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Comparative study of the chemical accumulation, population, and morphology of Banisil (*Faunus ater*) within Barangay Odiongan and Barangay Anakan, Gingoog City

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Abstract

Faunus ater is a gastropod mollusk, crucial to tropical East Asian ecosystems, especially in the Philippines. This study investigates its potential as a bioindicator by analyzing chemical accumulation, population, and morphology within Barangay Odiongan and Barangay Anakan in Gingoog City during wet season. The analysis revealed significant findings in chemical accumulation, population, and morphology. The total population of *F. ater* in Barangay Odiongan was 226, while Barangay Anakan had 316. Morphological characteristics of *F. ater* were larger in Anakan, with mean values (length: 78.79 mm, width: 15.18 mm, wet weight: 9.68 g) compared to Odiongan (length: 56.20 mm, width: 11.79 mm, wet weight: 8.01 g). Both barangays showed no detectable cadmium (Cd), but lead (Pb) levels varied, with Odiongan at 0.28 µg/g and Anakan at 0.27 µg/g, indicating higher levels in Odiongan. In the comparison of chemical accumulation and population of *F. ater*, data showed that despite Odiongan's lower population, it had higher Pb levels than Anakan. For the comparison of chemical accumulation and morphology of *F. ater*, Anakan, with no Cd detected, displayed larger morphology than Odiongan, which also showed no Cd but had smaller morphology. In comparing population and morphology of *F. ater*, both population and morphology in Anakan showed higher mean values than Odiongan. Adhering to Food and Drug Administration (US FDA) standards, Cd and Pb concentrations in both barangays are below tolerance limits, ensuring safety for *F. ater* and its habitat. The study suggests analyzing morphology and population using SPSS. Future research should include coliform analysis or occur during the dry season.

Keywords: *Faunus ater;* Population; Morphology; Chemical accumulation; Heavy metals; Tolerance level; Bioindicator

1. Introduction

Faunus ater, an aquatic gastropod mollusk known as the black devil snail, black spike snail, or lava snail (Michael, 2023), is locally called “Banisil” in Bisaya (Bureau of Fisheries and Aquatic Resources, 2022). Its dark brown or black elongated shell has about 20 coils and features two depressions: the anal sinus and the anterior sinus. The ovate white opening is one-fifth the shell height, reaching up to 90 mm (Mari, 2020; Michael, 2023). *F. ater* belongs to the Pachychilidae family and thrives in tropical regions with temperatures of 28 to 30 degrees Celsius, residing in shallow waters and estuarine environments (Agustina et al., 2018). *F. ater* is abundant in East Asia, especially the Philippines, found in brackish water and mangroves (Das et al., 2018). Its ecological distribution is limited to the tropical Indo-west Pacific region (Yap et al., 2023).

F. ater belongs to the Kingdom Animalia, Phylum Mollusca, Class Gastropoda, Order Caenogastropoda (unassigned), Superfamily Cerithioidea, Family Pachychilidae, Genus *Faunus*, and Species *F. ater* (Linnaeus, 1758). *F. ater* is the only

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species within the genus *Faunus*. Notably, the original description of this species was by Linnaeus (1758), while the genus *Faunus* was established by De Montfort (1810).

Natural biomonitors assess environmental health by detecting changes affecting human society (Parmar et al., 2016). Aquatic mollusks accumulate metals corresponding to environmental pollution (Yap et al., 2023), making *F. ater* a reliable bioindicator for heavy metal assessment (Baharuddin et al., 2023). Heavy metals stand out as highly detrimental elemental pollutants because of their elevated toxicity, posing potential harm to humans. Toxic heavy metals at high concentrations in organisms cause environmental issues (Maret, 2016), while lower concentrations can also harm aquatic environments (Agustina et al., 2019). Yap et al. (2023) analyzed heavy metals in *F. ater* by dissecting its soft tissues. The mangrove snail accumulates heavy metals due to its feeding habits and environmental exposure (Yap et al., 2023). Lead (Pb) and zinc (Zn) in sediments and *F. ater* in Bale Lhoknga, Aceh Besar District, indicate its utility for biomonitoring.

In the study by Yap et al. (2022), *F. ater* serves as a biomonitor for heavy metal contamination in the intertidal region of Peninsular Malaysia, assessing both the heavy metals present and the distribution of the species. Baharuddin et al. (2023) conducted a similar assessment of heavy metal pollution in *F. ater* populations in Malaysia, using it as a bioindicator. Agustina et al. (2019) investigated the heavy metals contributing to pollution in the Bale River of Indonesia, which is rich in natural resources such as sand, fish, and snails. Despite several studies on Southeast Asian rivers, there is a lack of information regarding *F. ater* and its relationship with heavy metals in Gingoog City, Philippines, particularly in the river areas. Considering their status as heavy metal accumulators, *F. ater* could be utilized as a potential biomonitor of heavy metal contamination, particularly since these gastropods are known to accumulate heavy metals (Baharuddin et al., 2023; Corrias et al., 2020; Yap et al., 2022).

