figure 9).

This study concluded that five species of marine fungi *A. flavus*, *Penicillium* spp., *Emericella* spp., *Cladosporium* spp., and *T. harzianum,* which are associated with the sponge *X. testudinaria* in the coral community at Hin Phloeng underwater pinnacle, Rayong Province, have the potential as indicators of seawater temperature changes (Figure 12).

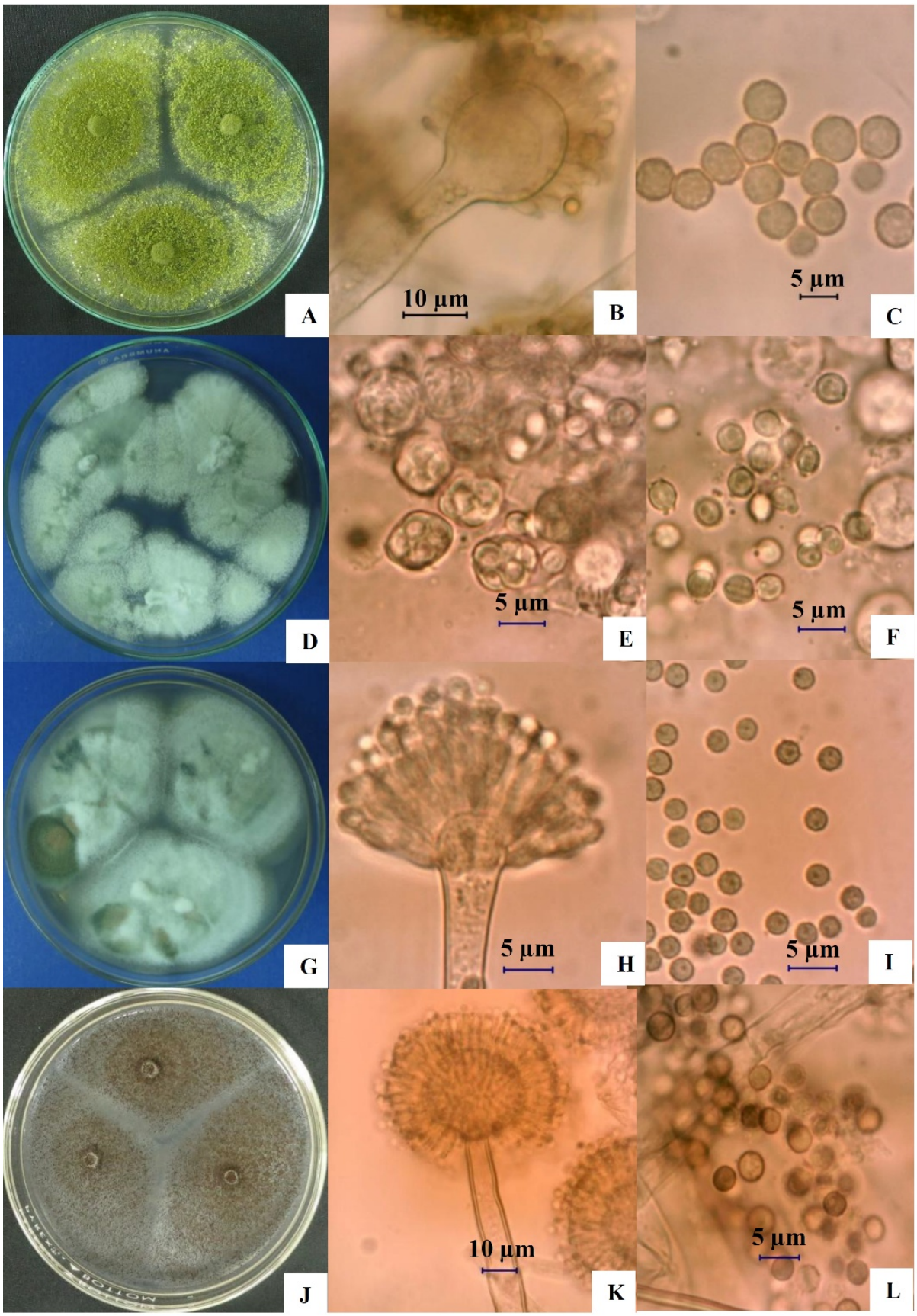

Figure 10. *A. flavus* (MMERU 26): Colonies on MEA with 70% seawater 28 °C, 7 days (A) conidial head (B); conidium (C). *A. hiratsukae* (MMERU 31): Colonies on MEA with 70% seawater 28 °C, 7 days (D); cleistothecium (E); ascospore (F). *A. unguis* (MMERU 32): Colonies on MEA with 70% seawater 28 °C, 7 days (G); conidial head (H); conidium (I). *Aspergillus* sp. (MMERU 30): Colonies on MEA with 70% seawater 28 °C, 7 days (J); conidial head (K); conidium (L).

