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Assessing the Educational Significance of Microplastic Impact on *Sardinella gibbosa*: Implications for Marine Sustainability and Public Health in Caraga Region, Philippines

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ABSTRACT

This research study aims to provide an educational assessment of microplastic contamination by examining the presence of microplastics in the gut contents of Sardinella gibbosa collected from the coastal waters of Magallanes, Agusan del Norte. Sixty fish samples were analyzed, revealing that 75% of them had ingested microplastics, with over 90% of the particles identified as fibers. These fibers are presumed to originate from environmental pollutants such as discarded fishing nets, degraded plastic debris, and other synthetic waste. The results highlight the urgent issue of microplastic pollution in local marine ecosystems and its potential impact on food safety and sustainability. Importantly, this study serves as an educational tool to raise awareness about marine pollution and its cascading effects on public health, marine biodiversity, and community livelihoods. While the research focused primarily on detecting microplastics in fish digestive systems, it underscores the need for further educational programs and research initiatives to explore the broader implications, particularly the health risks to humans consuming contaminated seafood. Integrating these findings into marine science education can foster environmental stewardship among students, policymakers, and local communities. Continued monitoring and public education on plastic waste reduction are crucial steps toward mitigating microplastic pollution and promoting sustainable marine practices in the Caraga Region.

INTRODUCTION

The Science History Institute (2022) defined plastic as a group of materials, either synthetic or naturally occurring, that may be shaped when soft and then hardened to retain the given shape. With plastic being durable and long-lasting, the British Plastics Federation (2022) stated that it is used in every sector, including to produce packaging, in building and construction, in textiles, consumer products, transportation, electrical and electronics and industrial machinery. This results in the massive production of plastic which according to the Natural Resources Defense Council (2022) sums up to 300 million tons of plastic each year. In the Philippines, plastic is not only vital in the national economy, but it also provides low-cost consumer goods that cater to the poor and middle-income families, thus according to the Market Study for Philippines: Plastics Circularity Opportunity and Barriers (2021) results to Philippines being known as the "sachet economy". The massive production of plastic leads to uncontrollable waste management and it is estimated by the research conducted by the UN Environment Programme (2021), that 75 to 199 million tons of plastic is currently found in the oceans.

According to the National Oceanic and Atmospheric Association (2021), plastic is the most prevalent type of marine debris that can come in all shapes and sizes but those that are 5 millimeters in length are called microplastics. Microplastics that are found in the sea emerged from land-based resources and ocean-based resources including sewage and storm water discarded and lost fishing items (Li, 2018). Microplastics are found everywhere, the study of Dris Rachid, et.al., (2015) stated that microplastics have been observed in both sediments and water samples. Its biodegradation-resistant properties allowed them to persist and accumulate in the marine environment thus causing physical and chemical effects on marine organisms after ingestion (Li, 2018).

A study by Ory, et al (2018) stated that visually oriented planktivorous fish are susceptible to ingest microplastics resembling or floating close to their planktonic prey. Along with that, Zara L.R., *et.al.,* (2019) stated that high concentrations of microplastic could induce suppressed feeding activity, prolonged gut residence times, inflammation and reduced energy reserves, impacting growth, reproduction and ultimately survival. In connection to that, You Li, *et al*., (2021) implied that microplastics inhibit growth and development of the Lugworm (*Arenicola marina)*, and the inhibition degree is positively correlated with the concentration of microplastics. Also, the study of Wen, B., et.al., (2018) stated that microplastics can cause blockage of the digestive tract and induce satiety which may result in reduced growth performance and survival rate of discus fish. It has also been noted that the accumulation of microplastics significantly increased the rate of respiration and excretion while significantly decreasing feeding and absorption efficiency leading to reduced amount of energy available for growth of manila clam (Weiwei Jiang, et al., 2021).

