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Abundance and Biomass of Tikam (*Pyganodon cataracta*) in the Rice Paddies of Maligcong, Bontoc, Mountain Province

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ABSTRACT

This study determined the differences in abundance and biomass of freshwater Tikam (*Pyganodon cataracta*) in Maligcong, Bontoc, Mountain Province, and assessed the soil and water quality between two study sites: (1) spring-fed rice paddies and (2) paddies affected by agricultural runoff and domestic wastewater. Mussels were collected, counted, measured, and analyzed for wet and dry biomass. Mean abundance, biomass, and shell growth of *P. cataracta* were significantly higher in spring-fed paddies than in runoff-affected paddies. In particular, wet biomass in spring-fed paddies was more than twice that of the polluted site, while mussels there also exhibited larger average shell length and width. Physico-chemical qualities revealed significant differences in soil pH, organic matter content, water temperature, and dissolved oxygen, while water pH showed no significant difference between sites. These findings indicate that higher temperatures, lower dissolved oxygen, and altered soil characteristics in runoff-affected paddies negatively affect mussel populations. The results underscore that *P. cataracta* can serve as a useful bioindicator of paddy ecosystem health. Beyond ecological significance, the reduced abundance of Tikam in polluted paddies also implies a decline in a traditional food source, highlighting the need for integrated management of rice agroecosystems for both biodiversity conservation and community food security.

Keywords: *Pyganodon cataracta*; Physicochemical; Abundance; Biomass; Rice Paddies; Bontoc

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1. Introduction

Rice agroecosystems, particularly flooded paddies, are not only central to global food production but also play an underappreciated role in sustaining biodiversity. These agricultural landscapes, cultivated for thousands of years, function as temporary wetlands and ecological surrogates for natural wetland systems that are rapidly disappearing under land-use change and development pressures. Within their matrix of shallow waters and irrigation networks, rice paddies provide habitats for a diverse array of aquatic species, including fish, amphibians, mollusks, crustaceans, insects, and aquatic plants. The ecological role of rice paddies in conserving biodiversity has been documented in various regions, where they serve as “novel ecosystems” supporting both endemic and migratory species^[1,2].

For rural and low-income communities, rice paddies also represent important socioecological systems. In addition to rice grain, which provides the caloric foundation of diets, aquatic organisms harvested from fields and irrigation canals supply critical proteins, minerals, and fatty acids. In Southeast Asia, for example, fish, snails, mussels, frogs, and crabs gathered from paddies are often consumed directly, dried, or sold in local markets, thereby contributing both to household nutrition and to livelihood resilience. The traditional practice of harvesting aquatic species from rice fields illustrates the long-standing integration of farming, nutrition, and culture in these agroecosystems^[3,4]. Recent advances in integrated rice–aquaculture systems further highlight the capacity of paddies to contribute simultaneously to food security and biodiversity conservation. These systems deliberately manage water quality and crop–fish interactions to enhance productivity and ecological health, reinforcing the value of rice fields as multifunctional landscapes.

Despite their ecological and socioeconomic importance, rice agroecosystems are increasingly vulnerable to the global biodiversity crisis. Scientific assessments have consistently reported alarming increases in threatened species and accelerated rates of extinction, with habitat change identified as a leading driver^[5–7]. Habitat fragmentation reduces the connectivity of ecosystems, diminishes dispersal pathways, and leads to smaller, less viable populations^[8,9]. Even in landscapes that appear intact, degradation frequently occurs through cumulative stressors such as chemical

pollution from fertilizers, pesticides, and domestic wastewater. These factors undermine the quality of aquatic habitats, reduce dissolved oxygen, alter soil chemistry, and shift nutrient balances, thereby reshaping community composition and ecosystem function^[10]. The dual pressures of agricultural intensification and climate change further amplify risks, calling for closer attention to how rice paddies can continue to sustain biodiversity under changing conditions.

The rapid acceleration of the global biodiversity crisis, marked by alarming increases in threatened species and extinctions, continues to be a profound concern. The majority of this loss is a direct or indirect consequence of human activities, with habitat change being the leading primary driver^[5]. For instance, habitat loss and fragmentation diminish the total area and connectivity of available habitats, resulting in smaller overall population sizes, altered species distributions, and decreased capacity for dispersal and colonization^[11]. Even without significant physical alteration, habitat degradation takes place, frequently driven by insidious, cumulative factors like chemical pollution from fertilizers and pesticides^[12], which ultimately reduce the quantity and quality of habitat for many species.

