ORIGINAL PAPER

Macroinfauna communities from coral reefs and an underwater pinnacle in Trat and Rayong Provinces, the Eastern Gulf of Thailand

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Received: 30 January 2024 / Revised: 30 April 2024 / Accepted: 30 April 2024

Abstract. Macroinfauna plays an important role in food webs in the benthic communities and a good bioindicator for assessing biodiversity status. Coral reefs and underwater pinnacles in tropical countries provide important marine habitats. However, macroinfauna research in these ecosystems is still limited. This study aimed to investigate the composition and abundance of macroinfauna in coral reefs and an underwater pinnacle in Trat and Rayong Province, the Eastern Gulf of Thailand. The sediment samples were collected by a new modified grab. The dominant groups of macroinfauna were Bivalvia, Amphipoda, and Polychaeta. The most abundant macroinfauna was recorded in *Rhinoclavis sordidula* (848.15 individuals/cm^2), followed by *Capitella* sp. (166.67 individuals/cm^2). Sabellidae, Sigalionidae, and Syllidae were present in underwater pinnacles while *Capitella* sp. was specifically associated with coral reef habitats. A cluster dendrogram from Bray-Curtis Similarity provided similarity of macroinfauna community among the study sites, showing three groups: Group 1: Ko Raet and Ko Pee, Trat Province, having high live coral cover; Group 2: Hin Phloeng an underwater pinnacle in Rayong Province; and Group 3: Ko Saket and Ko Man Nok, Rayong Province and Ko Maisi, Trat Province, having high dead coral cover. These study shows the importance of macroinfauna in coral reefs and underwater pinnacles. Our findings imply high potential of macroinfauna for predicting global changes, being a juvenile aquaculture feed in the aquaculture business, and providing a source of bioactive substances for medical and cosmetic purposes.

Keywords: coral reef, diversity, macroinfauna, Eastern Gulf of Thailand, underwater pinnacle

1. Introduction

Macroinfauna communities have multifaced roles played for marine ecosystems, such as a diverse assemblage of organisms functioning as predators, grazers, and decomposers within the food web (Hutchings, 1998). Beyond their ecological contributions, macroinfauna serve as valuable bioindicators of environmental health and constitute a significant portion of the benthic organic carbon stock in marine ecosystems (Pearson & Rosenberg, 1978; Zenetos & Bogdanos, 1987; Rodil et al., 2022).

The Gulf of Thailand is a prime example of the macroinfauna-rich biodiversity found within Thai waters, showcasing the high diversity and density of macroinfauna communities. A previous study conducted in Chumphon Province, located on the Gulf of Thailand identified 18 distinct macroinfauna taxa (Jungrak, 2021). This observed variation can likely be attributed to the dynamic nature of macroinvertebrate communities inhabiting in sandy beaches and coral reefs, where populations fluctuate seasonally and spatially (Gray, 2016). Furthermore, ecological interactions such as density-dependent mechanisms play a significant role in shaping these communities (Defeo & McLachlan, 2005). Environmental factors such as temperature, food availability, and natural disturbances (storms and rainfall) further serve as main drivers influencing the overall community structure (Taylor & McLachlan, 1980; Lercari & Defeo, 1999; Harris et al., 2011; Bergamino et al., 2013; Lercari & Defeo, 2015; Machado et al., 2016; Corte et al., 2017).

Research on macroinfauna communities in coral reefs and underwater pinnacles is needed as they potentially harbor unique and complex biodiversity. In addition, climate change and anthropogenic activities pose a significant threat to macroinfauna communities (Ulrike & Kröncke, 2013). To reduce this knowledge gap and gain a more comprehensive understanding of macroinfauna's role within the Thai marine ecosystems, this study investigates macroinfauna communities within coral reefs and an underwater pinnacle in Trat and Rayong Provinces of the Eastern Gulf of Thailand. The data acquired will contribute significantly to existing knowledge regarding macroinfauna distribution, providing crucial baseline information for future policy development and restoration projects.

2. Materials and Methods

2.1 Location of the study site and samples collection

The study sites are located in Trat and Rayong Provinces in the Eastern Gulf of Thailand (Figure 1). In Trat Province, the study sites were coral reefs at Ko Pee, about 35 km from the mainland; Ko Maisi and Ko Raet, about 50 km from the mainland, approximately 3–8 m in depth. Tourism activities were clearly observed at Ko Raet and Ko Maisi. The study sites in Rayong Province included the coral reefs at Ko Saket, Ko Man Nok, and an underwater pinnacle, Hin Phoeng, which are tourism areas. Ko Saket and Ko Man Nok are located about 3-7 km from the mainland and about 2-6 m in depth. Hin Phoeng is located about 30 km from the mainland and approximately 2 –20 m in depth. All study sites are not in the jurisdiction of marine national park. (Figure 1 and Table 1).

The coral communities at the study sites were investigated by SCUBA divers along a permanent belt transect with three replicates. The substrate compositions, i.e., live coral, dead coral, rubble, sand, and others were recorded within 50 cm of each side of the transect line (English et al. 1997). The underwater photographs were taken by a digital camera for data rechecking in the laboratory.

The sediment samples were collected by SCUBA divers using a new modified grab that was pushed manually into the sediment on coral reefs and an underwater pinnacle. The sediment samples were then preserved in a 10% buffered formalin solution until they were returned to the laboratory. They were stained with Rose Bengal and washed through a 0.5-mm mesh sieve. Macroinfauna were sorted with a dissecting microscope and identified to the lowest practical taxonomic level. The grain size measurement was conducted using a standard method of dry sieve analysis (English et al.,1997).

