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Assessment on species diversity of fishes in Buguey Lagoon, Cagayan, Northern Philippines

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Abstract

The diversity of fishes along Buguey Lagoon remains underrepresented in research and conservation efforts. This study generally aimed to assess the diversity and document the species richness of fishes. Specifically, the study was conducted to determine diversity indices, IUCN status, and to generate a database for policy formulation towards the conservation of species and its management. Results of the study showed significant differences in fish diversity index in terms of Shannon–Weinner index, Simpson's Reciprocal Index (1/D), Margalef's diversity index (d), and Berger-Parker dominance index (D), Sorensen's similarity index (Cs) at ($p<0.05$) only Pielou's measures of evenness (J) has no significant difference in the (3) sampling stations. Furthermore, significant differences were observed between sampling stations for Margalef's diversity index (d) and Sorensen's similarity index (Cs) at ($p<0.05$) on the diversity of fishes and only one (1) similar species can be found between sites. Furthermore, in IUCN Red List assessments on finfish species, 78.5% identified appeared to be of least concern, data deficient and not evaluated while only 45% of the species appeared to have data on Length at maturity. The results of this study served as a basis for policy formulation towards the sustainable management of resources along Buguey Lagoon.

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Introduction

Species diversity combines the number of different species (species richness) with the relative abundance of finfishes and crustaceans at a certain time and place. Diversity is the maximum when all species that make up the community are equally abundant or have similar population sizes (Emmanuel and Modupe, 2010). Relative abundance refers to how common or rare these organisms are relative to other community species at a certain period of the year. Parameters such as species composition, richness, and abundance have been used in many studies to assess fish community and diversity (Hewitt *et al.*, 2008). Today, fish diversity and associated habitat management is a great challenge because the ability to evaluate the effect of habitat change and other impacts on fish populations requires extensive surveying before and after the change occurs (Dungeon *et al.*, 2006).

The Philippines belongs to the world's richest megadiverse countries and is one of the 25 biological hotspots worldwide with great diversity of endemic species but significantly altered by human activities (Conservation International, 2003 as cited by Broad, 2003). About 70% of the 1,525 municipalities or more than half of the country's total population are in the coastal areas (Galenzoga and Quinonez, 2014), including Buguey of Cagayan North in the island of Luzon. This indicates how the lives of most Filipinos are closely linked with the coastal region and its biodiversity. Inland fisheries and aquaculture are among the major economic activities in coastal municipalities (Camarao-Tamaray *et al.*, 2012). Buguey Lagoon is also known as one of the most productive aquatic ecosystems in Cagayan Valley having diverse aquatic flora and fauna but limited studies have been conducted on species diversity.

Species composition is the identity of all the different organisms and their count which are essential to describe the status of an ecosystem. Parameters such as species composition, richness, and abundance have been studied to assess fish population and diversity. Species diversity combines the number of different organisms (species richness) with relative abundance (evenness) of finfishes and crustaceans at a certain period and place. Finfishes and crustaceans are of great commercial value but fisheries production declined due to the increasing human population and demand for protein sources. Thus, urgent conservation action is required especially to save threatened, native and endemic species including their habitat structure.

Materials and methods

Study site

The study sites are Brgy. Villa Leonora which is located in the mouth portion of the lagoon towards the estuary where salinity is high. Centro is located at the eastern portion of the bridge about 1 km away and Cabaritan is towards west about 3 km from fish port (Fig. 1).

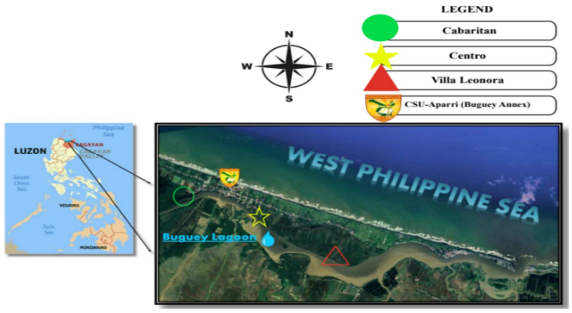

Fig. 1. Study site (Source: Google Earth Image)

Data collection

Fishermen were chosen based on ownership of fishing boats and respective single fishing gear only. Data gathering was done three times a month every 2:00-8:00 am at the landing sites to collect fresh samples from the catch of fyke net. Catch composition was sorted, separated, and recorded. The samples were collected from three fishermen each of Brgy. Cabaritan, Centro and Villa Leonora. These fishing villages have a higher frequency of fishing activities compared to other barangays.

