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Reef Fish Biodiversity and Behavior in The Seribu Islands of Jakarta, Indonesia

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Abstract

Coral reef ecosystems are centers of biodiversity and productivity in tropical waters, yet information on reef fish communities and their behavioral interactions with coral colonies in the Seribu Islands remains limited. This study aimed to identify reef fish species, coral genera utilized by reef fishes, and variations in reef fish behavior associated with coral colony structures. An Underwater Video Survey (UVS) was conducted at Panjang, Pelangi, Belanda, and Kelapa Islands, Jakarta, Indonesia. Video recordings were analyzed to identify reef fish species, coral genera, and behavioral patterns associated with coral colonies. A total of 215 reef fish species belonging to 82 genera and 29 families were identified. Kelapa Island had the highest species richness (120 species), followed by Belanda (119), Panjang (107), and Pelangi (83). Sixteen coral genera were recorded, with Acropora and Porites being the most dominant and occurring at all sites. These genera also supported the highest numbers of associated reef fish species. Thirteen behavioral categories were observed, with feeding, roaming, and hovering being dominant, while cleaning, resting, ambush, and aggression were less frequent. Variations in behavioral patterns among islands indicate that coral habitat complexity influences reef fish diversity and behavioral expression. These findings highlight the importance of structurally complex coral habitats in supporting reef fish diversity and ecological functions in the Seribu Islands.

Keywords: habitat utilization, reef fish behavior, reef fishes, Seribu Islands

1. Introduction

Coral reef ecosystems are one of the marine ecosystems with high biodiversity and productivity levels (Baird et al., 2002; Holbrook et al., 2015; Smith et al., 2024). These reef ecosystems have a complex physical structure that provides unique niches (Graham and Nash 2013). The structure of coral reef ecosystems supports a variety of biological interactions, one of which can be seen from the symbiotic relationship between reef-forming corals and their symbiotic algae zooxanthella (LaJeunesse et al., 2018). From the process of photosynthesis, algae are an energy source that allows corals to build and maintain reef structures (Barott et al., 2015; Wangpraseurt et al., 2017). These symbiotic relationships form complex food webs, supporting the life of a wide range of marine organisms, including reef fish (Akmal et al., 2025). However, despite this very important ecological role, reef ecosystems are vulnerable to degradation both due to global pressures such as climate change, as well as local anthropogenic pressures (Woodhead et al., 2019) The Seribu Islands, one of the most frequently researched coral reef areas (Cleary et al., 2016), are located north of Jakarta Bay and are part of its estuarine system This region was selected as the study site due to its high exposure to anthropogenic pressures from surrounding urban activities, resulting in increased sedimentation, water turbidity, and accumulation of organic pollutants and microplastics (Utami et al., 2021). These conditions affect the ecological dynamics of coral reef ecosystems in the region. These conditions affect the ecological dynamics of coral reef ecosystems in the region (Cleary et al., 2016). These environmental pressures directly impact coral reef ecosystems (Hughes et al., 2017). Reef fish have an important role in coral reef ecosystems (Sheppard et al., 2023). This role can be based on fish groups such as herbivorous fish controlling algae growth in reef ecosystems, carnivorous fish maintaining the balance of food webs, and detritivorous fish playing a role in nutrient cycling (Brandl et al., 2019). Some reef fish species are also used as indicators of coral reef health due to their abundance, sensitivity, and responses to environmental changes (Cook et al., 2024; Jarriel et al., 2024; Samoilys et al., 2025). Multiple taxa remain relatively scarce.

Previous research has generally examined the behavior of fish in response to specific disturbances, including climate-related pressures and anthropogenic impacts on the physical conditions of habitats (Mitchell et al., 2023; Priest et al., 2024). Several studies have shown a strong relationship between sedimentation rates, hard coral cover, and the feeding behavior of Chaetodon octofasciatus, a coralivorous indicator species (Madduppa et al., 2014; MacDonald et al., 2021). However, the research is still limited because it generally focuses on only one specialist species with obligatory coral-eating behaviors. Although previous research has identified a correlation between environmental conditions (e.g., coral cover, structural complexity, or gradient of disturbance) and the response of some indicator species, particularly related to feeding selectivity and dietary specialization in coralivorous fish groups (Madduppa et al., 2014), research on taxa that utilize reef colonies, reef colonies utilized, and research on reef fish behavior in coral colonies as multifunctional habitats are still rarely done (Heery et al., 2018; Sani et al., 2021). The lack of such research, especially in the Seribu Islands, Dutch Island, Panjang, Kelapa, and Pelangi, makes this research important in filling the research gap. This research can fill this gap in terms of knowledge about taxa that utilize reef colonies, types of coral reef colonies that taxa utilize, and know the activities carried out by taxa that utilize reef colonies. Because of this, this study aims to find out the taxa of reef colony users, the types of reef colonies used, and the activities of taxa in coral reef colonies.

2. Materials and Methods

2.1. Study Sites

This study employed an Underwater Video Survey (UVS) collected from February 18 to March 1, 2016, on four islands in the Seribu Islands, DKI Jakarta Province, Indonesia. The islands are Belanda Island (05°36′15.6″ S, 106°36′08.9″ E), Kelapa Island (05°39′33.4″ S, 106°33′57.2″ E), Pelangi Island (05°36′01.3″ S, 106°35′25.6″ E), and Panjang Island (05°38′35.5″ S, 106°33′27.1″ E), Seribu Island, DKI Jakarta Province, Indonesia, shown in **Figure 1**. For each island, videos were recorded at ten points, with each point having a duration of 80 minutes. The video recordings were analyzed to identify the taxa utilizing coral reef colonies, determine the types of colonies used by each taxon, and observe the interactions of taxa within the coral reef colonies during the study period.