2.2 Data analysis

The total densities of macroinfauna in coral reefs and an underwater pinnacle in Trat and Rayong Provinces were statistically analyzed using a Student’s *t*-test. A one-way analysis of variance (ANOVA) was used to detect the differences in total density of macroinfauna among the study sites. Where significant differences were found, the Tukey HSD (Honestly Significant Difference) test was used to determine which study sites statistically differed. The Shannon’s diversity index (H′) and Pielou’s evenness index (J’) were calculated based on the number of individuals from the study sites. The Pearson’s correlation was used to perform the correlation between total densities and grain sizes at the study sites. The similarity of the composition of macroinfauna in coral reefs and an underwater pinnacle was evaluated with a cluster analysis using Non-metric Multidimensional Scaling (NMDS).

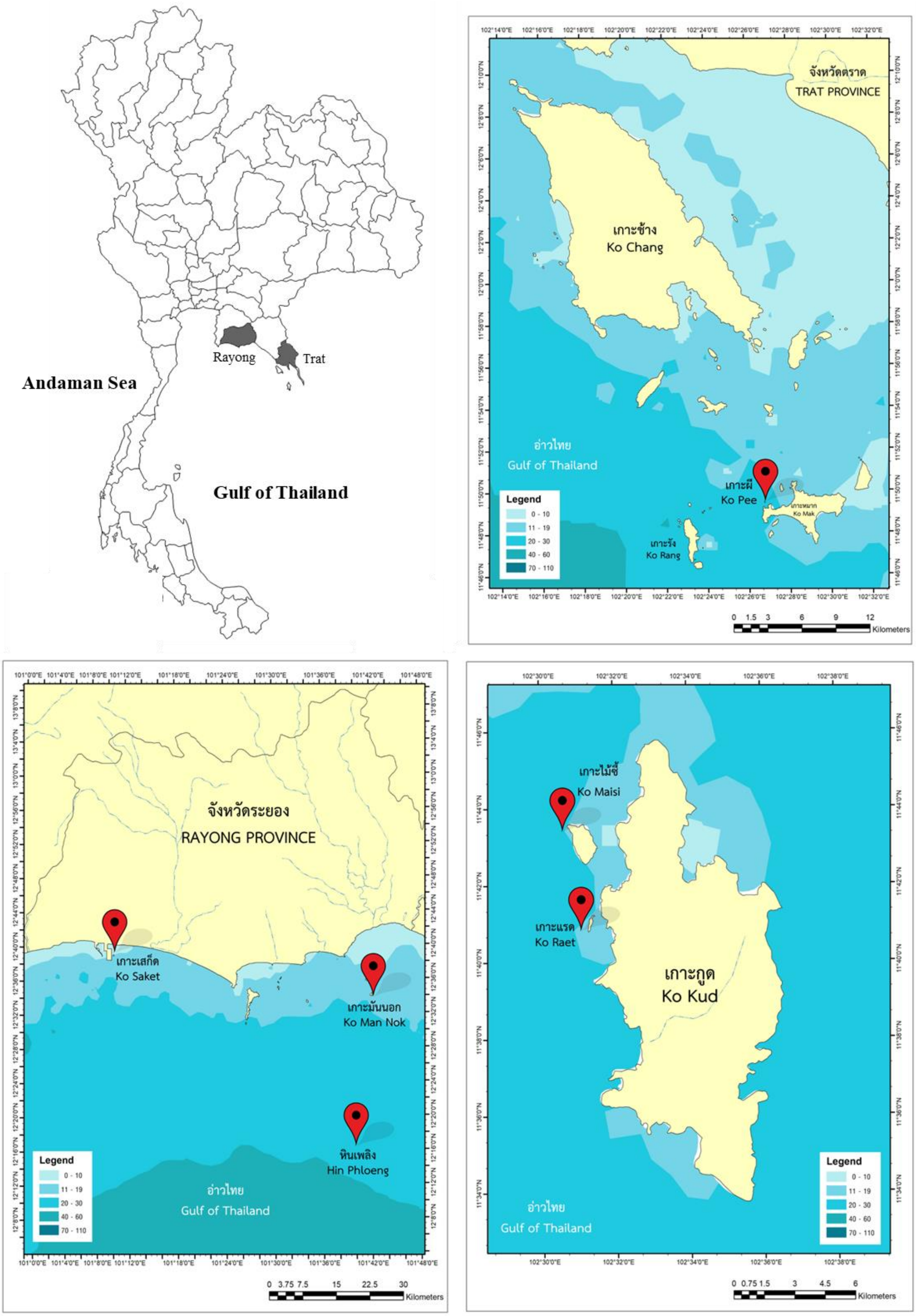

Figure 1. Map of the study sites in Trat and Rayong Provinces, the Eastern Gulf of Thailand

Table 1. Location and information of the study sites

Study Sites	Coral Reef Type	Distance from the Shore (km)	Water Transparency	Depth (m)	Anthropogenic Disturbances
Trat Province					
Ko Pee	Fringing reef	35	Clear	3-8	Tourism, Fishery
Ko Raet	Fringing reef	50	Clear	2-6	Tourism, Fishery
Ko Maisi	Fringing reef	50	Clear	2-6	Tourism, Fishery
Rayong Province					
Ko Man Nok	Fringing reef	7	Clear	2-6	Tourism, Fishery
Hin Phloeng	Underwater pinnacle	30	Clear	2-20	Tourism, Fishery
Ko Saket	Fringing reef	3	Turbid	2-5	Urban, Fishery

3. Results

The benthic components investigation revealed that live coral was the major component of the substrates at the study sites. The other components were sand, rubble, rock, dead coral, and other sessile invertebrates, including soft corals and sea anemones. The live coral cover at Ko Raet, Trat Province, was the highest (68.93%), followed by Hin Phloeng (68.52%) in Rayong Province, while high dead coral cover were found at Ko Man Nok (21.10%) and Ko Maisi (10.01%) indicating that the coral reefs at Ko Pee, Ko Raet, Trat Province and Hin Phloeng at Rayong Province, are very good conditions (Figures 2 and 3).