The Odiongan River and Anakan River holds significant importance as a vital water route for local maritime activities, with its flow influenced by both natural factors and human activities, which could pose harm to aquatic organisms. *F. ater* snails within the area are used for human consumption and sold in markets in Gingoog City.

Objective of the study

This research aims to determine the population, describe the external morphology, and assess Cadmium and Lead levels in *F. ater*. By using *F. ater* snails as bioindicators, the study also seeks to compare the chemical accumulation and population, the chemical accumulation and morphology, as well as the population and morphology of *F. ater* within the river areas.

1.1. Scope and Limitations

The scope of the study involves determining the population of *F. ater* snails using quadrat sampling, assess their morphology (shell length, width, and wet weight), and analyze heavy metal levels (Cadmium and Lead). It compares population, morphology, and chemical accumulation in Barangay Odiongan and Barangay Anakan, Gingoog City, during the wet season. Limitations include a focus on specific locations and the specification of genitalia in samples.

1.2. Significance of the Study

Locally, this research holds importance as the community consumes these snails. This research contributes to science and environmental studies by enhancing understanding of chemical accumulation's impact on biodiversity, especially in *F. ater* snails. It raises awareness about pollution effects, guides conservation efforts, and serves as a foundation for future research on chemical pollutants and brackish water biodiversity.

2. Methodology

2.1. Protocol Entry

The researchers obtained permits from the local government units of Barangay Odiongan and Barangay Anakan, Gingoog City, for the conduct of the study. Additionally, a Gratuitous permit was acquired from DENR Region X for the collection of *F. ater* snails in the area.

2.2. Sampling Area

The sampling locations were within the Odiongan river in Barangay Odiongan and the Anakan river in Barangay Anakan, Gingoog City. Sampling Site 1 represents the Odiongan river, with coordinates at 8°50'47.3"N 125°09'52.1"E, while

Sampling Site 2 represents the Anakan river, with coordinates at 8°50'48.6"N 125°09'08.5"E. Sampling Site 1 experiences more disturbance and heightened pollutant exposure due to increased human-induced impacts on the river close to residential areas, prompting concerns about contamination from housing, industries, and the effects of climate change (Abdel-Satar et al., 2017). Conversely, Sampling Site 2 shows limited human-induced activities as it is not situated near residential areas, making it less disturbed. Researchers exclusively assess the mollusk population density within a 50-meter radius surrounding the sampling site.

Figure 1 Brgy. Odiongan Coordinates (Screenshot from Google Maps**)**	**Figure 2** Brgy. Anakan Coordinates (Screenshot from Google Maps)

2.3. Collection of Samples (Agustina et al., 2018; Harman & Berg, 1971)

In conducting the collection of samples, each location was allocated with three (3) quadrat sampling plots measuring 1m x 1m, systematically designated with a distance of 3 meters per quadrat. The collection of snail samples was done by diving down to the bottom of the waters. Subsequently, two containers were designated for each site, and initially, the snails underwent relocation to a separate container containing distilled water to facilitate excretion overnight before being transported to the laboratory for subsequent analysis procedures (Agustina et al., 2018). During the collection of samples, the snails were collected using the hand-scooping method, employing a non-destructive approach to mitigate harm to *F. ater*, adhering to the protocols outlined in the earlier study by Harman and Berg (1971) conducted in both locations within Gingoog City. The number of samples was determined by the application of the quadrat sampling technique, as the collection is confined to the designated quadrat area.

2.4. Identification (Linnaeus, 1758)

The researchers followed and utilized the key taxonomic classification of the sample by Linnaeus (1758) for identification. However, further examination was conducted by the Department of Agriculture in Gingoog City.

2.5. Preparation for Measuring the Population and Abundance of *F. ater*

2.5.1. Assessing the population dynamics of F. ater snails during the wet season

Given the expansive and diverse nature of marine ecosystems, obtaining precise population figures for the *F. ater* snail was undertaken. Researchers adopted the direct counting method to approximate the snail population, involving the physical enumeration of sampled *F. ater* snails within the area of interest. To enhance accuracy, a quadrat survey approach was implemented, wherein one (1) 1m x 1m quadrat was positioned at each site, aligned parallel to the river. Subsequently, researchers tallied the snails observed within each quadrat. The recorded counts served as the foundation for estimating the *F. ater* snail population (Agustina et al., 2019).