Philippine Daily Inquirer published an article written by Subingsubing (2022) whereby fishermen of Mambacayao Island observed the decreased number of fishes caught and a noticeable trace of microplastics was found when they opened the fish. A total of 51 microplastics were also isolated from the various fish species based on the study of Espiritu, *et.al., (2019).* Barboza, *et. al., (2019)* concluded that the lipid oxidative damage in gills and muscle, neurotoxicity through lipid oxidative damage and acetylcholinesterase induction is directly related to the presence of microplastics in the gastrointestinal tract, gills and dorsal muscle of the fish. The study of Chen, et al (2020) concluded that exposure to microplastics significantly delayed the hatching time, altered the heartbeat and decreased the hatching rate of embryos of marine medaka and not only that, the genes involved in cardiac development were significantly upregulated, pathways involved in metabolism, immune response and genetic information processing and diseases were significantly enriched thereby concluding that microplastics have negatively affected embryogenesis and the immune response e of marine medaka.

Microplastics being found in marine residue, seabed, water fragments and manufactured substances even inside the gastrointestinal tract dwelling to skin, gills, liver and fish (Kazam, et al., 2021), it is inevitable for microplastics to be in contact with humans. Microplastics can absorb harmful chemicals and with this being in a human system, this may cause danger to the human body as the study of Prata, et al., (2020) stated that the inability of the immune system to remove synthetic particles may lead to chronic inflammation and increase the risk of neoplasia such that that article by Blackburn, et al., (2021) stated that high concentration of microplastics could provoke immune and stress responses and inducing reproductive and developmental toxicity. Added to that, the review study conducted by Peixoto, et al., (2019) mentioned that microplastics have the potential to bioaccumulate in secondary organs with possible impacts in the immune system and cell growth (Lusher, et al., 2020) and may be responsible for negative biological responses like inflammation, genotoxicity, oxidative stress, cell apoptosis, and tissue necrosis. Its potential hazardous effect on humans has also been noted in the study of Sharma, et al., (2017) and it includes alteration in chromosomes which may lead to infertility, obesity, and cancer.

Fish is a staple food and a source of income for most of the people, especially the residents of Magallanes Agusan del Norte and considering its possible danger to human health, the researchers believed that a study should be done to be aware and to know if microplastics can be seen in the food that is constantly consumed. Therefore, this study aimed to conduct a preliminary assessment of microplastics in the common fish species of sardines (*Sardinella gibbosa*) caught in the coastal area of Magallanes, Agusan del Norte, Philippines.

Materials and Methods

Sample collection and preparation

The study requires the collection of the gut of the fish *Sardinella gibbosa* (Figure 1), to determine whether its diet is affected by plastic pollution in its natural habitat. The researchers contracted a fisherman to be able to obtain samples of *S. gibbosa* coming from the same cohort caught in the coastal area of Magallanes, Agusan del Norte (Fig. 2) and to avoid selection bias.

Fish guts are considered waste for the market buyers and are usually disregarded after purchasing the fish. A total of 60 fish samples were bought and subjected to gut content analysis. All fish samples were stored in an icebox to maintain their physical integrity. It was then brought to the laboratory for examination.

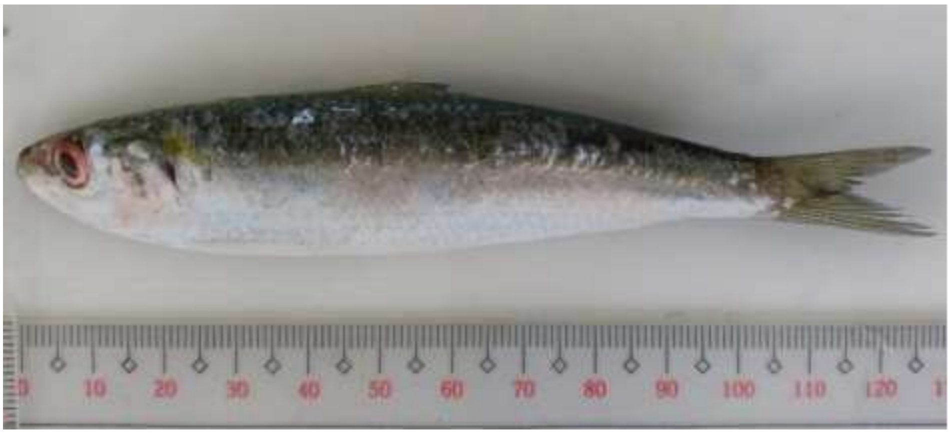

Figure 1. *Sardinella gibbosa* caught in the coastal areas.

The length and weight of the samples were taken by measuring the total length using a ruler and were weighed using a digital weighing scale. All measurements were recorded accordingly, for data management and statistical analysis. All the procedures were documented properly.

