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Coral Diversity Assessment in Kavaratti Island, Lakshadweep Archipelago, India: Implications for Conservation

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Abstract

Coral reefs are the most biodiverse marine ecosystems, supporting intricate symbiotic relationships and contributing an estimated $9.9 trillion annually to global benefits. Despite their ecological and economic significance, coral reefs are under severe threat, with 27% already lost and a 14% decline in coral cover over the last decade. India's coral reefs cover around 2,374 sq.km, yet regions like Kavaratti Island in Lakshadweep remain understudied. Its geographic isolation presents a unique opportunity for biodiversity research, potentially revealing novel species traits and serving as a key reference for Indo-Pacific coral diversity. This study evaluates coral species diversity in Kavaratti Island to bridge gaps in regional coral fauna knowledge using the LIT (Line Intercept Transect) method. Fourteen hard coral species across five families were documented, with *Acropora* (n=6) as the dominant group, followed by *Poritidae* (n=4). Spatial analysis across three reef zones showed that the intermediate lagoon had the highest live coral cover (56.0%), while the inner reef had the highest mortality (66.7%). These findings offer critical baseline data to inform conservation planning, reef management, and climate resilience strategies for coral ecosystems in the Indian Ocean region.

Keywords: Coral diversity, Lakshadweep, Kavaratti Island, Reef health, Conservation, Climate Change.

INTRODUCTION

Coral reefs, often called "rainforests of the sea" harbor the highest biodiversity among marine ecosystems. This remarkable diversity stems from complex symbiotic relationships, nutrient cycling, and energy flow that sustain these vital habitats (Venkataraman, 2006). With 845 reef-building coral species documented worldwide (Miththapala, 2008), the Indian Ocean ranks second in coral biodiversity, shaped by unique oceanographic

conditions, proximity to the Indo-Pacific biodiversity hub, and location along the south equatorial current (Obura, 2012). Yet despite this richness, Indian Ocean reefs remain among the least studied globally (Veron, 1995).
Coral reefs function as critical life-support systems for both marine life and human populations (Veron, 1995). Their skeletal records preserve long-term environmental histories, making them valuable indicators of past climate shifts (Nobi et al., 2009). Twenty-seven percent of the world's reefs have already disappeared due to environmental stresses (Cesar et al., 2003), with global coral cover declining by 14% in the last decade alone (Souter, 2021). This loss threatens not only marine ecosystems but also the 39% of the global population living within 100 km of the coast who depend on reefs for protection, livelihoods, and food (Cesar et al., 2003). Despite providing $9.9 trillion annually in economic benefits, these ecosystems face mounting pressures from both natural and anthropogenic activities (Global Coral Reef Monitoring Network [GCRMN], 2022), prompting urgent exploration of restoration techniques (Rinkevich, 2014).
India's position in the tropical Indian Ocean supports diverse coral reef habitats spanning approximately 2,374 sq.km (D.O.D and S.A.C, 1997). The reefs of Lakshadweep, the Andaman and Nicobar Islands, and the Gulf of Mannar harbour rich marine biodiversity, yet significant knowledge gaps remain. Many species await identification, and numerous locations lack thorough investigation. Kavaratti Island in Lakshadweep exemplifies this challenge; despite widespread coral distribution, faunal identification studies are remarkably scarce. While 208+ species have been recorded, comprehensive surveys could potentially identify up to 400 species (Venkataraman, 2006). The islands' unique geographic position and isolation make them particularly compelling for biodiversity research (Suresh, 1991). Understanding reef biodiversity is essential for deciphering ecosystem interactions, predicting future changes, and developing effective conservation strategies (De et al., 2016). However, baseline data on coral species abundance and distribution around Lakshadweep remain limited. To address these knowledge gaps, we evaluated coral species diversity and live coral coverage in Kavaratti Island, Lakshadweep archipelago. The rationale behind conducting this study is to provide a foundational overview of coral diversity and distribution patterns in Kavaratti Island, while contextualizing our findings within the broader challenges of global climate change and declining reef health across the Lakshadweep islands. We believe these baselines measurements contribute essential information for future conservation and management efforts of coral ecosystems.