Figure 3 Quadrat-Placing in Brgy. Odiongan

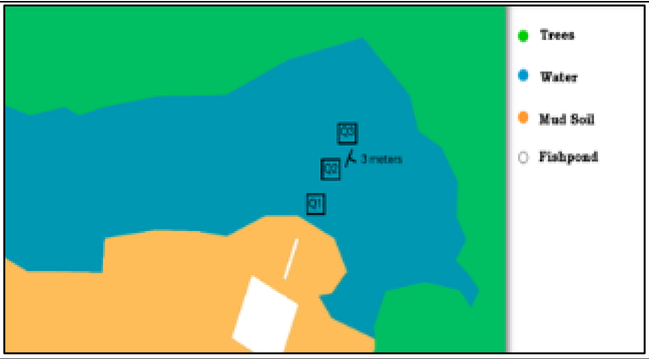

Figure 4 Quadrat-Placing in Brgy. Anakan

2.6. **Evaluating the Abundance and Population of *F. ater* snails during the wet season**

The data collected from each of the three (3) quadrats per site were measured and presented in the form of tables and graphs for descriptive discussion. Population referred to the number of individuals per unit area or volume (Campbell et al., 2004). The individual population density level was analyzed using the following formula (Conway & Adams, 2021):

$$D = Ni/A$$

where D is the number of individuals per unit area (Individual/m^2), Ni the number of individuals in quadratic transect, and A is the area of square transect (m^2).

2.7. Data Analysis

The population density of the Banisil (*Faunus ater*) in Barangay Odiongan and Barangay Anakan were calculated using the formula suggested by Conway & Adams (2021):

$$D = Ni/A$$

2.8. Preparation for Measuring the Physical Morphometric Assessment of *F. ater* (Baharuddin et al., 2023)

2.8.1. Width of the external shell of the F. ater

The researchers assessed the width of the widest part of *F. ater's* shell using a transparent ruler. The transparency of the ruler facilitated a clear view of the snail's shell, ensuring accurate alignment for measurement. The data were recorded in millimeters (mm). The longest mean width of the snail's outer shell per 1m x 1m quadrat plot was recorded in the table as the average width per quadrat.

2.8.2. Length of the external shell of the F. ater

The researchers calculated the average length of the snail by placing each individual on a flat surface and measuring the length of its shell using a transparent ruler. The data were recorded in millimeters (mm). The longest mean length of the snail's outer shell per 1m x 1m quadrat plot was recorded in the table as the average length per quadrat.

2.8.3. Wet Weight of the F. ater

After the collection of the samples, the researchers then carried the samples in-house for measurement. Each of the snails was carefully removed from the container and placed gently on the surface of the digital weighing scale. The weighing instrument was calibrated first to ensure accuracy and eliminate any potential tare weight errors. The tare button was pressed to reset the scale to zero, ensuring that only the wet weight of the snail was recorded. The data were recorded in grams (g). The average wet weight of the *F. ater* per 1m x 1m quadrat plot was recorded in the table as the average wet weight per quadrat.

2.9. Data Analysis

The collected data from the Morphological Characteristics (Length, width, and wet weight) of Banisil (*Faunus ater*) in Brgy. Odiongan and Brgy. Anakan were organized following the table by Baharuddin et al. (2023).

2.9.1. Procedure/Method for Chemical Accumulation Testing

The analysis of heavy metals in the food sample involved the use of Atomic Absorption Spectroscopy (AAS), as stated by the analytical report from the F.A.S.T Laboratory. This technique was employed to determine the concentration of specific heavy metals present in the snail samples. Reference used by the Laboratory is the Official Method of Analysis of AOAC International, 21st ed. (AOAC International, 2019)

2.9.2. Laboratory Analysis

The analysis of heavy metals in the *F. ater* snails was conducted at the F.A.S.T. Laboratory in Cagayan de Oro City. The study only used 200 grams of the soft tissue of *F. ater* for the chemical analysis, as requested by the Laboratory.

2.9.3. Standard Index

Table 1 Tolerances Levels for Cadmium (Cd) and Lead (Pb) in Molluscan Shellfish by NSSP in 2007

Heavy Metal	Dietary Standards (µg/g)	Interpretation	Standard Reference
Cadmium (Cd)	>4	Above Tolerance Limit	FDA Guidance Document
	<4	Below Tolerance Limit	
Lead (Pb)	>1.7	Above Tolerance Limit	FDA Guidance Document
	<1.7	Below Tolerance Limit	

US FDA/CFSAN & ISSC - In Guide for the Control of Molluscan Shellfish 2007—Section IV. Guidance Documents. Chapter II.

2.10. Data Analysis

The collected data from the analysis result of the heavy metals present in Banisil (*Faunus ater*) was organized in a table suggested by Baharuddin et al. (2023). Additionally, the analysis result was adhered to the standard index for both heavy metals Cadmium (Cd) and Lead (Pb) from the United States Food and Drug Administration (USFDA).

The standard value for the tolerance level of heavy metal substances from the US FDA was converted from parts per million (ppm) to micrograms per gram (µg/g) (Kapranov et al., 2021).

2.10.1. Comparing the Chemical Accumulation and Population of F. ater

The data gathered concerning the accumulation of heavy metals and the population of *F. ater*, the study explicitly addressed this comparison in the discussion section. The study's findings provide valuable insights on the potential effects of heavy metal pollution on the population of *F. ater*.