Based on the Diet Composition by Pinkas *et al*. (1971), Gut samples collected and cleaned were dissected to expose their content. It was washed in a Petri dish with 10 ml distilled water and was gradually stirred to release all the content into the water. The gut was then removed ensuring all contents are released into the solution. The Petri dish was visually examined for floating plastic materials and debris (difference in density). Plastics visible to the naked eye were then collected, photographed, and noted for documentation. For microplastics, (<5.0mm) determination, the solution in the Petri dish was then added 10 ml of 30% hydrogen peroxide to dissolve the remaining flesh in the solution. The solution was poured over to a pre-weighed filter paper to air dry at room temperature for 30 minutes. 60 pieces of filter paper with the air-dried undissolved gut content were then weighed and examined under an electron microscope for the presence of undissolved traces of plastic/synthetic materials in the samples.

Results and Discussion

A total of sixty (60) samples of the common sardine species of *S. gibbosa* were examined for gut content analysis. Table 1 shows that the average length of the samples ranges from 9.9 cm to 12.6 cm, with a standard mean of 11.328 cm. The average weight of the samples ranges from 5.896g to 17.690g, with a standard mean of 10.936 g. The data shows that the samples may not be truly representative of the same cohort or biological batch with a low positive correlation (r^2) value of 0.287 (Figure 4). This could be due to differences in ages, genders, or other characteristics of the individuals from which the samples were taken. Despite the low correlation, the high probability of the samples being in the same cohort and of the same biological batch suggests that there may still be some underlying similarities between them (Brown, 2020).

Table 1. Descriptive statistics of the size, weight and the gut content of *S. gibbosa* caught in the coastal areas.

	Length (cm)	Weight (g)	Gut Content Weight (g)
Mean	11.328	10.936	0.0629
Standard Error	0.081	0.358	0.006
Median	11.5	10.884	0.049
Mode	10.8	8.618	0.09
Standard Deviation	0.630	2.773	0.052
Sample Variance	0.397	7.692	0.002
Range	2.7	11.793	0.324
Minimum	9.9	5.896	0.009
Maximum	12.6	17.690	0.333
Count	60	60	60
Confidence Level (95.0%)	0.162	0.716	0.013

The results of the gut content analysis demonstrate a significant presence of microplastics in the gut of the samples examined. The fact that 75% of the samples had ingested microplastic highlights the widespread nature of this issue, and the potential harm it poses to the affected organisms.

Table 1 also shows that the ingestion of microplastics varies among the samples, with some having no observations while others having up to 5 observations. This suggests that there may be factors that influence the ingestion of microplastics, such as the location or behavior of the organism.

The average of ±1 observation per sample indicates that on average, each sample had ingested one piece of microplastic. This may not seem like a high number, but it is important to consider the cumulative effects of microplastic ingestion over time like the study of Smith (2021).

Table 2. Descriptive Statistics of the observations of microplastics ingestion of *S. gibbosa.*

Microplastics	
Mean	1.533
Standard Error	0.165
Median	1
Mode	1
Standard Deviation	1.281
Sample Variance	1.642
Range	5
Minimum	0
Maximum	5
Sum	92
Count	60
Confidence Level (95.0%)	0.331

Table 2 shows some of the microplastics documented during the gut content analysis. Most of the observed microplastics were fibers (a. and b.), accounting for more than 90% of the observations, followed by microplastic fragments and others. These fiber types of microplastics are probably from discarded nets, weather plastic fragments, polyester clothes,

