

ORIGINAL PAPER

Species Composition and Spatial Patterns of Scleractinian Corals on Shallow Reef Flats in Krabi Province, Andaman Sea

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Abstract. Shallow reef flats support diverse coral assemblages but are highly influenced by local environmental conditions and disturbance regimes. This study assessed spatial variation in live coral cover, species composition, and coral community structure at Ko Pu, Ko Ka, and Ko Sriboya in Krabi Province, Andaman Sea, Thailand. Coral communities were surveyed using three replicate 30 × 1 m belt transects at each site. Coral colonies were identified to species level. Live coral cover differed significantly among the three study sites (ANOVA, $p < 0.01$). Ko Ka exhibited the highest live coral cover ($55.1 \pm 4.9\%$), followed by Ko Pu ($42.3 \pm 3.7\%$) and Ko Sriboya ($33.2 \pm 2.9\%$). Coral species composition and relative density also varied among sites. *Porites lutea* was consistently the dominant species at all three locations, whereas other prominent taxa differed spatially. Ko Pu was characterized by *Galaxea astreata*, *Dipsastraea favus*, *Pavona decussata*, and *Favites abdita*, while *Turbinaria mesenterina*, *F. abdita*, *P. decussata*, *Diploastrea heliophora*, and *Montipora aequituberculata* were important components at Ko Ka. At Ko Sriboya, *Platygyra sinensis*, *P. decussata*, and *Lithophyllum undulatum* were among the prominent taxa. Several coral species occurred at all sites, whereas others showed site-specific distributions. These findings demonstrate marked spatial variation in live coral cover and coral assemblage composition among shallow reef flats in Krabi Province. The distinct assemblages supported by each site emphasize the importance of incorporating species-level information together with live coral cover in reef assessment and provide essential baseline data for long-term monitoring, site-specific conservation, and management of shallow reef flat ecosystems in the Andaman Sea.

Keywords: Reef flat, Species composition, Scleractinian coral, Community structure, Andaman Sea

1. Introduction

Coral reefs are among the most biologically diverse and ecologically important marine ecosystems in tropical regions. Reef-building scleractinian corals create complex three-dimensional habitats that support diverse reef-associated organisms, with colony morphology and size strongly influencing reef structural complexity (Richardson et al., 2017; Eddy et al., 2021; Voolstra et al., 2023; Cardenas et al., 2024). Reef functioning and resilience therefore depend not only on live coral cover but also on coral species composition, morphology, and spatial dynamics (Lam et al., 2023; Zhang et al., 2023; Matthews et al., 2024; Peixoto et al., 2025). Differences among coral taxa in growth, recruitment, life-history strategies, and disturbance tolerance can lead to contrasting responses and recovery trajectories (Gouezo et al., 2020; Carlson et al., 2024). Consequently, assessments of species richness, diversity, relative abundance, and community composition are essential for detecting ecological changes that may not be reflected by coral cover alone. Recent regional and long-term studies further demonstrate that apparently stable coral cover can conceal substantial shifts in community composition and associated reef biodiversity (Kusumoto et

al., 2020; Timmers et al., 2021; Geldard et al., 2025).

Coral communities on shallow reef flats are strongly influenced by environmental heterogeneity operating over relatively small spatial scales. Reef flats are typically characterized by shallow water, high irradiance, pronounced fluctuations in temperature, variable hydrodynamic conditions, and periodic exposure to elevated sedimentation and turbidity (Li et al., 2021; Rich et al., 2022; Liu et al., 2023). These environmental conditions can influence coral settlement, survival, growth, and competitive interactions and consequently shape coral species composition, abundance, and diversity. Variations in substrate characteristics, water quality, wave exposure, and sedimentation among reef flats may further generate substantial spatial differences in coral assemblage structure. Such patterns indicate that comparative studies of coral assemblages on reef flats can provide important insights into environmental filtering, disturbance history, and the capacity of different reef habitats to persist under changing environmental conditions. (Wulandari et al., 2022; Mattos et al., 2025).

