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Abundance and diversity of reef fish species and their relationship with corals along the eastern coast of Sri Lanka

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Abstract

Reef fish perform multiple ecological roles that are important for maintaining the structure and function of coral reefs. Reef fish assemblage patterns can be affected by natural and anthropogenic disruptions that change the structure of coral reef ecosystems. Our study aimed to understand the reef fish abundance, diversity, and relationships between reef fish families and coral families at five major coral reef ecosystems on the Eastern coast of Sri Lanka. In total, 272 reef fish species and 101 coral species were recorded. The highest and lowest relative abundance of fish was recorded at the Kayankerni (KR) and Adukkuparu reefs (AR) respectively. Pigeon Island Reef (PIR) had the highest fish diversity, evenness, and species richness followed by Parrot Rock Reef (PRR). Passikudah Reef (PR) had the lowest fish diversity indices and richness, but KR had the lowest fish evenness. In contrast, PRR had the uppermost percentage of live coral cover, coral diversity, evenness, and species richness. Coral species richness and live coral cover were lowest at the PR and AR respectively. The evenness of coral was lowest at PIR and the lowest Shannon-Weiner diversity was recorded at the AR. Reef fish family Lutjanidae and coral families Dendrophyllidae, Alcyoniidae, Plumulariidae, Mussidae, and Poritidae had a strong positive relationship. Coral family Acroporidae had a moderately positive relationship with fish families Pomacentridae and Pomoacanthidae. Overall, our results provide a comprehensive outlook of coral reef, reef fish diversity, and their relationship along the eastern coast of Sri Lanka.

Keywords Reef fish habitats · Tropical reefs · Coral-fish interaction · Live coral cover

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Introduction

Coral reef ecosystems cover around 1% of the earth's surface yet provide numerous ecological and socio-economic benefits to many tropical and subtropical countries around the world (Hoegh-Guldberg et al. 2017; Spalding et al. 2001). It is also identified as one of the highly diverse ecosystems that provide numerous ecological services such as habitat, food, and shelter for 25% of the world's fish and related species (Auster 2005). As a result, the coral reef has become one of the hot biodiversity hotspots in the world.

A number of studies have specified that coral cover and reef complexity are the most important factors in describing the abundance and diversity of reef fish (Jones et al. 2004; Gratwicke and Speight 2005; Friedlander et al. 2003). A high level of complexity of coral reefs may encourage increased fish diversity and abundance due to the reduced encounter rates between predators and prey (Almany 2004). Further studies also indicated that reef fish diversity and abundance are positively correlated with their live coral cover (Arias-Godínez et al. 2021; Jones et al. 2004).

Declining coral cover has a serious negative impact on reef fish species as loss of coral cover may also decline in the abundance of certain coral-dependent species (Jones et al. 2004). A previous study indicated that a loss of more than 10% of coral cover may reduce more than 60% of associated reef fish species (Wilson et al. 2006). This has been particularly noticeable in small-bodied reef fish species that live in and feed on corals, as they often experience large declines in population size following a significant loss of coral.

Although the global literature has indicated that there is a significant positive relationship between coral cover and reef fish species (Arias-Godínez et al. 2021; Clements et al. 2016; Komyakova et al. 2018; Tebbett et al. 2017), there is a large knowledge gap on coral reef status, diversity, and the relationship between coral cover and reef fish in Sri Lanka. Especially, on the eastern coast of Sri Lanka, there was a limited number of studies that have focused on coral reef and reef fish diversity and their relationship. Therefore, the purpose of this study was to assess the, i). reef fish and coral reef diversity and ii). relationship between coral reef families and reef fish families at selected locations on the eastern coast of Sri Lanka.

Materials and methods

Site selection

Five major coral reefs Pigeon Island Reef (PIR), Parrot Rock Reef (PRR), Adukkuparu Reef (ARR), Kayankerni Reef (KR), and Passikudah Reef (PR) on the Eastern coast of Sri Lanka were selected for the study. These five sites are located in the Batticaloa and Trincomalee districts (Fig. 1). The depths of the study areas of all the selected sites were less than 10 m.

Benthic survey

The survey was conducted in 2020 and in each site, three subsites were randomly selected. In each subsite, 10 spatially disconnected transects were deployed. In total there were 150 transects (30 m) were censused within the five sites.