2.10.2. Comparing the Chemical Accumulation and Morphology of F. ater

On the comparison of chemical accumulation and morphology of *F. ater*, the study argued this aspect in the discussion section. The study provided insights into how chemical accumulation relates to the physical characteristics of *F. ater* in different locations.

2.10.3. Comparing the Population and Morphology of F. ater

Regarding the population and morphology of *F. ater*, the study compared the population and morphology of *F. ater* in the discussion. The findings of the study provide important insights into the potential influence of morphology on the Population of *F. ater*.

2.10.4. Photography

To ensure that the findings were reliable, reproducible, and impactful, important processes while undertaking the research were documented. The processes from preparing the materials to conducting the study, where researchers began to plot the quadrats, dived down to the bottom of the waters, and collected the sample, were documented. Furthermore, the proper execution of measuring the morphological characteristics of the snail, the transportation of the sample to the laboratory, and other important documents were also photographed and documented.

3. Results and discussion

Table 2 presents the data on the population density of *F. ater* within quadrats sampled in Barangay Odiongan and Barangay Anakan, Gingoog City.

As shown in the table, Barangay Odiongan Quadrat 3 stands out with the highest population density, recording 116 individuals. In contrast, Quadrat 2 exhibits the lowest population density, with only 71 individuals observed. In Barangay Anakan, Quadrat 3 stands out with the highest population density, recording 136 individuals. In contrast, Quadrat 1 exhibits the lowest population density, with only 83 individuals observed.

Overall, this result shows that Barangay Anakan exhibit the highest total Population density (N=316) compared to Barangay Odiongan (N=263). These findings highlight variations in population distribution within sampling areas.

Table 2 Population Density of Banisil (*F. ater*) in Barangay Odiongan and Barangay Anakan

Quadrat No.	Population Density	
	Brgy. Odiongan	**Brgy. Anakan**
1	76	83
2	71	97
3	116	136
Total (N)	263	316

Table 3 presents the average measurements of various morphological characteristics of *F. ater*, including shell length (mm), shell width (mm), and wet weight (g) per quadrat, collected from Barangay Odiongan and Barangay Anakan, Gingoog City.

The table indicates that in Barangay Odiongan, Quadrat 3 has the highest average measurements for both shell length and width of *F. ater*, at 58.69 mm and 12.72 mm, respectively. In terms of the wet weight, Quadrat 2 shows the highest average value at 8.55 g. In contrast, Quadrat 1 displays the lowest average values for shell length, shell width, and wet weight measuring 54.46 mm, 11.05 mm, and 7.68 g, respectively. Meanwhile, in Barangay Anakan, Quadrat 2 shows the highest average values for both shell length and wet weight of *F. ater*, measuring 80.09 mm and 10.54 g, respectively. Quadrat 3 has the highest average value for the width of the shell, at 15.61 mm. However, Quadrat 3 displays the lowest average values for shell length and wet weight, at 77.40 mm and 8.60 g, respectively. Quadrat 1 exhibits the lowest average value for the width of the shell, measuring 14.58 mm.

Table 3 Mean Value of the Morphological Characteristics (Length, width, and wet weight) of Banisil (*F. ater*) in Barangay Odiongan and Barangay Anakan (Baharuddin et al., 2023)

Quadrat No.	Length of the shell (mm)		Width of the shell (mm)		Wet Weight of *F. ater* (g)	
	Odiongan	**Anakan**	**Odiongan**	**Anakan**	**Odiongan**	**Anakan**
1	54.46	78.89	11.05	14.58	7.68	9.90
2	55.46	80.09	11.62	15.36	8.55	10.54
3	58.69	77.40	12.72	15.61	7.81	8.60
Total	56.20	78.79	11.79	15.18	8.01	9.68

Overall, the data reveals that in terms of morphological characteristics of *F. ater*, Barangay Odiongan exhibits higher averages compared to Barangay Anakan. Specifically, Quadrat 3 in Barangay Odiongan demonstrates the highest average measurements for shell length and width, while Quadrat 2 in the same barangay has the highest average wet weight. Conversely, in Barangay Anakan, Quadrat 2 showcases the highest average values for shell length and wet weight, while Quadrat 3 records the highest average shell width.

Table 4 shows the levels of the heavy metals Cadmium (Cd) and Lead (Pb) detected in the soft tissue of *F. ater* collected from two sampling locations, Barangay Odiongan and Barangay Anakan, in Gingoog City. The table additionally indicates the standard index reference as FDA Guidance Document.

The data revealed that the concentration of Cd at both sampling sites is below the reporting limit of 0.01 µg/g. The "tt" indicates that there is no Cd detected (Agustina et al., 2019). However, both areas exhibit a concentration of Pb. Barangay Odiongan exhibits the highest level of Pb, with a concentration of 0.28 µg/g compared to Barangay Anakan, which has the lowest level of Pb, with a concentration of 0.27 µg/g.

