Allometry and condition indices of reef fishes caught by *bobo* fish traps in Barangay Bato, Sta. Cruz, Davao del Sur

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Abstract. The reef fishes that were caught during the sampling period through the use of *bobo* fish traps were identified and were subjected to length-weight relationship analysis as well as condition index establishment. The results revealed that there were 16 species belonging to 9 families associated with *bobo* fish traps in the study area. The establishment of length-weight relationship for fourteen species indicated that they all grew allometrically in which ten (10) species out of the 14 attained negative allometric growths while the remaining 4 species attained positive allometric growths indicating that most of the fish becomes less round or slender as they grow in length. The condition index (relative weight) of the 10 species in this study attained more than a hundred percent value indicating that they attained more weight in comparison with the observed population. Based on these findings, it has been concluded that only a small number of species of reef fishes were associated with *bobo* fishing method in the area. The obtained negative allometric growths attained by most of the species implied that the specimens probably face possible threats regarding food availability. Condition index analysis results may indicate an overall healthy environment for the fishes regardless of the possible threats on food resource. Nevertheless, the confounding result manifests the complex interaction of fish growth with environmental changes which was deemed difficult to extrapolate.

1. Introduction

The coral reef areas in the Philippines contain a diverse community of 915 reef fish species. It is the second largest in Southeast Asia ranging at 26,600 square kilometers [3]. Fish species that depend on coral reef resources throughout their lifetime are known as reef fishes [13]. However, due to the increasing human population and consequent increased demand for reef fishes, many reef ecosystems have been damaged [17] also because of indispensable factors like sedimentation and siltation from coastal development projects and land activities [6]. These issues call for the formation of appropriate fishery management that will promote safe and sustainable consumption of aquatic resources [10]. Length-weight relationships are useful tools in the supervision and exploitations of fish populations since they show the degrees of stabilization of taxonomic fish characters in fish species and biomass estimates [9]. Length-weight relationships (LWR) have major applications in fish stock assessments, population, and ecological studies since the sizes attained by individual fishes is an interplay of several factors such as climatic conditions, food supply variation, and the degree of competition among
organisms; thus, making LWR an important indicator of environmental changes and the alteration in human maintenance practices [11; 16; 14]. Moreover, length-weight data can be a basis in determining fish conditions (condition indices) in varying environments which generally assumes that fishes of greater weight with a given length are of greater conditions than lighter fishes [2]. This parameter has been regarded as the most important biological parameter as it provides crucial information on the overall health of a fish species as well as environmental cues on the community in which the fishes live. It measures the crude healthiness of fishes and is frequently used in cases such as a comparison of two or more populations of the same species cohabitating similar or varying conditions of food density, and climate, establishment of the period and duration of gonadal maturity, and observation of the changes in feeding activity of the populations which can be an indicator of food resource modifications. Condition indices are also of high importance for the management and conservation of natural populations under consideration [14].

The general objective of this study is to determine the allometry of the reef fishes with the use of the length-weight relationships of the fish species associated with the bobo fishing method in Barangay Bato, Sta. Cruz, Davao del Sur. Specific objectives include identification of fishes according to morphological features and determination of condition index of the fishes derived from their length-weight relationship values.

2. Materials and Methods
The study was conducted at Barangay Bato, Municipality of Sta. Cruz, Davao del Sur. The barangay is situated at the southernmost part of the municipality and is a local fishing ground since the barangay itself is situated along the shoreline of Davao Gulf. Figure 1 shows a map derived from Google Earth (2016) [7] that indicates the location of Barangay Bato. Figure 1a shows the map of Mindanao and Figure 1b shows the location of sampling area (shown in red borders). Figure 1c shows the dropping areas in which the fisher drops and establish the traps throughout the sampling period with coordinates on Appendix A.

![Figure 1](image-url)

**Figure 1.** Sampling sites in Barangay Bato with specific dropping points for bobo traps shown as points S1 through S12 (Google Earth, 2016) [7].
The study was conducted from the month of August 2016 to March 2017, a period of 8 months and samplings were done at every available harvesting schedule. The fisherman was observed to establish and retrieve the traps daily but because of student unavailability on weekdays, the sampling was preferably done on weekends. Environmental disturbances such as rainy and windy weather which occurred during the course of the sampling period did not allow the researcher to conduct the sampling thus resulting in irregular time intervals between sampling dates. Weather disturbance, turbid waters, and low tides were considered as the environmental factors which could significantly constrain the efficacy of the bobo fish trapping method [1].

