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Habitat of Banggai Cardinalfish (*Pterapogon kauderni*) Spread Across the Coast of Kayumalue Village, Palu Bay, Central Sulawesi

Habitat Banggai Cardinalfish (Pterapogon kauderni) yang Tersebar di Pesisir Pantai Kelurahan Kayumalue, Teluk Palu, Sulawesi Tengah

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Abstract

The Banggai cardinalfish (*Pterapogon kauderni* Koumans, 1933) is an endemic species that inhabits a limited habitat in shallow waters. This species is a widely traded marine ornamental fish. However, since late 2007, the International Union for Conservation of Nature (IUCN) has classified *P. kauderni* as an endangered species. Changes in *P. kauderni* habitat in Palu Bay have been reported, particularly in the waters of Mamboro Village Beach. According to local community information, this species has been introduced to Kayumalue Pajeko Village Beach, also within the Palu Bay area. Daily human activities and environmental changes caused by natural disasters and post-tsunami recovery necessitate annual updates on population development data and habitat conditions. This study aimed to reassess the habitat conditions of *P. kauderni* in the waters of Kayumalue Village, Palu Bay. Observation results showed that *P. kauderni* was only found in the macrohabitat of sea urchins. Meanwhile, along the observed transect, no recruit-sized *P. kauderni* were found. This is suspected to be due to the limited availability of macro habitat types such as anemones or other soft corals.

Keywords: Macro Habitat, Banggai Cardinalfish, Endemic Fish, Palu Bay.

Abstrak

Ikan Banggai cardinalfish (*Pterapogon kauderni* Koumans, 1933) spesies endemik yang hidup di habitat terbatas diperairan dangkal. Ikan Banggai cardinalfish (*P. kauderni*) merupakan ikahias air laut yang diperdagangkan secara luas. Namun ikan *P. kauderni* telah ditetapkan oleh Lembaga International *Union for ConservationInternational Union for Conservation of Nature* (IUCN) sebagai biota Endangered (terancam punah) pada akhir tahun 2007. Laporan perubahan habitat *P. kauderni* di Teluk Palu khususnya di Pantai Kelurahan Mamboro telah dilakukan dan menurut informasi dari masyarakat bahwa telah terintroduksi di Pantai Kelurahan Kayumalue Pajeko yang juga masih dalam wilayah Teluk Palu. Perlu dilakukan update data perkembangan populasi dan kondisi habitat setiap tahunnya karena adanya aktifitas masyarakat setiap hari dan terjadinya perubahan lingkungan baik disebabkan bencana alam dan akibat pemulihan kembali pasca tsunami. Tujuan penelitian untuk mengkaji kembali kondisi habitat *P.kauderni* diperairan Kelurahan Kayumalue, Teluk Palu. Hasil pengamatan di perairan kayumalue, Teluk Palu menunjukan bahwa *P. kauderni* hanya ditemukan pada makro habitat Bulu

babi. Sementara itu sepanjang transek yang dibentangkan tidak ditemukan *P. kauderni* ukuran recruit, hal tersebut diduga kurangnya jenis makro habitat yang tersedia seperti jenis anemone atau *soft coral* lainnya.

Kata kunci: Makro Habitat, Banggai cardinalfish, Ikan endemik, Teluk Palu

1. Introduction

Banggai cardinalfish (*Pterapogon kauderni* Koumans, 1933) is an endemic species that lives in a limited habitat with a depth of <5m. Banggai cardinalfish, often called BCF, is found in shallow waters in the district of Banggai, Banggai islands, Banggai sea, and surrounding small islands (Vagelli, 2011). Banggai cardinalfish is an ornamental fish commodity widely traded since the 1980s (Ndobe et al., 2019). The IUCN has designated *P. kauderni* as Endangered since 2007 (IUCN, 2007).

Around the year 2000, Banggai cardinalfish was introduced in the bay of Palu Husunya in the waters of Mamboro village, as a form of preservation of *P. kauderni* fish, then in 2006, it was reported to have experienced significant population growth (Moore et al., 2013). Habitat and population developments of Banggai cardinalfish have been reported almost annually by researchers in Central Sulawesi from academia, the environmental community, and the conservation community. The tracking of population and habitat developments reported before the tsunami that occurred in September 2018 and three years after the tsunami (Ndobe et al., 2023) is of particular interest. Several reports on macro-habitat and population of Banggai cardinalfish show fluctuations in both population and habitat conditions of Banggai cardinalfish in Mamboro Beach, Palu Bay. It is necessary to update data on population development and habitat conditions every year due to daily community activities and environmental changes, natural disasters, industrial activities around Palu Bay, and post-tsunami recovery efforts. Monitoring needs to be done again because of information from the community that Banggai cardinalfish has spread to Kayumalue village, which is still on the coast of Palu Bay. The spread of Banggai cardinal fish in Kayumalue village is the second habitat record for *P. cauderni* in the waters of Palu Bay. Environmental changes that can occur at any time cause changes in fish habitat on the coast of Palu Bay.