Coral communities on shallow reef flats are particularly susceptible to environmental disturbances because of their proximity to the sea surface and their exposure to pronounced fluctuations in physical conditions. Elevated seawater temperatures and high solar irradiance during periods of thermal anomalies can result in coral bleaching and mortality, while sedimentation, nutrient enrichment, coastal development, fishing activities, and tourism may impose additional local pressures (Dunne et al., 2021; Dumas et al., 2022; Harmelin-Vivien et al., 2022). The magnitude of these impacts, however, can vary considerably among reef locations and coral taxa because individual species differ in their physiological tolerance, morphology, growth strategies, and capacity for recovery.

Consequently, disturbance may alter not only total live coral cover but also species composition, relative abundance, and diversity, potentially leading to shifts toward assemblages dominated by more stress-tolerant coral taxa (Comfort et al., 2019; Webber et al., 2022; Girard et al., 2025).

Understanding these changes requires assessments that extend beyond measurements of percentage live coral cover. Reefs with similar coral cover may differ substantially in species richness, diversity, relative abundance, and the identity of dominant taxa. Changes in coral assemblage composition may therefore occur even when overall coral cover appears relatively stable (Chan et al., 2023). Species-level assessments are particularly important for detecting the loss of disturbance-sensitive taxa, increasing dominance of stress-tolerant species, and changes in community structure that may ultimately affect habitat complexity and ecological functioning. Evaluating spatial variation in coral communities among shallow reef flats can thus provide a more comprehensive understanding of reef condition and ecological resilience than coral cover alone. (Reid et al., 2019; Xie et al., 2024; Kenyon et al., 2025).

Despite the ecological importance of coral reefs along the Krabi coastline, comparative information on coral species composition and diversity among shallow reef flats remains limited, particularly at Ko Siboya, Ko Pu, and Ko Ka. These reef flats are likely to experience different environmental conditions and degrees of exposure to natural and anthropogenic disturbances, potentially resulting in spatial variation in coral assemblage structure, species richness, and diversity. Establishing site-specific information on coral assemblages is therefore essential for detecting ecological changes, identifying reefs of high biodiversity and conservation importance, and providing baseline data for long-term monitoring and management.

This study aimed to assess the species composition and diversity of scleractinian corals on shallow reef flats at Ko Siboya, Ko Pu, and Ko Ka, Krabi Province, the Andaman Sea, Thailand. Specifically, spatial variation in coral species richness, diversity, and the relative abundance of dominant coral taxa was examined among the three study sites. The findings provide essential baseline information for evaluating spatial patterns in coral community structure and reef condition and for supporting long-term monitoring, site-specific conservation, and sustainable management of coral reef ecosystems in the Andaman Sea.

2. Materials and Methods

2.1 Location of study sites

The study was conducted on shallow reef flats at Ko Siboya, Ko Pu, and Ko Ka, Krabi Province, Thailand, in the Andaman Sea (Figure 1). These sites were selected to represent spatially separated shallow reef habitats along the Krabi coastline. Coral communities and benthic composition were surveyed using standardized transect-based methods to allow quantitative comparisons among the three study sites.