Reef fish abundance was surveyed using the Fish Belt Transect (FBT) method (Beck et al. 2014; Caldwell et al. 2016). Visual census of reef fish was surveyed while diving and snorkeling along the 30 m long transect lines. The standard coral reef survey method was followed for studying the benthic percentage of fauna and flora species in the seabed (Leujak and Ormond 2007; Valles et al. 2014), whereas the benthic survey was conducted by the Line Intercept Transect (LIT) method (Beenaerts and Berghe 2005). The 30 m fibreglass tape was laid along with the reef and data from the substrate was recorded alongside the tape. Underwater videos and photographs of fish species and coral species were taken for further analysis (Caldwell et al. 2016). This includes digital images and videos of live coral, dead coral, hard coral, algae cover, etc.).

Data analysis

Shannon–Wiener Diversity, Simpson's index, Pielou's evenness index, and Margalef's index-species richness were calculated to determine the diversity of coral reef and reef fishes (Zar 1999; Williams et al. 2005; Das et al. 2017). One-way Analysis of Variance (One-way ANOVA) was employed to assess potential variations in diversity indices, evenness, and species richness between different sites in both coral reef and reef fish communities. The Pearson correlation coefficient was utilized to determine the relationship between different coral families and reef fish families. The strength and direction of the linear relationships were assessed by the method as described by Costa et al. (2020).

Results

The abundance of reef fish

During the study period, a total number of 12,909 reef fish individuals representing 272 species and 35 families were recorded from five study sites (Table 1).