Among the aquatic organisms inhabiting rice paddies, freshwater mussels (Order Unionida) are particularly significant. These bivalves are long-lived benthic filter feeders that draw in large volumes of water, removing suspended particles, algae, and bacteria, and releasing clarified water back into the system. In so doing, they enhance water clarity, regulate nutrient cycling, and influence sediment dynamics^[13]. Freshwater mussels also contribute to benthic biomass, serve as prey for fish, birds, and mammals, and provide habitat structure for smaller invertebrates. In many ecosystems, mussels are considered “ecosystem engineers” due to their capacity to modify physical and biological environments. However, their ecological contributions are often overlooked, and populations are globally declining at unprecedented rates. Habitat loss, sedimentation, flow alteration, invasive species, and chronic pollution have placed freshwater mussels among the most imperiled faunal groups worldwide^[13,14].

A unique class of creatures called freshwater mussels (Order Unionida) can be found on the bottom of streams, rivers, ponds, and lakes. The majority of their lives are spent largely buried in the substrate, where they consume water by

drawing it into their siphons, filtering it to extract planktonic food and particulates, and then expelling the cleaned water back into the environment. These "living filters" are critical to the health of our water bodies; they help increase water clarity, regulate nutrient and energy flow by consuming algae and zooplankton, and serve as a food source for a variety of fish, birds, and mammals. They also play a significant structural role in natural ecosystems. Within a water body, mussels frequently make up a substantial portion of the animal biomass and effectively store a massive amount of minerals and nutrients, which they release slowly, influencing local biogeochemical cycles^[15].

The Eastern Floater (*Pyganodon cataracta*), locally known in Mountain Province as Tikam, is one of the unionid species found in agricultural landscapes. This medium-to-large mussel is highly tolerant of a wide range of substrates and water conditions, and is frequently observed in nutrient-rich habitats such as ponds, irrigation canals, and rice paddies^[16]. Despite its tolerance, growth and reproduction in *P. cataracta*, as in other mussels, remain strongly dependent on physicochemical water and soil parameters. Factors such as dissolved oxygen, water temperature, soil pH, and calcium availability directly influence shell formation, tissue growth, and reproductive cycles^[13,14]. Because of these close linkages, mussels serve not only as integral components of aquatic food webs but also as sensitive bioindicators of environmental quality. A decline in mussel abundance or biomass is often an early warning signal of ecosystem degradation.

P. cataracta is known for its wide environmental tolerance and can be found in many different aquatic environments and substrate types, including slow-moving streams, rivers, ponds, and lakes. It is particularly tolerant of deep silt and mud, and often thrives in the nutrient-rich waters typical of man-made habitats like agricultural ponds and rice paddies^[17]. Similar to other mussels, *P. cataracta* extracts calcium carbonate from the aquatic environment to form its shell. The soft body consists of a large muscular foot used for movement, specialized breathing gills, a digestive tract for processing filtered food, and mantle tissue responsible for shell secretion. In reproduction, the male mussel releases sperm into the water, which is drawn in by the female to fertilize the eggs. The fertilized eggs develop into minute larval forms called glochidia, which are then released to attach to

the gills or fins of a host fish (often generalist species like yellow perch or bluegill) to complete their parasitic developmental stage and achieve dispersal^[18].

Globally, freshwater mussels are among the most imperiled faunal groups, with significant declines in both abundance and diversity driven by widespread human activity. The primary stressors include: the fragmentation and alteration of river systems by dams and channeling, habitat loss due to sedimentation from agriculture and urban development, and chronic water pollution from industrial, mining, and urban runoff^[19].

