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RESEARCH ARTICLE

SPATIAL VARIATION OF REEF FISH BASED ON CORAL LIFEFORM ON LIHAGA ISLAND, LIKUPANG, NORTH SULAWESI

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ABSTRACT

The world's coral reefs are under increasing pressure due to local and global triggering factors (e.g., acidification, pollution, plastic waste, rising temperatures, and wastewater) that degrade the condition and function of coral reefs. These pressures have the potential to cause drastic changes in coral reefs, such as a "shift to the algal phase," in which Scleractinia coral-dominated communities "switch" to macroalgae-dominated communities or less productive algal grasses. The purpose of these research consists of to identify comprehending the influence of variables influencing fish community dynamicsand figuring out the mechanisms that give corals and reef fish resilience in the face of change. The collecting data need two months of fieldwork, conducted in 2023, beginning in October and finishing in November 2023. The study location is Lihaga Island in the North Minahasa Regency with the focus of research is coral ecosystems. The underwater photo transect method, also known as the Underwater Photo Transect (UPT) method, utilizes advancements in computer software and digital camera technology. A roll-meter was placed 50 meters away from each site, and 50 images were taken at each station. Reef fish data was obtained from the results of research conducted by 37 people on Lihaga Island, North Sulawesi. This publication specifically uses data on reef fish that are targeted for fishing and has not been published before. The method used was the underwater visual census method on the belt transect. Visual censuses were conducted by divers along a 50-meter transect line with left and right-side widths of 2.5 m each, resulting in a census area of 250 m2 per transect. The study of the coral cover at Lihaga Beach revealed that the cover value of dead coral groups was about 40.32%, that of living coral groups was approximately 38.58%, and that of other groups (OT) was approximately 21.11%.: Coral lifeform types ACB, CMR, HA, ACD, CA, ACE, ACT, CF, DC, ACS, SC, CE, SP, OT, CS, and CM forms are what define Group 1. DCA and S are characteristics of Group 2. ACB, CMR, HA, ACD, CA, ACE, ACT, CF, DC, ACS, SC, CE, SP, OT, CS, and CM are the characteristics of Group 3. Group 2 is distinguished by S and DCA. HA, ACD, CF, DC, ACS, SC, CE, SP, OT, CS, CM, DCA, and S are the characteristics of Group 3. CB and RB make up Group 4. Every one of the four sizable groupings has a certain function or portion within an ecosystem. The results of the analysis showed that the uniformity value (E) of reef fish on Lihaga Island was included in the stable category with a value of 0.79 or included in the > category with a value of 0.75. The results of the reef fish cluster analysis (target group) are divided into 3 major groups, namely, the first group consists of *Zebrasoma scopas* and *Parupeneusmultifasciatus*. The second group is of the type *Ctenochaetus striatus*. The third group of *Ctenochaetusbinotatus* species, which has the greatest value of all target fish species, represents two observation stations on Lihaga Island. The large number of fish species, *Ctenochaetusbinotatus* and *Ctenochaetus striatus*, which became the largest group based on the results of this cluster analysis

INTRODUCTION

Coral reefs are among the highest biodiverse ecosystems on the planet, supporting approximately three million species and about 25% of all marine life (1, 2). Unfortunately, the world's coral reefs are under increasing pressure due to local and global triggering factors (e.g., acidification, pollution, plastic waste, rising temperatures, and wastewater) that degrade the condition and function of coral reefs (3–6).These pressures have the potential to cause drastic changes in coral reefs, such as a "shift to the algal phase," in which scleractinian coral-dominated communities "switch" to macroalgae-dominated communities or less productive algal grasses (7-9).