Banggai cardinalfish, one of the species with a wealth of biodiversity in Central Sulawesi, needs to be preserved so that conservation policies and habitat monitoring can be carried out to support the survival of Banggai cardinalfish. If the condition of the Banggai cardinalfish habitat is monitored well, what needs to be done is socialization and action to maintain the habitat in the coastal waters of Kayumalue, North Palu sub-district. However, if habitat conditions are poor, the solution offered is habitat improvement through macro-habitat transplantation on the coast of Palu Bay, especially in Kayumalue village.

Monitoring the distribution and macro habitat conditions and populations of Banggai cardinalfish that spread in Kayumalue waters, Palu Bay has not been included in articles or publications, and is still limited to information from the community. After the 2018 earthquake and tsunami, habitat data in Kayumalue waters have not been reported, so monitoring is needed to produce complete data on macro habitat conditions in the coastal waters of Palu Bay.

2. Materials and Methods

2.1. Time and Place

The research was conducted in October 2024 in the coastal waters of Kayumalue village, Palu Bay. This research was exploratory, starting from preparation, literature study, and direct observation. Biophysical sampling locations were carried out purposively to represent sampling points in the estimated population (Hill & Wilkinson, 2004). The research location can be seen in Figure 1.

Figure1. Research location (Scale 1:100) (0°45'02.7 "S 119°51'30.3 "E)

2.2. Tools and Materials

The tools and materials used are scuba as a diving tool for installing transects, visual observations, and underwater cameras documenting underwater activities. Transect is a tool to measure the sample boundaries of the observed area, a sector disk to measure brightness, and a current kite to measure the current speed around the observation.

2.3. Procedures

Macro habitat observation of Banggai cardinalfish using underwater visual census (UVC) (English et al., 1997) in combination with belt transect (Hill & Wilkinson, 2004) for survey and monitoring studies (Serdiati et al., 2021). Macro habitat observations were carried out by two people using SCUBA equipment, using a roll meter made of 0.2 mm rope marked every 1 m for 20 m long. Drawing a transect line along 20 m parallel to the shoreline based on habitat conditions with left and right boundaries at a radius of 2.5 m, so that the observation area is 20 x 5 = 100 m^2 (Subhan et al., 2022).

2.4. Observed Parameters

Observations were made at two sampling points along the transect line, and observations included substrate, macrohabitat, physical and chemical parameters of waters in situ (Huwae et al., 2023). Physical parameters observed were brightness, temperature, and current speed. Chemical parameters measured were pH and salinity. Macrohabitat observations are limited to hard corals, soft corals, sea urchins, seagrass, and sand substrates, which will be assumed as habitat in general, 100% in each macrohabitat.

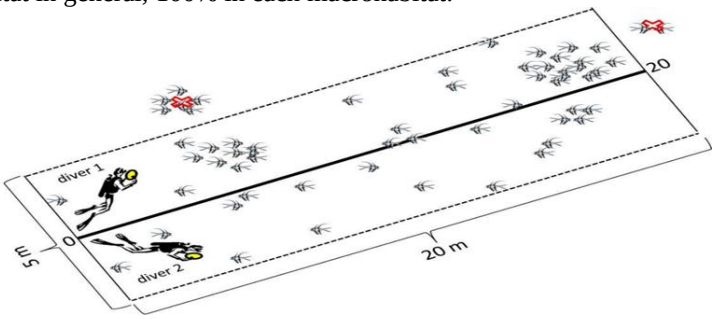

Figure 2. Belt transect (Wibowo et al., 2019)

2.5. Data Analysis

Microhabitat density seen based on the observation area at each station is calculated using a modified equation formula as follows (Tambunan et al., 2022).

$$d = \frac{c}{A}$$

Description:

d = Density (Ind/m^2)
c = Number of individuals (Ind)
A = Area of observation transect (m^2)

The percentage of the number of individuals to determine the relative abundance at each station can be calculated using the following formula (Tambunan et al., 2022):

$$KR = \frac{NI}{N} \times 100\ \%$$

Description:

KR = Relative abundance
Ni = Number of individuals
N = Total number of individuals per observation station

Data obtained from visual observation and measurement of in situ quality parameters were tabulated using Microsoft Excel and then analyzed descriptively.