Overall, both of the sampling area exhibits no presence of Cd. However, there is a presence of Pb in both sampling areas, Barangay Odiongan exhibits a higher concentration of Pb with only a slight difference compared to Barangay Anakan, and both the concentrations of Cd and Pb in both areas are below the tolerance limit set by the US FDA.

Table 4 Levels of Heavy Metal Cadmium (Cd) and Lead (Pb) present in Banisil (*F. ater*) in Barangay Odiongan and Barangay Anakan (Baharuddin et al., 2023)

Heavy Metals	**Level of Heavy Metal Content (µg/g)**		**Reference (Standard Index)**
	Odiongan	**Anakan**	
Cadmium	tt	tt	FDA Guidance Document
Lead	0.28	0.27	FDA Guidance Document

*Reporting limit of Cadmium = 0.01 mg/kg = 0.1 µg/g

* tt: not detected

The findings of the study suggested varying results in the population, morphology, and chemical accumulation of *F. ater* in two locations, Barangay Odiongan and Barangay Anakan, Gingoog City.

The study found that population density in Barangay Odiongan varies across different quadrats, with Quadrat 3 having the highest density and Quadrat 2 the lowest (see Table 2). This variation is likely due to residential households nearby, leading to more people collecting *F. ater* in shallow parts. Quadrat 3, being farther from residential areas, experiences less human activity, explaining its higher density. Areas near human settlements typically offer fewer resources due to disturbances, while less disturbed areas are more suitable for some organisms (Jamil, 2022; Begon et al., 2020). Similarly, in Barangay Anakan, Quadrat 3 has the highest density and Quadrat 1 the lowest. This is due to mollusk collection in shallow areas. Quadrat 3, in the deepest water, faces less collection, leading to higher density. Ecosystems near human activity are more disturbed, providing fewer resources, while distant areas experience less disturbance, favoring certain organisms (Jamil, 2022; Begon et al., 2020).

For the morphology of *F. ater* (see Table 3), Quadrat 3 in Barangay Odiongan exhibits the highest mean values for both shell length and width of *F. ater*, measuring 58.69 mm and 12.72 mm, respectively. However, Quadrat 2 records the highest mean value for the wet weight of *F. ater*, at 8.55 g. Conversely, Quadrat 1 displays the lowest mean values for shell length, shell width, and wet weight of *F. ater*, measuring 54.46 mm, 11.05 mm, and 7.68 g, respectively. In Barangay Anakan, Quadrat 2 exhibits the highest mean values for both shell length and wet weight of *F. ater*, measuring 80.09 mm and 10.54 g, respectively. However, Quadrat 3 records the highest mean value for the width of *F. ater* shell, at 15.61 mm. Conversely, Quadrat 3 displays the lowest mean values for shell length and wet weight of *F. ater*, measuring 77.40 mm and 8.60 g, respectively. Quadrat 1 shows the lowest mean value for the width of *F. ater* shell, at 14.58 mm. There are variations in the mean values between the two sampling locations. Barangay Anakan exhibits the highest total mean value of the morphological measurements. According to Baharuddin et al., (2023) the average length of *F. ater* shell ranges from around 30 mm to 70 mm, the average width of *F. ater* shell ranges from around 11 mm to 15 mm, and the average wet weight of the *F. ater* ranges from around 7 g to 17 g. Comparing these findings with the total mean values from the results, there is only a slight deviation from the literature.

In the chemical accumulation (see Table 4), levels heavy metal cadmium (Cd) in both sampling sites shows the similarity in the absence of Cd. The "tt" indicated that there are no Cd detected (Agustina et al., 2019). In the accumulation of heavy metal Lead (Pb), the area with highest concentration with 0.28 µg/g was in Barangay Odiongan River, followed by the area with lowest concentration with 0.27 µg/g in Barangay Anakan. In the study of Agustina et al. (2019), it was stated that there were many domestic wastes that was visually observable in their sampling site and due to its location close to agricultural and residential area, the wastes produced by the anthropogenic activities were directly released to the river. Similarly, the sampling site along the Odiongan River, situated near residential areas, leads to the release of domestic waste into the river. Generally, household waste consists of solid items (like peels, vegetables, plastics, cans, bottles, etc.) and liquid waste. These facts contribute to the presence of Pb in the water and thus can be accumulated by nearby organisms, such as the *F. ater* (Augustina et al., 2019). This heavy metal is known to be harmful. Pb belongs to a group of metals that are toxic and harmful to the life of living organism (Baharuddin et al., 2023; Augustina et al., 2019). Conversely, the heavy metal accumulation in Barangay Anakan with 0.27 µg/g of Pb which is the lowest, where Cd is not also detected. The lower presence of lead in *F. ater* within less disturbed river areas results from a combination of natural processes, reduced anthropogenic impact, and ecological interactions (Agustina et al., 2019). As per FDA Guidance Document (see Table 1), concentrations below 4 µg/g for Cd and concentration below 1.7 µg/g for Pb are considered safe. According to the study's findings, Cd was absent in both sampling sites, and Pb concentrations measured at 0.28 µg/g and 0.27 µg/g in the two sampling sites respectively, fall within safe levels.