Marine ecologists confront a significant difficulty in trying to tackle the issue: comprehending the influence of variables influencing fish community dynamics (10–13) and figuring out the mechanisms that give corals and reef fish resilience in the face of change (14–16). One significant ecological activity that shapes and regulates biodiversity is spatial distribution. However, compared to keystone species, which have a far bigger influence than other species, species have less of an influence on the surrounding biodiversity. Predatory and prey populations can support other species through cooperative interaction (mutualism), linking mutualistic species (hosts, clients), and creating habitats that affect the ecosystem environment. These species are influenced by ecosystem processes through the regulation of prey and predator populations. Some herbivorous fish species are keystone species found in coral reefs across the world. These species are varied and offer a range of ecological services, including the ability to help live hard corals recover. On the other hand, certain significant species—like damselfish fish—can support the growth of algal zones and protect them from other herbivorous fish. Knowledge of the underlying variables that drive or affect spatial distribution and species abundance, such as environmental and niche determinants, might increase understanding of how patterns of species distribution may vary as a result of the numerous threats confronting coral reefs (14-16). Carnivores make up the majority of fish species that are targeted for capture; these species are particularly vulnerable because of the numerous facultative or mandatory needs that corals have for their environment (14, 15, 17). The majority of these fish are large in size, and many of them use coral formations for both foraging and shelter. Therefore, the reduction in coral cover may put a cap on reef fish populations, particularly those in Indonesia (20, 21), as noted in references 11, 14, 18, and 19. However, fish interactions with target fish caught around North Sulawesi waters are still poorly publicized and are presented only in the form of changes in composition and species richness (22.23).In addition, small-scale studies focused more on reef fish groups as a whole, such as studies of their food, trophic status, habitat associations, and recruitment (14, 17). These studies have revealed that coral habitat and niche partitions appear to be important general determinants of the spatial patterns of target fish capture. The fact that target fish groups and other fish groups often experience population declines after corals are lost due to major disturbances (16, 24) In fact, many studies further highlight the importance of coral habitat to reef fish groups and how this can encourage reef fish distribution (18, 20).

Although habitat preferences may initially determine the spatial distribution of many reef fish, the patterns formed can change through a variety of ecological processes, including mortality, competitiveness, and fish behavior (25–28). Because many captured target fish lose interest in moving once they've settled in. As a matter of reality, a great deal of fish species has fairly limitedranges and seem to have a strong attachment to a particular area (29–31). The structure, dietary habits, and degree of habitat disturbance or fishing operations at the tropic level all have a significant impact on the regulation of fishing targets in coral reef ecosystems (11, 14, 32, 33). Reef fish arrangements are traditionally defined as the arrangement of food webs by consumers, while other arrangements are based on resource availability. Many studies have attempted to gain ecological support for such regulatory mechanisms, with varying results and some debate over the importance of one over the other.Lately, there has been a generally accepted concept that both processes must run to some extent, and the importance of regulatory mechanisms can vary in space and time. That is, these regulatory processes can change the distribution patterns of target fishing fish formed in coral reef ecosystems. There is some evidence that the regulation of fishing target fish in coral ecosystems can occur due to their interaction with coral habitats (7, 34–36). The influence of reef fish habitat in the form of coral lifeforms on the interaction pattern and distribution of target fish needs to be studied. The interaction is certainly more variable in space and time because this interaction will affect the composition of fish communities and the spatial patterns of target fish fishing in coral reef ecosystems. The general nature of fish regulation remains to be further confirmed through research.

RESEARCH METHODS

Time and Location of Research: Two months of fieldwork are conducted in 2023, beginning in October and finishing in November. Lihaga Island in the North Minahasa Regency is the study location (Figure 1). The focus of research is coral ecosystems.