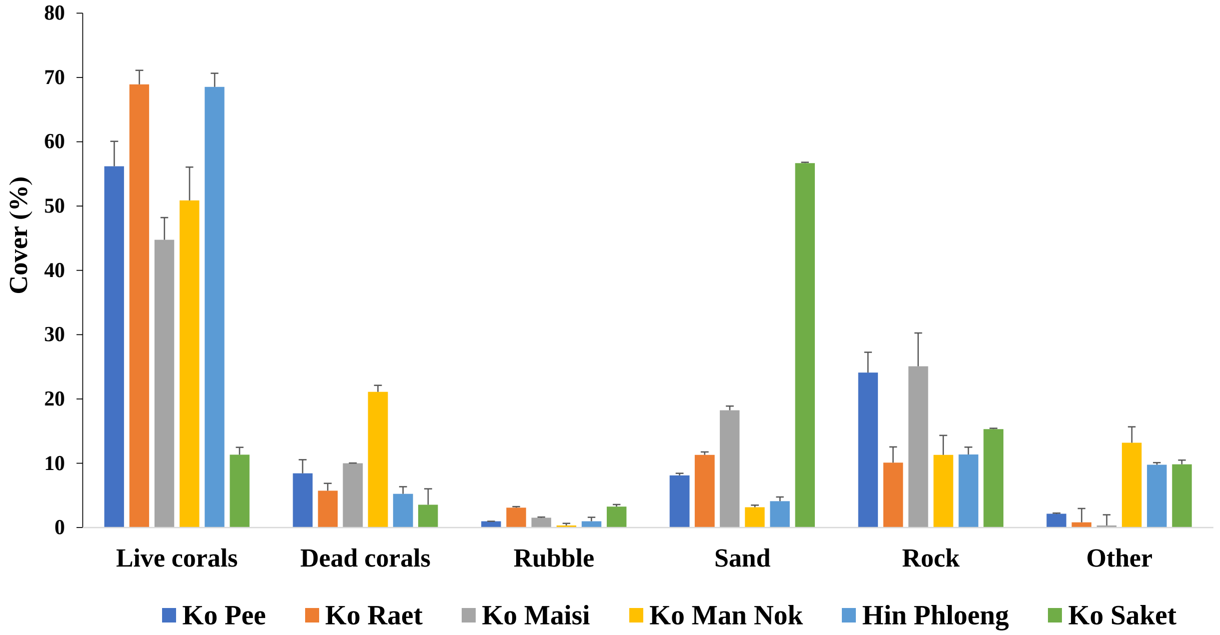

Figure 2. Benthic composition at the study sites (Mean ± SE)

