Species diversity of wrasses caught by fishermen in the Spermonde Islands, South Sulawesi, Indonesia

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Abstract. Wrasses are reef fish that play an important role in maintaining the health of coral reef ecosystems. Some species of wrasse, such as the Napoleon wrasse Cheilinus undulates, have high economic value and are threatened with overexploitation. This study aims to analyse the species diversity of wrasses caught by fishermen operating in the Spermonde Islands, South Sulawesi, Indonesia. The study was conducted from January 2018 to May 2019, on a monthly basis. Sampling was carried out by collecting all wrasses landed on one chosen day at Makassar Fisheries Port. The species diversity parameters observed were the species name and the number of individuals of each species. Based on these data, the diversity index, evenness index, domination index, and similarity index were calculated. Wrasse diversity was always in the medium range, indicating that ecologically wrasse habitat is still quite productive and has remained balanced over a considerable period time. It appeared that capture fisheries had not caused serious problems for the wrasse community diversity and structure.

1. Introduction

Wrasses (Family Labridae) are a group of fish inhabiting tropical and temperate seas, predominantly found in shallow coastal areas. Wrasse diversity levels vary around the world, with the most diverse wrasse communities generally found in the coral reef ecosystems of the Western Indo-Pacific region [1]. Most species are small, attaining a maximum body length of less than 20 cm; however some species, such as the large hogfish (Lachnolaimus), can grow to more than 70 cm in length and 10 kg in weight.

The family Labridae is the third largest fish family after the Gobiidae and Serranidae [2]. It is the second largest fish family living in salt water [3] with a total of 70 genera and 504 species described in 2011 [4]. This number has grown to 548 species with records of 41 new species; most of the discoveries of new species have been made in the Western Pacific Ocean and the Western Indian Ocean [2]. The Labridae are also one of the most morphologically and ecologically diverse families in terms of size, shape, and colour.

Wrasses diversity is related to the unique distribution patterns of each species since some wrasses have a large home range area which correlates positively with the fish total length. In certain species, when individuals become adults, the home range area reaches a peak and then remains relatively
constant, even though fish growth continues [5]. This pattern of spatial dynamics is one of the important demographic variables that affect population and community structure in wrasses [6] as in many other reef-associated fishes [7]. This distribution pattern may affect the catch of wrasses.

Some wrasses have a high economic value and are captured both in juvenile and adult phases. The bluehead wrasse *Thalassoma bifasciatum* [8] and the red-breasted wrasse *Cheilinus fasciatus*, are known as ornamental fish when they are in juvenile phase, but become food fishes when they reach the adult phase [9]. The adult blue-throated wrasse *Notolabrus tetricus* [10] and the humphead or Napoleon wrasse *Cheilinus undulatus* [11] are fish known for consumption. Other species of wrasse belonging to the genus *Labroides* are well known as cleaner fish, and play an important role in maintaining the health of coral reef fish communities.

There have been several previous studies on wrasse diversity [12,13] however none of those examine wrasse diversity in a way that can be used as a reference in stock assessment studies. Stock assessment is essential in the management of fisheries resources, especially for vulnerable species to overfishing.

Wrasse stock assessment is particularly urgent [11]. As herbivorous fish, wrasses feed on macroalgae which covers the surface of dead coral [14]. Their presence in coral reef areas guarantees the availability of substrates on which coral planulae can settle, thus promoting coral recruitment. Besides being important due to ecological considerations, wrasse should also be seen in terms of socio-economic factors. A study is needed to ascertain whether overfishing of wrasse has occurred, and to evaluate whether the fishing pressure of these species have disturbed the balance of the population in terms of species composition and other aspects of population dynamics [15].

This research was conducted to analyse the diversity of wrasse species captured by fishermen operating in the Spermonde Islands which is one of the fishing ground in South Sulawesi Province, Indonesia [16]. Wrasses are commonly caught in and around the Spermonde Islands, as can be seen from the number of wrasses landed at the fishing port in Makassar, the capital of South Sulawesi. This research is expected to provide scientific data regarding the impacts of wrasse capture fisheries.