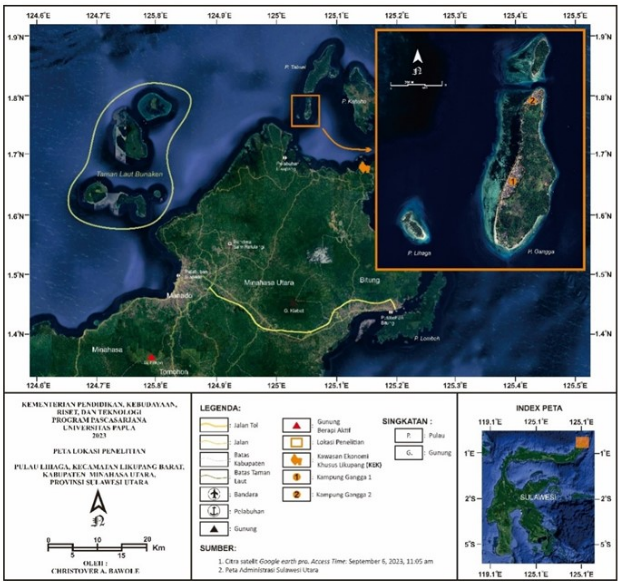


Figure 1. Lihaga Island Research Location

Coral Observation: The underwater photo transect method, also known as the Underwater Photo Transect (UPT) method, utilizes advancements in computer software and digital camera technology. Underwater photo data collection was conducted using a housing-equipped Canon G-16 camera (Giyanto et al., 2014). A roll-meter was placed 50 meters away from each site, and 50 images were taken at each station. Using random point samples, data analysis was done on each frame in order to produce quantitative data based on underwater photos created from this UPT motif. This point is used to calculate the amount of random points utilized to evaluate the photo. The number of random points utilized is 30 for each frame, and this is typical of calculating the proportion of category and substrate cover (Giyanto, 2013). This method uses sampling, where a population is chosen at random intervals throughout the image. In this manner, biota and substrates that are precisely at the location of a randomly selected point by the CPCe program are the only data that are collected. A computer program called Coral Point Count with the Excel extension (CPCe) may be used to determine the area of the base substrate from an observed snapshot taken with an underwater digital camera. Besides being able to be used to calculate the percentage of basic substrate cover with the point count method, it can also be used to calculate the area of each type of basic substrate to be analyzed. The percentage value of the category cover for each frame may be computed using the following formula (Giyanto et al., 2014) based on the picture analysis procedure performed on each photo frame:

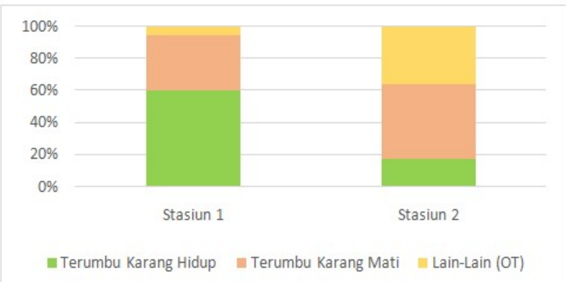
$$\text{Percent cover} = \frac{100\text{x Number of points for which a category is recorded}}{\text{Total number of points on transects}}$$

Fish Observation: Reef fish data was obtained from the results of research conducted by 37 people on Lihaga Island, North Sulawesi. This publication specifically uses data on reef fish that are targeted for fishing and has not been published before. The method used was the underwater visual census method on the belt transect (38.39). Visual censuses were conducted by divers along a 50-meter transect line with left and right-side widths of 2.5 m each, resulting in a census area of 250 m2 per transect. The visual census was conducted at a depth of 5 m, where observations of coral reefs were made. Types and approximate numbers of target fish are recorded in worksheets. Fish species identification using Allen's book Reef Fishes of the East Indies (40)

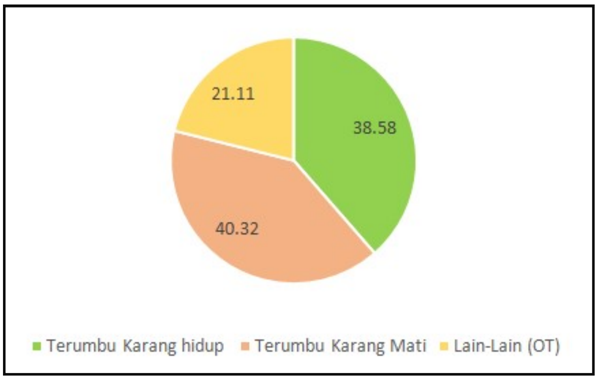
Data Analysis: The analysis of diversity, uniformity, and dominance of reef fish was calculated using Formula (41). Principal component analysis (AKU) is used to describe reef fish habitat characteristics (42). The AKU results were confirmed by Klater analysis to ascertain the grouping of reef fish habitats based on coral lifeform type. Cluster analysis was also used to describe the spatial distribution of reef fish based on coral lifeform type (42).

RESULTS AND DISCUSSION

Coral Condition: Three categories are used to categorize coral reef conditions: live coral groups, dead coral groups, and others (OT) (Figure 3). The following are living coral groups: ACB, ACS, ACD, ACE, ACT, CB, CE, CF, CM, CMR, and CS. There are several life forms in the dead coral group, such as DC, DCA, and RB. The OT (other types of groupings) are FS, S, OT, and SP. At Station 1, there is 5.73% other biota, 34.20% dead coral, and 60.07% hard coral in the state of the coral reefs. The CB (coral branching) species' growth form predominates at this site. Subsequently, the hard coral data presented at station 2 shows that the state of the reefs is about 17.08%, dead coral is at 46.48%, and other biota or OT is at around 36.49%. The species CM (coral massive) growth form predominates in the second station.