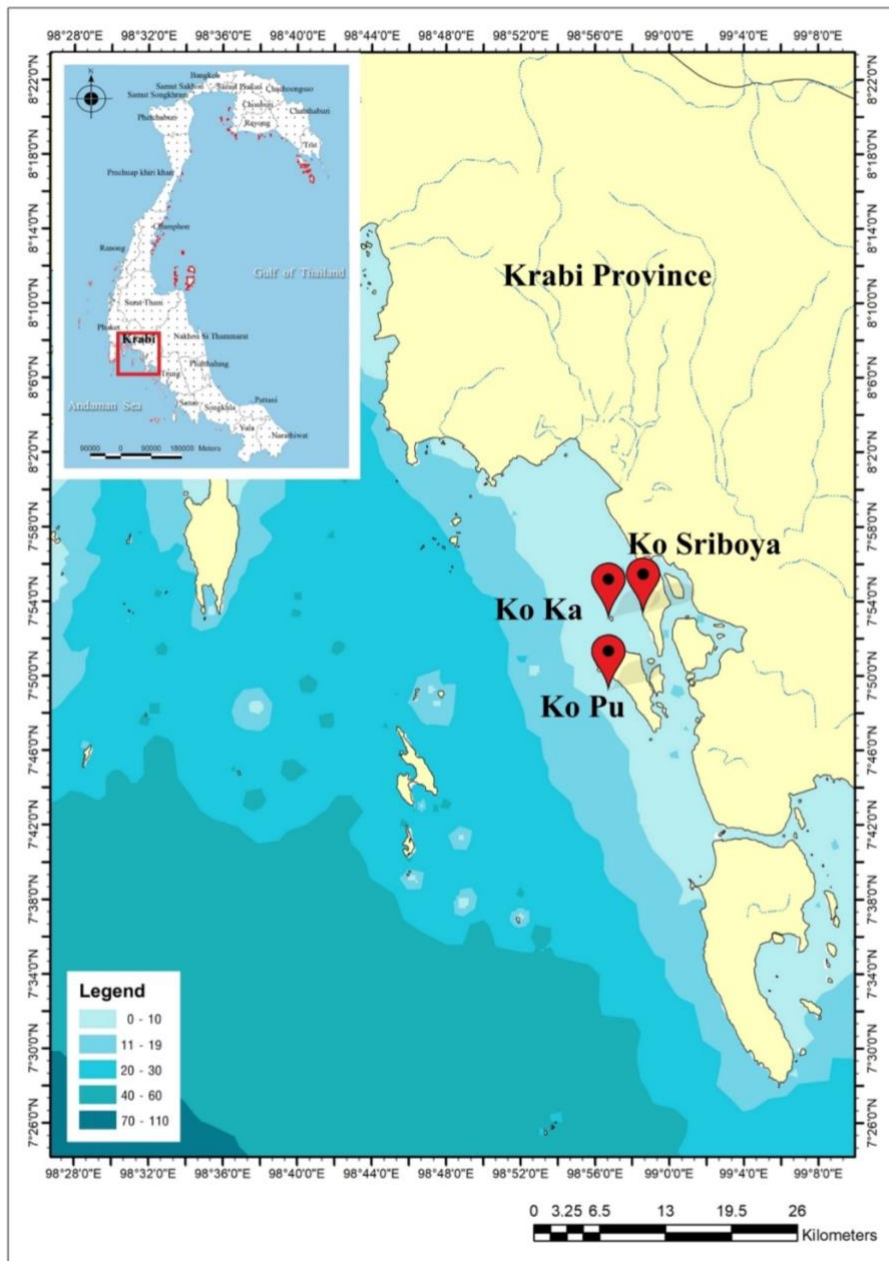


Figure 1 The location of study sites at Krabi Province

2.2 Data Collection

Coral communities were surveyed using permanent belt transects measuring 30 m × 1 m, with three replicate transects established at each study site. Along each transect, benthic photographs were systematically collected using a 50 × 50 cm quadrat placed at predetermined intervals. Images were captured with a high-resolution digital camera and subsequently examined in the laboratory for species verification and quantitative analysis. Live coral cover was estimated in situ, and all coral colonies occurring within each quadrat were identified to the lowest possible taxonomic level, preferably species, following Veron (2000). The percentage cover of other benthic components, including dead coral, coral rubble, sand, algae, and other substrate categories, was also recorded for each quadrat.

2.3 Data analysis

At each study site, species diversity was quantified using the Shannon–Wiener diversity index (H'), calculated based on the relative

abundance of coral species. Differences in the diversity index among study sites were assessed using one-way analysis of variance (ANOVA). When significant differences were detected ($p < 0.05$), Tukey's honestly significant difference (HSD) post hoc test was applied to identify which pairs of study sites differed significantly.

3. Results

3.1 Live Coral Cover

Live coral cover varied considerably among the three study sites. The highest live coral cover was recorded at Ko Ka ($55.5 \pm 4.9\%$), followed by Ko Pu ($42.3 \pm 3.7\%$), whereas the lowest value was observed at Ko Sriboya ($33.5 \pm 2.9\%$) (Figure 2). Statistical analysis revealed a significant difference in live coral cover among the study sites (one-way ANOVA, $F = 12.08$, $p < 0.01$) (Figure 3). Overall, these results demonstrate clear spatial variation in live coral cover among the surveyed shallow reef flats, with Ko Ka exhibiting comparatively higher live coral cover than Ko Sriboya.