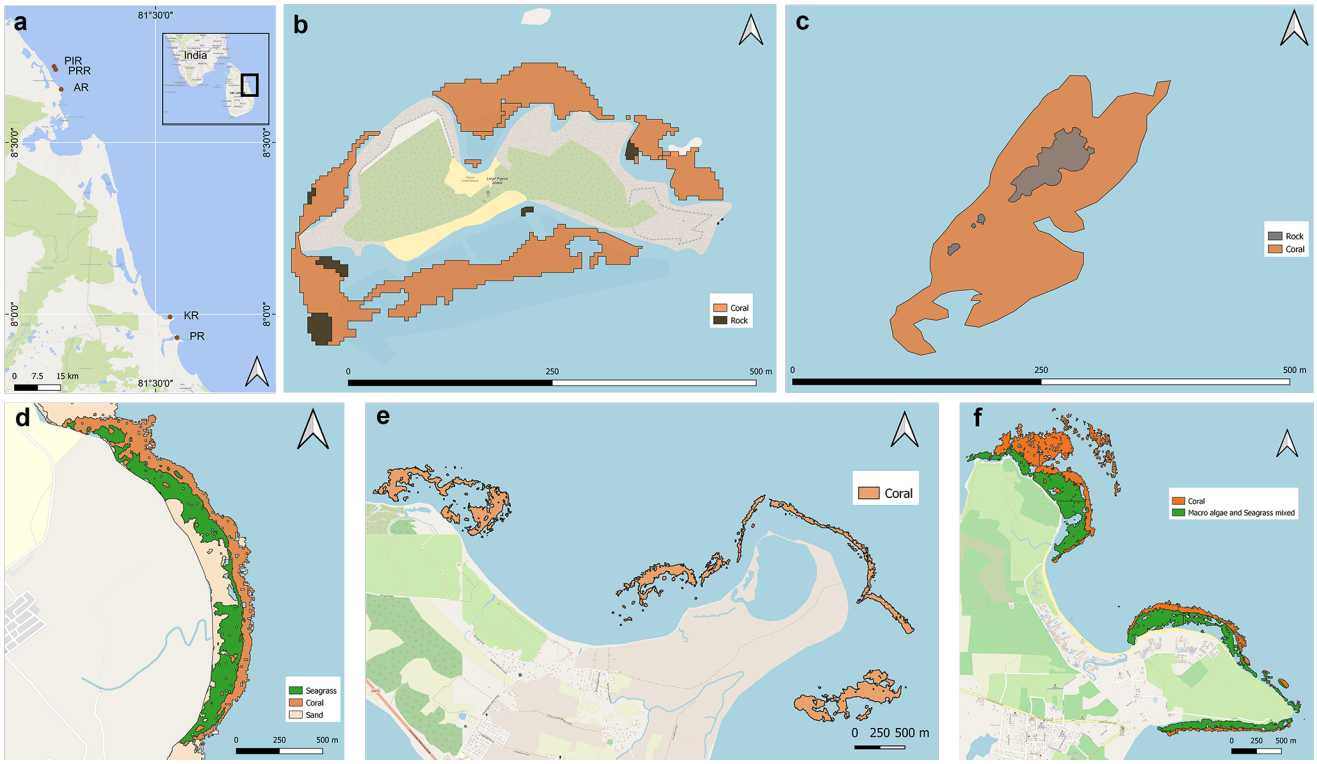

Fig. 1 Pigeon Island Reef (PIR), Parrot Rock Reef (PRR), and Adukkuparu Reef (AR) are situated in the Trincomalee district, while Kayankerni Reef (KR) and Passikudah Reef (PR) are situated in the Batticaloa District of Eastern province in Sri Lanka **a** PIR ($8^0$43'N, 81°12'E) is situated around Pigeon Island which is 1 km off from the Nilaveli shore **b** PRR ($8^0$42'N, $81^0$12'E) is situated around 1 km Southeastern of PIR **c** AR (8°39'N, 81°13'E) is situated in Uppuveli in Trincomalee **d** KR **e** and PR **f** are situated in the Kaldudha region (7°58'N, 81°34'E) (7°99'N, 81°54'E)

The largest and lowest relative abundances of reef fish were found in KR (48.81%) and AR (6.34%) respectively. The relative abundance of reef fishes in PIR (29.78%) was followed by PRR (8.23%) and PR (6.85%) (Fig. 2).

Relative abundance of reef fish families at each site indicated that the family Pomacenthidae (51.68%), Acanthuridae (24.16%), and Pseudochromidae (8.4%) were dominant in the KR while Pomacenthidae (62.25%) and Acanthuridae (26.09%) were dominant in PR (Fig. 3). Acanthuridae (25.92%), and Pomacanthidae (22.05%) were the most abundant reef fish species in the PIR. In AR, Scaridae (22.69%), and Siganidae (19.92%) were the most abundant reef fish species, while the most abundant reef fish families were Blennidae (39.62%), Pomacenthidae (19.97%), and Acanthuridae (19.97%) at PRR.

Reef fish diversity

The highest reef fish diversity was recorded by the PRR (Shannon-Weiner (3.68) and Simpson's (0.96) diversity indices). The lowest diversity indices were recorded from the PR (Shannon-Wiener index (1.84) and Simpson index (0.66)). At the same time, the highest species richness was recorded from the PIR (181), and the lowest species richness was recorded from the AR (38) whereas the highest species evenness was recorded from the PRR (Table 2). All the recorded diversity indices values were significantly different ($p < 0.05$) among different study sites.

Abundance and diversity of coral species

A total of 16 families and 101 species of coral were found across all sites (Table 3), with the Acroporidae (27), Faviidae (15), Alcyoniidae (15), and Poritidae (10) families having the greatest species counts. However, only one species was found from the family Siderastreidae, Nephtheidae, Fungiidae, and Merulinidae.

The highest (3.38) and lowest values (1.87) of the Shannon Weiner diversity index for the coral species were reported in PRR and AR respectively (Table 4). PRR also showed the highest value (0.93) for Simpson's index while the lowest Simpson's index was reported from the PIR. The highest number of coral species (58) was recorded from the PRR and the lowest number (15) of species was recorded from the PR. PR and PIR showed the highest (0.74) and lowest (0.57) evenness values. Among all the study sites,

Table 1 The number of reef fish species and their families recorded at five different study sites along the Eastern coast of Sri Lanka