Diversity indices of fishes and crustaceans

A diversity index is a mathematical measure of species diversity in a given community. Based on the species richness (the number of species present) and species abundance (the number of individuals per species) the more species you have, the more diverse the area.

Samples were randomly collected and counted for diversity analysis (Bolarinwa *et al.*, 2015; Olawusi-Peters and Ajibari, 2014). The numbers were used to estimate the various measures of diversity using the procedure and formula:

Shannon-Wiener index

The idea behind this index is that the diversity of a community is similar to the amount of information in a code or message. Similar to Simpson's index, the measurement takes into account species richness and the proportion of each species within the local aquatic community. The index comes from information science. It has also been called the Shannon Index and the Shannon-Weaver Index in the ecological literature. It is calculated in the following way:

Calculate the # of individuals of the species sample and the total # of individuals of all species. This is Pi. Multiply the fraction by its natural log (Pi*lnPi). Add all the (Pi*lnPi) products to get the value of H.

Shannon-Wiener Index (H) = $\Sigma - (Pi^{*}lnPi)$

$i = 1$

Where: H = The Shannon diversity

Pi = fraction of the entire population made up of species i

S = number of species encountered

∑ = sum from species 1 to species S

Note: The power to which the base e (e = 2.7182818….) must be raised to obtain a number is called the Natural Logarithm (Ln) of the number.

Simpson's reciprocal index

The value of this index starts with one (1) as the lowest possible figure. This figure would represent a community containing only one species. The maximum value is the number of species (or category being used) in the sample. For example, if there are five species in the sample, then the maximum value is 5. In calculating the Simpson's reciprocal index get first the value of D (Simpson's index) where the formula is $D = \Sigma (n/N)^2$, after getting it, one (1) is then divided to it. Simpson's Reciprocal Index = 1/D

Margalef's diversity index

Species richness is the simplest measure of biodiversity and is simply a count of the number of different species in a given area. This measure is strongly dependent on sampling size and effort. To compute Margalef's Diversity Index, first, subtract 1 from the number of species (S). Divide the difference by the natural logarithm of the number of individuals (N).

$d = (S - 1) / \ln N$

Where S is the number of species, and

N is the total number of individuals in the sample

Pielou's measure of evenness

Pielou's measure of evenness measures the evenness with which individuals were distributed among the species. In calculating Pielou's measure of evenness, divide the Shannon- Wiener index by the natural logarithm of (S) number of observed species.

$J = H'/\ln(S)$

Where S = number of observed species.

H'= Shannon-Wiener index.

Berger-Parker dominance index

The Berger–Parker index equals the maximum p_i value in the dataset, i.e., the proportional abundance of the most abundant type. This corresponds to the weighted generalized mean of the p_i values when q approaches infinity and hence equals the inverse of the true diversity of order infinity ($1/^{\infty}D$).

Berger-Parker's index of dominance is simply the proportion of the most common species in the community or sample. In calculating the Berger-Parker Index, divide the number of individuals of the most abundant species (N_{max}) by the total number of observed species (S).

$D = N_{Max}/S$

Where Nmax = the number of individuals of the most abundant species,

S = the total number of observed species.

Sorensen's similarity index

This is the degree of similarity between the fish communities in the different locations. It is expressed

according to Krebs as twice the number of species common to a given pair of locations divided by the sum of species occurring in either of the two locations.

$Cs=2j/a+b$

Where Cs is Sorensen's index,

j is the number of species common to a given pair of locations,

a and b are the number of species occurring in either of the two locations.

IUCN status and conservation of fishes

The category and status of species classified were identified using the IUCN Red List. Conservation measures are noted, discussed, and disseminated. Endemic, native, and alien species were also identified.

Data analysis

Species diversity is analyzed using six indices: Shannon-Wiener Index, Simpson's Reciprocal Index, Margalef's diversity Index, Pielou's measure of evenness, Berger-Parker dominance, and Sorensen's Index. The data were further subjected to two-way analysis of variance (ANOVA) to compare the variations in parameters among stations.

Results and discussion

Species diversity of fishes and decapods crustaceans

When studying fish composition and distribution, several diversity indices are commonly used, primarily to assess the current health status of rivers and adjacent tributaries (Corpuz *et al.,* 2015). The numbers were used to estimate the various diversity measures using the method and formulas.