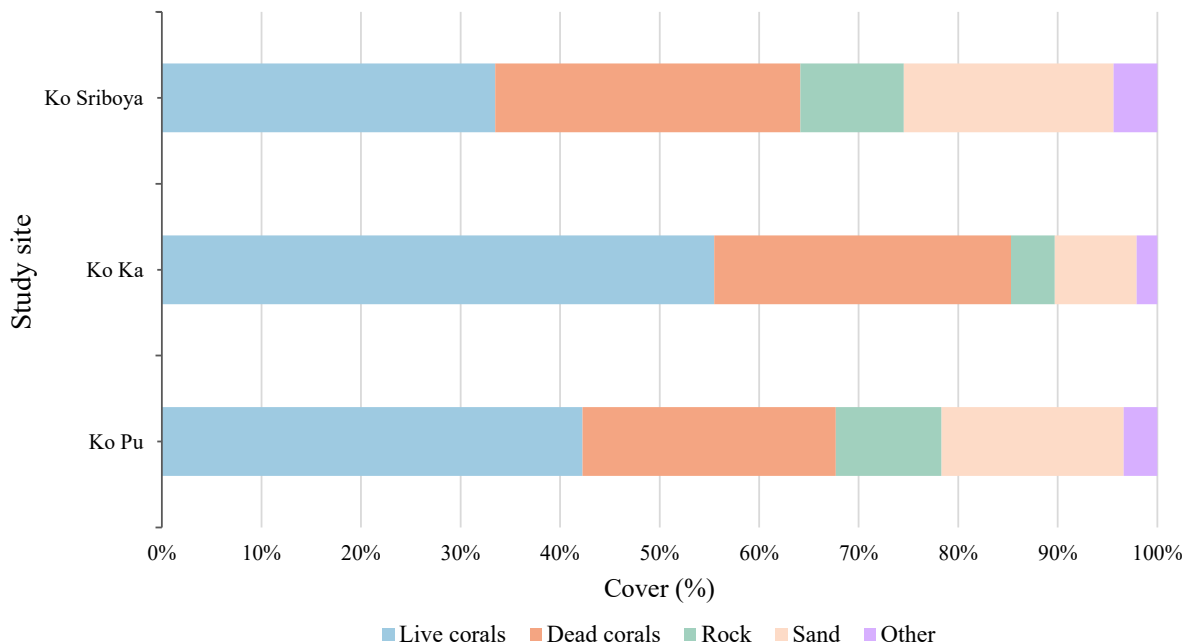


Figure 2 Average percentage cover of live corals, dead corals and other benthic components at the study sites.