2.2. Data Collection

This study utilized secondary data in the form of underwater video recordings documenting reef fish activity and coral reef colony characteristics in the Seribu Islands, DKI Jakarta, Indonesia. The study sites included four islands: Belanda Island, Kelapa Island, Pelangi Island, and Panjang Island. Data were collected from a total of 40 coral reef colonies, with 10 colonies observed at each island. Reef fish observations were conducted using an Underwater Video Survey (UVS) approach. Each colony was recorded using a GoPro underwater action camera positioned at a fixed location to continuously capture reef fish activity associated with coral colonies. Video recordings were stored in MP4 format at a resolution of 1280 × 960 pixels and a frame rate of 29.97 frames s^{-1}. Four video recordings were obtained for each colony, each lasting approximately 20 min, resulting in a total observation time of approximately 80 min per colony. The collected video data included visual records of reef fish occurrences, behavioral interactions, and coral colony characteristics within the camera field of observation. Observations were restricted to reef fishes and coral colony features visible within the video frame. Therefore, the sampling unit in this study was the focal coral colony and its associated reef fish assemblage captured by the camera rather than a predefined observation area based on a fixed radius or distance from the camera. Screenshots were extracted from the video recordings to document both reef fish and coral colony features observed during the study. Reef fish species were identified to the lowest possible taxonomic level using the field guide Reef Fish Identification: Tropical Pacific (Allen et al., 2003) and validated using data from FishBase. Coral colony identification was conducted based on morphological characteristics observed from extracted images, focusing on growth forms such as branching, massive, and foliose, as well as genus-level traits. Identification at the genus level was supported by reference guidance from the Indo Ocean Project. Behavioral data were collected by observing reef fish activities captured in the video recordings, including interactions with coral colonies and other organisms. Behavioral observations were categorized into predefined groups, including aggressive, ambush, cleaning, feeding, foraging, hovering, predatory, resting, roaming, schooling, sheltering, stationary, and territoriality, based on observable visual indicators such as movement patterns, spatial position, and interaction context.

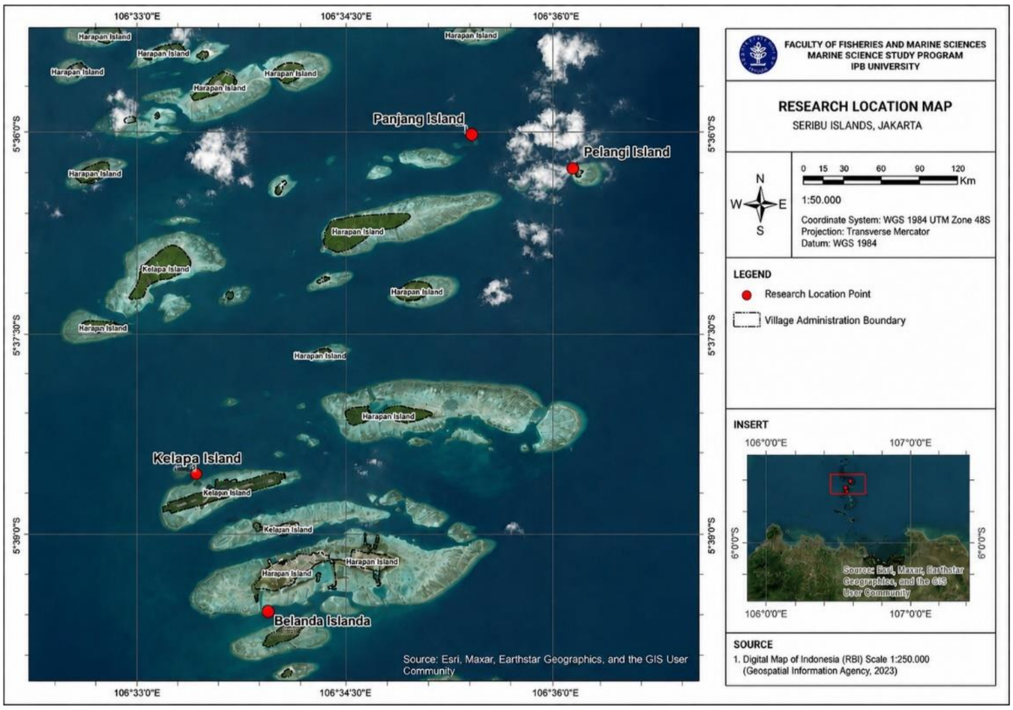

Figure 1. The location of Belanda, Kelapa, Panjang, and Pelangi Islands, which is part of the Seribu Islands, is north of Jakarta, Indonesia. The four locations are marked with a red dot and number symbols. Belanda Island (05°36′15.6″ S, 106°36′08.9″ E), Kelapa Island (05°39′33.4″ S, 106°33′57.2″ E), Pelangi Island (05°36′01.3″ S, 106°35′25.6″ E), and Panjang Island (05°38′35.5″ S, 106°33′27.1″ E).

2.3. Data Analysis

2.3.1. Video Data Analysis

All video recordings were stored on an external hard drive and systematically reviewed using VLC Media Player. A screen capture technique was applied to extract representative images of reef fishes and coral colonies observed within each recording. The extracted images and corresponding observations were organized, compiled, and tabulated in Microsoft Excel worksheets, structured by colony codes and video sequences to facilitate systematic data tracking and further analysis. Reef fish species were primarily identified using the standard taxonomic reference Reef Fish Identification Tropical Pacific, based on observable morphological characteristics such as body shape, coloration, fin structure, and patterning. Species identification was further validated using FishBase. Individuals that could not be reliably identified due to image limitations were recorded as unidentified taxa. Within each video, repeated appearances of the same individual were not counted as separate observations; instead, all observable activities of the individual during the 20-minute recording period were recorded as part of a continuous behavioral sequence. Behavioral records were then compiled and organized at the species, colony, and island levels. Fish behavior was classified based on observable visual indicators derived from the video recordings, including movement characteristics, spatial positioning relative to the substrate, and interaction patterns with surrounding organisms. Behavioral categories included aggressive, ambush, cleaning, feeding, foraging, hovering, predatory, resting, roaming, schooling, sheltering, stationary, and territoriality, following established frameworks in reef fish behavioral ecology (Pink and Fulton, 2014; Rueger et al., 2021; Kasumyan and Pavlov, 2023; Davidson et al., 2024). For example, ambush behavior was defined as a stationary position followed by a rapid and brief movement to attack nearby prey or individuals located close to the coral substrate.

Coral colony identification was conducted using screenshots extracted from video recordings, focusing on growth forms (branching, massive, and foliose) and genus-level morphological traits. All coral identification data were compiled and recorded in structured datasets containing colony code, island, colony images, and morphological descriptions to support the analysis of associations between coral colonies and reef fish species. Identification at the genus level was supported by reference guidance from the Indo Ocean Project. Data organization, compilation, and processing were conducted using Spyder (version 6.1.0) with Python 3.12.11. Descriptive analyses were applied to characterize reef fish composition, behavioral variation, and coral colony types across colony and island scales. The distribution of families, genera, and species was visualized using boxplots, while community similarity patterns were examined using Bray–Curtis-based dendrograms and Principal Coordinates Analysis (PCoA). Heatmaps were used to illustrate species distribution across islands based on behavioral categories. All video recordings were reviewed repeatedly to ensure consistency and accuracy in species identification and behavioral classification

3. Results and Discussion

3.1. Result of the Analysis of Reef Diversity, Behaviour Patterns, and Coral Genera Across the Panjang, Belanda, Pelangi, and Kelapa Research Islands

The diversity of reef fishes across the four study islands showed considerable variation **Table 1**. Kelapa Island exhibited the highest species richness, with 21 families, 56 genera, and 120 species. This was followed by Belanda Island, 23 families, 54 genera, and 119 species, and Panjang Island, 22 families, 53 genera, and 107 species. In contrast, Pelangi Island showed the lowest richness, with 15 families, 37 genera, and 83 species.