MATERIALS AND METHODS

Study area

This study was carried out on an island in Lakshadweep (71° -74° E longitude and 8°-12°30'N latitude) namely the Kavaratti Island, a hotspot for tourists which has a warm and humid climate and is situated at 10°33'N and 71°38'E and 404 km from Cochin (George, 2008).The corals found on this island are mainly atolls formed by constant deposition of corals (Jones, 1986). The lagoon is about 4.5 km long, 12 km wide, with a depth of 2m (Mallik, 2017) and salinities range from 36 to 39.4 ppt, their SST is between 22° and 28° C, and their oxygen content is between 1 and 15 mg/l (Girijavallabhan et al., 1989). The Islands are biologically significant due to their isolation from the mainland and remain the least studied areas (Sobha and Amma, 2020). The islands here have strong tidal currents.

Line Intercept Transect (LIT) method

The LIT method (English et al., 1997) was adopted to assess the coral community and composition. The area selected for study is the Kavaratti Island of Lakshadweep, which lies between 10°32' and 10°35'N and 72°35' and 72°40'E longitude having an area of 4.22 sq km. The study was carried out by laying down a transect of 50m in different areas of the outer reef, intermediate reef and inner reef and the different lifeforms were recorded as shown in the respective figure below along with underwater photography using the TG-7 Underwater camera. The species were identified using field guides as Coral Finder and the hard corals (Scleractinia) of India: a revised checklist (De et al, 2020).
A preliminary survey was conducted to identify a representative section of the coral reef characterized by diverse coral life forms. The selected site was ensured to be free from disturbances and safe for diving activities. GPS coordinates were recorded to facilitate accurate location tracking, and essential equipment including transect lines, measuring tools, and data recording sheets was prepared. The transect line was positioned parallel to the mid-reef slope, an area with relatively stable coral conditions. The transect was set at a length of 50 meters, with measurements taken at 10-meter intervals. Efforts were made to establish a 0-meter permanent submerged transect as a reference point, ensuring that the transect line was placed as close to the substrate as possible (0–15 cm above) to minimize interference. Excessive hovering of the line was avoided to ensure precise documentation of substrate conditions and coral formations. Data collection was performed

systematically along the transect, with careful observation and recording of coral life forms and substrate types directly beneath. Changes in coral growth forms, associated organisms, and substrate composition were documented with centimeter-scale accuracy to maintain consistency in records for further analysis. Once data collection was completed, the transect line was carefully retrieved, and all equipment was transported ashore for subsequent data consolidation and analysis.

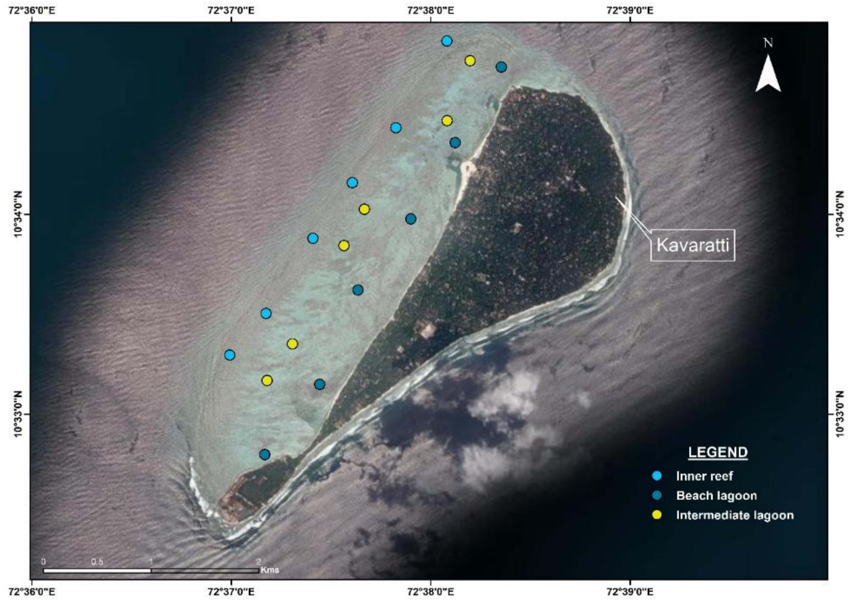


Figure 1. Study area representation. LIT stations and their respective co-ordinates utilized for the study.