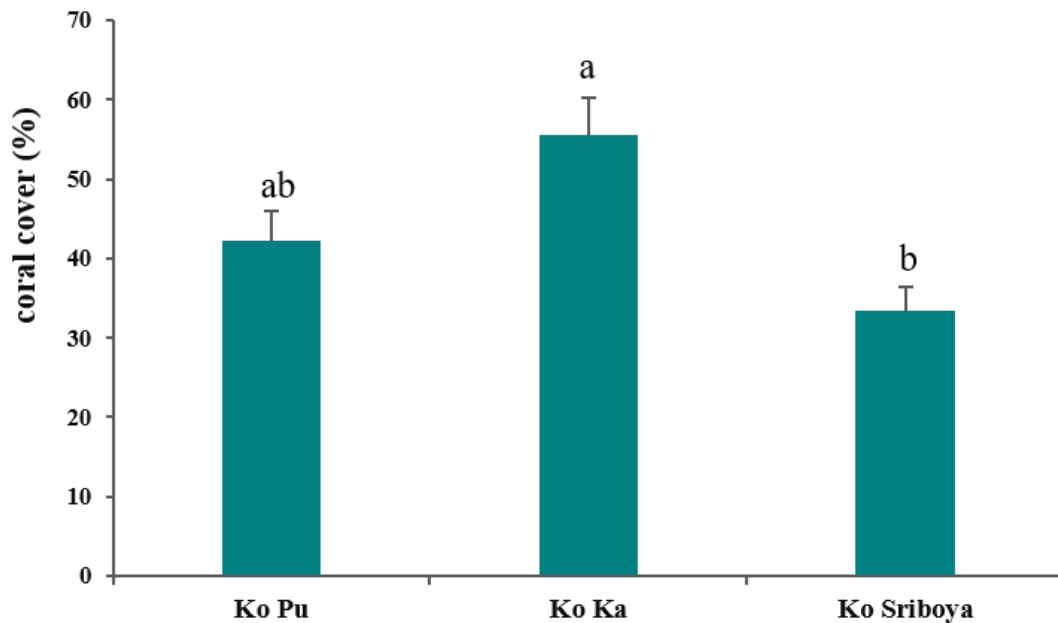


Figure 3 Live coral cover on shallow reef flats at the study sites.

3.2 Coral Species Composition and Distribution

Coral species composition and density varied among the three-shallow reef-flat sites. *Porites lutea* was the dominant species at all sites, indicating its widespread occurrence and prominence across the surveyed reefs. At Ko Pu, *P. lutea* was followed by *Galaxea astreata*, *Dipsastraea favus*, *Pavona decussata*, and *Favites abdita*. At Ko Ka, relatively high densities of *Turbinaria mesenterina*, *F. abdita*, *P. decussata*, *Diploastrea heliopora*, and *Montipora aequituberculata* were recorded. At Ko Sriboya, *P. lutea* was also the most abundant species, followed by *Platygyra sinensis*, *P. decussata*, *Lithophyllon undulatum*, *M. aequituberculata*, and *F. abdita*.

Several coral species, including *P. lutea*, *P. decussata*, *F. abdita*, *Fungia fungites*, and *Pocillopora acuta*, occurred at all three sites, although their relative densities varied among locations. In contrast, several taxa exhibited more restricted distributions. *Acropora digitifera*,

Astreopora myriophthalma, *Coelastrea aspera*, *Galaxea astreata*, and *Lobophyllia radians* were recorded exclusively at Ko Pu, whereas *Acropora muricata* and *Echinopora lamellosa* occurred only at Ko Ka. Other taxa, including *Diploastrea heliopora*, *Galaxea fascicularis*, *Goniopora columna*, *Lithophyllon undulatum*, and *Montipora aequituberculata*, were shared between two of the three sites. (Figures 4 and 5).

Overall, coral communities showed clear spatial variation in species composition and density among Ko Pu, Ko Ka, and Ko Sriboya. The consistent dominance of *P. lutea* across all sites indicates that this species represents a major component of shallow reef-flat coral communities in the study area. Differences in the occurrence and relative abundance of other coral taxa further contribute to overall assemblage diversity and underscore the ecological importance of these shallow reef flats in supporting coral biodiversity in Krabi Province.

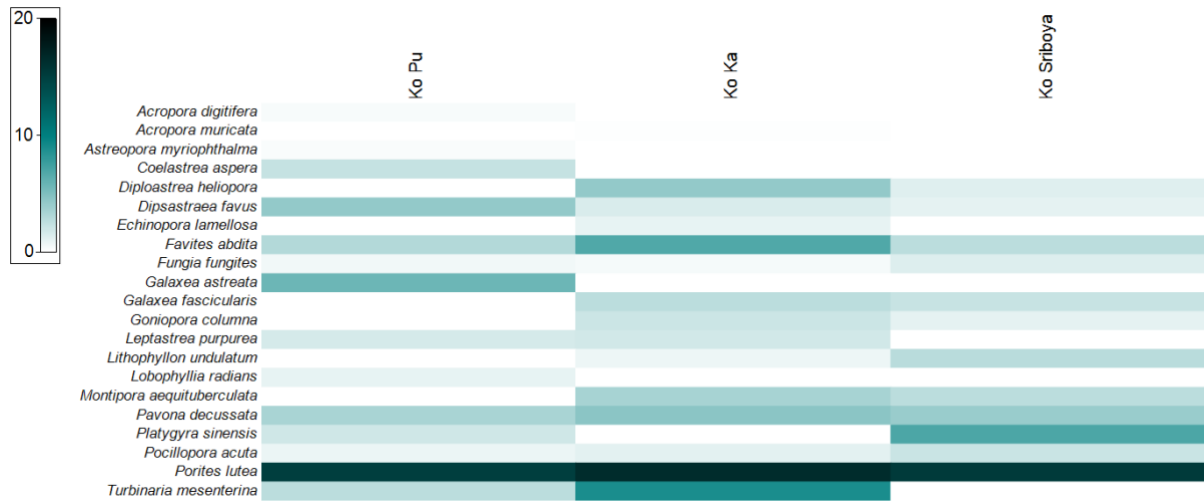


Figure 4 Species composition of live corals at the study sites.