Table 1. Checklist of reef fish species recorded at Panjang, Belanda, Kelapa, and Pelangi Islands, Seribu Islands, Indonesia, based on Underwater Video Survey (UVS) recordings. Species occurrences were determined through post-recording analysis of underwater video footage. Check marks (✓) indicate the presence of a species at a given island. The checklist was used to assess variations in species composition and taxonomic richness among the study islands.

Family/Species	Panjang	Belanda	Kelapa	Pelangi
Acanthuridae				
Acanthurus auranticavus	✓			
Acanthurus maculiceps	✓			
Naso caeruleacauda	✓	✓	✓	✓
Naso reticulatus		✓		✓
Naso unicornis				✓
Zebrasoma velifer			✓	
Apogonidae				
Apogon chrysopomus				✓
Cheilodipterus intermedius				✓
Cheilodipterus isostigmus				✓
Cheilodipterus zonatus	✓			
Ostorhinchus cyanosoma		✓		
Siphamia elongata	✓			
Balistidae				
Balistapus undulatus	✓			
Balistoides viridescens	✓	✓	✓	
Sufflamen fraenatum		✓		
Belonidae				
Tylosurus crocodilus	✓	✓	✓	✓
Blenniidae				
Diodon hystrix	✓			
Caesionidae				
Caesio cuning	✓	✓	✓	✓
Pterocaesio flavifasciata		✓		
Pterocaesio monikae			✓	
Pterocaesio pisang		✓	✓	
Pterocaesio tessellata			✓	
Pterocaesio tile		✓		

Family/Species	Panjang	Belanda	Kelapa	Pelangi
Callionymidae				
Synchiropus splendidus		✓		
Carangidae				
Atule mate				✓
Chaetodontidae				
Chaetodon auriga		✓		✓
Chaetodon lineolatus				✓
Chaetodon melannotus				✓
Chaetodon octofasciatus	✓	✓	✓	✓
Chaetodon speculum		✓	✓	
Chelmon rostratus			✓	
Coradion altivelis	✓			
Coradion chrysozonus		✓		✓
Diodontidae				
Chilomycterus reticulatus	✓			
Diodon hystrix	✓			
Ephippidae				
Platax pinnatus	✓			
Haemulidae				
Plectorhinchus chrysotaenia	✓		✓	
Plectorhinchus orientalis	✓			
Holocentridae				
Myripristis murdjan			✓	
Myripristis trachyacron		✓	✓	
Sargocentron rubrum			✓	
Labridae				
Cheilinus abudjubbe				✓
Anampses caeruleopunctatus			✓	
Anampses elegans			✓	
Gomphosus varius	✓			
Bodianus bilunulatus	✓			
Bodianus mesothorax	✓	✓		
Stethojulis strigiventer	✓			
Halichoeres hortulanus				✓
Cheilinus abudjubbe		✓		✓
Cheilinus chlorourus	✓	✓	✓	✓
Cheilinus fasciatus	✓	✓	✓	✓
Cheilinus trilobatus	✓	✓	✓	
Cheilinus undulatus	✓			
Choerodon anchorago	✓	✓	✓	✓
Cirrhilabrus temminckii	✓			
Coris batuensis		✓		
Coris gaimard		✓		
Diproctacanthus xanthurus	✓	✓	✓	✓
Epibulus brevis				✓
Epibulus insidiator	✓	✓	✓	✓
Gomphosus varius	✓	✓	✓	✓
Halichoeres argus	✓	✓	✓	✓
Halichoeres bathyphilus		✓		
Halichoeres bicolor	✓			
Halichoeres chloropterus	✓	✓	✓	✓
Halichoeres chrysotaenia		✓	✓	✓
Halichoeres cosmetus				✓
Halichoeres hatzfeldii		✓		
Halichoeres hortulanus	✓	✓	✓	
Halichoeres kneri				✓
Halichoeres leucoxanthus			✓	
Halichoeres leucurus	✓	✓	✓	✓
Halichoeres marginatus		✓		
Halichoeres melanurus	✓	✓	✓	✓
Halichoeres nigrescens		✓		✓
Halichoeres prosopeion		✓	✓	
Halichoeres richmondi	✓	✓	✓	✓
Halichoeres scapularis		✓	✓	
Halichoeres vrolikii	✓	✓	✓	✓
Hemigymnus melapterus	✓	✓	✓	✓
Labrichthys unilineatus	✓		✓	✓
Labroides bicolor	✓			
Labroides dimidiatus	✓	✓	✓	✓
Oxycheilinus digramma	✓	✓	✓	✓
Oxycheilinus unifasciatus	✓	✓	✓	✓
Labrichthys unilineatus	✓			
Pteragogus trispilus		✓	✓	✓
Epibulus insidiator				✓
Stethojulis albovittata	✓			
Stethojulis interrupta	✓			
Stethojulis strigiventer	✓	✓	✓	
Thalassoma hardwicke	✓	✓	✓	
Thalassoma jansenii	✓	✓		
Thalassoma lunare	✓	✓	✓	✓
Cheilinus trilobatus				✓
Lethrinidae				
Gymnocranius elongatus			✓	
Gymnocranius grandoculis	✓			
Lethrinus erythropterus		✓	✓	✓
Lethrinus harak	✓	✓	✓	
Lethrinus lentjan	✓		✓	✓
Lethrinus maxweberi		✓		
Lethrinus microdon	✓			✓
Lethrinus obsoletus		✓		✓
Lethrinus olivaceus		✓	✓	✓
Lutjanidae				
Lutjanus bengalensis			✓	
Lutjanus biguttatus			✓	
Lutjanus decussatus	✓	✓	✓	✓
Lutjanus ehrenbergii	✓	✓	✓	
Lutjanus fulviflamma	✓	✓	✓	
Lutjanus johnii		✓		
Lutjanus lemniscatus		✓		✓
Lutjanus rivulatus			✓	
Lutjanus semicinctus			✓	
Malacanthidae				
Dipterygonotus balteatus			✓	
Malacanthus brevirostris		✓		
Monacanthidae				
Aluterus scriptus	✓			
Monacanthidae				✓
Pervagor janthinosoma		✓		
Pseudomonacanthus peroni			✓	
Mullidae				
Parupeneus barberinus	✓	✓	✓	