3. Result and Discussion

3.1. Macro Habitat Diversity of Kayumalue Pajeko Beach Waters

The substrate of Kayumalue waters is sand covered with coral fragments, and there is sedimentation, which is thought to be soil or dust deposits carried by water through the surrounding rivers and the ocean currents of the hammer bay. For 24 hours, the water was murky at a depth of 3 m, but the bottom was still visible due to the low tide position. In the Kayumalue coastal area, the brightness decreases during high tide so that the bottom of the water is no longer visible from the surface.

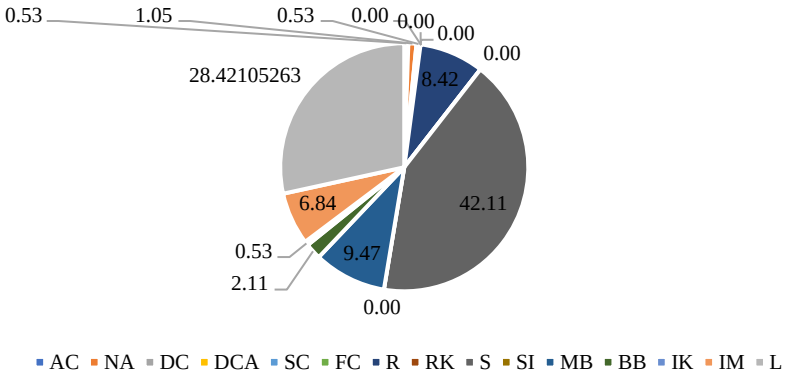

Figure 3. Macrohabitat types in Kayumalue waters
Description: Acropora Coral (AC), Non Acropora (NA), Dead Coral (DC), Dead Coral Overgrown with Algae (DCA), Soft Coral Species (SC), Macro Algae Species (FC), Broken Coral (R), Hard Substrate (RK), Sand (S), Mud (SI), Mega Benthos (MB), Seagrass (L), Boar Feather (BB).

Visual observations of habitats found in the waters of Kayumalue village, non-acropora coral 6.8%, broken coral fragments (8.42%, sand 42.11%, and seagrass about 28%. Mamboro waters, which are still in Palu Bay, have *P. kauderni* macrohabitats with various types such as soft corals, sea urchins, and seagrasses (Hermawan et al., 2022; Syahril et al., 2020).

3.2. Habitat Individual Density

Habitats that were visible and could be counted in a 100 m^2 transect included sea urchins, artificial fish houses (ART), and small corals (non-acropora). The density of individuals from the three habitats that could be counted can be seen in Figure 4.

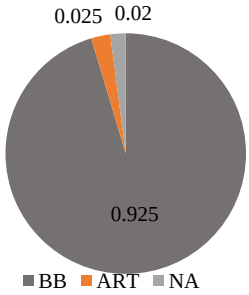

Figure 4. Habitat individual density
Description: BB (sea urchin); ART (artificial fish house); NA (non-acropora coral)

Sea urchins in Palu Bay generally have species that become the macro habitat for *P. kauderni*, namely *D. setosum* and *D. savignyi* (Moore et al., 2017). According to Ndobe et al. (2023), the macrohabitat of mamboro waters, Sea urchins are ecologically damaged. In contrast to Kayumalue waters, where many macro habitats are still found, sea urchins are the most common habitat for *P. kauderni*. Artificial fish houses and non-acroporated corals were not found to have *P. kauderni* populations.

3.3. Relative abundance

Based on observations of relative abundance for three macro habitats that can be calculated, namely sea urchins, non-acroporous corals, and artificial habitats found in Kayumalue waters (Figure 5).

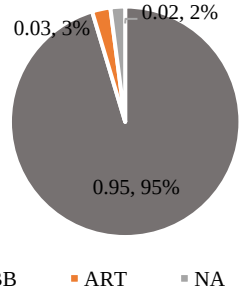

Figure 5. Relative abundance
Description: BB (sea urchin); ART (artificial fish house); NA (non-acropora coral)

Based on the results of macro visual observations, the habitat seen on Kayumalue beach is dominated by sand mixed with coral fragments as a substrate, seagrass, and several populations of sea urchins (*Echinometra*). Live corals are also found (1%), but are still small in sand substrates, as many dead coral fragments as 28% were found in the transects. Visual observations showed that *P. kauderni* was only seen in the macro habitat of sea urchins (*Echinometra*). Only adult-sized *P. kauderni* were observed in the sea urchin macrohabitat. Recruits were not seen along the transect, presumably because no marine anemone habitat was available. According to Moore et al. (2013), recruits prefer sea anemone macrohabitats, although sea urchins are the habitat of all sizes of *P. kauderni; however*, in this study, no recruits were found in sea urchin macrohabitats.