As for the comparison of chemical accumulation and Population, the study found that in both Barangay Odiongan and Barangay Anakan, the presence of Cadmium (Cd) was not detected in the soft tissues of *F. ater*. This lack of detectable Cd levels is a positive finding that there is less Cd heavy metal pollution in the area (Briffa, 2020). The fact that Cd was not detected in the sampled snails suggests a lower risk of Cd contamination in the water and sediment of both barangays. The differences in population abundance can be attributed to variations in pollution levels and residential proximity (Nwoko, 2022). If heavy metals are not detected, it implies a higher population abundance, and the absence of Cd indicates reduced human activities (Genchi et al.,2020). In Barangay Odiongan, *F. ater* had a Lead (Pb) concentration of 0.28 µg/g, slightly higher than Barangay Anakan's 0.27 µg/g. Both locations show Pb contamination, with Odiongan having higher levels. Pb poses threats to aquatic life and human health if the snails are consumed (Agustina et al., 2019). Barangay Odiongan had a lower population abundance of *F. ater* due to human disturbances, as this area is near households with high pollution levels (Min et al., 2022). Pb accumulation can reduce population density, impair growth, and increase mortality rates (Agustina et al., 2019).

For the comparison of chemical accumulation and morphology of *F. ater*, Barangay Odiongan shows a Lead (Pb) concentration of 0.28 µg/g and no detected Cadmium (Cd), with a morphology of 56.20 mm in length, 11.79 mm in width, and 8.01 g in wet weight. This Pb concentration aligns with findings by Agustina et al. (2019), suggesting that domestic waste may contribute to Pb accumulation in nearby organisms. The morphology of *F. ater* in Barangay Odiongan, which is lower compared to Barangay Anakan, indicates that Pb levels may significantly affect morphology. However, the absence of Cd and the maintained size may suggest a relatively healthy ecosystem. In Barangay Anakan, Pb concentration is 0.27 µg/g, with morphology measuring 78.79 mm in length, 15.18 mm in width, and 9.68 g in wet weight. The lower Pb levels and absence of Cd suggest less impact from pollution, supporting stable growth conditions and favorable environments (Baharuddin et al., 2023; Mendoza et al., 2023).

In the comparison of *F. ater* morphology and population, Barangay Odiongan shows reduced abundance due to human disturbance and overharvesting, which stress the population and lead to premature spawning (Rahayu et al., 2023). Overcollection without size consideration has further declined wild populations. Supported by Dewi et al. (2022) emphasized that increased coastal activity and use of the area as a landfill contribute to higher waste levels and population impacts. In Barangay Odiongan, the average shell length has longer length with 56.20 mm. Shell have a width range of 11. 79. The mean total wet weight of *F. ater* was documented as 8.01 g, a figure closely resembling the average size of *F. ater* as indicated by Baharuddin et al. (2023). Meanwhile, In Barangay Anakan, there is less disturbance because of its far distance from residence and less population stress. *F. ater* seen at the featured location in Barangay Anakan have a higher population of 316 than Barangay Odiongan, which has only 263. Morphologically with those from Barangay Anakan in their larger size, more slender shape, apparent absence of predation scar or encrustation, and with less eroded early whorls (Lup & Sow-Yan, 2019). In Barangay Anakan, the average shell length has the longest length at 78.79 mm. Shell has a width range of 15.18, which is normal. The average total wet weight of *F. ater* was the highest recorded at 9.68g, which is closely align to the average measurements according to Baharuddin et al. (2023).

In adherence to the Standard Tolerance Level set by the United States Food and Drug Administration for the concentration of heavy metals Cd and Pb in *F. ater*, both heavy metals in both barangays exhibit levels below the tolerance limit. This signifies that *F. ater* at all sampling areas is safe from harmful heavy metals (Cd and Pb) as well as its habitat, similar to the results of Baharuddin et al. (2023).

In contrast to the study by Kapranov et al. (2021), where results suggest that the areas are likely contaminated with heavy metals such as Cd and Pb, the sampling area of the study exhibits high pollution of heavy metals due to contamination with hazardous pollutants such as pesticides and heavy metals from anthropogenic sources.

4. Conclusion

The study concluded that there are differences in terms of population density, morphology, and the levels of heavy metals present in both sampling sites, Barangay Odiongan and Barangay Anakan, Gingoog City. The observed differences are linked to different environmental conditions, including increased disturbance due to residential waste, human activities in the area, and the presence of heavy metals, all of which affected the population dynamics and morphology of *F. ater*. The findings align with previous research indicating the impact of heavy metals on *F. ater*'s morphological characteristics. Moreover, this study emphasizes the level of heavy metals the snail accumulated in comparing the morphology and population of the snail. Additionally, Barangay Anakan shows more abundant, has the highest mean value in terms of its morphological characteristics, and has less level of heavy metal compared to Barangay Odiongan. Adhering to Food and Drug Administration (US FDA/CFSAN & ISSC) standards indicates that Cd and Pb concentrations in both barangays are below tolerance limits, suggesting *F. ater* at all sampling areas is safe from harmful heavy metals (Cd and Pb) as well as its habitat. The study underscores the ecological implications of residential pollution, as seen in the lower *F. ater* abundance in areas with higher heavy metal level. Overall, these findings contribute to our understanding of how heavy metals such as Lead shape the dynamics of *F. ater*'s populations and morphological characteristics in distinct marine habitats.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors, including the corresponding authors, confirm that they have no conflicts of interest pertaining to the publication of this paper.