In the Philippine context, however, research on freshwater mussels remains scarce. Most malacological studies in the country have concentrated on marine species, reflecting the economic importance of coastal fisheries and aquaculture. The global biodiversity crisis is primarily driven by habitat fragmentation and degradation. Rice agroecosystems, particularly the high-altitude terraces of the Cordillera, represent "novel ecosystems" that have functioned for millennia as stable wetland surrogates. However, the shift toward agricultural intensification—marked by increased chemical runoff—threatens the capacity of these fields to support sensitive taxa like Unionida. The Cordillera Administrative Region (CAR), despite being home to extensive rice terrace systems recognized globally for their cultural and ecological significance, has received very little attention with respect to freshwater mollusk diversity and ecology^[20]. While global literature extensively documents the decline of North American and European freshwater mussels, the Philippine context remains remarkably understudied. Most national malacological research focuses on commercially lucrative marine species, leaving high-altitude freshwater bivalves like the Tikam largely ignored. There is a critical lack of baseline data regarding how different irrigation sources—specifically mountain springs versus runoff-affected channels—impact mussel biomass in indigenous agroecosystems. This lack of baseline data hinders the ability of researchers and policymakers to assess the role of mussels in local agroecosystems, to monitor population trends, or to design interventions that sustain both biodiversity and food security. Given that communities in Mountain Province continue to utilize mussels as supplementary food sources, there is both ecological and cultural urgency to investigate their status.

This study therefore addresses a critical knowledge

gap by documenting the abundance, biomass, and growth of *Pyganodon cataracta* in the rice paddies of Maligcong, Bontoc, Mountain Province. Specifically, it determines the differences between mussel populations between the two sites, which are a) spring-fed paddies and b) those affected by agricultural runoff and domestic wastewater, and relates these patterns to soil and water physicochemical properties. By establishing this baseline, the research aims to contribute to the broader understanding of how rice agroecosystems function as habitats, how local practices shape aquatic biodiversity, and how traditional food resources can be sustained in the face of environmental change.

2. Materials and Methods

2.1. Study Sites

The study was situated within the terraced rice pad-

dies of Barangay Maligcong, a significant agricultural highland area located in the municipality of Bontoc, Mountain Province (**Figure 1**). Positioned approximately 8.5 km from the municipal center of Bontoc Poblacion, Maligcong occupies a strategic geographic location bounded by Barangay Mainit to the north, Bontoc Central to the south, Tocucan to the east, and Guina-ang to the west. The total land area of the barangay encompasses 1,500 ha, reflecting a diverse ecological landscape characterized by 775 ha of forest land, 510 ha of dedicated agricultural land, and 180 ha of grassland. The residential zones, which serve as the source of the domestic waste mentioned in this study's Site B, occupy a relatively small footprint of 35 ha^[21]. This concentrated residential area adjacent to expansive agricultural land provides a unique environmental gradient for assessing the impact of anthropogenic runoff on the native *P. cataracta* populations.

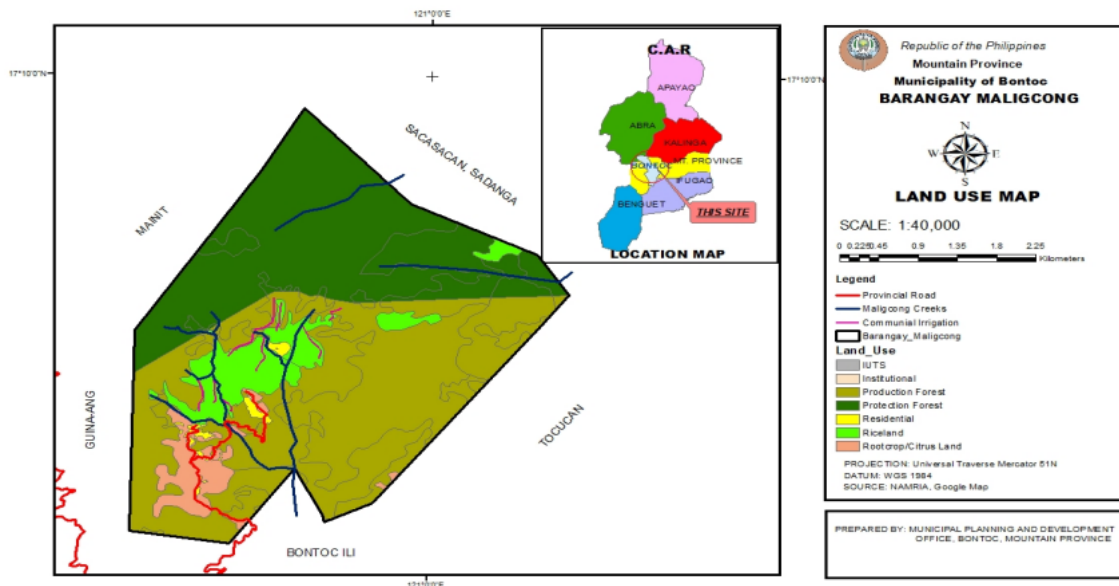


Figure 1. Map of study site in Maligcong, Bontoc, Mountain Province.