No	Family	Common name	Total species count of 5 sites	Species count of the site				
				PIR	PPR	AR	KR	PR
1	Chaetodontidae	Butterfly fish	24	10	5	3	20	5
2	Pomacentridae	Damsel / Chromis	30	9	14	4	21	6
3	Acanthuridae	Surgeonfishes	27	15	12	4	15	9
4	Siganidae	Rabbitfishes	5	5	1	0	1	0
5	Nemipteridae	Coral breams	5	1	1	0	3	1
6	Sphyraenidae	Barracudas	1	1	0	0	0	0
7	Synodontidae	Lizardfish	2	1	0	0	1	0
8	Scaridae	Parrotfishes	28	25	11	0	6	4
9	Labridae	Wrasses	47	28	19	5	22	6
10	Pomacanthidae	Angelfish	10	4	2	1	6	1
11	Belonidae	Needlefish	1	1	0	0	0	0
12	Pseudochromidae	Dottyback	5	0	1	1	4	0
13	Haemulidae	Sweetlips	6	1	0	0	6	1
14	Serranidae	Grouper/Anthias	14	10	3	0	7	0
15	Apogonidae	Cardinalfish	4	2	1	1	2	0
16	Holocentridae	Squirrelfish	6	0	2	2	1	1
17	Triconotidae	Sand divers	2	0	0	0	2	0
18	Blenniidae	Blennies	6	4	1	1	2	0
19	Lutjanidae	Snappers	8	5	7	0	2	2
20	Monodactiledae	Dimonfish	2	2	1	0	1	0
21	Triplefins	Forsterygion	5	1	0	1	3	1
22	Caesionidae	Fusiliers	4	2	1	0	2	0
23	Scorpaenidae	Scorpionfishes	2	0	0	1	0	2
24	Gobiidae	Gobies	2	0	0	1	0	1
25	sparidae	Seabreamfish	1	0	0	0	0	0
26	Plotosidae	Catfish	1	0	0	0	0	0
27	Gobiesocidae	Clingfishes	1	0	0	0	0	0
28	Tetraodontidae	Puffer fish	1	1	1	1	0	0
29	Mullidae	Goatfishes	5	1	4	1	0	0
30	Centropomidae	Snooks	1	1	0	0	0	0
31	Fistulariidae	Pipefishes	1	1	0	0	0	0
32	Lethrinidae	Emperorfish	8	6	3	0	1	0
33	Monacanthidae	Filefishes	5	5	1	0	0	0
34	Cirrhitidae	Hawkfishes	1	1	0	0	0	0
35	Carangidae	Jacks	1	1	0	0	0	0
	Total		**272**	**143**	**91**	**27**	**128**	**40**

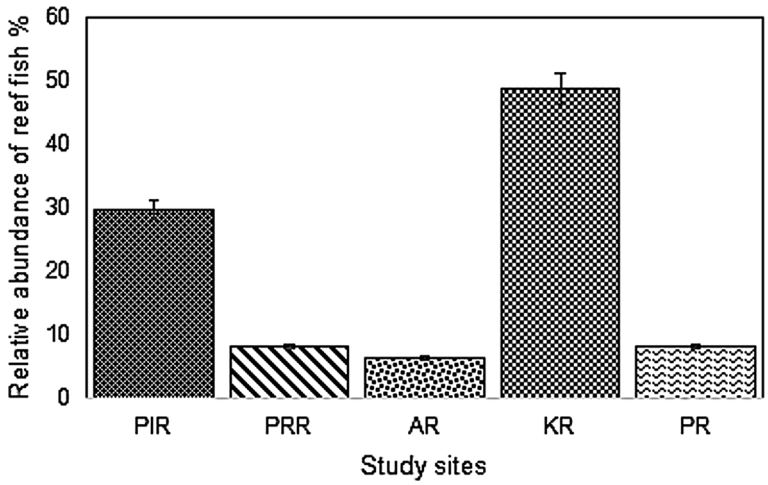

Fig. 2 Relative abundance of reef fishes recorded from Pigeon Island Reef (PIR), Parrot Rock Reef (PRR), Adukkuparu Reef (AR), Kayankerni Reef (KR), and Passikudah Reef (PR)