The fishes caught by the bobo traps during the entire sampling period served as the source of data for this study. Data collection was performed during the retrieval of the bobo together with the fishermen. Photos of the caught fishes were taken for species identification. The total length of each fish was measured in centimeters (cm) using an improvised measuring device made of wood with an attached measuring tape and weighed in grams using a digital weighing scale with values up to the nearest tenth place. Data were regrouped according to families of reef fishes for easier and more convenient reviews.

Allometry of the fishes was determined from length-weight relationship of the fish samples. Condition indices expressed as relative weights of the fishes were also determined in this study. Length-weight relationship (LWR) was used to determine the allometric coefficient (b) of the fishes which describes the allometric growth of the reef fishes in the study area. The length-weight relationship is expressed in the formula:

\[ W = aL^b \]

wherein:
- \( W \) = weight of the fish (in grams),
- \( L \) = total length of the fish (in centimeters),
- \( a \) = exponent describing the rate of change of weight with length, and
- \( b \) = weight at unit length

The \( a \) and \( b \) parameters of the length-weight relationship stated above are determined by logarithmic transformation using the natural logarithm of the observed length and weights of the samples; that is in the form of \( \ln W = \ln a + b \ln L \) [15; 11]. Using SPSS Statistics 20 Software, \( a \) and \( b \) parameters as well as the correlation coefficients (r) for each species were determined.

The condition index of a fish was used to measure the overall health of the fish by comparing its weight with the average weight of other fish of the same length and kind cohabitating similar or varying conditions of food, density, and climate among other factors; which can be a crucial indicator of food resource modifications [14]. This study employs the relative weight condition factor in determining the condition indices of the fishes. It is expressed as:

\[ W_r = W/W_s \times 100 \]

wherein:
- \( W_r \) (relative weight) = the fish’s condition index,
- \( W \) = weight of the sample fish, and
- \( W_s \) (standard weight) = the expected weight of the fish

Calculations for determining the condition indices were done using Microsoft Excel Software. Standard weight was determined from the length-weight relationship parameters (\( a \) and \( b \)) as \( W_s = aL^b \). Condition indices values were expressed as percentages with values greater than 100% (CI >100%) showing healthy fish conditions [1; 5]. Mean relative weight condition indices of the accounted fish species were determined following the method used by Isa and colleagues (2010) [9].
3. Results and Discussion

There were a total of 16 species belonging to nine families of reef fishes that were found in the study, namely: Acanthuridae (*Naso vlamingii*), Balistidae (*Balistoides viridescens*), Carangidae (*Gnathanodon speciosus*), Labridae (*Halichoeres melanurus*, *Novaculaichthys taeniourus*), Lethrinidae (*Lethrinus lentjan*), Lutjanidae (*Lutjanus ehrenbergii*), Pomacentridae (*Stegastes nigricans*), Scatophagidae (*Scatophagus argus*), and Siganidae (*Siganus punctatus*, *S. guttatus*, *S. argenteus*, *S. canaliculatus*, *S. virgatus*, *S. fuscescens*, and *S. spinus*). The Family Siganidae has the highest number of species among the samples taken with seven (7) species accounted. This observation can probably be influenced by the abundance of seagrasses in the study area as siganids which are primarily bottom dwelling plant-feeders in reef ecosystems [4]. The following table shows the data on species sample numbers (N), values of \( a \) and \( b \) variables of the fish length-weight relationships and the condition indices of the fishes in the present study.

**Table 1.** Sample number, \( a \) and \( b \) values of fish length-weight relationships, and condition indices of fish species.