Statement of ethical approval

The present research involves the use of animals. The researchers obtained permits from the local government units of Barangay Odiongan and Barangay Anakan, Gingoog City, for the conduct of the study. Additionally, a Gratuitous Permit was acquired from DENR Region X for the collection of *F. ater* snails in the area. All procedures adhered to the ethical guidelines set forth by the Animal Welfare Act (Republic Act No. 9147).

Department of Environment and Natural Resources (DENR). Wildlife Gratuitous Permit No. R10-2024-100, Region X; issued June 6, 2024, for the collection of *F. ater* snails.

References

[1] Abdel-Satar AM, Ali MH, Goher ME. Indices of water quality and metal pollution of Nile River, Egypt. The Egyptian Journal of Aquatic Research [Internet]. 2017 Mar 1;43(1):21–9. Available from: https://doi.org/10.1016/j.ejar.2016.12.006

[2] Agustina R, Sarong MA, Yulianda F. Accumulation of Heavy Metal in *Faunus ater* and its Population Structure in Bale River Lhoknga Aceh Besar Indonesia. Pakistan Journal of Life & Social Sciences. 2018 May 1;16(2).

[3] Agustina R, Sarong MA, Yulianda F. Analysis of Lead (Pb) and Zinc (Zn) Content in Sediments and *Faunus ater* at Bale Lhoknga Aceh Besar District. InJournal of Physics: Conference Series 2019 Sep 1 (Vol. 1232, No. 1, p. 012007). IOP Publishing.

[4] AOAC International. Official methods of analysis of the Association of Official Analytical Chemists. Association of official analytical chemists; 1970.

[5] Baharuddin N, Mustaffa NK, Ong MC. *Faunus ater* (Mollusca, Gastropoda) as a potential bioindicator contamination by heavy metals. InIOP Conference Series: Earth and Environmental Science 2023 Oct 1 (Vol. 1251, No. 1, p. 012006). IOP Publishing.

[6] Begon M, Townsend CR. Ecology: from individuals to ecosystems. John Wiley & Sons; 2021 Feb 1.

[7] Briffa J, Sinagra E, Blundell R. Heavy metal pollution in the environment and their toxicological effects on humans. Heliyon. 2020 Sep 1;6(9)

[8] Bureau of Fisheries and Aquatic Resources. Monthly NCR - Regional Consolidated Price Monitoring Report (RCPMR). Department of Agriculture; 2022 April 4-30. Available from: https://www.bfar.da.gov.ph/wp-content/uploads/2022/05/AprilMonthlyRetail2022.pdf

[9] Campbell A, Yeung CW, Dovey G, Zhang Z. Population biology of the Pacific geoduck clam, Panopea abrupta, in experimental plots, southern British Columbia, Canada. Journal of Shellfish Research. 2004 Dec 1;23(3):661-74.

[10] Conway TL, Adams MA. Population density. In: Springer eBooks [Internet]. 2021. p. 1–2. Available from: https://doi.org/10.1007/978-3-319-69909-7_2209-2

[11] Corrias F, Atzei A, Addis P, Secci M, Russo M, Angioni A. Integrated environmental evaluation of heavy metals and metalloids bioaccumulation in invertebrates and seaweeds from different marine coastal areas of sardinia, mediterranean sea. Environmental Pollution. 2020 Nov 1;266:115048.

[12] Das RR, Jeevamani JJ, Sankar R, Kumar DS, Krishnan P, Ramachandran P, Ramachandran R. Limited distribution of Devil snail *Faunus ater* (Linnaeus, 1758) in tropical mangrove habitats of India.

[13] de Montfort PD. Conchyliologie systématique, et classification méthodique des coquilles... Par Denys de Montfort... (No Title). 1808. Available from: https://doi.org/10.5962/bhl.title.10571

[14] Department of Environment and Natural Resources (DENR). Wildlife Gratuitous Permit No. R10-2024-100, Region X; issued June 6, 2024, for the collection of *F. ater* snails.

[15] Dewi E, Agustina R, Sarong MA, Yulianda F, Suhendrayatna S. Histopathological analysis of *Faunus ater* ovotestis in Bale and Reuleueng rivers, Aceh Besar Regency, Aceh Province Indonesia. Open Access Macedonian Journal of Medical Sciences [Internet]. 2022 Jul 17;10(A):1273–7. Available from: https://doi.org/10.3889/oamjms.2022.9878

[16] Genchi G, Sinicropi MS, Lauria G, Carocci A, Catalano A. The effects of cadmium toxicity. International journal of environmental research and public health. 2020 Jun;17(11):3782.