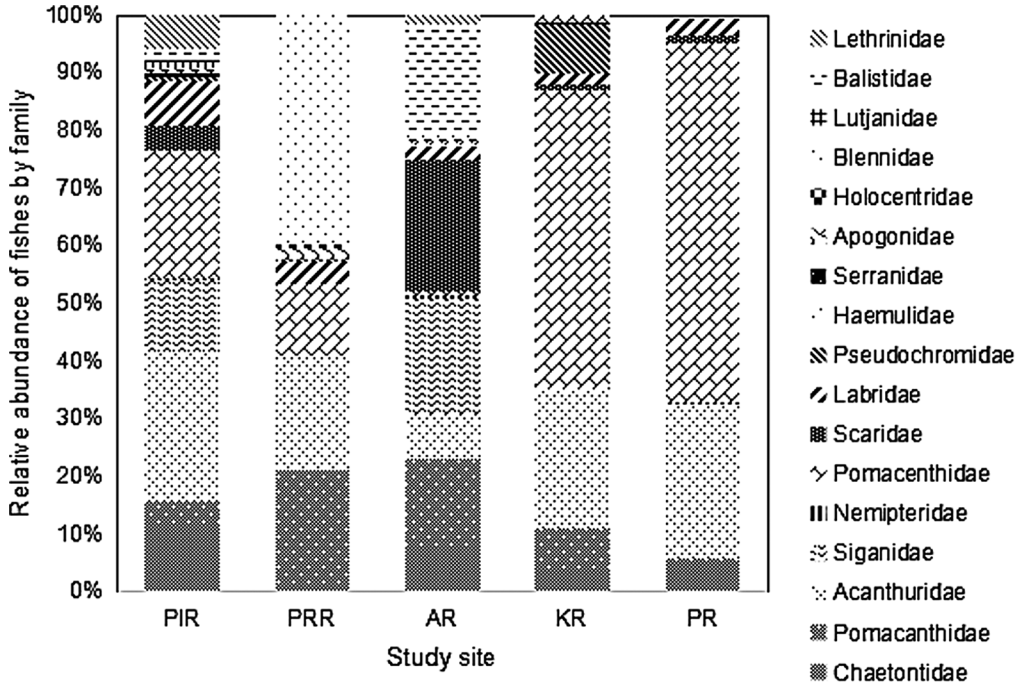

Fig. 3 Relative abundance of reef fish families recorded from Pigeon Island Reef (PIR), Parrot Rock Reef (PRR), Adukkuparu Reef (AR), Kayankerni Reef (KR), and Passikudah Reef (PR)

Table 2 Results of the reef fish diversity, evenness, and richness at different study sites

Parameter	PIR	PRR	AR	KR	PR
Shannon-Weiner	3.65[b]	3.68[a]	2.24[c]	2.16[d]	1.84[e]
Simpson's Index	0.95[b]	0.96[a]	0.83[c]	0.75[d]	0.66[e]
Pieoul's Evenness	0.44[b]	0.55[a]	0.32[c]	0.25[e]	0.27[d]
Species Richness	181[a]	123[c]	38[e]	149[b]	51[d]

[a,b,c,d,e] Means with different superscript letters differ significantly ($p < 0.05$)

there was a significant difference among the coral diversity indices ($p > 0.05$).

Relationships between coral families and reef fish families

Pearson's correlation coefficient analysis indicated that there was a moderate positive ($0.5 \leq R_{XY} < 0.8$) relationship between the coral family Acroporidae and the fish family

Table 3 The number of coral families and species recorded from five different study sites along the Eastern coast of Sri Lanka

No.	Family	Total species count in 5 sites	Species count of the site				
			PIR	PPR	AR	KR	PR
1	Family Mussidae	7	0	7	1	1	0
2	Family Pocilloporidae	2	1	2	0	1	1
3	Family Pectiniidae	2	0	2	0	0	0
4	Family Acroporidae	27	8	7	3	20	1
5	Family Dendrophylliidae	6	1	4	1	2	0
6	Family Poritidae	10	7	0	1	0	0
7	Family Agariciidae	8	2	6	1	4	2
8	Family Faviidae	15	3	7	4	8	5
9	Family Siderastreidae	1	0	0	0	0	1
10	Family Halichondriidae	3	0	0	1	2	0
11	Family Caryophylliidae	2	0	1	0	2	0
12	Family Alcyoniidae	12	3	9	3	2	0
13	Family Nephtheidae	1	0	1	0	0	0
14	Family Fungiidae	1	0	1	0	0	0
15	family Plumulariidae	3	0	2	0	0	1
16	Family Merulinidae	1	1	1	1	1	0
	Total	**101**	**26**	**50**	**16**	**43**	**11**

Table 4 Diversity indices, evenness, and the richness of coral species in different study sites