The rice terraces of Maligcong are located at elevations of 1,200–1,400 m above sea level and are typically irrigated by perennial mountain springs. The area experiences a temperate–subtropical climate with a pronounced wet season from May to October and a cool dry season from November to March. Rice farming is the dominant livelihood activity, with farmers cultivating at least one to two cropping cycles per year. This environmental setting provides a suitable habitat for freshwater mussels and of-

fers a unique agroecological context for assessing mussel abundance and biomass. Prior to the commencement of field activities, formal administrative approval was secured from the Bontoc Mayor’s Office and the Barangay Maligcong Captain to ensure the study aligned with local community guidelines. Furthermore, all necessary legal permissions and collection permits were obtained to utilize *P. cataracta* for laboratory experiments. The handling, transport, and processing of the specimens strictly followed

approved standard ethical procedures, ensuring minimal environmental impact and the humane treatment of the biological samples during the census and biomass determination phases.

Two representative sites were selected for comparison. Site A consisted of spring-fed rice paddies irrigated directly by perennial mountain springs, ensuring relatively stable water quality and minimal contamination. Site B comprised rice paddies located downslope near residential clusters, receiving irrigation water mixed with agricultural runoff and domestic wastewater.

These sites were chosen to represent contrasting environmental conditions: one minimally impacted by anthropogenic inputs and another highly influenced by human activities. Although farmers shared a common irrigation system, the intensity of fertilizer and herbicide use varied among households. At each site, four permanent 2 m × 2 m quadrats were randomly established to standardize sampling using the transect-quadrat method. This design allowed for a robust comparison of mussel abundance and biomass under two distinct ecological scenarios. In terms of the collection of samples and measurements, data were collected at the same day and time of day.

2.2. Physico-Chemical Measurements

Water and soil parameters were analyzed using a combination of in situ measurements and standardized laboratory procedures. The physical characteristics of the study sites, specifically water and soil temperature, were recorded on-site using a heavy duty stainless-steel dial thermometer (REOTEMP Instrument Corporation/Greentest). Similarly, the chemical analysis of dissolved oxygen (DO) was performed immediately at each station with a Pro20 Handheld Dissolved Oxygen Meter to ensure high-precision, real-time data collection in the challenging field conditions of Maligcong. These instruments allow for the immediate capture of dissolved oxygen and temperature, which are highly volatile in shallow paddy waters. For the soil analysis, representative samples were collected and transported to the Benguet State University-Soil Science Laboratory, where they were air-dried to prepare for the determination of organic matter content and chemical properties.

The soil pH was determined via the electrometric

method, which involved mixing 10 g of air-dried soil with 10 ml of distilled water in a 100 ml beaker. This solution was stirred continuously for 30 min to ensure adequate equilibrium before a glass electrode was immersed to record the precise pH value. To determine the organic matter content, the Walkley-Black Method was employed. This procedure required passing one gram of air-dried soil through a 0.5 mm mesh sieve and placing it into a 500 ml Erlenmeyer flask. The sample was then treated with 10 ml of 1N K₂Cr₂O₇ and 20 ml of concentrated sulfuric acid, mixed thoroughly for 30 min to facilitate oxidation. After dilution with 200 ml of distilled water and 10 ml of phosphoric acid, 1 ml of diphenylamine indicator was added. The final step involved titrating the mixture with a standard iron sulfate solution until the endpoint was reached, indicated by a transition to a brilliant green color.