Species diversity is a useful parameter for assessing communities under the effects of biotic disturbances or for determining the succession and stability status in the community (Olawusi and Ajibare, 2014). The highest value of the Shannon-Winner Index (H) for fish was 1.84 in Villa Leonora, followed by 1.54 in Cabaritan and the lowest value was 1.51 in Centro. Villa Leonora and Cabaritan showed a significant difference ($p<0.05$) between the (3) three sampling sites (Fig. 2).

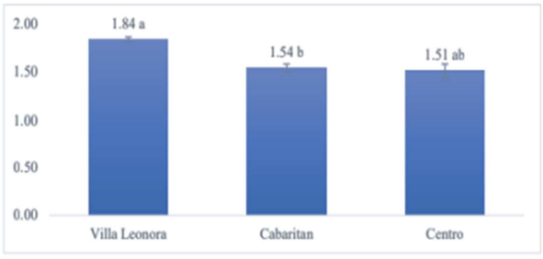

Fig. 2. Shannon-Weiner Index of Fishes Caught along Buguey Lagoon

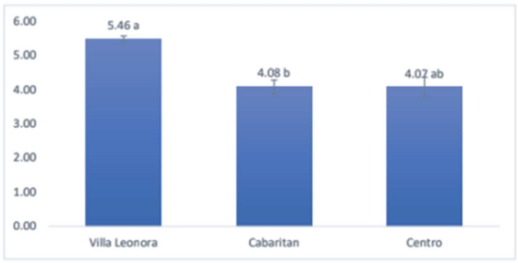

Fig. 3. Simpson's Reciprocal Index Fishes Caught along Buguey Lagoon

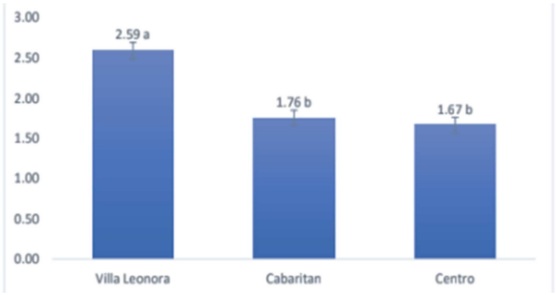

Fig. 4. Margalef's Diversity Index Fishes Caught along Buguey Lagoon

The study of the biodiversity of fish populations at different sampling sites, measured by the Shannon-Wiener index (H), has provided interesting insights into the ecological conditions of these areas. Notably, there are significant differences in overall species diversity between the sites, with Villa Leonora standing out for having significantly higher diversity compared to Cabaritan and Centro. However, an important aspect of these results is the interpretation of the Shannon-Wiener index (H) values. Values above 3.0 indicate a stable and balanced habitat structure, while values below 1.0 indicate pollution and habitat degradation, according to Akbar *et al.* (2013).

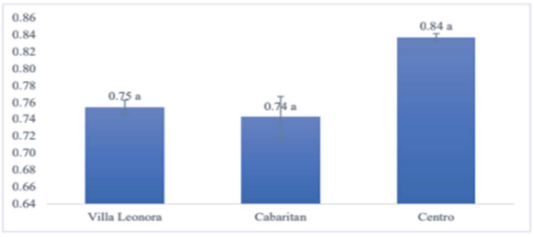

Fig. 5. Pielou's Measure of Evenness of Fishes Caught along Buguey Lagoon

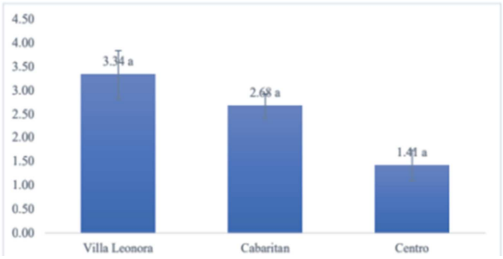

Fig. 6. Berger-Parker Dominance Index of Fishes Caught along Buguey Lagoon

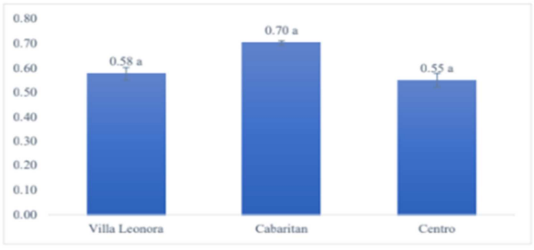

Fig. 7. Sorensen's Similarity Index of Fishes Caught along Buguey Lagoon

Unfortunately, all of the sites have lower Shannon-Wiener Index (H) values, indicating potentially severe pollution and habitat destruction. These results raise critical concerns about the environmental health of these sites and conduct further investigation into the specific causes of these challenges, such as water quality problems due to heavy siltation and some pollutants coming from the residential waste as well as disturbances affecting habitat. On the other hand, Villa Leonora with its relatively higher Shannon-Wiener index value (H) represents a slightly more stable habitat. However, this value remains below the 3.0 threshold, suggesting that concerns remain consistent. Concerns may include decreases in natural productivity and habitat quality, which could be caused by factors such as heavy use.