Graph 3. Coral reef conditions at stations 1 and 2



The study of the coral cover at Lihaga Beach revealed that the cover value of dead coral groups was about 40.32%, that of living coral groups was approximately 38.58%, and that of other groups (OT) was approximately 21.11% (Figure 4). According to the Minister of Environment's Decree No. 04/2001, Gomez & Yap (1988), Lihaga Beach's coral reef cover falls into the medium category, making up around 40.32% of the total. The major component analysis and clustered cluster analysis methods were utilized to examine the environmental features of corals, taking into account many life forms (Figure 5). The features of coral habitats fall into four primary categories, which are as follows: Coral lifeform types ACB, CMR, HA, ACD, CA, ACE, ACT, CF, DC, ACS, SC, CE, SP, OT, CS, and CM forms are what define Group 1. DCA and S are characteristics of Group 2. ACB, CMR, HA, ACD, CA, ACE, ACT, CF, DC, ACS, SC, CE, SP, OT, CS, and CM are the characteristics of Group 3.

Group 2 is distinguished by S and DCA. HA, ACD, CF, DC, ACS, SC, CE, SP, OT, CS, CM, DCA, and S are the characteristics of Group 3. CB and RB make up Group 4. Every one of the four sizable groupings has a certain function or portion within an ecosystem (Figure 5). Group 2 (two) has RB (rubble), which impacts the environment of Group 2; Group 3 (three) is also heavily impacted by S (sand), then supported again by DCA (dead coral with algae). Group 1 has CM (coral massive), which has a significant impact on the habitat of Group 1 (one). Group 4 was influenced by the magnitude of the percent cover values of R (rubble) and CB (coral branching) from both observation stations that had been carried out.

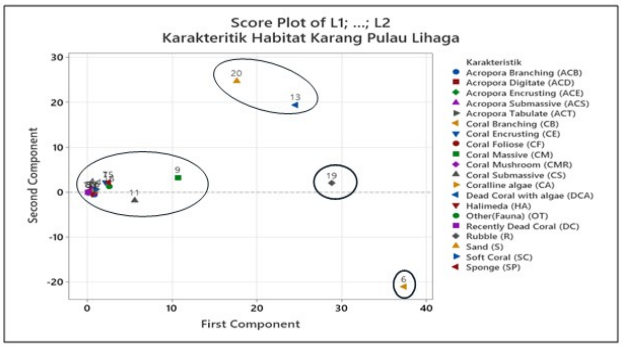


Figure 5. Habitat characteristics of Lihaga Island

Reef Fish: The stability value of the target fish community is computed by analyzing the fish dominance, diversity, and uniformity index (Figure 4). According to the findings of the data analysis, the diversity of reef fish on Lihaga Island was determined to be about 3,136 at station 1 (one), placing it in the category H' <2.30 = high variety according to the category of the Odum diversity index (1971).

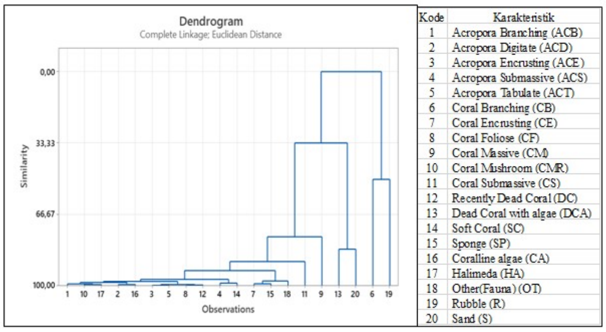
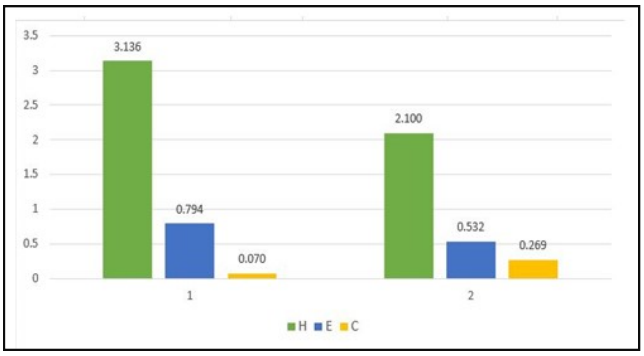


Figure 3. Lihaga Island Coral Dendogram Cluster Analysis

In contrast to station 1, which had a larger diversity value, station 2 (two) had a diversity value of about 2,100 and was placed in category H' <2.10 = moderate diversity.