Porites lutea



Pavona decussata



Turbinaria mesenterina



Favites abdita

Figure 5 Composition of macrobenthic invertebrates on coral reefs at the study sites

4. Discussion

The present study revealed clear spatial variation in live coral cover and species composition among the shallow reef flats at Ko Pu, Ko Ka, and Ko Sriboya in Krabi Province. Live coral cover was highest at Ko Ka, followed by Ko Pu and Ko Sriboya, demonstrating marked spatial differences among reefs within the same geographic region. Shallow reef flats are inherently dynamic habitats, where coral communities may be shaped by local variation in temperature, irradiance, sedimentation, substrate characteristics, and hydrodynamic conditions. Recent surveys from Mu Ko Surin National Park in the Andaman Sea similarly documented substantial differences in live coral cover and coral species composition among shallow reef-flat sites, highlighting the influence of local environmental conditions on coral community structure (Sutthacheep et al., 2025). A recent nationwide assessment of 115 coral reef sites across eight provinces in Thailand also demonstrated pronounced geographic variation in coral community structure, emphasizing the need to consider spatial heterogeneity when evaluating reef condition at regional scales (Monchanin et al., 2025).

At a broader geographic scale, recent research has shown that variation in benthic composition and reef structure is closely associated with differences in environmental setting and substrate characteristics among reef locations (Rich et al., 2025; Wu et al., 2025). Collectively, these findings suggest that the spatial patterns observed among the shallow reef flats in Krabi Province may reflect site-specific habitat and environmental conditions. Such variability reinforces the importance of site-specific monitoring approaches that incorporate both live coral cover and coral species composition when assessing reef condition and detecting ecological change.

The relatively high live coral cover observed at Ko Ka may reflect local environmental conditions that are comparatively favorable for coral persistence and growth. Nevertheless, live coral cover alone may not fully represent

coral community structure because reefs with similar levels of coral cover can support markedly different taxonomic assemblages. A regional analysis of reefs across the East Asian Seas demonstrated that apparently stable coral cover can mask substantial changes in coral community composition over time (Chan et al., 2023; Cardenas et al., 2024). Recent international studies have similarly documented pronounced spatial variation in benthic and coral community structure, emphasizing the influence of local environmental conditions and habitat characteristics on reef assemblages (Hoegh-Guldberg et al., 2019; Eddy et al., 2021; Lawrence et al., 2025). These findings reinforce the importance of considering species composition together with live coral cover when evaluating reef condition.

Despite spatial differences in coral assemblage structure, *Porites lutea* was consistently the dominant coral species at Ko Pu, Ko Ka, and Ko Sriboya. A similar pattern has recently been reported from shallow reef flats in Mu Ko Surin National Park, where *P. lutea* was also among the dominant coral taxa across surveyed sites (Aunkhongthong et al., 2019; Klinthong et al., 2025; Sutthacheep et al., 2025). The persistence of *P. lutea* across environmentally variable shallow reef habitats may be associated with its relatively high tolerance to thermal and other environmental stresses. Recent studies have shown that stress-tolerant coral taxa can maintain greater persistence than more disturbance-sensitive taxa during prolonged thermal stress and other disturbances (Sutthacheep et al., 2013; Bellwood et al., 2018; Harris et al., 2023; Tietjen et al., 2025). These characteristics may partly explain the widespread occurrence and consistent dominance of *P. lutea* across the shallow reef flats examined in the present study.

