



Fig. 4. Distribution of reef fish abundance based on trophic levels on Kaliage Island.

3.4 Reef fish community structure

The assessment of the reef fish community structure is based on the ecological index, which includes the diversity index (H'), evenness index (E), and dominance index (C). The results of the ecological index analysis are presented in **Table 3**. The highest value of the diversity index was at St. 3 (2.84), followed by St. 2 (2.59), St. 1 (2.47), and St. 4 (2.23). The highest evenness index values were obtained at St. 4 (0.93), St. 3 (0.91), and St. 2 (0.88), and the lowest at St. 1 (0.79). The highest dominance index values were observed at St. 1 and 4 (0.12) and St. 2 (0.10), and the lowest at St. 3 (0.07).

Table 3. Diversity, Evenness, and Dominance Index Values on Kaliage Island.

| Stations | H' | E | C |
|----------|------|------|------|
| 1 | 2.47 | 0.79 | 0.12 |
| 2 | 2.59 | 0.88 | 0.10 |
| 3 | 2.84 | 0.91 | 0.07 |
| 4 | 2.23 | 0.93 | 0.12 |

St. 1 had a Shannon Diversity Index (H') of 2.47, indicating a moderate level of diversity. An evenness value (E) of 0.79 indicates a relatively even distribution of species, while a dominance index (C) of 0.12 does not imply significant dominance of a single species. St. 2 had a slightly higher diversity with an H' of 2.59 and a higher evenness value (E) of 0.88, indicating a balanced ecosystem. A lower dominance index (C) of 0.10 further supports this and indicates reduced dominance of individual species. Conversely, St. 3 had the highest

diversity ($H' = 2.84$) and high evenness ($E = 0.91$), indicating a very diverse and balanced ecosystem with a very low species dominance ($C = 0.07$). St. 4 showed the lowest diversity ($H' = 2.23$) but the highest evenness ($E = 0.93$), suggesting that although fewer species exist, individuals are evenly distributed. Dominance (C) corresponds to St. 1 at 0.12 and indicates a moderate level where no single species is overly dominant. St. 1 and 2 had moderate levels of diversity and low dominance, indicating a healthy ecosystem. These indices are critical for ecologists to assess ecosystem health and make informed conservation and management decisions.

4 Discussion

Table 2 indicates that St. 1 has the highest count of individual fish. According to Madduppa's study [26], several areas in the Seribu Archipelago still maintain good coral reef conditions. Several factors influence the difference in the number of individual reef fish at each station, namely the condition of coral reefs, food sources, timing of data collection, and water conditions [2]. The family Pomacentridae was found most frequently at the four stations because it has a high diversity of individuals and species. The family Pomacentridae generally has omnivorous eating habits; some are herbivores or plankton eaters, while others eat small invertebrates on coral reefs [27]. The family Pomacentridae dominates the reef fishes on Kaliage Island with a proportion of 55.02% (1715 individuals). The family Pomacentridae tends to be territorial and has limited mobility [28]. The most abundant species on Kaliage Island, *Pomacentrus alexanderae* (331 individuals), was found at each station. The results are the same as Prabowo et al. [29], showing that the most common fish in the Seribu archipelago is *P. alexanderae* (278 ind/100 m²).

Fig. 3 shows the distribution of reef fish based on their ecological roles. Three categories can be used to classify the environmental aspects of reef fish: target, indicator, and major fish. Target fish are those that are specifically targeted by fishermen or have a high economic value. Indicator fish have a close relationship with coral reefs; therefore, their presence can indicate the health of a coral reef ecosystem. The discovered target fish category came from five families: Caesionidae, Lutjanidae, Scaridae, Serranidae, and Siganidae. Fishing activities typically result in fluctuations in target fish populations, coral reef substrate life forms, and currents [30]. Eight species of target fish were identified in this study: *Caesio teres*, *Caesion spruce*, *Cephalopolis boenak*, *Lutjanus lutjanus*, *Scarus niger*, *Scarus tricolor*, *Scarus rivulatus* and *Siganus virgatus*. Reef fish, classified as indicator fish, belong to the family Chaetodontidae. These coral fishes are considered indicator species because they are genuine inhabitants of coral reefs [27]. In this study, only two species classified as indicator fish were found: *Chaetodon octofasciatus* (82 individuals) and *Chelmon rostratus* (3 individuals). *C. octofasciatus* was found at every station, whereas *C. rostratus* was found only at St. 1. This is consistent with the previous research [17, 31] that proposed *C. octofasciatus*, commonly known as striped, is a more common species in the Chaetodontidae family than other species. Major fish play a general role in the food chain and are primarily used as ornamental fish [28]. The major fish species belonged to several families, including Apogonidae (6.74%), Blenniidae (0.83%), Centriscidae (2.31%), Fistulariidae (0.03%), Holocentridae (0.32%), Labridae (16.75%), Nemipteridae (2.89%), Pomacanthidae (0.67%), Pomacentridae (55.02%), and Pterelotridae (0.52%).