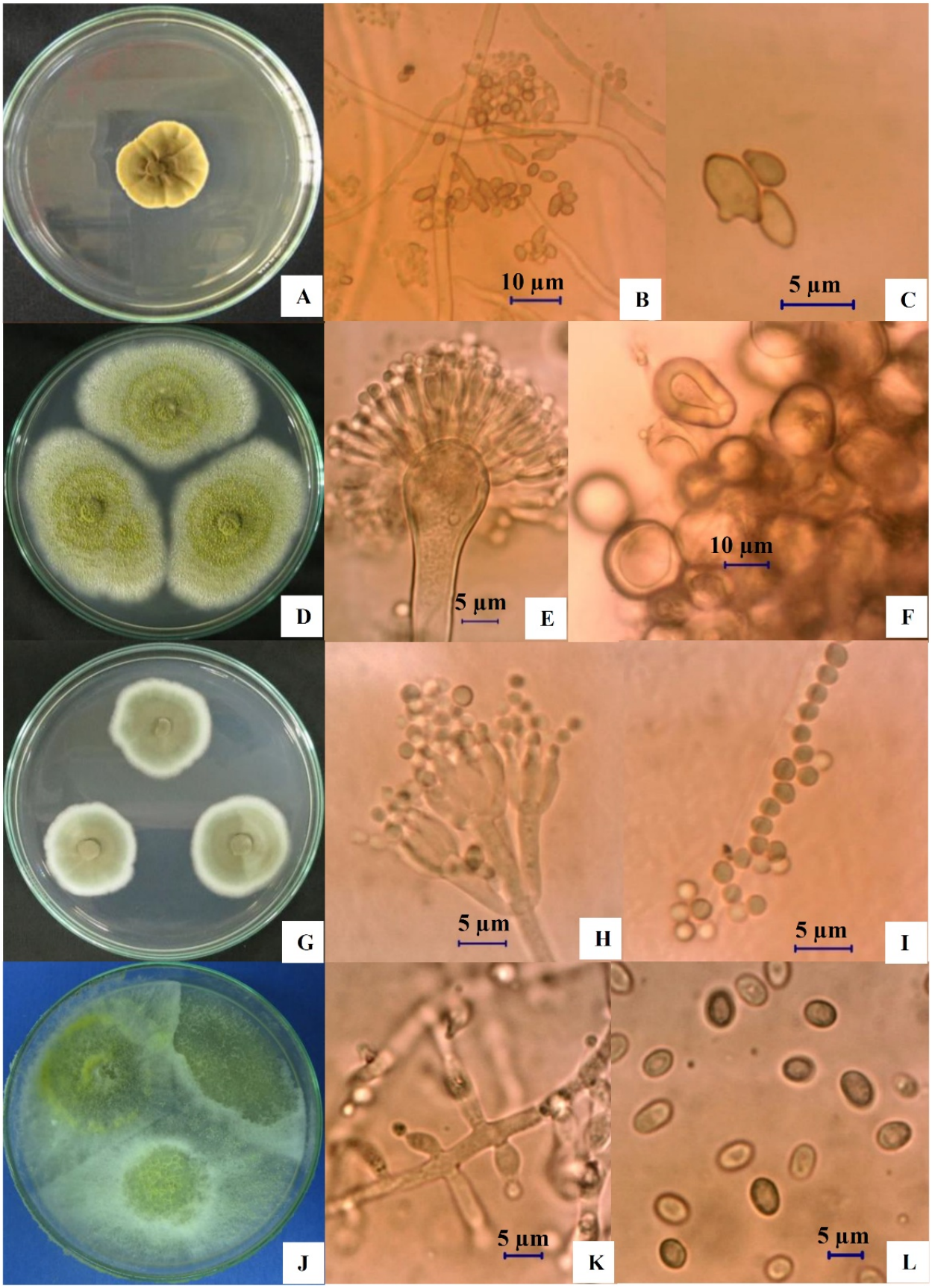

Figure 11. *Cladosporium* sp. (MMERU 27): Colonies on MEA with 70% seawater 28 °C, 7 days (A) conidium (B-C). *Emericella* sp. (MMERU 29): Colonies on MEA with 70% seawater 28 °C, 7 days (D); conidiophore, conidium (E); hulle cell (F). *Penicillium* sp. (MMERU 28): Colonies on MEA with 70% seawater 28 °C, 7 days (G); conidiophore (H); conidium (I). *T. harzianum* (MMERU 33): Colonies on MEA with 70% seawater 28 °C, 7 days (J); phialide (K); conidium (L).