2.3. Mussel Collection

Specimens of *Pyganodon cataracta* were collected via manual excavation within designated 2m × 2m quadrat frames. To ensure data consistency and account for the vertical distribution of infaunal bivalves, excavation was standardized to a uniform depth of 15 cm [22]. Sampling was strictly conducted between 08:00 AM and 11:00 AM employing the transect-quadrat method to minimize the influence of diurnal metabolic fluctuations and solar-driven temperature shifts in the shallow paddy water. Due to limited turbidity and poor visibility at most stations, a tactile sampling technique was employed to locate the mussels within the substrate, followed by sifting through a 2 mm mesh sieve to ensure the inclusion of all age classes. Following collection, the samples were secured in clean, labeled containers and transported to the laboratory at Mountain Province State University (Bontoc, Mountain Province) for immediate analysis. The processing phase began with an initial count and the recording of the total wet weight for both the shell and soft tissue across all sites. To determine the dry biomass, the soft tissues were carefully extracted and subjected to oven-drying at 60 °C for a minimum of 48 h until a constant weight was achieved, after which the dry weight was recorded using a high-precision digital balance. Morphometric data, including total shell length

and width, were meticulously measured to the nearest 0.1 mm using a Vernier caliper to ensure an accurate representation of the population structure [5].

3. Results

3.1. Abundance, Biomass and Morphometric Variation of *Pyganodon cataracta*

The census of *Pyganodon cataracta* across the two distinct rice paddy environments in Maligcong revealed substantial disparities in population density and physical development (Table 1). A total of 157 individuals were collected, with a markedly higher concentration found in

the spring-fed paddies of Site A (n = 92) compared to the runoff-affected paddies of Site B (n = 65). Statistical analysis confirmed that this difference in abundance is highly significant ($p = 0.0011$), suggesting that the environmental stability provided by natural spring sources supports a larger carrying capacity for these bivalves. Statistical analysis confirmed that both wet and dry biomass were more than twice as high in Site A, indicating healthier and larger mussel populations under less-polluted conditions. Wet biomass reached 468.7 g at Site A, compared to 212.6 g at Site B. Similarly, the dry shell biomass was 205.3 g in Site A versus 45.93 g in Site B, while dry flesh biomass was 12.07 g compared to only 2.93 g.

Table 1. Mean values of the abundance, biomass and growth of *Pyganodon cataracta*.

Parameters	Site A (Spring-Fed)	Site B (Runoff-Affected)	p-Value
Abundance	92	65	0.0011**
Wet biomass (shell + flesh)	468.7 g	212.6 g	0.0011**
Dry biomass (shell)	205.3 g	45.9 g	0.002**
Dry biomass (flesh)	12.1 g	2.9 g	0.0016**
Shell length	50 mm	35.7 mm	0.001**
Shell width	30.7 mm	21.7 mm	0.002**

Note: **: highly significant at 0.05 level.

Morphometric analysis further underscored the physiological advantages of the Site A environment. Mussels in the spring-fed paddies exhibited significantly larger shell dimensions, with a mean length of 50 mm and a mean width of 30.7 mm. In contrast, those sampled from the runoff-affected Site B were notably smaller, averaging only 35.7 mm in length and 21.7 mm in width ($p = 0.001$ for length; $p = 0.002$ for width). While both sites contained multiple size classes, representing a mix of juveniles and adults, the stunted dimensions in Site B suggest a disruption in the standard growth trajectory of the species.

The significant difference in population counts between the two sites indicates that *P. cataracta* production in the Maligcong terraces is primarily determined by the water source of water. The significantly higher abundance and biomass recorded in the spring-fed paddies (Site A) indicate that the stable, cool, and well-oxygenated water supplied by natural springs creates the ideal conditions for tissue growth and calcium carbonate deposition. This is most evident in the dry flesh biomass, which was over four times higher in Site A (12.1 g) than in Site B (2.9 g), sug-

gesting that mussels in runoff-affected areas are experiencing significant physiological stress.

The reduced growth parameters in Site B—averaging only 35.7 mm in length compared to the 50 mm observed in Site A—imply that agricultural and domestic runoff may be introducing pollutants or excessive siltation that interfere with the filter-feeding efficiency of the *P. cataracta*. Additionally, the significant variation in dry shell biomass (205.3 g vs. 45.93 g) suggests that shell mineralization is probably inhibited by the slightly acidic soil conditions and decreased dissolved oxygen at Site B. The findings of the study imply that the spring-fed irrigation systems of Maligcong are not only vital for rice cultivation but are also essential for the conservation of local aquatic bivalves. On the other hand, these bivalve populations may be stunted and eventually diminish as a result of the switch to runoff-heavy irrigation or increased nitrogen loading, which would affect local biodiversity and food availability.