[17] Greķe K. New observations and distribution on *Faunus ater* (Linnaeus, 1758) (Caenogastropoda: Pachychilidae) in the Papuan Region. Acta Biologica Universitatis Daugavpiliensis [Internet]. 2023 Dec 30;23(2). Available from: https://doi.org/10.59893/abud.23(2).005

[18] Harman WN, Berg CO. The freshwater snails of central New York with illustrated keys to the genera and species. Cornell University Agricultural Experiment Station in Entomology. Ithaca, NY. 1971.

[19] Jamil A, Zubair M, Manzoor SA, Wali Muhammad M, Yasin G, Ur Rahman S, Alzain MN, Alqarawi AA, Abd_Allah EF. Impact of human settlements on diversity of range vegetation. Sustainability. 2022 Jan 4;14(1):519.

[20] Kapranov SV, Karavantseva NV, Bobko NI, Ryabushko VI, Kapranova LL. Element contents in three commercially important edible mollusks harvested off the southwestern coast of Crimea (Black Sea) and assessment of human health risks from their consumption. Foods. 2021 Sep 29;10(10):2313.

[21] Linnaeus C. Systema Naturae per regna tria naturae, secundum classes, ordines, genera, species; cum characteribus, differentiis, synonymis, locis. apud JB Delamolliere; 1789.

[22] Lup LW, Sow-yan C. A population of the black-snail, *Faunus ater*, in eastern Singapore. Singapore Biodiversity Records. 2019 May 31;2019:63-4.

[23] Maret W. The metals in the biological periodic system of the elements: concepts and conjectures. International journal of molecular sciences. 2016 Jan 5;17(1):66.

[24] Mari. Caresheet: Black devil snail | *Faunus ater* - Aquariadise [Internet]. Aquariadise. 2020. Available from: https://www.aquariadise.com/caresheet-faunus-ater/

[25] Mendoza DM, Aquino MG, Mendoza GC. Shell Dimension-Weight Relationship and Condition Index of the Invasive Mussel Mytella strigata in Sasmuan, Pampanga, Philippines.

[26] Michael. Black Devil Snail – Detailed guide: Care, diet and breeding - Shrimp and Snail Breeder [Internet]. Shrimp and Snail Breeder. 2023. Available from: https://aquariumbreeder.com/black-devil-snail-detailed-guide-care-diet-and-breeding/

[27] Min F, Wang J, Liu X, Yuan Y, Guo Y, Zhu K, Chai Z, Zhang Y, Li S. Environmental factors affecting freshwater snail intermediate hosts in Shenzhen and Adjacent region, South China. Tropical Medicine and Infectious Disease. 2022 Dec 9;7(12):426.

[28] Nwoko OE, Kalinda C, Manyangadze T, Chimbari MJ. Species diversity, distribution, and abundance of freshwater snails in KwaZulu-Natal, South Africa. Water. 2022 Jul 21;14(14):2267.

[29] Parmar TK, Rawtani D, Agrawal YK. Bioindicators: the natural indicator of environmental pollution. Frontiers in Life Science 9 (2): 110–118. DOI. 2016;10(21553769.2016):1162753.

[30] Rahayu SR, Muchlisin ZA, Fadli N, Razi NM, Ramadhaniaty M, Handayani LS, Maulida S, Nur FM, Nurlaili N, Siti-Azizah MN. Morphometric and genetic variations of four dominant species of snappers (Lutjanidae) harvested from the Northern Coast of Aceh waters, Indonesia. Zoologischer Anzeiger. 2023 Mar 1;303:26-32.

[31] USFDA/CFSAN ISSC. 04 Action levels, tolerances and guidance levels for poisonous or deleterious substances in seafood. In: Guide for the Control of Molluscan Shellfish 2007—Section IV. Guidance documents. Chapter II. Growing areas. Silver Spring (MD): U.S. Food and Drug Administration; 2007. p. 280. Available from: https://www.issc.org/Data/Sites/1/media/2007%20nssp%20guide/section%20iv%20chap%20ii%20.04.pdf

[32] Yap CK, Kumar K, Mnd H, Cheng WH, Syazwan WM, Azrizal-Wahid N, et al. Zinc Concentrations in Different Parts of the Gastropod, *Faunus ater*, Collected from Intertidal Areas of Peninsular Malaysia. Journal of Biomedical Research & Environmental Sciences [Internet]. 2022 Oct 1;3(10):1224–8. Available from: https://doi.org/10.37871/jbres1581

[33] Yap CK, Yaacob A, Ismail MS. Distributions of Ni and Fe in the different tissues of snail *Faunus ater* and bivalve Psammotaea elongata. Int J Hydro. 2023;7(3):137-41.