Family/Species	Panjang	Belanda	Kelapa	Pelangi
Upeneus tragula			✓	
Muraenidae				
Gymnothorax javanicus	✓			
Nemipteridae				
Pentapodus aureofasciatus		✓		
Pentapodus bifasciatus	✓	✓	✓	
Pentapodus setosus		✓		
Scolopsis affinis		✓		
Scolopsis aurata		✓		✓
Scolopsis bilineata	✓	✓	✓	
Scolopsis ciliata			✓	✓
Scolopsis lineata	✓	✓	✓	
Scolopsis margaritifera	✓	✓	✓	✓
Scolopsis trilineata	✓			✓
Pomacanthidae				
Centropyge eibli	✓	✓		✓
Centropyge nox			✓	
Chaetodontoplus mesoleucus	✓	✓	✓	✓
Paracentropyge multifasciata				✓
Pomacanthus sexstriatus		✓	✓	
Pomacentridae				
Abudefduf bengalensis	✓	✓		
Abudefduf lorenzi	✓			
Abudefduf septemfasciatus	✓			
Abudefduf sexfasciatus	✓	✓	✓	✓
Abudefduf vaigiensis	✓	✓	✓	✓
Abudefduf whitleyi	✓			
Amblyglyphidodon curacao	✓	✓	✓	✓
Amblyglyphidodon flavopurpureus		✓	✓	✓
Amblyglyphidodon indicus	✓		✓	
Cheiloprion labiatus			✓	
Chromis atripectoralis		✓	✓	
Chromis caudalis	✓			
Chromis verater				✓
Chromis viridis		✓	✓	
Chromis xanthochira		✓		
Chrysiptera hemicyanea		✓		
Chrysiptera springeri			✓	
Dascyllus aruanus		✓		
Dischistodus perspicillatus		✓		✓
Dischistodus prosopotaenia	✓	✓	✓	
Neoglyphidodon melas	✓	✓	✓	✓
Neopomacentrus anabatoides			✓	✓
Neopomacentrus azysron		✓	✓	
Neopomacentrus bankieri		✓	✓	
Neopomacentrus cyanomos			✓	

Family/Species	Panjang	Belanda	Kelapa	Pelangi
Neopomacentrus filamentosus	✓	✓	✓	✓
Neopomacentrus violascens				✓
Pomacentrus alexandri	✓	✓	✓	✓
Pomacentrus burroughi		✓		
Pomacentrus coelestis			✓	
Pomacentrus lepidogenys	✓	✓	✓	✓
Pomacentrus littoralis	✓		✓	
Pomacentrus moluccensis	✓	✓	✓	✓
Pomacentrus nigromanus			✓	
Pomacentrus reidi	✓			✓
Pomacentrus stigma				✓
Pomacentrus tripunctatus	✓		✓	
Pomancetrus mileri	✓			
Stegastes fasciolatus			✓	
Stegastes lacteatus			✓	
Stegastes nigricans		✓	✓	
Pseudochromidae				
Pseudochromis fuscus	✓	✓		
Scaridae				
Cetoscarus ocellatus	✓			
Chlorurus bleekeri	✓		✓	
Chlorurus capistratoides		✓		✓
Chlorurus sordidus	✓	✓	✓	✓
Chlorurus spilurus		✓	✓	✓
Chlorurus troschelii			✓	
Scarus prasiognathos				✓
Hipposcarus longiceps	✓	✓	✓	
Scarus dimidiatus	✓	✓		
Scarus festivus			✓	
Scarus flavipectoralis		✓	✓	
Scarus frenatus	✓			
Scarus fuscocaudalis	✓	✓		✓
Scarus ghobban	✓	✓	✓	
Scarus hypselopterus	✓		✓	
Scarus maculipinna			✓	
Scarus niger	✓	✓	✓	
Scarus prasiognathos		✓		
Scarus quoyi	✓	✓	✓	
Scarus rivulatus	✓	✓		
Scarus rubroviolaceus	✓			
Serranidae				
Cephalopholis argus			✓	
Cephalopholis boenak		✓	✓	
Cephalopholis microprion	✓	✓	✓	✓
Cephalopholis panamensis		✓		
Epinephelus bontoides	✓			
Epinephelus ongus			✓	
Epinephelus undulosus	✓			
Epinephelus waandersi			✓	
Siganidae				
Siganus argenteus		✓		
Siganus corallinus	✓			✓
Siganus doliatus	✓			
Siganus fuscescens		✓	✓	✓

Family/Species	Panjang	Belanda	Kelapa	Pelangi
Siganus guttatus	✓			
Siganus lineatus	✓	✓	✓	
Siganus puellus	✓		✓	✓
Siganus punctatissimus			✓	✓
Siganus punctatus	✓	✓	✓	✓
Siganus stellatus	✓			
Siganus virgatus	✓	✓	✓	✓
Tetraodontidae				
Arothron stellatus		✓		
Canthigaster epilampra			✓	
Canthigaster tyleri		✓	✓	

The diversity of reef fishes across the four islands in the study area was considerable, with a total of 29 families, 82 genera, and 215 species recorded across coral reef colonies. Structurally, reef fish communities at all study sites were dominated by the family Labridae. At a finer taxonomic scale, variation in genus dominance was observed among islands, with Panjang Island dominated by the genus Scarus, while Belanda, Kelapa, and Pelangi Islands were dominated by the genus Halichoeres. Overall, reef fish diversity exhibited notable variation among coral colonies across the four islands, as seen in **Figure 2**.