Morphometric analysis revealed that mussels in spring-fed paddies were significantly larger than those in runoff-affected areas (Table 1). While shell size can be

influenced by age, the uniform presence of multiple size classes and the use of a 2 mm mesh sieve ensured that the census included both juveniles and adults across both sites. The significantly higher dry flesh biomass in Site A (12.1 g) compared to Site B (2.9 g)—a fourfold difference—strongly suggests a disparity in physiological productivity rather than age alone. In unionids, energy is typically prioritized for shell growth during early life stages; therefore, the stunted shell dimensions observed in Site B likely reflect chronic environmental stress, such as low dissolved oxygen (4.77 mg/L) and acidic soil (6.53), which inhibit metabolic efficiency and shell mineralization.

3.2. Comparative Biomass and Productivity Analysis

The most profound differences between the two study sites were observed in the biomass metrics, which serve as direct indicators of energy acquisition and metabolic health. The total wet biomass recorded at Site A (468.7 g) was more than double that of Site B (212.6 g). This trend of superior productivity in spring-fed paddies was consistent across all dry weight measurements. Particularly noteworthy is the disparity in dry flesh biomass. Site A yielded 12.1 g of dry flesh, whereas Site B yielded only 2.9 g. This fourfold difference is highly significant ($p = 0.0016$) and suggests that mussels in Site B are under severe physiological stress, likely due to a combination of limited nutrient availability or high metabolic costs associated with poor water quality. Additionally, dry shell bio-

mass followed a similar pattern of decline, dropping from 205.3 g in Site A to a mere 45.9 g in Site B. This suggests that shell mineralization—the process of depositing calcium carbonate—is significantly inhibited in runoff-affected areas, potentially due to the slightly acidic soil conditions (pH 6.53) observed at that site.

3.3. Physicochemical Profiling of Soil and Water Quality of the Rice Paddies

Table 2 presents the soil and water quality characteristics of the two sites. Soil pH was significantly higher in Site A (7.57, slightly basic) than in Site B (6.53, slightly acidic). Conversely, organic matter was almost twice as high in Site B (2.3%) compared to Site A (1.2%), suggesting accumulation from agricultural and domestic inputs. Soil pH in the spring-fed paddies was slightly basic at 7.57, whereas the runoff-affected paddies were significantly more acidic at 6.53 ($p = 0.035$). This acidity in Site B is likely linked to the significantly higher organic matter content (2.3% vs. 1.2% in Site A), which suggests an accumulation of agricultural or domestic inputs. The decomposition of this organic matter typically consumes oxygen and lowers pH, creating a challenging environment for bivalve survival and calcification. The environmental data provided a clear context for the observed biological variations. The soil and water chemistry of Site A reflected a stable, oxygen-rich lotic system, while Site B exhibited signs of organic enrichment and metabolic demand.

Table 2. Mean value of physico-chemical characteristics of soil and water.

Parameters	Site A (Spring-Fed)	Site B (Runoff-Affected)	p-Value
Soil pH	7.57	6.53	0.035*
Organic matter (%)	1.2	2.3	0.031*
Water pH	7.7	6.7	0.080 ^{ns}
Water temperature (°C)	27.96	32.77	0.033*
Dissolved Oxygen (mg/L)	7.1	4.77	0.003*

Note: *: Significant at 0.05 level; ns: not significant.

For water quality, Site A had significantly lower temperature (27.96 °C) compared to Site B (32.77 °C). Dissolved oxygen (DO) was also significantly higher in Site A (7.1 mg/L) than in Site B (4.77 mg/L). Water pH showed no significant difference between sites (7.7 vs. 6.7, $p =$

0.080). Water quality parameters corroborated these findings. Site A maintained a cooler, more stable temperature (27.96 °C) compared to the significantly warmer waters of Site B (32.77 °C). Critically, Dissolved Oxygen (DO) was significantly higher in Site A at 7.1 mg/L, falling to a sub-

optimal 4.77 mg/L in Site B ($p = 0.003$). While water pH showed a downward trend in Site B (6.7 vs. 7.7 in Site A), this specific parameter did not reach statistical significance ($p = 0.080$). Collectively, these factors suggest that Site B represents a habitat undergoing eutrophication, which directly impacts the filter-feeding efficiency and metabolic vitality of *P. cataracta*.