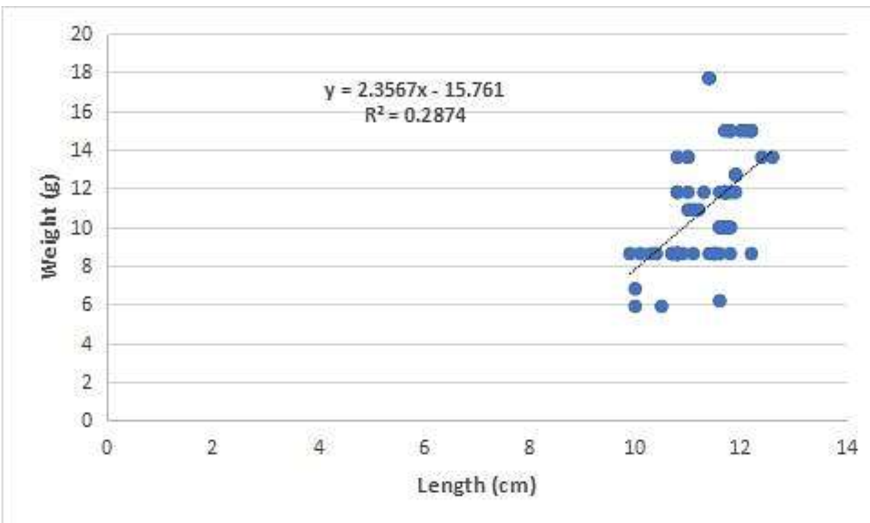

Figure 2. Correlation between length-weight samples of *S. gibbosa.*

and others (Lusher et.al 2017). It is important to note that the presence of microplastics in the gut content of marine organisms is a major concern for their health and well-being. These small plastic particles can cause physical damage to the digestive system, as well as potentially introducing toxic chemicals into the organism's body (Koelmans, 2019). Furthermore, the fact that fibers make up the majority of the microplastics observed in this study highlights the need for better management and disposal of products such as fishing nets and clothing made from synthetic materials. These items are major sources of microplastic pollution in the ocean and can have devastating impacts on marine life (Eriksen, et.al., 2014).

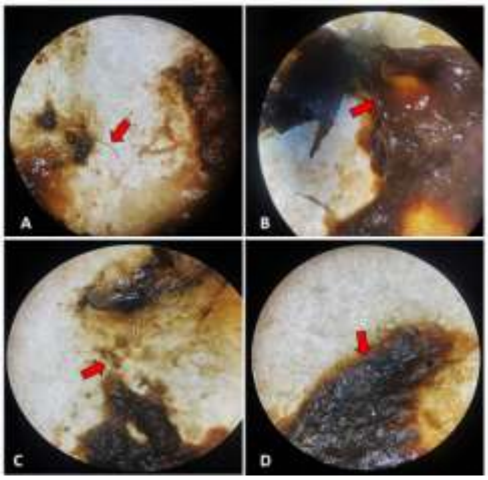

Figure 3. Types of microplastics observed in the gut of *S. gibbosa* caught in Coastal Areas.

The occurrence of microplastic in the gut of *S. gibbosa* was also correlated to its length and weight. Figures 6 and 7 show that there was a very low correlation between the size and weight of the fish to their gut content with r^2 values of 0.002 and 0.020 respectively. This means that the presence and volume of microplastics in the gut of *S.gibbosa* is directly proportional to their size, similar to what is reported by Pazos et.al., (2017), and Filgueiras et.al., (2020). However, Van der Meulen, et.al., (2018) reported that this correlation does not necessarily mean that larger fish are consuming more microplastics. It could also be a result of larger fish having a larger gut capacity, which allows them to hold more microplastics. Additionally, it could also be influenced by other factors such as feeding habits and habitat. For example, fish that live in areas with higher levels of pollution may have a higher chance of consuming microplastics.

Furthermore, the presence of microplastics in the gut of S. gibbosa can also have negative impacts on their health. Microplastics can cause physical injury to the gut lining and can also disrupt the fish' metabolism and nutrient absorption. This can lead to reduced growth and reproduction and can also make fish more susceptible to disease (Ko-elmans, et.al., 2017).