Table 5 BLAST results of marine fungi associated with the sponge *X. testudinaria* collected from the coral community at Hin Phloeng underwater pinnacle

Marine Fungi (MMERU No.)	BLAST-Identification	% Similarity	GenBank Accession No.
A. flavus (MMERU 26)	*Aspergillus flavus*	99.00	KX462773
A. hiratsukae (MMERU 31)	*Aspergillus hiratsukae*	99.83	MW865715.1
A. unguis (MMERU 32)	*Aspergillus unguis*	99.47	ON332123.1
Aspergillus sp. (MMERU 30)	*Aspergillus* sp.	99.00	KX611073
Cladosporium sp. (MMERU 27)	*Cladosporium* sp.	100	MH864552.1
Emericella sp. (MMERU 29)	*Emericella* sp.	100	MK028997
Penicillium sp. (MMERU 28)	*Penicillium* sp.	100	MG733738
T. harzianum (MMERU 33)	*Trichoderma harzianum*	100	MG707197.1

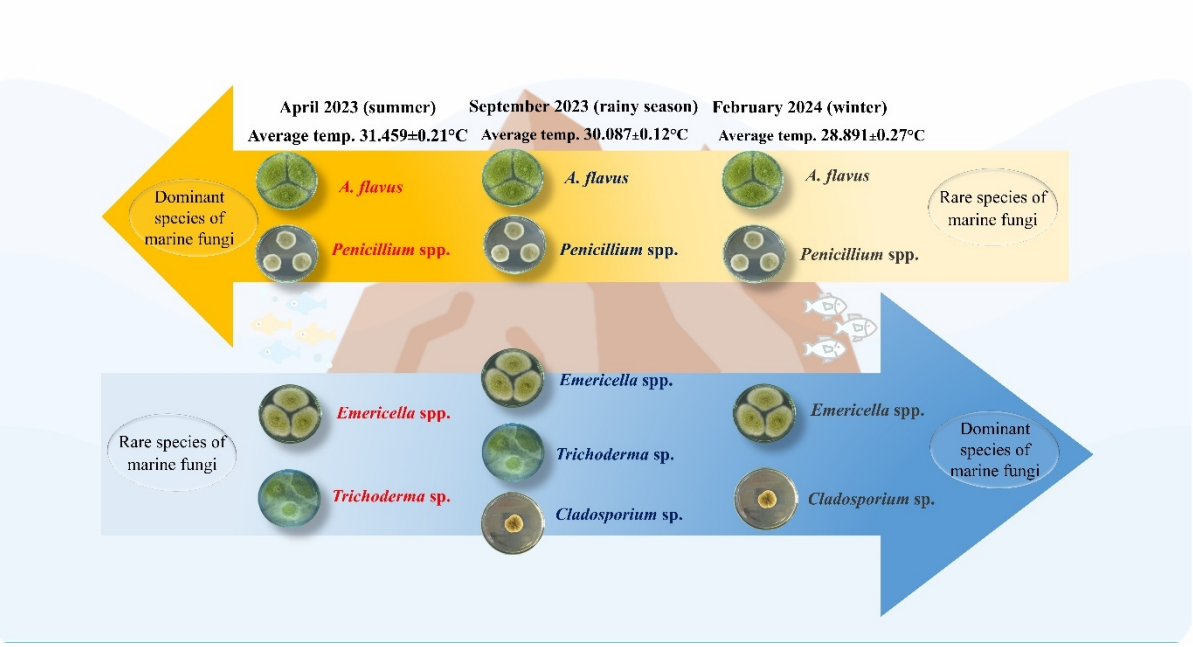

Figure 12. Illustrations of five species of marine fungi associated with the sponge *X. testudinaria*, highlighting their potential as indicators of seawater temperature changes.

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