Data analysis

The Line Intercept Transect (LIT) technique helps define the structure of the coral community by estimating the percentage cover (% cover) on the substrate. The abundance of each lifeform brings economic and ecological benefits. It is determined using a specific calculation method:

$$\%\ \text{coral coverage} = \frac{pk}{pt} \times 100\%$$

Where Pk is the total length of each coral life form category consisting of hard corals and Pt is the total length of a transect.

Live coral cover percentage will give a detailed summary of reef health and can be used to study ecosystem stability and resilience to climate change. Live coral influences fish diversity and abundance. The percentage of coral is calculated as shown below:

$$\%\ \text{Live Coral Cover} = \frac{Totallengthoflivecoralcover}{Totallengthoftransect} \times 100\%$$

Dead coral percentage will give a detailed summary of the phase shift data from a coral dominated ecosystem to an algal dominated ecosystem and the impacts or effects of all the natural and anthropogenic stresses. The percentage of dead coral is calculated as shown below:

$$\%\ \text{Dead Coral Cover} = \frac{Totallengthofdeadcoralcover}{Totallengthoftransect} \times 100\%$$

RESULT

Taxonomic classification of coral species

In the course of the survey, we identified 14 species across 5 families along the coastline of Kavaratti Island in Lakshadweep (Table 1, Figure 2). Acropora was the dominant family (*n=6 species)*, followed by the *Poritidae* family *(n= 4 species)* and subsequently, followed by *Pocilliporidae* family (n=2 species). The coral on this island is mostly dominated by *Acropora* spp. and *Porites* spp. (Department of Ocean Development [DOD], 2000). Additionally, families *Agariciidae* and *Euphylliidae* or *Oculinidae* are represented by a single species each.

Table 1. Taxonomic classification of coral species identified in this study.

Sl. no.	Scientific name	Class	Order	Family	IUCN status	Feeding habit
1	*Acropora muricata*	Anthozoa	Scleractinia	*Acroporidae*	Endangered	Suspension feeder
2	*Acropora robusta*	Anthozoa	Scleractinia	*Acroporidae*	Endangered	Plankton feeder
3	*Acropora hyacinthus*	Anthozoa	Scleractinia	*Acroporidae*	Endangered	Suspension feeder
4	*Acropora gemmifera*	Anthozoa	Scleractinia	*Acroporidae*	Endangered	Plankton feeder
5	*Isopora palifera*	Anthozoa	Scleractinia	*Acroporidae*	Endangered	Plankton feeder
6	*Montipora danae*	Anthozoa	Scleractinia	*Acroporidae*	Endangered	Photosynthetic; Heterotrophic
7	*Pavona venosa*	Anthozoa	Scleractinia	*Agariciidae*	Least Concern	Photosynthetic; Plankton feeder
8	*Pocillopora damicornis*	Anthozoa	Scleractinia	*Pocilloporidae*	Endangered	Plankton feeder
9	*Pocillopora grandis*	Anthozoa	Scleractinia	*Pocilloporidae*	Least Concern	Algae; Plankton feeder
10	*Porites lobata*	Anthozoa	Scleractinia	*Poritidae*	Least Concern	Plankton feeder
11	*Porites lutea*	Anthozoa	Scleractinia	*Poritidae*	Least Concern	Photosynthetic; Heterotrophic
12	*Porites rus*	Anthozoa	Scleractinia	*Poritidae*	Least Concern	Phototrophic; Heterotrophic
13	*Porites cylindrica*	Anthozoa	Scleractinia	*Poritidae*	Least Concern	Phototrophic; Heterotrophic
14	*Galaxea fascicularis*	Anthozoa	Scleractinia	*Euphylliidae/ Oculinidae*	Least Concern	Phototrophic; Plankton feeder