Graph 2. Fish Ecology Index

The results of the analysis showed that the uniformity value (E) of reef fish on Lihaga Island was included in the stable category with a value of 0.79 or included in the > category with a value of 0.75. The value at Station 1 indicates that the fish species are in an even or stable distribution. However, the uniformity value at Station 2 is different from Station 1, where the value of Station 2 is lower by about 0.53 or is included in the category of <0.5, which means that the distributed fish community is uneven (unstable). This value shows that the uniformity on Lihaga Island is uneven because Station 1 with a high value does not indicate any fish species that dominate on Lihaga Island. This is by the statement of Odum (1993), which states that the greater the value of uniformity, the higher the species diversity. At Stations 1 and 2, the dominance index has an average value of 0.170 with a range of 0.070 to 0.269. The aforementioned findings indicate that there exists an inverse relationship between the diversity index and the dominance index, with the latter having an average value of 0.170. As to Odum's (1993) findings, a dominance index value below 0.5 denotes low dominance, meaning that there is no domination of reef fish in the community. This suggests that a few species do not control the majority of fish abundance.

Spatial Distribution of Reef Fish: The results of the reef fish cluster analysis (target group) are divided into 3 major groups, namely, the first group consists of *Zebrasoma scopas* and *Parupeneusmultifasciatus*. The second group is of the type *Ctenochaetus striatus.* The third group of *Ctenochaetusbinotatus* species, which has the greatest value of all target fish species, represents two observation stations on Lihaga Island. The large number of fish species, *Ctenochaetusbinotatus* and *Ctenochaetus striatus*, which became the largest group based on the results of this cluster analysis, is very evident from the coral data contained in Station 1, which is characterized by a fairly high CB (coral branching) lifeform of around 42.87%. This fish is a planktivorous species that lives under corals because it likes areas of rock crevices or between branching corals, and this type of fish is found in colony or solitary form (43). Coral reef fish have an important role both economically and ecologically, in addition to being the main habitat for reef fish. The results of the analysis show that the condition of coral reefs has a close relationship with corals (44–47). In addition to the closure of live corals, the presence of reef fish is also associated with coral lifeforms (48–50).

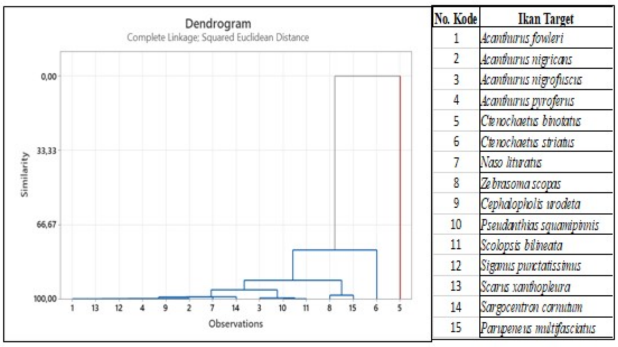


Figure 4. Results of Target Reef Fish Dendogram Cluster Analysis

The target fish group has an abundance value of around 0.170 ind/m2. The Acanthuridae families of *Ctenochaetusbinotatus* and *Ctenochaetus striatus* species are the source of this abundance value. This kind of fish, which is herbivorous, typically inhabits places with an abundance of algae or clear, open waters found on the seaward slopes of coral reefs. The botana fish (*Ctenochaetus striatus*) is one species that is very active both during the day and at night, according to Dyansyah (2017). The Acanthuridae family of target fish includes the species *Ctenochaetus striatus.* Local fisherman may be able to exploit the region as a fishing spot given the high number of *Ctenocaetus striatus* species.

CONCLUSION

- The influence of variables influencing fish community dynamics show thatThe results of the reef fish cluster analysis (target group) are divided into 3 major groups, namely, the first group consists of *Zebrasoma scopas* and *Parupeneusmultifasciatus*. The second group is of the type *Ctenochaetus striatus.* The third group of *Ctenochaetusbinotatus* species, which has the greatest value of all target fish species, represents two observation stations on Lihaga Island.
- The coral reef fish have an important role both economically and ecologically, in addition to being the main habitat for reef fish. The results of the analysis show that the condition of coral reefs has a close relationship with corals.The mechanisms that give corals and reef fish resilience in the face of change.

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