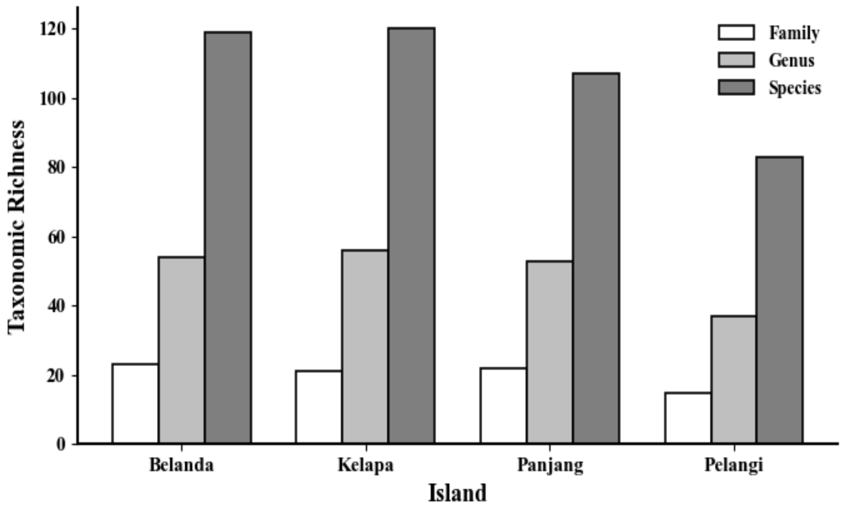

Figure 2. Reef fish taxonomic richness associated with coral colonies in the Seribu Islands, Jakarta. Richness is expressed as the number of families, genera, and species recorded at Belanda, Kelapa, Panjang, and Pelangi Islands. Kelapa and Belanda Islands supported the highest taxonomic richness, whereas Pelangi Island exhibited the lowest richness across all taxonomic levels.

The results of the similarity analysis of reef fish community composition using the Bray–Curtis dissimilarity and Principal Coordinates Analysis (PCoA) in **Figure 3.** show that the level of similarity of reef fish communities among the study islands varies depending on their taxonomic richness. At the species level, the highest similarity was observed between Belanda Island and Kelapa Island, while the lowest similarity occurred between Panjang Island and Pelangi Island. This indicates that the structure of reef fish community composition at the species level differs among the study sites. This pattern is also reflected in the PCoA results, where Belanda Island and Kelapa Island are clustered close to each other. Panjang Island occupies a separate position, while Pelangi Island is located farther away, although it still belongs to the same cluster as Belanda Island and Kelapa Island. Based on the results of the similarity analysis of community composition at the genus level, the similarity between Belanda Island and Kelapa Island increased. This suggests that although species composition differs among islands, many reef fish genera are consistently present across the study sites. The results of Principal Coordinates Analysis (PCoA) at the genus level also show that Belanda Island and Kelapa Island form a closer cluster, while Pelangi Island is slightly separated, although the separation is not as pronounced as at the species level. At the family level, the similarity of reef fish communities among islands is higher across all research locations, as reflected by the results of the Bray–Curtis dissimilarity analysis. This pattern can be observed in the PCoA results, where Kelapa Island clusters with Pelangi Island, while Belanda Island clusters with Panjang Island. These results suggest that reef fish communities at the family level are relatively similar despite differences in species composition. The PCoA ordination further supports this pattern, with all islands forming closer clusters, indicating that the stability of reef fish community structure at the family level is relatively high across the study sites. Overall, the results of the Bray–Curtis similarity and PCoA analyses indicate that the similarity in reef fish community composition among islands varies greatly at the species level, but becomes increasingly similar at the genus and family levels. This suggests that although the species present differ among the study sites, the community structure at higher taxonomic levels remains relatively stable.

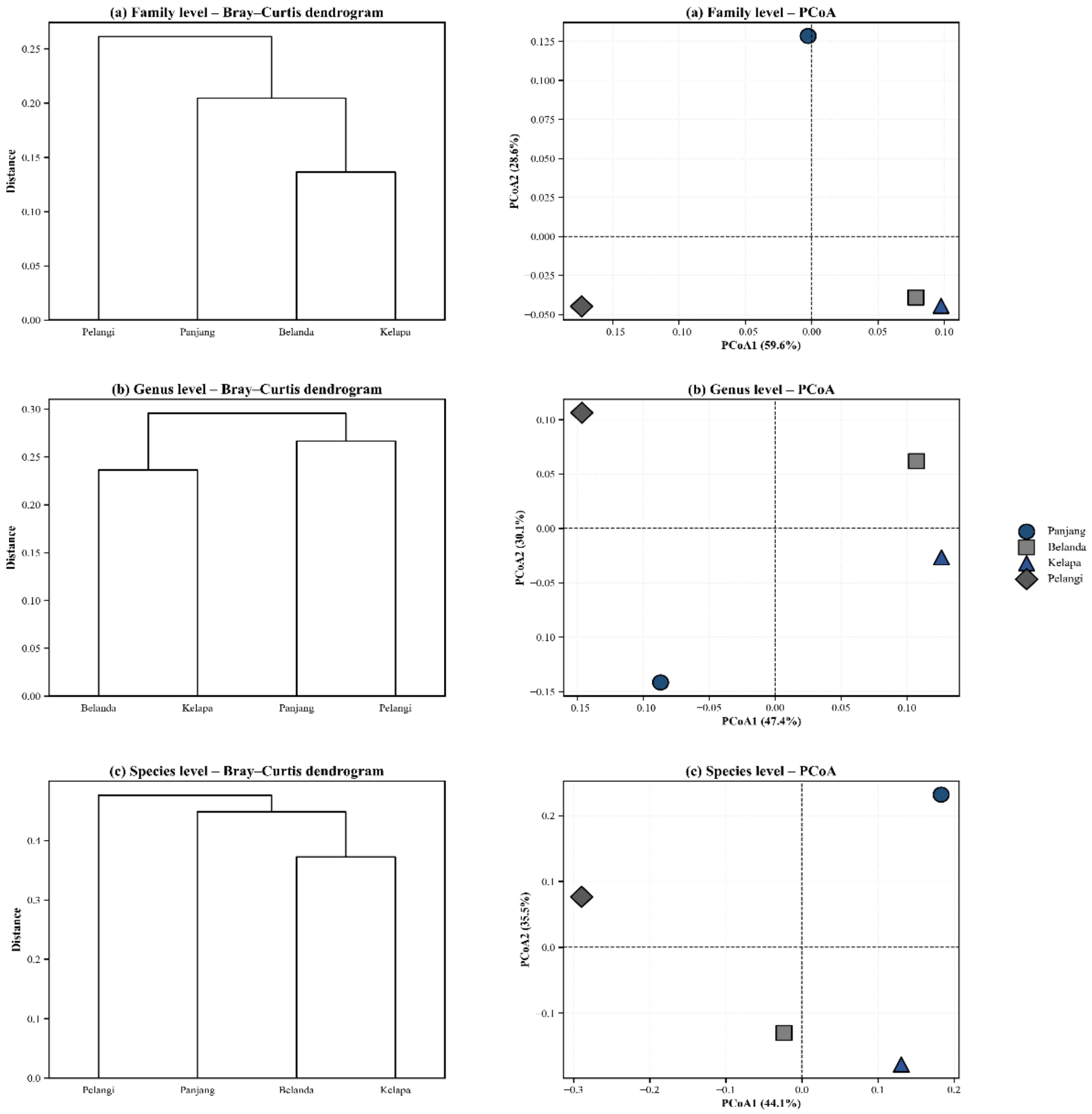

Figure 3. Bray–Curtis dendrogram (left) and principal coordinates analysis (PCoA) ordination (right) showing similarity patterns of reef fish communities among Panjang, Belanda, Kelapa, and Pelangi Islands in the Seribu Islands, Indonesia. (a) Family-level, (b) genus-level, and (c) species-level analyses illustrate the clustering of reef fish communities based on Bray–Curtis similarity (left panels) and their spatial distribution in ordination space based on PCoA (right panels).