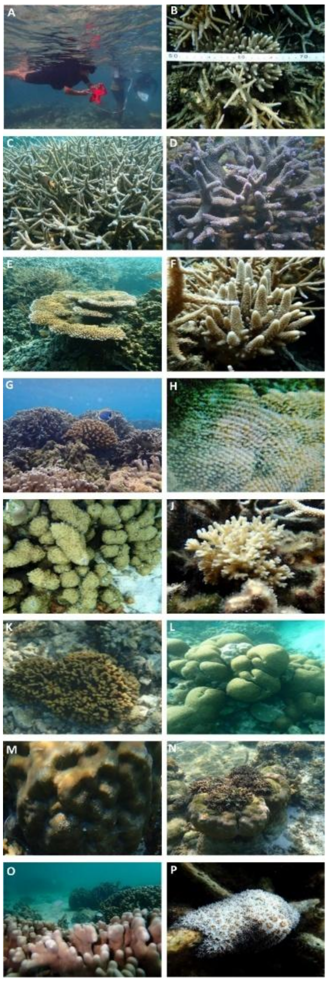
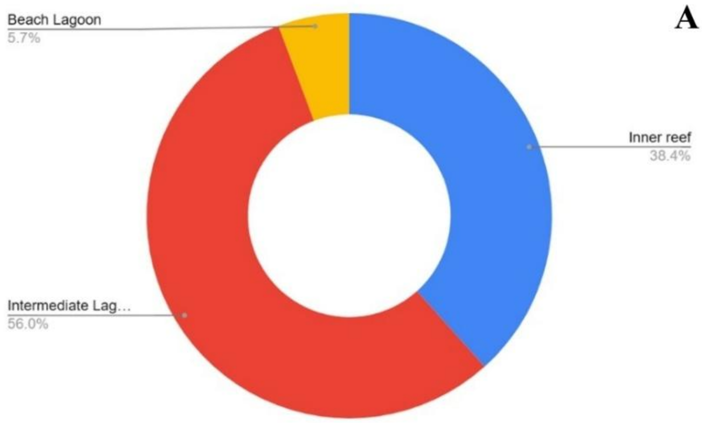


Figure 2. (A) Using LIT method for observations. (B) Measurement of coral attributes. Species identified in this study: (C) *Acropora muricata*. (D) *Acropora robusta.* (E) *Acropora hyacinthus.* (F) *Acropora gemmifera.* (G) *Isopora palifera.* (H) *Montipora danae.* (I) *Pavona venosa.* (J) *Pocillopora damicornis.* (K) *Pocillopora grandis.* (L) *Porites lobata.* (M) *Porites lutea*. (N) *Porites rus.* (O) *Porites cylindrica.* (P) *Galaxea fascicularis*.

Live and dead coral

The benthic survey revealed significant spatial heterogeneity in coral coverage across the three distinct reef zones of Kavaratti Island. Live coral coverage exhibited a distinct gradient from the shore to the outer reef, with the intermediate lagoon demonstrating the highest live coral percentage at 56.0%, followed by the inner reef at 38.4%, and the beach lagoon showing the lowest coverage at 5.7% (Figure 3A). Dead coral coverage showed an inverse relationship to live coral distribution, with the highest mortality observed in the inner reef zone (66.7%), moderate levels in the intermediate lagoon (30.0%), and minimal dead coral in the beach lagoon (3.4%) (Figure 3B). This pattern suggests zone-specific stressors affecting coral survival and recruitment.

A



B

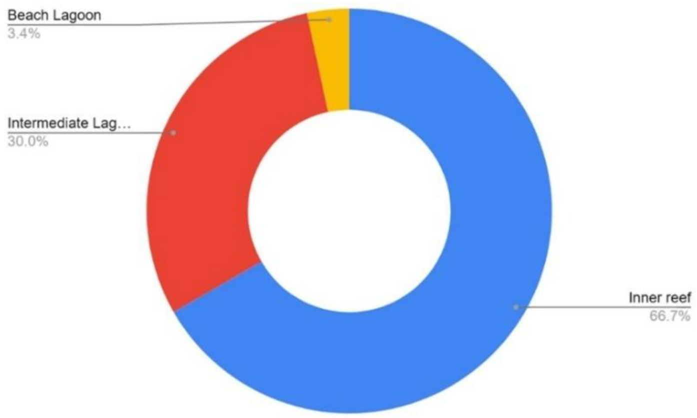


Figure 3. (A) Live coral percentage in different zones of the study area. (B) Dead coral percentage in different zones of the study area.