2. Materials and Methods

2.1. Study site and sample collection

The Spermonde Archipelago in South Sulawesi Province, Indonesia, is located in the Makassar Strait (Figure 1), one of the main fishing grounds in Indonesia [16]. It covers an area of about 2,500 km$^2$ with 120 islands [17]. Among the islands, only 50 are vegetated [18] with a total human population of around 50,000 [19] whose livelihoods are directly or indirectly dependent on fishing. Their catches are generally landed at the Fisheries Port in Makassar.

Wrasses were sampled from January 2018 to May 2019 on a monthly basis. Almost all sampling times were in the middle of the month. All wrasses landed in the Makassar Fisheries Port on the sampling day were collected. This sampling pattern was designed to provide a snapshot of the wrasse diversity caught in and around the Spermonde Archipelago.

Each individual collected was examined carefully to identify the species. Determination of the species was based on morphological characteristics in the form of body shape, *colour* patterns, and the fins bones, using Allen, Swainston and Ruse [20], Kuiter and Tonozuka [21] and Allen and Erdmann [22]. The number of individuals for each species was also counted in order to calculate the Diversity Index (H'), Evenness Index (E), Domination Index (C), and Similarity Index (Si) [23–25]. Based on the results of these calculations, the classification for each ecological index was determined [23–25].

3. Results

A total of 1,188 wrasses were sampled during the study, with 848 fish collected in 2018 and 340 in 2019 (up to May). The number of species, as well as the number of specimens, varied greatly, both between years of sampling (Table 1), and between months within each year (Figure 2).
Figure 1. Map of Makassar Strait (A), showing the location of Spermonde Archipelago and the Makassar City where the Makassar Fisheries Port is situated (B), modified after [26]

Table 1. Number of wrasse specimens and species found in each sampling year

| Statistics | Number of species | Number of fish |
|------------|------------------|----------------|
|            | 2018 (12 months) | 2019 (Jan-May) | 2018 (12 months) | 2019 (Jan-May) |
| Average    | 8                | 9              | 71              | 68              |
| STD        | 3                | 3              | 53              | 36              |
| Min        | 3                | 4              | 6               | 20              |
| Max        | 12               | 13             | 162             | 113             |

Figure 2. Number of species (A) and number of specimens (B) of wrasses sampled on a monthly basis in each year
During the study, 30 species of wrasses were found. The number of samples for each species varied greatly during the study (Table 3).

Table 2. The wrasse species identified and their abundance during the study.

| No | Species                          | Number of fish |
|----|----------------------------------|----------------|
|    |                                  | 2018 (12 months) | 2019 (Jan-May) |
| 1  | Anampses caeruleopunctatus       | 1              | 9              |
| 2  | A. geographicus                 | 1              | 0              |
| 3  | A. meleagrides                  | 1              | 8              |
| 4  | Cheilinus chlorourus             | 32             | 13             |
| 5  | C. fasciatus                    | 44             | 479            |
| 6  | C. trilobatus                    | 9              | 49             |
| 7  | Cheilinus sp.                    | 0              | 1              |
| 8  | Cheilinus herma                  | 0              | 2              |
| 9  | Choerodon anchorago             | 90             | 85             |
| 10 | C. rubescens                     | 2              | 0              |
| 11 | C. schoenleinii                  | 2              | 20             |
| 12 | C. zosterophorus                 | 1              | 0              |
| 13 | Coris cuvieri                    | 3              | 0              |
| 14 | C. gaimard                       | 8              | 4              |
| 15 | Epibulus insidiator              | 1              | 6              |
|    |                                  | 2018 (12 months) | 2019 (Jan-May) |
| 1  | Halichoeres chrysus              | 0              | 2              |
| 2  | H. hortulanus                    | 0              | 5              |
| 3  | H. scapularis                    | 0              | 1              |
| 4  | Hemicoriscroederi               | 2              | 0              |
| 5  | Hemigymnus fasciatus            | 3              | 2              |
| 6  | H. melapterus                    | 46             | 31             |
| 7  | Hemitautoga hortulana            | 0              | 9              |
| 8  | Hologymnus oxyrhinchus           | 0              | 1              |
| 9  | Iniistius dea                    | 0              | 3              |
| 10 | Novaculichthys taeniourus        | 45             | 12             |
| 11 | Oxycheilinus bimaculatus         | 1              | 67             |
| 12 | O. celebicus                     | 0              | 9              |
| 13 | O. digramma                      | 46             | 28             |
| 14 | Pseudodax moluccanus             | 2              | 1              |
| 15 | Thalassoma hardwicke             | 0              | 1              |