Parameter	PIR	PRR	AR	KR	PR
Live coral cover (%)	59[b]	70[a]	12[e]	38[c]	21[d]
Shannon Weiner Index	1.97[e]	3.38[a]	1.87[d]	2.46[b]	2.05[c]
Simpson's Index	0.76[e]	0.93[a]	0.79[d]	0.79[c]	0.83[b]
Evenness	0.57[e]	0.73[b]	0.64[c]	0.62[d]	0.74[a]
Species richness	20[c]	58[a]	18[d]	49[b]	15[e]

[a, b,c,d,e] Means with different superscript letters differ significantly ($p < 0.05$)

Pomacanthidae, Blennidae, and Pomacantridae. Meanwhile, fish families Chaetodontidae, Acanturidae, Signidae, Nemipteridae, and Haemulidae, indicated weak positive relationships ($0.1 \leq R_{XY} < 0.4$) with the coral family Acroporidae. There was no significant relationship ($p > 0.05$) between Acroporidae and other fish families (Table 5).

The Coral family Agaricidae showed a moderate positive relationship ($0.5 \leq R_{XY} < 0.8$) with the fish families Pomacentridae, Holocentridae, Haemulidae, and Pseudochromidae while there was weak negative relationship ($-0.1 \leq R_{XY} < -0.4$) with the families Siganidae, Mullidae, Blennidae, Lethrinidae and Monacanthidae. Coral family Alcyoniidae built a strong positive relationship ($0.7 \leq R_{XY} < 1$) with the fish family Lutjanidae. However, there was no strong or moderate relationship between the coral family Alcyoniidae and other reef fish families. The Coral family Dendrophylliidae showed strong positive relationships ($0.7 \leq R_{XY} < 1$) with the fish family Blenniidae and Pomacentridae. The Coral family Faviidae did not have a strong or moderate relationship with any reef fish families. The coral family Plumularidae and Mussidae had a strong relationship ($0.7 \leq R_{XY} < 1$) with the fish family Lutjanidae while the coral family Poritiade had a moderate positive relationship ($0.5 \leq R_{XY} < 0.8$) with the fish family Lutjanidae.

Relationship between coral cover and butterflyfish (family Chaetodontidae)

Several studies have indicated that there is a strong relationship between butterflyfish (family Chaetodontidae) and hard coral cover as butterflyfish's obligate and/or facultative coral feeding behaviour (Graham et al. 2009; Gregson et al. 2008). Butterflyfish can also be used as a bioindicator of healthy reef ecosystems (Yusuf and Ali 2004). In our study, the highest number (20) of butterflyfish were recorded at KR followed by PIR (10), PRR (5), PR (5), and AR (3) (Fig. 4). The regression analysis indicated that there is a positive relationship ($R^2 = 0.58$) between the relative abundance of live coral cover and the relative abundance of Butterflyfish. However, the relationship was not significant ($p > 0.05$) in our study sites.

Discussion

Reef fish diversity

The present study aimed to understand the i). abundance and biodiversity of coral reefs and reef fish and ii). relationship between the reef fish and coral cover along the Eastern coast of Sri Lanka. In total, 272 reef fish species and 101 coral species were found in all of the study sites. Our results are