| Family          | Species                      | Sample Number (N) | Length-weight relationship parameters | Condition Index (%) |
|-----------------|------------------------------|-------------------|---------------------------------------|---------------------|
| Acanthuridae    | *Naso vlamingii*             | 2                 | 0.0556 2.615                           | 99.99701249         |
| Balistidae      | *Balistoides viridescens*    | 2                 | 0.0254 3.119                           | 99.9880554          |
| Carangidae      | *Gnathanodon speciosus*      | 1                 | --- ---                               | --                  |
| Labridae        | *Halichoeres melanurus*      | 2                 | 0.0215 2.854                           | 100.0104985         |
|                 | *Novaculaichthys taeniourus* | 2                 | 0.0045 3.485                           | 100.9041062         |
| Lethrinidae     | *Lethrinus lentjan*          | 2                 | 0.0735 2.376                           | 99.99853202         |
| Lutjanidae      | *Lutjanus ehrenbergii*       | 1                 | --- ---                               | --                  |
| Pomacentridae   | *Stegastes nigricans*        | 3                 | 0.2992 1.807                           | 100.054839          |
| Scatophagidae   | *Scatophagus argus*          | 3                 | 0.1172 2.516                           | 100.0497733         |
| Siganidae       | *Siganus punctatus*          | 2                 | 0.0001 4.946                           | 99.97660945         |
|                 | *S. guttatus*                | 3                 | 0.0186 3.062                           | 100.2344335         |
|                 | *S. argenteus*               | 7                 | 0.0240 2.779                           | 100.2561931         |
|                 | *S. canaliculatus*           | 11                | 0.0447 2.606                           | 100.407299          |
|                 | *S. virgatus*                | 13                | 0.0330 2.816                           | 100.7369394         |
|                 | *S. fuscescens*              | 19                | 0.0211 2.88                            | 100.3683008         |
|                 | *S. spinus*                  | 108               | 0.0278 2.82                            | 100.7586204         |

A total of 181 fish specimens were collected during the sampling period and a large percentage of this number was constituted by the member species of family Siganidae. This observation, as mentioned earlier, can be attributed to the abundance of seagrasses in the study area. The \( a \) and \( b \) parameters were determined by logarithmic transformation using the natural logarithm of the observed length and weights of the samples. Establishment of \( a \) and \( b \) values for fish length-weight relationships were done on species with a sample number of more than one, thus only 14 out of 16 species identified were subjected to length-weight relationship analysis. Consequently, the 14 species subjected to LWR analysis were also subjected to condition index analysis since the \( a \) and \( b \) parameters were crucial variables in determining the standard weights of the fishes. Condition indices of the fishes were expressed as the mean relative weight of individual specimens for each species following the methods of Isa et al (2010) [9].
Results from the establishment of length-weight relationships revealed that all species grow allometrically as suggested by their $b$ values (allometric coefficient) which are not equal to 3 ($b \neq 3$). Only 4 species out of 14 species analyzed attained positive allometric growths ($b > 3$). This suggests that the majority of the fishes (ten out of fourteen species analyzed) shows negative allometric growths which means that those fishes become slenderer as they grow in length. Condition index establishment also reveals that 10 species out of fourteen species analyzed showed positive condition indices as indicated by CI values of greater than 100%. Shown in red font in the table above, are negative condition indices (CI < 100%) of the other four species analyzed. This result indicates that the majority of the fishes had relatively good health which can be attributed to good nutrient supply for the fish populations in the study area; as condition indices also serve as an indicator of feeding activity of the populations and therefore implies modifications in the food resource for the fishes.

The CI establishment results however are contradicting the established $b$ values for the LWR parameter of the fishes in this study. There are ten fish species that showed negative allometric growths ($b < 3$) in the study. However, relative weight condition index establishment results in ten species which showed good conditions. The result is confounding, but Liao and colleagues (1995) suggested a lack of relationship between the relative weight and the $b$ parameters. Hussain et al (2012) also argued that fish conditions reflect ecological and physical circumstances such as feeding habit fluctuations, parasitism and other physiological factors while growth can be correlated with food availability. Furthermore, several characters such as sexual maturity, age, and sex of the fishes which are vital factors in the differences of condition index of some fish species were not considered in this study which somehow could possibly have affected the result of the analysis. Nevertheless, the fish growth interaction with environmental parameter changes is a very complex phenomenon that is believed to be difficult to explain.

Appendix

| Sampling Points | Coordinates     |
|-----------------|-----------------|
|                 | Latitude        | Longitude       |
| S1              | 6°47'33.21” N   | 125°23'38.27” E|
| S2              | 6°47'28.65” N   | 125°23'37.51” E|
| S3              | 6°47'25.16” N   | 125°23'40.51” E|
| S4              | 6°47'38.72” N   | 125°23'35.02” E|
| S5              | 6°47'30.56” N   | 125°23'33.77” E|
| S6              | 6°47'23.25” N   | 125°23'35.81” E|
| S7              | 6°47'25.78” N   | 125°23'35.02” E|
| S8              | 6°47'44.07” N   | 125°23'29.46” E|
| S9              | 6°47'38.23” N   | 125°23'39.42” E|
| S10             | 6°47'43.02” N   | 125°23'35.62” E|
| S11             | 6°47'22.19” N   | 125°23'39.75” E|
| S12             | 6°47'22.75” N   | 125°23'31.93” E|

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