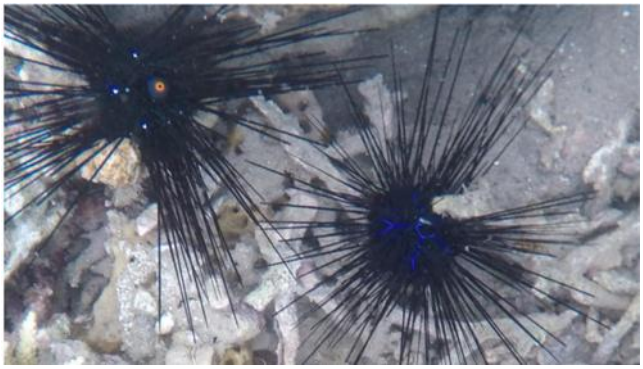

Figure 6. Sea urchin species as habitat for *P. caudeni* in Palu Bay *D. setosum* (left) and *D. savignyi* (right) in *P. cauderni* habitat, Palu Bay (Moore et al., 2017)

3.4. Water Quality

The original habitat of P. *kauderni*, found around the waters of Banggai Laut and Banggai Islands, is 31-34 ppt (Ndobe et al., 2013). In-situ measurement of salinity in the habitat of *P. kauderni* in the Kayumalue river was found to be 31 ppt. This condition still follows the conditions of its natural habitat. Fluctuations in seawater salinity are influenced by several factors, including seawater circulation patterns, evaporation, rainfall, and river flow into the sea (Patty et al., 2020). Kayumalue seawater's temperature, which is *P. kauderni's* habitat, is at 28^{o}C. According to Hamuna et al. (2018), temperature is an external factor affecting aquatic organisms' metabolic activities, including fish distribution. Temperature is influenced by geographic conditions of latitude position, season, weather, flow, and water depth. The pH parameter plays a vital role in the aquatic environment. According to Jóźwiakowska et al., (2020), pH can affect the rate of chemical reactions in a body of water. An increase in salinity and temperature will affect the acid-base condition of the air. Based on in situ measurements, the pH of Kayumalue waters is at a value of 6.8

Table 1. Water quality of the *P. kauderni* habitat

Parameters	In situ measurement	Reference
Salinity (ppt)	31	31-35 (Ndobe et al., 2013)
Temperature ($^{(o)}$C)	28	28-33 ^{0}C (Vagelli, 2011)
pH	6.8	6,9-7,8
brightness (%)		-
current speed (m/s)	0.23	-
depth (m)	3-4,5	2-15 m (Ndobe et al., 2023)

Salinity, temperature, and pH have a mutually influencing relationship; for example, low water temperature tends to reduce salinity because low water temperature only holds a small amount of salt content. Furthermore, high salinity has an impact on increasing pH, and this is due to salt levels that can buffer and neutralize the acid-base level of a body of water (Yolanda, 2023). Kayumalue waters are usually observed to be murky with 80% brightness at high tide, but at low tide, the bottom is visible at a depth of about 3 meters. Kayumalue waters have a depth of about >4 meters, and the bottom is no longer visible. Decreased water brightness is due to high suspended solids of organic and inorganic matter and the presence of microorganisms, making the water look cloudy (Alwi et al., 2020; Ernawati & Restu, 2021; Patty et al., 2020).

Ocean currents are the movement of water masses in the vertical direction or horizontal movement of water influenced by wind movements on the sea surface, the occurrence of tides, and also influenced by density (Irawan et al., 2018; Mutiara & Indra, 2017; Permadi et al., 2015; Saputro et al., 2023). The surface current speed measured in situ in Kayumalue coastal waters is 0.23 m/s. According to Hiwari & Subiyanto (2020), surface currents occur because the sea surface wind provides energy to the sea surface, then the current occurs in the area of bays, straits, and estuaries, dominantly influenced by tides. *P. kauderni* is scattered in the waters of Kayumalue, Palu bay area, at a depth of 3.5 to 4.5 m. While in its natural habitat around the Banggai Islands and Banggai Sea, *P. kauderni* can be found in habitats with a depth of 2 - 15 m (Ndobe et al., 2013).

4. Conclusions

Coastal waters in Kayumalue village, which are part of the Palu Bay, are a new habitat for Banggai cardinalfish. However, only the macro habitat of sea urchin showed adult *P. kauderni* population, while other habitats did not find adult or recruit *P. kauderni*. Habitat restoration is needed to increase the population of *P. kauderni*, especially soft coral habitat for *P. kauderni* recruitment.

5. Acknowledgments

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