Although *P. lutea* dominated all three study sites, the composition and relative densities of other coral taxa differed markedly among locations. Ko Pu was characterized by relatively prominent *Galaxea astreata*, *Dipsastraea favus*, *Pavona decussata*, and *Favites abdita*, whereas *Turbinaria mesenterina*, *F. abdita*, *P. decussata*, *Diploastrea heliopora*, and *Montipora aequituberculata* were important

components of the assemblage at Ko Ka. At Ko Sriboya, *Platygyra sinensis* was relatively prominent together with *P. decussata*, *Lithophyllon undulatum*, and other massive and foliose coral taxa. Similar site-specific differences in coral assemblage composition have been reported in recent international studies, where reefs exposed to comparable broad-scale conditions nevertheless supported contrasting coral assemblages and followed different ecological trajectories after disturbance (Loya et al., 2001; et al., Ford et al., 2023; Cacapit et al., 2025).

The occurrence of several coral taxa only at particular sites further suggests that local habitat characteristics and ecological processes play an important role in structuring shallow reef-flat assemblages. Spatial variation in coral composition may arise from differences in substrate suitability, hydrodynamic exposure, thermal regimes, sedimentation, water quality, larval supply, and disturbance history. Coral species also differ substantially in colony morphology, growth strategy, recruitment characteristics, and susceptibility to physical and thermal disturbances. Recent evidence has demonstrated that the initial taxonomic composition of coral assemblages can strongly influence their subsequent responses to disturbance, resulting in contrasting trajectories among reefs (Yeemin et al., 2001; Chen et al., 2018; Hoarau et al., 2023;). These findings emphasize that species composition is an important determinant of reef response and should therefore be incorporated into long-term monitoring programs.

Disturbance history is also likely to contribute to spatial variation in shallow coral communities. Recent studies have demonstrated that prolonged thermal stress, local anthropogenic pressures, storms, and bleaching events can produce substantial changes in live coral cover and assemblage composition, while the magnitude of response differs among coral taxa and life-history strategies (Fan et al., 2024; Sumayed et al., 2025; Tietjen et al., 2025). These observations are consistent with the patterns recorded among Ko Pu, Ko Ka, and Ko Sriboya and suggest that shallow coral communities are shaped by interactions among local environmental

conditions, species-specific traits, and disturbance history.

Recent observations from Krabi Province further demonstrate that coral responses may vary according to habitat and taxon. During the 2024 coral bleaching event, underwater pinnacles in Krabi Province experienced relatively low bleaching prevalence, although responses differed among coral species and study sites (Sutthacheep et al., 2024). Although underwater pinnacles differ environmentally from shallow reef flats, these findings illustrate the habitat- and species-specific nature of coral responses within the same geographic region. Such variability suggests that the differences observed among Ko Pu, Ko Ka, and Ko Sriboya may result from interactions between site-specific environmental conditions and the ecological tolerances of individual coral taxa.

The present findings indicate that the shallow reef flats at Ko Pu, Ko Ka, and Ko Sriboya support distinct but complementary coral communities. Ko Ka was characterized by comparatively high live coral cover, whereas Ko Pu and Ko Sriboya supported different combinations of dominant and site-associated coral taxa. The occurrence of species restricted to particular reef flats further suggests that individual sites make different contributions to coral biodiversity at the broader geographic scale. Similar patterns of spatial differentiation have been documented in recent international studies of shallow coral reef systems, demonstrating that fine-scale environmental heterogeneity and assemblage composition are important determinants of reef structure and response to disturbance (Rich et al., 2022; Levy et al., 2023; Huang et al., 2025; Lawrence et al., 2025).

Overall, the present study highlights the ecological importance of the shallow reef flats at Ko Pu, Ko Ka, and Ko Sriboya, each of which supports a distinctive coral assemblage within Krabi Province. Spatial differences in live coral cover, species composition, and coral density emphasize the need for site-specific and species-level monitoring rather than assuming uniform reef condition across the region.

Continued monitoring, combined with measurements of seawater temperature, sedimentation, turbidity, water quality, substrate characteristics, and hydrodynamic exposure, would help clarify the ecological processes underlying the observed spatial patterns. The baseline information generated by this study therefore provides an important foundation for detecting future changes in coral communities and for developing locally appropriate conservation and management strategies for shallow reef flat ecosystems in Krabi Province, the Andaman Sea.

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