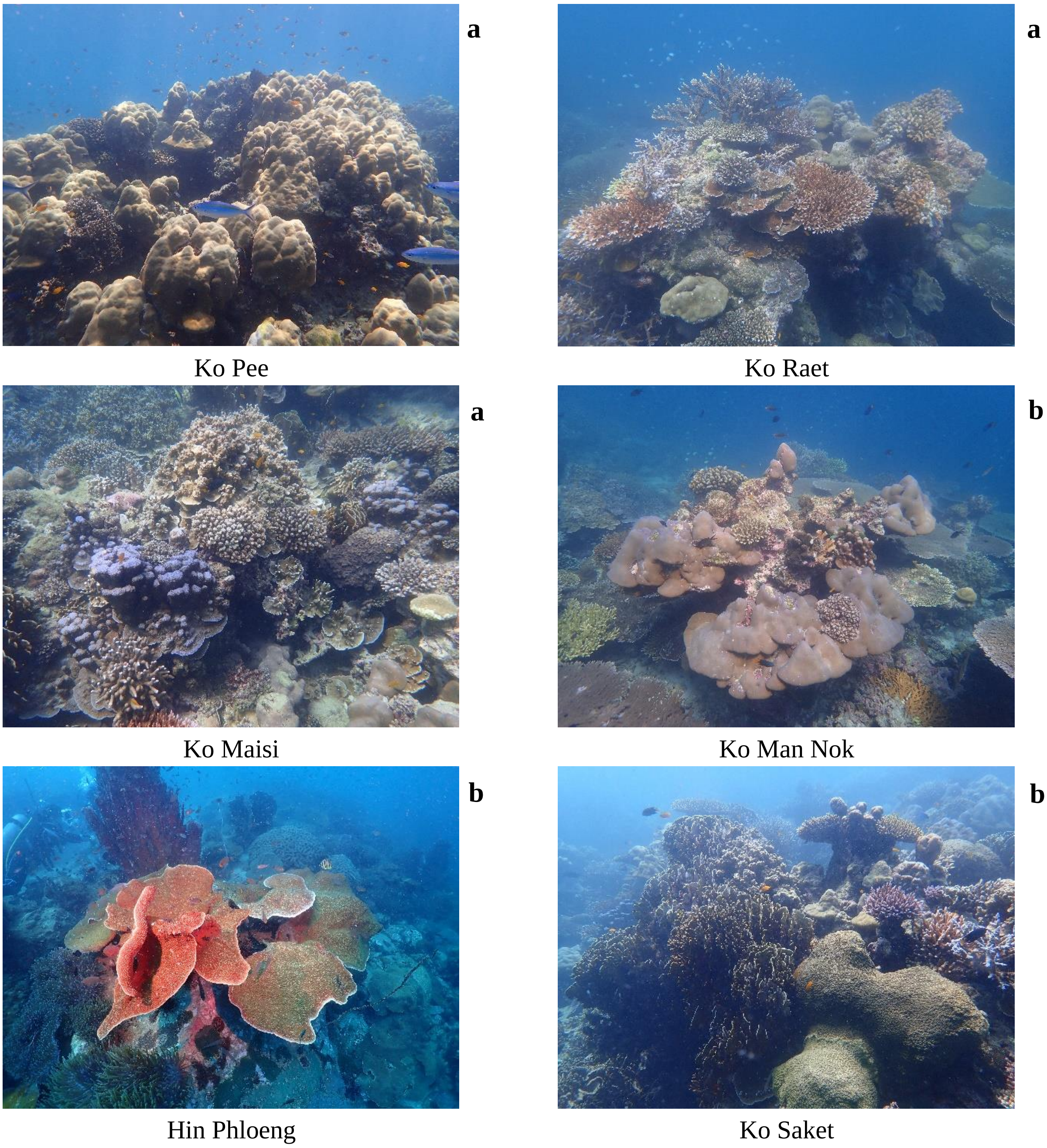

Figure 3. Coral reefs at the study sites (a) Trat Province (b) Rayong Province

The results showed that the density of macroinfauna on coral reefs and an underwater pinnacle in Trat Province (488.89± 75.43 individuals/m^2) was significantly higher than that in Rayong Province (330.86± 56.37 individuals/m^2) (*t*-test, p<0.05) (Figure 4). Thirty-six group of macroinfauna were found in Trat Province, while twenty groups were observed in Rayong Province. Polychaeta, including Aphroditidae, Arenicolidae, Amphinomidae, Cossuridae, Goniadidae, Orbiniidae, Oweniidae, Dorvilleidae, Maldanidae, Scalibregmidae, *Sphaerosyllis* sp., *Polydora* sp., Malacostraca, including Apseudidae, Leptochelia, Copepoda (Cyclopoida), Bivalvia (*Pillucina vietnamica*), Gastropoda (*Euspira* sp.), and Leptocardii (Amphioxiformes) were found only in Trat Province while Polychaeta (Lacydoniidae, Sabellidae, and Sigalionidae) were found in Rayong Province. Polychaeta, including *Capitella* sp., *Neanthes glandicincta*, Hesionidae, Paraonidae, and Nephtyidae, Oligochaeta, Malacostraca (Amphipoda, and Isopoda), Copepoda (Harpacticoida), Ostracoda, Bivalvia, including *Corbula* sp., *Anadara* sp., *Tellina* sp., *Rhinoclavis sordidula* and Ophiuroidea (*Ophiocomella ophiactoides*) were found at both study sites.

The most abundant macroinfauna was recorded in *Rhinoclavis sordidula* (848.15 individuals/cm^2), followed by *Capitella* sp. (166.67 individuals/cm^2). *Capitella* sp. was specifically associated with coral reef habitats, while Sabellidae, Sigalionidae, and Syllidae were present in underwater pinnacles. The Shannon – Wiener index (H’) and Evenness index (J’) were significantly among the study sites (p<0.05) (Table 2). The statistical analysis revealed that the densities of macroinfauna on coral reefs and an underwater pinnacle were significantly different among the study sites (One-way ANOVA, p<0.05; Figures 5 and 6).