The Simpsons Reciprocal Index of fishes (1/D) showed that Villa Leonora (5.46), Cabaritan (4.08) and Centro (4.07) have almost the same number of species, meaning that for each fishing activity 4– 5 common species were caught. Villa Leonora and Cabaritan showed a significant difference ($p<0.05$) between the (3) three sampling sites (Fig. 3).

The results showed differences in Margalefs diversity index (d) between the three sampling sites. Specifically, the highest diversity index value was observed in Villa Leonora (2.59), followed by Cabaritan (1.76), which had relatively higher diversity compared to Centro (1.67). Significantly, the statistical analysis showed that Villa Leonora stood out with a statistically significant difference ($p < 0.05$) compared to Cabaritan and Centro (Fig. 4).

Pielous measurements of evenness (J) revealed consistent uniformity values for both fish and decapods at all three sampling locations. The uniformity values for fish were 0.75 in Villa Leonora, 0.74 in Cabaritan, and 0.84 in Centro (Fig. 5). Overall, these values indicate a high uniformity in the distribution of fish species within the respective ecosystems. A high level of uniformity means no single species dominates the fish population at any of the three locations. Instead, there is a balanced presence of different species, making fish communities ecologically diverse. Furthermore, statistical analysis confirmed that there were no significant differences in evenness between the three sites.

The Berger-Parker fish dominance index (D) showed that there were no statistically significant differences ($p > 0.05$) between the three sampling sites. Villa Leonora had the highest dominance index (3.24), indicating relatively higher dominance of certain species within the fish community. There was also a relatively high index in Cabaritan (2.68), although lower than that of Villa Leonora. Centro (1.41) had comparatively lower dominance (Fig. 6).

The Sorensens similarity index (Cs) was used to assess the similarity of species composition among different sampling sites. Cabaritan had the highest Cs value (0.70) compared to the other sites. Centro (0.55) and Villa Leonora (0.58) also showed a distribution of species similarity between them (Fig. 7). This could indicate similarities in environmental conditions, habitat characteristics, or ecological niches that favor similar species assemblages. Statistical analysis indicated that these similarities in species composition between sites were not statistically significant ($p > 0.05$). This suggests that any observed similarities or differences in species composition may be due to random variation or factors not accounted for in the analysis. It's possible that other environmental variables, such as habitat complexity, substrate type, or hydrological conditions, may play a significant role in shaping species composition patterns beyond what the Sorensen similarity index alone can capture.

Conclusion

Based on the results of the One-way ANOVA tests conducted on the diversity indices within the three sampling stations, several significant findings have emerged, providing insights into the biodiversity patterns of fishes within the study area. The significant differences observed in the Shannon-Weiner index, Simpson's Reciprocal Index (1/D), Margalef's diversity index (d), and Berger-Parker dominance index (D) between the sampling stations ($p < 0.05$) indicate variations in species richness, diversity, and dominance among the different habitats within the study area. This suggests that certain habitats may support a higher number of species and exhibit greater diversity, while others may be dominated by a few species.

However, it is noteworthy that Pielou's measure of evenness (J) did not show significant differences between the sampling stations ($p > 0.05$). This implies that, despite variations in species richness and dominance, the distribution of individuals across species within each habitat remains relatively equitable, indicating a balanced community structure in terms of evenness.

Furthermore, the lack of significant differences between sampling stations for Simpson's Reciprocal Index (1/D), Pielou's measure of evenness (J), and Sorensen's similarity index (Cs) in the diversity of decapod crustaceans ($p > 0.05$) suggests that these specific aspects of biodiversity are relatively consistent across the study area. This could be indicative of similar ecological conditions or connectivity between habitats, which may facilitate the exchange of species and maintain consistent biodiversity metrics.

While the research has provided valuable baseline data on biodiversity in Buguey Lagoon, there is a need for continued monitoring and research to track changes over time, assess emerging threats, and evaluate the effectiveness of conservation interventions. Long-term studies and interdisciplinary research collaborations are crucial for advancing our understanding of the lagoon's ecosystem dynamics and informing evidence-based management decisions.

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