Table 5 Relationship between reef fish families and coral families in all sites

	Pearson's correlation coefficient							
Fish Family	Coral family							
	Acroporidae	Agaricida	Alcyoniidae	Dendrophylliidae	Faviidae	Plumulariidae	Mussidae	Poritidae
Chaetodontidae	0.4*	0.1	-0.1	-0.1	-0.2*	-0.2	-0.2	-0.1
Acanthuridae	0.2*	0.1	-0.3*	0.2*	0.0	-0.2*	-0.3*	-1.5
Siganidae	0.3*	-0.3*	-0.1	-0.1	-0.4*	-0.2	-0.1	-0.1
Nemipteridae	0.4*	-0.1	-0.1	-0.2	-0.3*	-0.2*	-0.2	-0.1
Pomacentridae	0.5*	**0.6***	-0.2*	**0.9***	0.4*	-0.2*	-0.2*	-0.1
Labridae	0.2	0.1	-0.1	-0.1	-0.2*	-0.1	-0.1*	0.1
Pomacanthidae	**0.6***	0.3*	-0.2	0.4*	0.2	-0.2*	-0.2	-0.1
Haemulidae	0.4*	**0.5***	-0.2*	0.4*	0.3*	-0.2*	-0.2*	-0.1
Pseudochromidae	0.1	**0.6***	-0.1	-0.1	0.1	-0.1	-0.1*	-0.1
Serranidae	0.2	0.2*	-0.1	-0.1	-0.2	-0.1	-0.1	0.1
Holocentridae	0.1	**0.6***	-0.1	-0.1	0.2*	-0.1	-0.1	0.1
Blenniidae	0.5*	-0.2*	-0.2	**0.9***	0.4*	-0.2	-0.1	-0.1
Lutjanidae	0.1	-0.1	**0.8***	-0.1	-0.1	**0.8***	**0.8***	**0.7***
Mullidae	-0.1	-0.1*	0.1	-0.1	-0.3*	-0.1	0.1	0.1
Lethrinidae	0.1	-0.1*	0.1	-0.1	-0.3*	-0.1	-0.1	0.1
Monacanthidae	0.2	-0.3*	-0.1	-0.1	-0.4*	-0.1	-0.1	-0.1

*Correlation is significant at the 0.01 level (2-tailed), and moderate to high relationships are boldfaced. The classification of correlation coefficients was based on Costa et al. (2020)

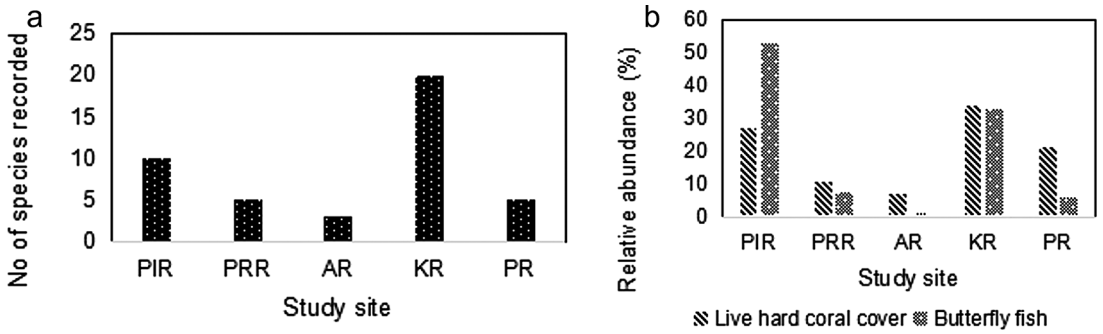

Fig. 4 **a** The number of Butterflyfish recorded at Pigeon Island Reef (PIR), Parrot Rock Reef (PRR), Adukkuparu Reef (AR), Kayankerni Reef (KR), Passikudah Reef (PR) and **b** relative abundance of live hard coral cover and the relative abundance of Butterflyfish at each site

comparable with the results indicated by Rajasuriya (2000) who recorded approximately 100 species of coral and 300 species of reef along the Eastern coastal region.

We found significantly high reef fish diversity, evenness, and species richness at PIR and PRR. Similarly, live hard coral cover, reef diversity, evenness, and species richness were also high in PIR and PRR. This high reef fish diversity at both places may correspond to the increased healthy coral cover (Ditzel et al. 2022) as indicated by the strong relationship between the percentage of live coral cover and the reef fish diversity.

Except for PRR and AR, the relative abundance of reef fish families Acanthuridae and Pomacnetridae dominated in all the study sites. A high abundance of Acanthuridae is common to Indo-Pacific reefs and it dominates within the reef fish community in many coral reef ecosystems (Marshell and Mumby 2015). Pomacentridae is a common reef fish family that is closely associated with the coral reefs (Frédérich et al. 2009; Ulfa et al. 2020). Previous findings indicated that the most abundant reef fish in Sri Lankan coral reefs were Pomacentridae, Acanthuridae, Scaridae, and Labridae (Ellepola et al. 2015). Similarly, our study also revealed that Pomacentridae and Acanthuridae are the most abundant fishes at PR.