3.2. Fish Behavior

The behaviors observed across the four study islands (Panjang, Pelangi, Kelapa, and Belanda) are presented in **Table 2**. A total of 13 types of behavior were recorded across all research locations. Belanda Island exhibited the highest behavioral diversity, with 11 types of behavior, followed by Pelangi Island with 9 types, Kelapa Island with 8 types of behavior, Kelapa Island with 8 types, and Panjang Island with 7 types. The diversity of reef fish behaviors observed across the four islands is illustrated in **Figure 4**. Feeding behavior was the most frequently observed behavior at all study locations, particularly at Panjang Island and Belanda Island. Wandering behavior was also commonly recorded across all study sites. Similarly, hovering and foraging behaviors were frequently observed. In contrast, ambush and cleaning behaviors were rarely observed, as these behaviors are typically performed by only a limited number of species. Other behaviors, such as circulating, resting, remaining motionless, and territorial behavior, were very rarely observed or were absent at certain islands. Schooling behavior was observed at all study sites, indicating that each island supports species that occur in groups and exhibit similar collective behavior patterns. Overall, among the recorded behaviors, feeding and wandering behaviors were the most widespread across all study sites, whereas predatory and territorial behaviors occurred at relatively low frequencies.

Table 2. A list of observed reef fish behaviors (n = 13) at the study sites on Panjang Island, Kelapa Island, Pelangi Island, and Belanda Island, Seribu Islands, Jakarta. The behaviors were identified based on visual indicators from video recordings that illustrate patterns of reef fish activity associated with coral colonies.

Fish Behaviours	Panjang	Pelangi	Kelapa	Belanda
Aggressive		✓		✓
Ambush	✓	✓	✓	✓
Cleaning	✓	✓	✓	✓
Feeding	✓	✓	✓	✓
Foraging		✓		✓
Hovering	✓	✓	✓	✓
Predatory			✓	
Resting				✓
Roaming	✓	✓	✓	✓
Schooling	✓	✓	✓	✓
Sheltering			✓	
Stationary				✓
Territoriality	✓	✓	✓	✓

Among the behaviours observed across the four study sites, each reef fish species may exhibit more than one type of behaviour. The distribution of reef fish species and their associated behaviours at each island is presented in **Figure 4.** Based on the total species recorded at Belanda Island, *Choerodon anchorago* was observed exhibiting multiple behaviours, including feeding, foraging, exploring, territorial, and resting behaviours. Meanwhile, *Diproctacanthus xanthurus* and *Pteragogus trispilus* displayed feeding, hovering, and roaming behaviours. At Kelapa Island, roaming, hovering, and schooling behaviours were dominant, particularly among *Halichoeres chloropterus*, *Pentapodus bifasciatus*, and *Pomacentrus moluccensis*. In contrast, *Chaetodontoplus mesoleucus* and *Lutjanus fulviflamma* exhibited predatory and ambush behaviours. On Pelangi Island, several species showed dominant behaviours such as feeding, foraging, exploring, hovering, schooling, and territorial behaviour, notably *Cheilinus fasciatus*, *Halichoeres chloropterus*, and *Pomacentrus brachialis*. At Panjang Island, reef fish species were observed displaying behaviours such as feeding, exploring, hovering, and schooling. These behaviors were recorded in species such as *Cheilinus fasciatus* and *Halichoeres chloropterus*, while *Pomacentrus moluccensis* also exhibited territorial behavior.

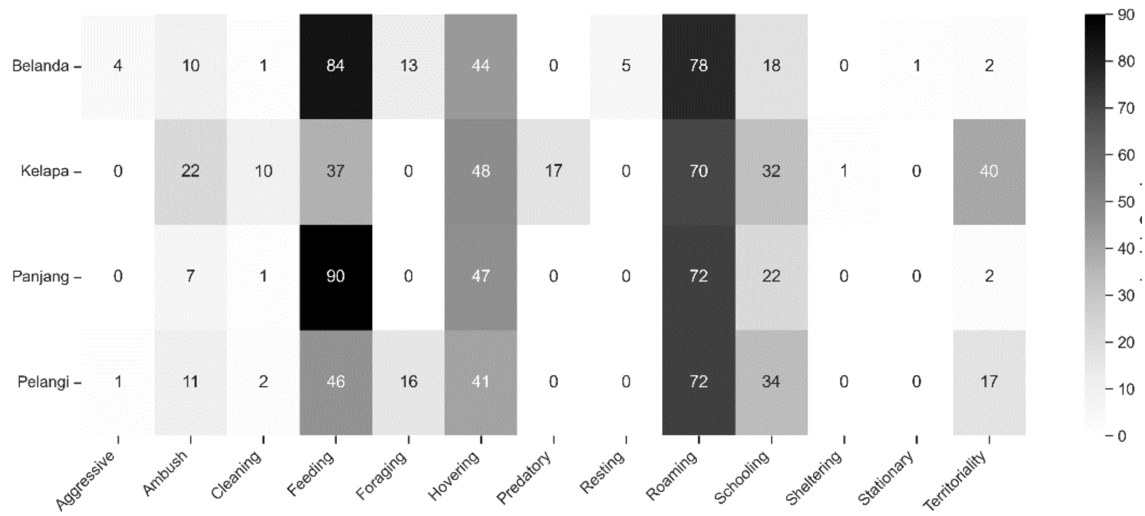

Figure 4. A heatmap showing the distribution of reef fish species based on behaviour categories at the study sites in the Seribu Islands (Panjang Island, Kelapa Island, Pelangi Island, and Belanda Island), Jakarta. The values presented in the heatmap represent the total number of species exhibiting each type of behavior observed during the research period at each study site.