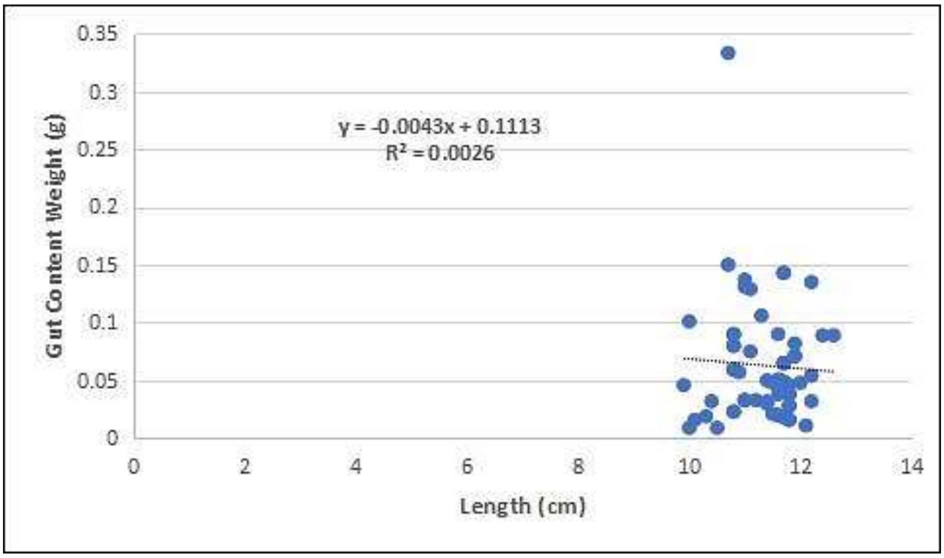

Figure 4. Length-gut content correlation of *S. gibbosa* caught in Coastal Areas.

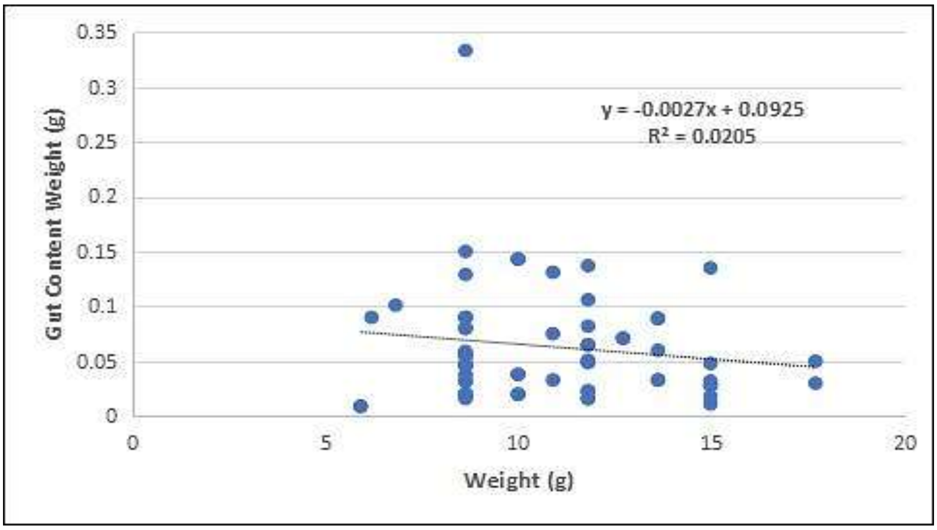

Figure 5. Weight-gut content correlation of *S. gibbosa* caught in Coastal Areas.

The r2 values mentioned (0.002 and 0.020) are measures of the strength of the correlation, with a value closer to 1 indicating a strong correlation and a value closer to 0 indicating a weak correlation. In this case, the values of 0.002 and 0.020 indicate that there is a very weak correlation between the size and weight of the fish and the amount of microplastics found in their gut. This suggests that other factors may be more important in determining the presence and volume of microplastics in the gut of *S. gibbosa*.

Conclusion

A total of sixty (60) *Sardinella gibbosa* samples were collected from the coastal area of Magallanes, Agusan del Norte, in collaboration with local fishermen. Analysis of the gut contents revealed that 45 samples, or 75%, had ingested microplastics, predominantly in the form of fibers. These fibers likely originated from discarded fishing nets, weathered plastic fragments, synthetic fabrics, and other anthropogenic sources commonly found in the bay's vicinity. While statistical analysis showed a low correlation between the presence of microplastics and the fish's length and weight, a positive direct relationship was observed. These findings serve as an important educational resource, highlighting the pervasive nature of microplastic pollution in local marine environments. The study not only raises awareness of environmental impacts but also underscores the need for integrating marine pollution topics into educational curricula to inform students, policymakers, and the public. Although the study primarily focused on microplastic ingestion and cannot conclusively determine the bay's overall pollution status, the high percentage of contamination is a strong indication of environmental concerns. Future research and continuous educational efforts are recommended to explore the broader ecological and public health implications, fostering greater environmental stewardship and sustainable practices within coastal communities.

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