DISCUSSION

The major bleaching in 1998 and the tsunami in 2004 have decreased the abundance of live coral species worldwide (Sreenath et al., 2015). The major bleaching of corals which occurred in 1998 and 2010 has affected many fast-growing coral species, including Acropora and slow-growing massive species such as Porites (Arthur, 2000). The effects of *El Niño* and global warming may be inferred in this study as the observations show a minor phase shift from a coral-dominated community to an algae-dominated ecosystem (Done, 1992; McCook, 1999; Chadwick and Morrow, 2011). However, reports suggest the corals of Lakshadweep have managed to recover (Arthur et al., 2006).

The coral reef system around Kavaratti Island displays distinct zonation patterns driven by varying environmental conditions. The intermediate lagoon emerges as the optimal coral habitat with balanced wave energy, adequate water circulation, and reduced terrestrial influence, resulting in the highest live coral coverage. In contrast, the inner reef experiences significant stress from physical disturbance and oceanic fluctuations, leading to high mortality rates. At the same time, the beach lagoon faces extreme environmental variability, heavy sedimentation, and direct anthropogenic impacts (Arthur, 2008) from plastic pollution (Stefatos et al., 1999) and tourism activities that severely limit coral establishment and growth. The dominance of Acropora and Porites species observed in our study aligns with historical patterns documented by Wafar (1986) and Pillai and Jasmine (1989), suggesting some stability in community composition despite ongoing environmental pressures. However, the relatively low species diversity recorded (14 species) compared to potential diversity estimates of 400+ species for the region (Venkataraman, 2006) highlights the need for more comprehensive and spatially extensive surveys. The spatial heterogeneity in coral coverage across the three reef zones may be attributed to multiple factors. The intermediate lagoon's higher live coral coverage (56.0%) likely results from optimal environmental conditions including moderate water flow, reduced sedimentation, and suitable light penetration. Conversely, the high mortality in the inner reef zone (66.7%) may reflect more intense environmental and anthropogenic stressors. These patterns align with carrying capacity assessments that suggest Lakshadweep reef systems reached critical thresholds in the 1980s due to increasing population pressures, passenger traffic, and development activities (Rodrigues, 1996).

Climate change presents perhaps the most significant long-term threat to Lakshadweep coral systems, with sea surface temperatures in the Arabian Sea rising faster than global averages, placing these reefs at heightened risk (Sarkar, 2019). Under these warming conditions, taxonomic studies become increasingly vital, as many species remain undiscovered and their responses to thermal stress cannot be adequately studied without proper identification. Our documentation of coral diversity in Kavaratti directly addresses these knowledge gaps, complementing recent advances such as environmental DNA (eDNA) metabarcoding that have revealed the need for more comprehensive biodiversity assessment methodologies in these fragile ecosystems (Frontiers in Marine Science, 2025). As we strengthen these research initiatives, we simultaneously build the foundation needed for effective conservation planning. For Kavaratti specifically, our findings highlight the importance of zone-specific management approaches that target the distinct stressors affecting different reef areas, particularly the vulnerable inner reef and beach lagoon regions. Practical conservation measures could include restricting boat traffic in sensitive zones, improving waste management to reduce pollution, expanding marine protected areas, and developing sustainable tourism practices that balance economic needs with ecosystem preservation.

CONCLUSION

This study provides data on assessment of coral species diversity and distribution patterns across different reef zones in Kavaratti Island, Lakshadweep. Our findings reveal significant spatial heterogeneity in coral coverage, with varying levels of mortality in the inner reef zone, highlighting the need for zone-specific conservation strategies. The limited species diversity documented (14 species across 5 families) relative to potential diversity in the region underscores the importance of continued systematic surveys. These baseline data will prove invaluable for future monitoring efforts aimed at tracking ecosystem health, evaluating conservation effectiveness, and developing sustainable management practices for these ecologically and economically vital coral reef systems.

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Conflict of interests
The authors declare that there is no competing interest.

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