Our results also indicated that the relative abundance of the Chaetodontidae, Surgeon species, and Scaridae at KR was lower than that in a prior study (Weerasinghe et al. 2019). Although the exact reason is unknown, this lower abundance of the above fish families, in our study may be due to the diurnal and seasonal variations in temperature, increased waste pollution, and enormous fishing activities around the region (Perera 2019; Thilakarathne et al. 2023; Walther et al. 2002; Wilson et al. 2008).

Area with high coral cover is likely to be occupied by more butterflyfish compared to regions with lesser live coral cover, which may be utilized as an indicator of the health of the coral reef ecosystem (Fadli et al. 2019). We also found that the increased number of butterflyfish in the areas where live coral cover also dominates. Rajasuriya (2005) indicated a higher relative abundance of butterflyfish at PIR than in our study. This higher abundance of butterflyfish at PIR may be due to the pulse of the recruitment of four corallivore coral reef species (*Chaetodon trifasciatus*, *C. trifasicalis*, *C. meyeri*, and *C. plebeius*).

These findings are consistent with previous findings that provide evidence that butterflies affect the survival of coral reefs (Graham et al. 2009; Rajasuriya 2005; Prabowo et al. 2019). Previous studies have reported that the abundance of branching corals was favourably connected with the density of obligate corallivores. However, only *Acropora* sp. was found to have a significant association with this butterflyfish (Fadli et al. 2019). Different studies revealed that ocean pollution, climate changes, and anthropogenic activities caused to decrease in the number of coral species and butterflyfishes (Rice et al. 2019) which are used as a bioindicator of the state of health of reef ecosystems (Yusuf and Ali 2004), it also can be a reason for this recorded degradation. Further, this study discovered that there was inadequate data on the distribution of butterflyfish along the Eastern coast of Sri Lanka, emphasising the need for further study in this area.

The relationship between coral family and fish species

The highest percentage of live coral cover was recorded at PRR followed by PIR. In contrast, the percentage of live coral cover was lowest at AR which may be mainly due to support to the coral species with the unhealthy condition in the reef and the high level of human activities recorded around the reef (Denis et al. 2023; Hansani et al. 2023; Thilakarathne et al. 2023). The percentage of coral cover recorded at PR in our study is comparatively lower than a previous study (64.31%) (Ellepola et al. 2015). Similarly, we found that the percentage of live coral cover at PIR in our study (59%) was comparatively lower than the expected live coral cover percentage (74.2%) in the same area in 2005 (Rajasuriya 2002; Rajasuriya et al. 2005). One of the possible reasons for this decline could be the increased feeding

behaviour of the Crown of Thrones starfish (*Acanthaster planci*) that thrive on live coral at PIR (Dissanayake and Kumara 2015). The reduction of live coral cover at PIR may also be attributed to the coral bleaching events induced by elevated sea surface temperature (Sewwandi et al. 2021; Thilakarathne et al. 2023) and extreme anthropogenic pressure caused by local and foreign visitors (Perera 2016; Setter et al. 2022).

Conservation status of reef fish

Majority of the reef fish species found in this study are classed as the least-concern species (73.7%), while only a few species are listed as Vulnerable (VU) (1.57%) (IUCN Red List of Threatened Species 2022). Further, a small number of species (1.18%) were classified as Data Deficient (DD) as data were insufficient to determine the extinction risk. Around 11% of identified marine species along the Eastern coast were collected as marine ornamental fish and many of the species are at greater risk due to unsustainable fishing practices (Bozec et al. 2016; Dhanasundara et al. 2022).

Conclusion

The findings of the present study provided insights into the current status of reef fish and coral reef diversity of five major coral reefs along the Eastern coast of Sri Lanka. We found that coral reefs on the eastern coast were highly diverse with 272 reef fish species and 101 coral species. .In-depth analysis of reef fish and coral reef diversity indices indicated high biodiversity in the KR, PIR, and PRR ecosystems. We also reported that there were strong to moderate relationships between reef fish families and coral reef species. These findings urge the necessity of strong management and conservation of coral reefs and reef fish along the Eastern coast of Sri Lanka.

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Data availability All data included in this study are available upon sensible request from the corresponding author.

Declarations

Competing interests The authors declare that they have no known competing financial concerns or personal associations that could have appeared to influence the work reported in this paper. All authors have read, understood, and have complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors and are aware that with minor exceptions, no changes can be made to authorship once the paper is submitted.

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