Of the 30 species found (Table 2), there were six species of wrasses whose average presence was above 50%. Those were: *Cheilinus fasciatus*, *C. trilobatus*, *Choerodon anchorago*, *Hemigymnus melapterus*, *Novaculichthys taeniourus*, and *Oxycheilinus digramma* (Figure 2).

Figure 3. The percentage of presence for each species of wrasse during the 17 months of the study. There were five Labridae species with an average presence above 50% indicated by the red arrows.

The ecological indices of diversity, evenness and dominancy for the wrasse collected during this study varied between years (Table 3). These indices also varied between months within each sampling year (Figure 4)
Table 3. Values of ecological indices of diversity, evenness and dominance for the wrasse collected during each sampling year

| Statistics   | Diversity | Evenness | Dominancy |
|--------------|-----------|----------|-----------|
|              | 2018  | 2019  | 2018  | 2019  | 2018  | 2019  |
| Average      | 1.40  | 1.71  | 0.682 | 0.829 | 0.353 | 0.226 |
| STD          | 0.55  | 0.26  | 0.233 | 0.065 | 0.175 | 0.046 |
| Minimum      | 0.26  | 1.29  | 0.143 | 0.772 | 0.134 | 0.194 |
| Maximum      | 2.20  | 1.98  | 0.921 | 0.930 | 0.746 | 0.295 |

Figure 4. The Diversity Index (A), Evenness Index (B) and Dominance Index (C) of wrasse by month and year over the study period

4. Discussion

Generally the Diversity Index was in the range of 0.26 to 2.20, which means that the wrasse community has a moderate level of diversity, indicating a moderate level of productivity, fairly balanced ecosystem, and moderate ecological pressure. The number of wrasse species found in the present study (30 species) is higher than that found by previous studies [5,7,27]. This diversity is related to the unique distribution patterns of each wrasse species. Some wrasses have a large home range area, which usually correlates positively with total fish length. In certain species, when individuals become adult, the home range area reaches a peak, remaining fairly constant thereafter, even though the fish continues to grow [5]. This pattern of spatial dynamics is one of the important demographic variables that affect population and community structure, both in wrasses [6], and in other reef fish [7]. This distribution pattern affects the catch of wrasses in a particular area.

The Evenness Index was in a wide range. There were 4 months in 2018, where the value fell below 0.6. In these months, *Cheilinus fasciatus* was very dominant. This pattern indicates that the wrasse populations are fairly evenly distributed. Based on the values of this index, it can be concluded that the wrasses species caught during the study were fairly well distributed. In 2019, the Dominance Index was in the range of 0.194 to 0.295. This means that in 2019 there were no dominant species, whereas
in 2018, the Dominance Index was in the medium range, with values from 0.134 to 0.746, indicating that during 2018 some species were quite dominant, but only at a medium level.

These results show that there are no truly dominant wrasse species found. The absence of dominance by a particular species in the wrasse community is good news, because it should give every species of wrasse a reasonable opportunity to fulfil their ecological role. This is important, because wrasses are one of the main functional groups in coral reefs, and have roles to play in maintaining the balance of coral ecosystems, especially when facing potential phase changes (increasing resistance) and during periods of regeneration after interference (promoting resilience) [28].

The similarity index value of only 0.5 indicates that the 30 species found during the research period did not really spread evenly at each sampling period (years). This was due to the dominance of *Cheilinus fasciatus*. The general condition of the population was moderate to good over a relatively long period of time (January 2018-May 2019).

5. Conclusion
Wrasse diversity was relatively stable at a moderate level. This indicates that, ecologically, the wrasses’ habitat in and around the Spermonde Islands in South Sulawesi, Indonesia was still quite productive and balanced over the 17 months study period (January 2018-May 2019). The findings of this study imply that capture fisheries have not yet caused serious disruption to the wrasse community in the study area in terms of species diversity and community structure.

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