3.3. Coral Genera in the Study Islands

The identification of coral reef genera recorded from video observations at the study sites on Panjang Island, Kelapa Island, Pelangi Island, and Belanda Island is presented in **Table 3**. The composition of coral genera varies among islands; however, the genera *Acropora* and *Porites* were recorded at all four islands. This indicates that these two genera represent the main structural components of the coral reef communities in the study area. In addition to these dominant genera, other coral genera such as *Seriatopora* and *Pocillopora* were also recorded at several islands. These genera are commonly known as branching corals. Other identified genera belong to massive and foliose coral forms, although their distribution is not uniform across the study sites. For example, the genus *Goniastrea* was recorded only at Panjang Island and Pelangi Island, while *Favites* was found at Belanda Island, Panjang Island, and Kelapa Island. The genus *Platygyra* was recorded only at Panjang Island. These patterns may reflect differences in substrate characteristics among the islands. In addition to branching, massive, and foliose corals, solitary coral genera such as *Fungia* and *Ctenactis* were also recorded at Belanda Island, Kelapa Island, and Panjang Island. Several coral genera were found only on a single island. For instance, *Echinophyllia* was observed only at Pelangi Island, *Cyphastrea* was recorded only at Belanda Island, while Platygyra was found exclusively at Panjang Island. Furthermore, the genera *Montastraea* and *Pocillopora* were recorded only at Kelapa Island.

Table 3. List of identified coral reef genera (n = 16) at the study sites on Panjang Island, Kelapa Island, Pelangi Island, and Belanda Island, Seribu Islands, Jakarta. This table shows the coral genera utilized by reef fishes during observations across all study sites.

Genera	Belanda	Kelapa	Panjang	Pelangi
Acropora	✓	✓	✓	✓
Ctenactis	✓		✓	
Cyphastrea	✓			
Echinophyllia				✓
Echinopora		✓		
Favites		✓	✓	
Fungia	✓	✓		
Montastraea		✓		
Montipora	✓	✓		
Pachyseris	✓		✓	
Pavona	✓	✓	✓	

Genera	Belanda	Kelapa	Panjang	Pelangi
Platygira			✓	
Pocillopora		✓		
Porites	✓	✓	✓	✓
Seriatopora	✓		✓	✓
Stylophora		✓	✓	✓

Of the total coral genera utilised by reef fishes at the study sites, the distribution of fish species associated with each coral genus is presented in **Figure 5.** The genus *Acropora* was the most frequently utilised coral genus by reef fish species. At Belanda Island, a total of 131 fish species were recorded in association with this genus, followed by Panjang Island with 129 species, Kelapa Island with 118 species, and Pelangi Island with 104 species. In addition to *Acropora*, several other coral genera commonly utilised by reef fishes include *Porites*, *Montipora*, and *Pachyseris*. Conversely, some coral genera supported relatively lower numbers of fish species at each island. These include *Cyphastrea* at Belanda Island with 34 species, *Pocillopora* at Kelapa Island with 25 species, *Pavona* at Panjang Island with 31 species, and *Stylophora* at Pelangi Island with 50 species.

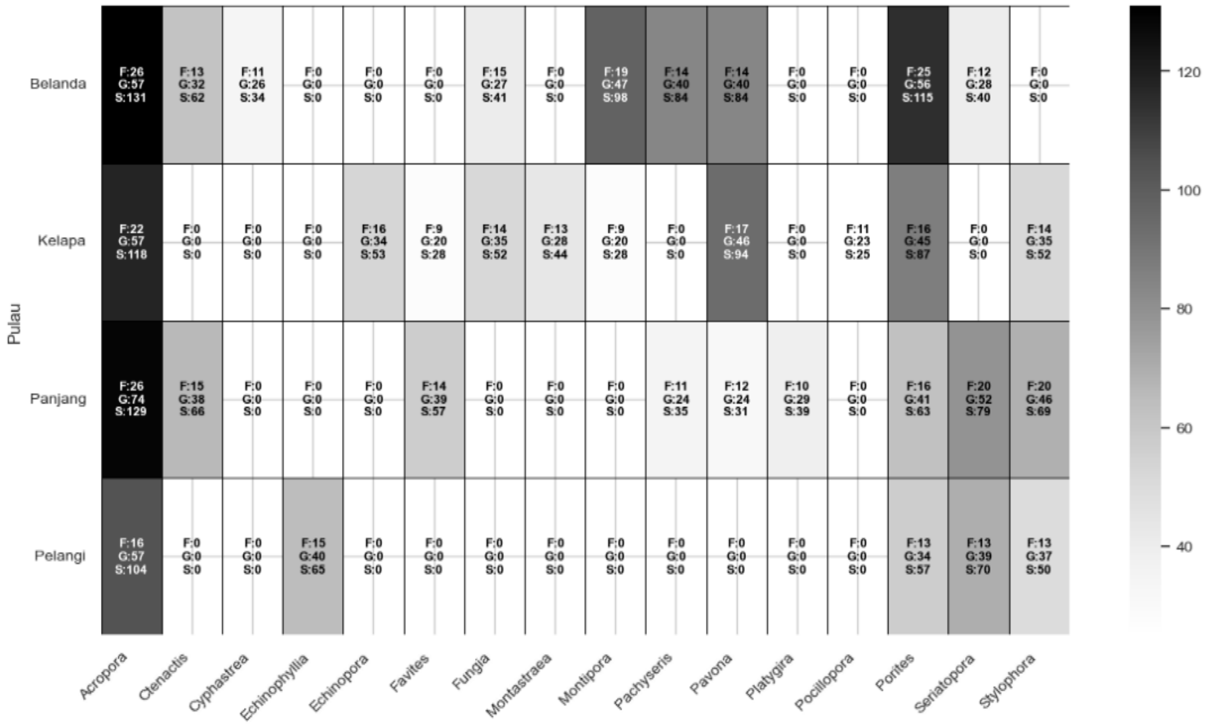

Figure 5. Heatmap illustrating the distribution of reef fish presence across different coral genera at the study sites in the Seribu Islands (Belanda Island, Panjang Island, Kelapa Island, and Pelangi Island), Jakarta. The heatmap presents the number of reef fish families, genera, and species recorded interacting with each coral genus at each study site. Differences in colour intensity represent variations in the number of fish taxa recorded, with darker colours indicating higher numbers of associated species.