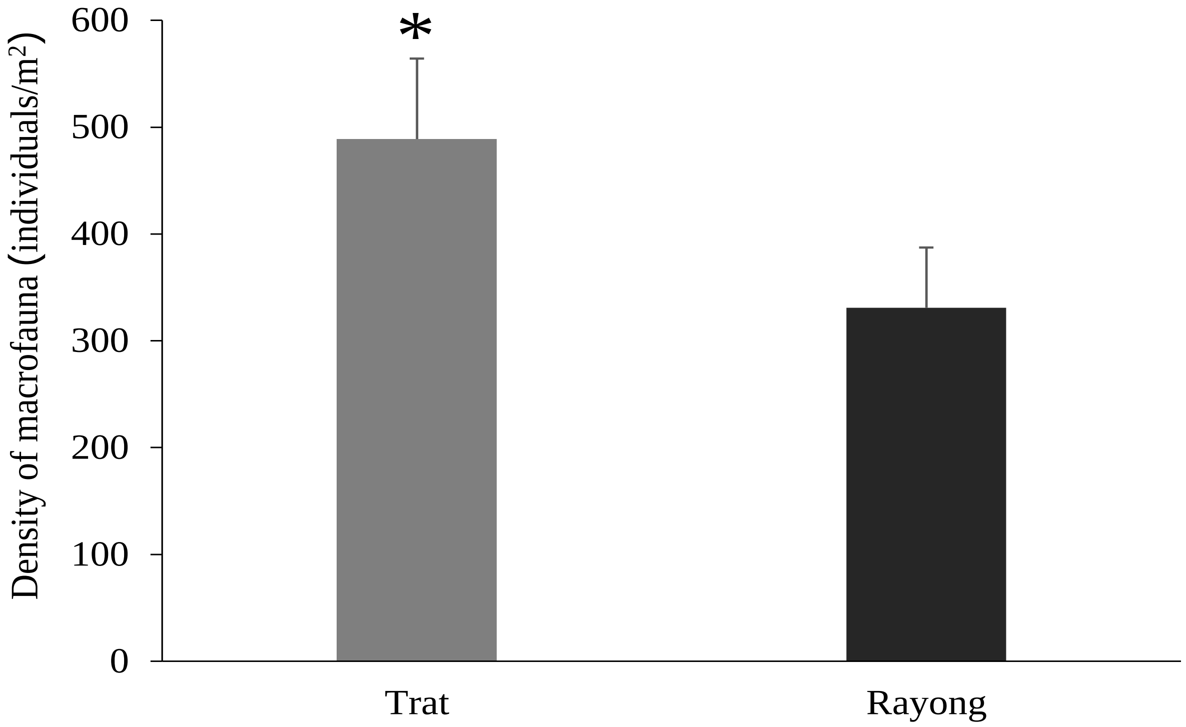

Figure 4. Density of macroinfauna on coral reefs in Trat and Rayong Provinces (Test, *p<0.05)

Table 2. Shannon diversity index and evenness index at the study sites

Study Sites	H’	J’
Trat Province		
Ko Pee	2.43	0.84
Ko Raet	2.48	0.80
Ko Maisi	1.78	0.58
Rayong Province		
Ko Man Nok	1.52	0.61
Hin Phloeng	2.39	0.86
Ko Saket	1.01	0.48

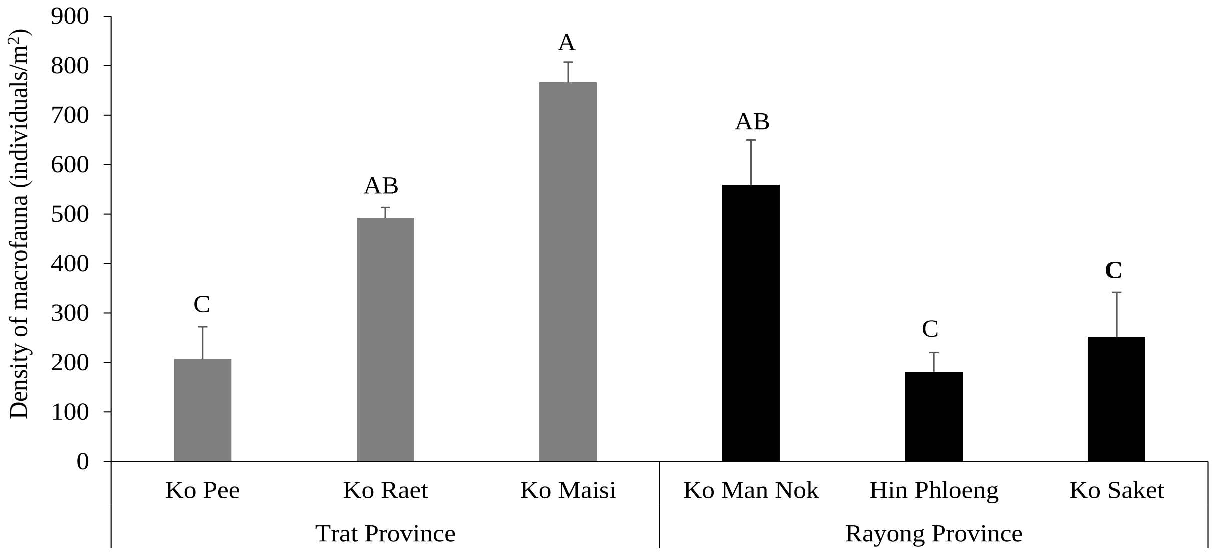

Figure 5. Density of macroinfauna on coral reefs at the study sites (One-way ANOVA, p <0.05)