Fig. 4 shows the distribution of reef fish based on their trophic levels. In terms of trophic level, the fish population on Kaliage Island consists mainly of omnivores (45.01% - 1,403 individuals), planktivores (23.10% - 720 individuals), carnivores (19.19% - 598 individuals) and herbivores (9.46% - 295 individuals). The least common were coral-eating fish (coral eaters) (3.24% - 101 individuals). Among the omnivorous fish species identified on Kaliage Island, there are four species from the family Labridae: *Halichoeres melanurus* (2

individuals), *Halichoeres trimaculatus* (80 individuals), *Pteragogus cuttatus* (10 individuals) and *Thalassoma lunare* (103 individuals) than 15 species from the family Pomacentridae. The total number of omnivorous fish from the family Pomacentridae was 1,208, with the highest numbers recorded for *Pomacentrus alexanderae* (331 individuals) and *Amblyglyphidodon curacao* (305 individuals). The planktivorous fishes on Kaliage Island belong to four families: Apogonidae (four species), Blenniidae (one species), Caesionidae (two species), and Pomacentridae (two species). The most common reef fish species among the planktivores included *Neopomacentrus anabatooides*, with 234 individuals from the family Pomacentridae; *Apogon parvulus*, with 120 individuals from the family Apogonidae; *C. teres*, with 105 individuals; and *Caesio cuning* with 94 individuals from the family Caesionidae. The carnivorous fishes identified on Kaliage Island belonged to eight families: Labridae (six species), Nemipteridae (two species), Centriscidae, Fistulariidae, Holocentridae, Lutjanidae, Pomacentridae, and Serranidae, each with one species. Among them, the three most abundant carnivorous fish species were *Halichoeres richmondi* (173 individuals) from the family Labridae, *C. boenak* (95 individuals) from the family Serranidae, and *Neopomacentrus cyanomous* (80 individuals) from the family Pomacentridae. Herbivorous fishes on Kaliage Island belong to four families: Scaridae (3 species), Pomacentridae (2 species), Siganidae, and Pomacanthidae, each with one species. Among them, the three most common species of herbivorous fish are *Disschistodus prosopotaenia* (128 individuals) from the Family Pomacentridae, *S. virgatus* (60 individuals) from the family Siganidae, and *S. rivulatus* (56 individuals) from the family Scaridae. The family Chaetodontidae (2.73%) was the dominant coral-feeding species. Only two species from the family Chaetodontidae were identified as coral eaters, namely, *C. octofasciatus* (60 individuals) and *C. rostratus* (3 individuals). Reef fish, categorized as coral eaters, typically feed on coral organisms [3]. Therefore, coral reef fishes from the family Chaetodontidae could be bioindicators of coral reef health because of their close association with coral reefs.

Table 3 lists the ecological index values recorded at each observation station. Although the diversity, evenness, and dominance index values varied from station to station, no significant differences were observed. According to Ulfah et al. [32] favorable water conditions are characterized by high diversity and evenness index values coupled with low dominance values. The diversity index (H') values at all four stations range from 2.23 and 2.84, indicating moderate diversity. This suggests that the reef fish community structure on Kaliage Island tends to be stable and that the environmental conditions are relatively constant. Furthermore, this diversity index value is not significantly different from that reported by Madduppa et al. [26] near the island of Kaliage. The evenness index (E) values range between 0.79 and 0.93, with no significant differences observed between stations, and the values were close to 1. This indicates a high level of evenness in the reef fish population on the Kaliage Island. The dominance index values range between 0.07 and 0.12, indicating low dominance across the four stations. This suggests that no single species predominates in the waters surrounding the Kaliage Island. Overall, the diversity, evenness, and dominance index values at the four stations indicated that the waters of Kaliage Island were in reasonably good condition.

5 Conclusion

The Pomacentridae family accounts for 55.02 percent of the reef fish population on Kaliage Island. *Amblyglyphidodon curacao* and *Pomacentrus alexanderae* were the two most common omnivorous species. *Dishistodus prosopotaenia* is the dominant species among herbivorous reef fishes, and *Neopomacentrus anabatooides* is the most widespread planktivore. While *Chaetodon octofasciatus* is a coral-eating species in the family Chaetodontidae, *Halichoeres richmondi* is the most common carnivorous fish in the family

Labridae. Major fish species account for 85.98 percent of the population on Kaliage Island; This is followed in percentage terms by target fish (11.29 percent) and indicator fish (2.73 percent). The top three species in this category were *Chaetodon octofasciatus*, *Caesio teres* and *Pomacentrus alexanderae*. The study's results at the four stations on Kaliage Island showed moderate levels of diversity, indicating a stable community structure of reef fish living in a reliable habitat. The evenness index values showed a balanced distribution by showing that the reef fish population was evenly distributed among different species. A low value for the dominance index emphasizes the balanced structure of the ecosystem by indicating the lowest level of species dominance. These signs indicated that the waters surrounding Kaliage Island were in good condition.

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