3.4. Discussion

The observed variation in reef fish diversity across the study sites indicates relatively comparable species richness among Kelapa, Belanda, and Panjang Islands, with only slight differences in the number of recorded species. In contrast, Pelangi Island consistently showed lower species richness. This pattern is likely related to differences in coral genus composition and the resulting habitat complexity. The islands of Kelapa, Belanda, and Panjang support relatively diverse assemblages of coral genera, including branching, massive, and foliose growth forms, which provide heterogeneous habitats with numerous microhabitats and refuge spaces. In contrast, the lower diversity observed at Pelangi Island may reflect more limited coral genus composition and reduced structural complexity. These morphologically diverse coral assemblages enchance structures complexity by creating varied three-dimensional structures that support greater niche availability for reef fish (Ferreira et al., 2025). As highlighted by (González-Barrios et al., 2025), shifts in coral community composition correlate more strongly with changes in reef fish diversity than fluctuations in coral cover alone. Similarly, Helder et al. (2022) demonstrated that intra-habitat structural complexity, particularly vertical relief generated by different coral morphologies, significantly drives the distribution and richness of fish functional groups by providing essential shelter and microhabitats. When the number of coral genera was compared among islands, Kelapa Island was recorded to have nine coral genera, namely Acropora, Faviter, Fungia, Montastraea, Montipora, Pavona, Pocilipora, Porites, and Stylophora. A similar number was also recorded at Panjang Island, where nine coral genera were identified: Acropora, Ctenactis, Favites, Pachyseris, Pavona, Platygra, Porites, Setiapora, and Stylophora. Meanwhile, Belanda Island contained eight coral genera, including Acropora, Ctenactis, Cyphastrea, Fungia, Montipora, Pachyseros, Pavona, and Porites. Pelangi Island had the lowest number of coral genera, with only five recorded: Acropora, Echinophyllia, Porites, Seriatopora, and Stylophora. Although Kelapa and Panjang Islands contained more coral genera than Belanda Island, the differences in reef fish richness among these three islands were relatively small. In contrast, Pelangi Island, which supported the fewest coral genera, also exhibited the lowest reef fish richness. These findings indicate that reef fish diversity may not be determined solely by the number of coral genera present. Instead, the structural characteristics of coral habitats and the complexity of the reef environment are likely to play an important role in supporting diverse reef fish assemblages. Variations in coral community composition can influence three-dimensional reef structure, microhabitat availability, and refuge complexity, all of which are important factors shaping reef fish distribution and diversity (Komyakova et al., 2018; Priest et al., 2024). Based on the observed behavioural variation, Belanda Island exhibited the greatest diversity of reef fish behaviours, followed by Pelangi Island and Kelapa Island, while Panjang Island showed relatively lower behavioural variation. These differences further suggest that habitat characteristics, particularly the structural complexity generated by different coral growth forms, may influence not only reef fish diversity but also the range of behaviours expressed by reef fish communities across the study sites.

A total of 13 reef fish behavioural categories were identified in this study, reflecting a wide range of ecological strategies in utilising coral reef habitats. Among these, feeding, roaming, and hovering were the most dominant behaviours across all study sites. In particular, feeding can be considered the most dominant (ecologically successful) behaviour, as it exhibited the highest number of species at all islands, especially at Panjang Island (90 species) and Belanda Island (84 species). This high feeding activity indicates the availability of abundant food resources, including benthic algae, plankton, and small organisms associated with coral structures. The roaming behaviour also showed consistently high values across all sites (70–78 species), suggesting that most reef fish actively utilise the habitat for movement, exploration, and ecological interactions. Meanwhile, hovering (41–48 species) highlights the importance of coral structural complexity in providing shelter while allowing fish to maintain position in the water column, particularly under current-exposed conditions. In contrast, behaviours such as aggressive, ambush, resting, and cleaning were among the least dominant, as they were recorded in relatively low numbers of species across all sites. These behaviours are typically more specialised and dependent on specific ecological conditions, such as predator–prey interactions (ambush), territorial competition (aggressive), or symbiotic relationships (cleaning), resulting in their limited and uneven distribution (ecologically restricted behaviours). Variations in behavioural patterns among islands indicate differences in ecological requirements and habitat conditions. Panjang and Belanda Islands were dominated by feeding and roaming behaviours, suggesting habitats that strongly support foraging activities. In contrast, Kelapa Island exhibited a dominance of territoriality (40 species), indicating higher competition for space and resources. The relatively low feeding activity at this site (37 species) further suggests that fish allocate more energy towards defending territories rather than active foraging. Meanwhile, Pelangi Island showed relatively higher schooling behaviour (34 species), which may reflect more open habitat conditions or lower predation pressure, allowing group formation as a protective strategy.

These behavioural differences are closely linked to variations in habitat complexity across sites. Heatmap analysis revealed that fish associations are unevenly distributed and tend to be concentrated on coral genera with complex morphological structures. The genus Acropora was the most frequently utilised coral genus, with the highest number of associated fish species recorded at Belanda Island (131 species), followed by Panjang Island (129 species), Kelapa Island (118 species), and Pelangi Island (104 species). In addition, genera such as Porites also showed high levels of association, reaching 115 species at Belanda Island and 79 species at Panjang Island, while Montipora reached 98 species at Belanda Island. Other genera, such as Pachyseris and Pavona, also contributed to fish associations, although with lower numbers of species. In contrast, genera such as Echinophyllia, Echinopora, and Platygyra exhibited more limited associations and were restricted to specific locations. The dominance of Acropora and other structurally complex corals indicates that branching and heterogeneous coral forms provide critical microhabitats for reef fish. These structures offer three-dimensional space, protection from predators, and substrates that support the growth of food organisms, thereby facilitating multiple activities such as feeding, sheltering, and social interactions. The high level of association observed at Belanda and Panjang Islands is consistent with the dominance of feeding and roaming behaviours, suggesting that structurally complex habitats promote intensive foraging activity. In contrast, despite the continued dominance of Acropora at Kelapa Island, the high occurrence of territorial behaviour indicates spatial limitations within the coral structure that may drive competition. At Pelangi Island, the relatively lower association values likely reflect more open or less structurally complex habitats.

4. Conclusions

This study highlights the importance of coral colonies as essential habitats supporting reef fish diversity and behavioural activities in the Seribu Islands. Reef fishes utilized coral colonies feeding, roaming, sheltering, territoriality, and social interactions, with patterns of habitat use varying among islands according to differences in coral community composition and structural complexity. The results suggest that habitat complexity and coral morphology have a greater influence on reef fish assemblages and behavioural diversity than coral genus richness alone. Coral genera with structurally complex growth forms provided critical microhabitats that enhanced fish associations and ecological interactions. Therefore, maintaining diverse and structurally complex coral communities is fundamental for sustaining reef fish biodiversity, ecological functions, and the resilience of coral reef ecosystems in the Seribu Islands.

Conflicts of Interest Statement

The authors declare that there are no conflicts of interest.

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AI Writing Statement

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) for language editing, translation, and improving the clarity of the manuscript, and Grammarly for grammar checking and language refinement. The authors reviewed and edited the content and take full responsibility for the final manuscript.

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