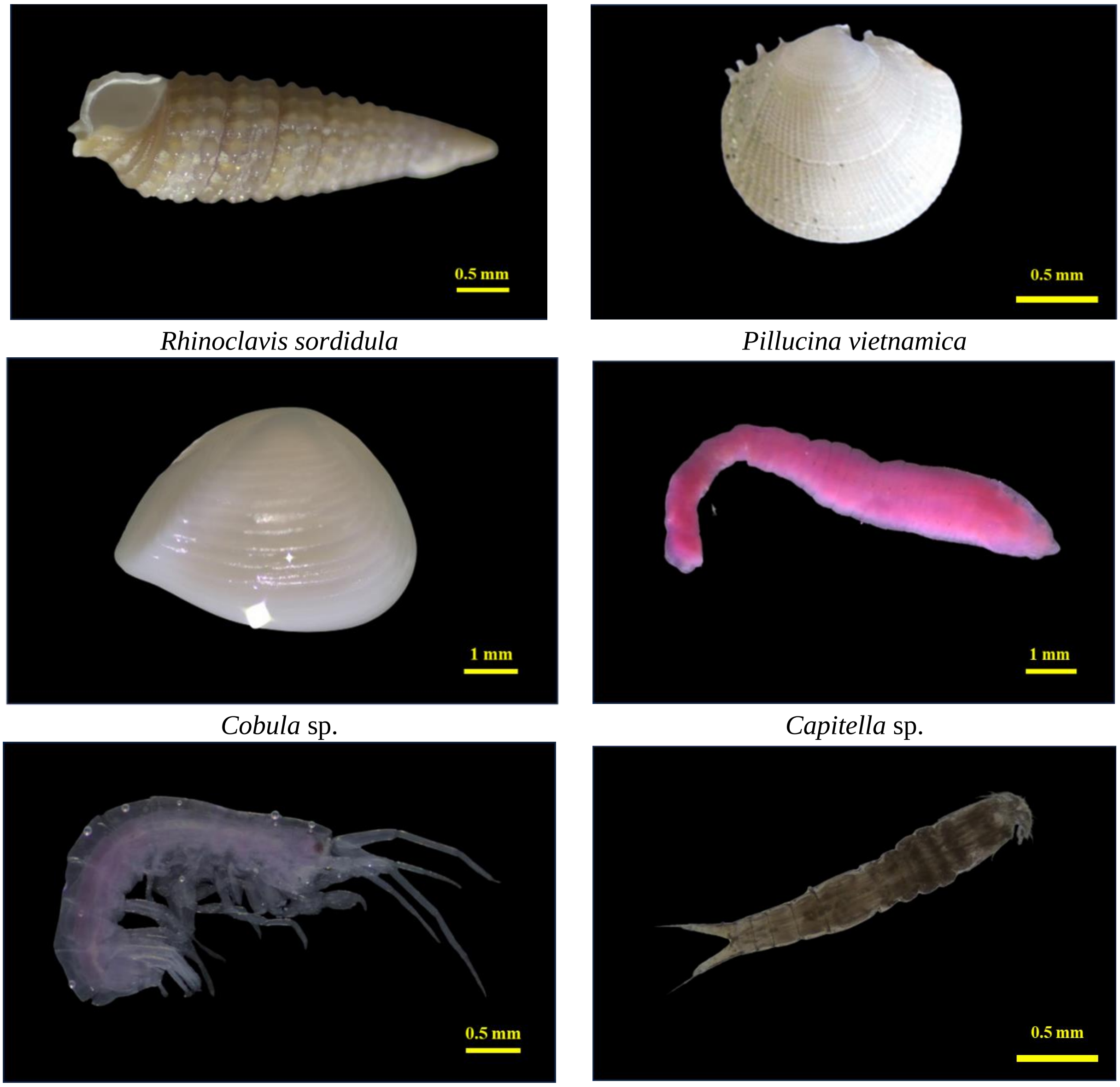

Figure 6. Dominant macroinfauna at the study sites

The cluster analysis using Non-metric Multidimensional Scaling (NMDS) showed that at 50% Bray-Curtis similarity, the macroinfauna in coral reefs and an underwater pinnacle could be divided into three groups. i.e., Group 1: Trat Province, in the areas of Ko Raet and Ko Pee; Group 2: Hin Phloeng in Rayong Province and Group 3: Ko Saket and Ko Man Nok, Rayong Province; and Ko Maisi, Trat Province (Figure 7). Maldanidae and Amphioxiformes were found only at the study sites in Group 1 whereas Sabellidae, Sigalionidae, and Syllidae were found only at the study site in Group 2. The correlation analysis showed a significant relationship (r = -0.257, p<0.05) between macroinfauna density and median grain size. A negative correlation between total macroinfauna density and median grain size was found (Table 3 and Figure 8).

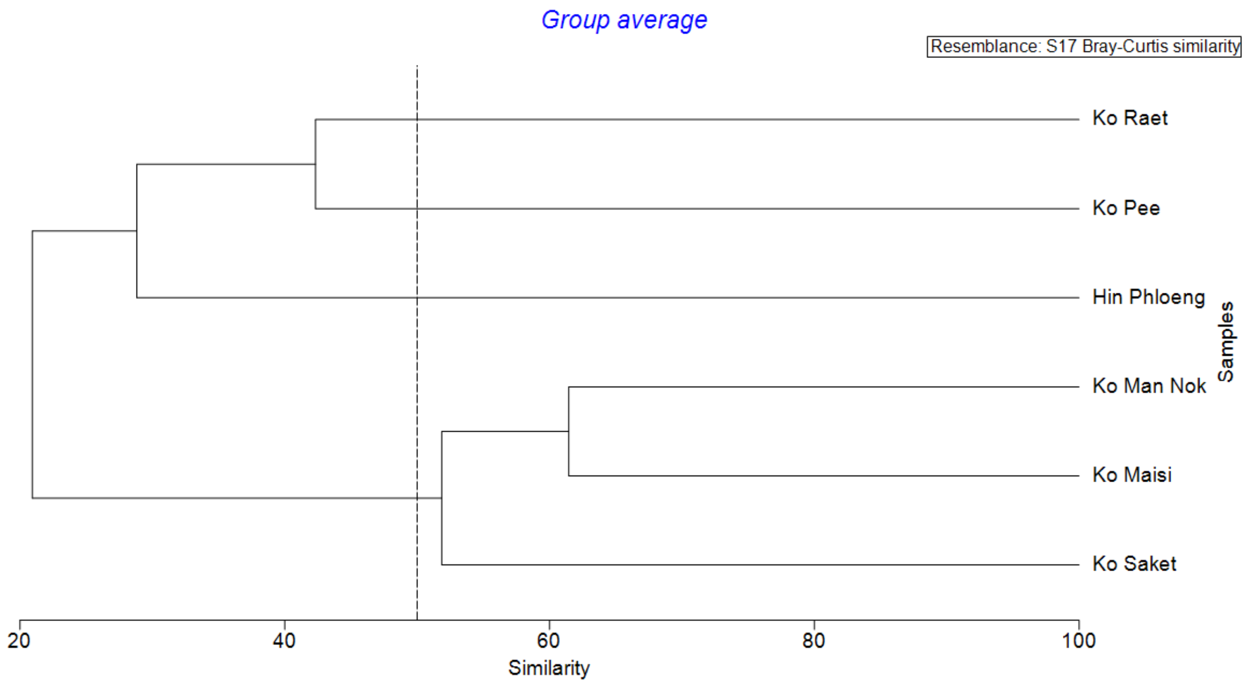

Figure 7. Dendrogram for hierarchical clustering of 6 study sites using complete linkage of Bray-Curtis similarities of coral diseases and signs of compromised health

Table 3. The correlation analysis between macroinfauna density and median grain size

	Correlation	Density (individuals/cm^2)
Median grain size (mm)	Pearson Correlation	-0.257
	Sig. (2-tailed)	0.048
	N	60

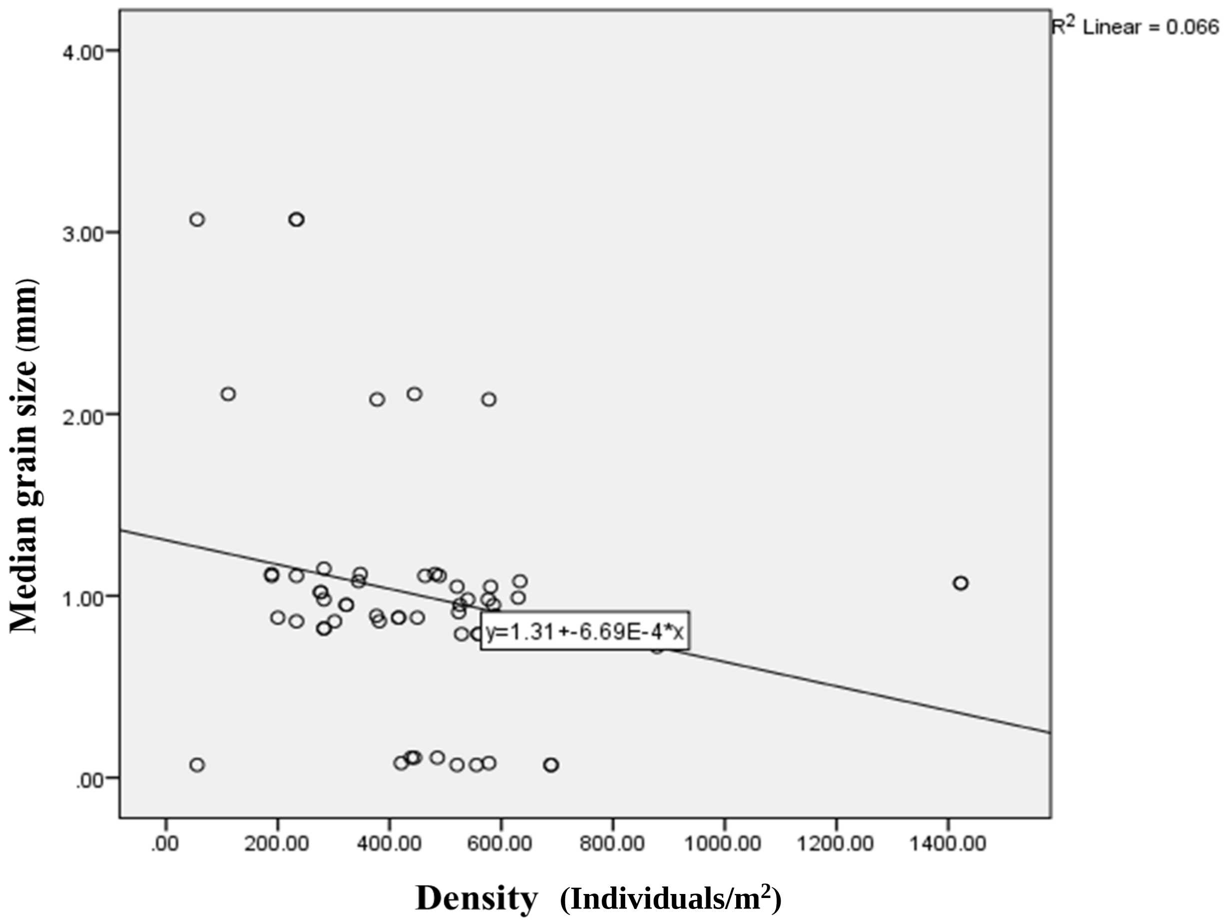

Figure 8. Correlation of macroinfauna density and median grain size at the study sites

4. Discussion

Macroinfauna in coral reefs plays an important role in maintaining the health and biodiversity of reef ecosystems. One of the key roles of macrofauna is their involvement in food webs and trophic interactions. The present study shows that the density of macroinfauna in coral reefs (455.56 individuals/m^2) was higher than the underwater pinnacle (181.48 individuals/m^2). The structure of the benthic macroinfauna was significantly influenced by habitat complexity (Riddle 1988; Carvalho et al., 2017; Bridier, 2024). In the present study, the study sites with high live coral cover had high density and diversity of macroinfauna, probably because of a combination of greater food availability and higher habitat heterogeneity that reduced competition and predation (Klumpp et al. 1988, Clemente et al. 2024). Nevertheless, obvious variations in macroinfauna were observed among different locations within the coral reef, probably due to varying larval influxes and levels of wave exposure. (Frouin and Hutchings 2001; Kahma et al., 2023). The composition of the macroinfauna communities found in coral reefs was similar to other studies in coral reef habitats (Frouin and Hutchings 2001; Abierno and Armenteros, 2017). Bivalves, amphipods, and polychaetes were the most abundant taxa at the study sites. Polychaeta *Capitella* sp. was specifically associated with coral reef habitats, while Sabellidae, Sigalionidae, and Syllidae were present at underwater pinnacles. Polychaetes have been the most common and important taxa in terms of abundance and diversity in most studies of macrobenthos (Gray and Elliott 2009; Morais and Lee, 2014; Nogueira et al. 2023). Relationships between sediments and the macrobenthos have often been described in terms of the range of granulometric variations tolerated by each species (Van Hoey et al., 2004; Hily et al., 2008; Dutertre et al., 2013). According to macroinfauna lifestyle, they require specific sediment characteristics for tube building, burrowing or feeding (Self and Jumars, 1988; Pinedo et al., 2000). The macroinfauna in the present study was also clearly influenced by grain sizes. The relationships between macroinfauna densities and grain sizes were not restricted to species composition level but also exhibited at the community level as demonstrated by cluster analysis.

Benthic macrofauna are commonly recognized as bioindicators because of their high sensitivity to environmental shifts and their short life cycle in ecosystem conditions provides a rapid response from these organisms (Warwick and Clarke, 1998; Elliott and Quintino, 2007). One of the macrobenthos evaluated as a reliable bioindicator is the mollusk group. Mollusks, being invertebrates, possess the capacity to serve as bioindicators of water pollution due to their sensitivity to pollutants present in ecosystems. A macrobenthic mollusk, *Rhinoclavis sordidula* was found in the Awerange Gulf, situated within the Barru District, South Sulawesi. It is one of macrobenthic mollusks as bioindicators in response to environmental disturbance (Putro et al. 2017). The diversity and abundance of macromolluscan assemblages in Brgy, Talao-talao, Lucena City, Quezon Province, may be influenced primarily by the marine area's use for traditional fishing and its popularity as a tourist destination for water activities (Bernabe et al. 2023). Many studies showed that there were strong relationships between the nutrient contents and the grain size on individual macroinfauna, as well as the population density. *Capitella* sp. can be used as a bioassay approach to estimate sediment nutrients (Hu et al., 2003) and as a probiotic for fish aquaculture (Balasubramanian et al., 2023). There are several benefits from polychaetes that have been reported, such as indicators of organically enriched marine sediments, feeds of aquatic animals, and enhancing reproduction in shrimp and fish broodstocks (Giangrande et al. 2005; Meunpol et al., 2005; Palmer et al. 2014; Nederlof et al., 2019; Jungrak et al., 2021). Furthermore, polychaetes several potentials pharmaceutical applications, including their potential for antimicrobial, antibacterial, anticancer, and antifungal activities. (Elayaraja et al., 2008; Fonseca et al., 2008; Bruno et al., 2019).

The marine benthic amphipods of India can play a crucial role in the monitoring and health assessment of coastal ecosystems and also in the sector of coastal aquaculture (Bhoi et al., 2023). The amphipod, along with polychaetes, is being employed as an ecological marker for assessing oil pollution as part of the Benthic Opportunistic Polychaetes Amphipods Index, commonly referred to as the BOPA index (Dauvin and Ruellet 2007; Dauvin et al. 2016). According to research conducted by Gesteira and Dauvin (2000), the genus Ampelisca serves as a reliable indicator for investigating the effects of oil spills. Benthic amphipods have demonstrated significant utility in assessments of sediment toxicity. *Corophium volutator* emerges as a promising candidate for evaluating sediment toxicity across various metals such as Hg, Cd, Cu, Zn, Cr, As, Ni, as well as crude oil (Bat 2005). *Grandidierella japonica* Stephensen, 1938, proves valuable in bioassay tests for assessing the toxicity of TBT, PAH compounds, as well as metals such as Cd and Hg (Bat 2005; Lee et al. 2005).

Overall, macroinfauna functions and the importance of macroinfauna in ecosystems are crucial for conserving them and ensuring the long-term sustainability of ecosystems and human well-being (Coleman et al., 2007; Ruiz et al., 2008). In addition to their ecological roles, macroinfauna within coral reefs also possess fisheries and economic importance. However, coral reef macroinfauna faces numerous threats, including overfishing, habitat destruction, pollution, climate change, and invasive species (Harley et al., 2006; Defeo et al., 2009). These pressures can disrupt the ecological balance, degrade habitats, and threaten the survival of both macroinfauna and the coral reefs they inhabit. Efforts to conserve coral reef macroinfauna and their habitats are therefore crucial for preserving the biodiversity and ecological health of these vulnerable ecosystems. Conservation strategies might involve establishing marine protected areas, implementing sustainable fishing, reducing pollution, promoting coral reef restoration, and raising awareness about the importance of coral reef ecosystems and their inhabitants.

This research offers important insights into the composition and density of macroinfauna found in sediment samples collected from coral reefs and an underwater pinnacle in the Eastern Gulf of Thailand. Our finding marks the inaugural documentation of macroinfauna communities inhabiting coral reefs and underwater pinnacles within Thai waters. The present study underscores the importance of underwater pinnacles as ecosystems of comparable significance to coral reefs.

Acknowledgements

We are most grateful to the staff of Marine Biodiversity Research Group, Faculty of Science, Ramkhamhaeng University and Department of National Parks, Wildlife and Plant Conservation, for their support and assistance in the field. This research was supported by Thailand Science Research and Innovation (TSRI), National Science, Research and Innovation Fund (NSRF) and Ramkhamhaeng University (RU).

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