The two locations' different environmental profiles indicate that Site A represents a more oxygen-rich, stable lotic environment, while Site B is characterized by higher metabolic demand and nutrient loading. The significantly higher dissolved oxygen (7.1 mg/L) and lower water temperature (27.96 °C) in Site A create an ideal physiological environment for *Pyganodon cataracta*, because cooler water stores more oxygen and lessens the metabolic burden on freshwater bivalves.

On the other hand, the elevated water temperature (32.77 °C) and reduced DO (4.77 mg/L) at Site B, coupled with nearly double the organic matter (2.3%), indicate a habitat undergoing higher rates of decomposition and potential eutrophication from agricultural or domestic runoff. While *P. cataracta* is known for its resilience, the slightly acidic soil pH (6.53) and lower oxygen levels in Site B may impede shell calcification and survival rates compared to the slightly basic (7.57) and well-oxygenated conditions of Site A. These results suggest that although *P. cataracta* may survive in a variety of paddy environments, its biomass and abundance are probably greater in sites with improved water movement and decreased organic enrichment, demonstrating how these mussels are sensitive to community land-use practices in the Maligcong terraces.

4. Discussion

Site A supported a substantially larger population with 92 individuals, compared to only 65 in Site B. This suggests that the pristine spring-irrigated conditions of Site A are more conducive to mussel survival and colonization than the runoff-impacted residential areas of Site B. The significant reduction in biomass and shell size at Site B aligns with studies showing that domestic wastewater often contains surfactants and high organic loads that can impair the filtration rates and metabolic efficiency of mussels [23].

The biomass data reveals a large disparity between productivity and health. Site A's total wet weight (shell and flesh) is 468.73 g, more than twice as much as Site B's (212.6 g). This tendency is even more noticeable in the dry meat biomass, where location A recorded 12.067 g and Site B recorded a pitiful 2.93 g. This indicates that the polluted location produced significantly less soft tissue. The lower growth rates in polluted paddies may be attributed to chronic hypoxia caused by the decomposition of domestic organic waste, as bivalves in low-oxygen environments prioritize survival over shell deposition and tissue growth [24]. The results strongly support the hypothesis that stable soil and water conditions in rice paddies positively influence the abundance and growth of *Pyganodon cataracta*. Mussels in spring-fed paddies exhibited significantly higher abundance, biomass, and shell growth compared to those in runoff-affected paddies. This is consistent with earlier reports that juvenile mussels allocate most of their energy to shell growth during early life stages, making them especially sensitive to environmental stressors [25]. Growth and survival in unionids depend on habitat stability, calcium availability, water temperature, and overall environmental quality [16,24].

With respect to soil conditions, the runoff-affected paddies had higher organic matter but lower soil pH, creating more acidic conditions. Agricultural practices and organic matter accumulation are known drivers of acidification [19,20]. Acidic soils can reduce calcium availability, which is critical for shell formation, explaining the smaller shell sizes in mussels from Site B.

Water quality factors appeared even more decisive. Mussels in polluted paddies were exposed to warmer water and lower dissolved oxygen (DO). Warmer temperatures reduce oxygen solubility while increasing oxygen demand for biological processes, thereby stressing aquatic organisms [26]. Low DO has been identified as a critical stressor for invertebrates and fish alike [27]. These conditions likely account for the lower abundance and smaller biomass of mussels at Site B. Elevated temperatures in shallow paddies can exacerbate the metabolic rate of mussels while simultaneously decreasing the water's oxygen-carrying capacity. According to Adamski et al. [28], freshwater bivalves often experience reduced filtration efficiency and increased metabolic stress when water temperatures exceed 30 °C,

particularly when paired with hypoxic conditions ($DO < 5$ mg/L). These adverse conditions at Site B—characterized by thermal stress and limited oxygen—likely explain the highly significant reduction in mussel abundance and biomass observed in the biological data.

The spring-irrigated site is also favored by growth factors. While mussels in Site B remained stunted, averaging only 35.67 mm in length and 21.67 mm in width, those in Site A attained a mean shell length of 50 mm and a width of 30.67 mm. Differences in soil organic matter, likely played a role; research indicates that excessive siltation and altered sediment chemistry from agricultural runoff can physically interfere with the feeding apparatus of unionid mussels, leading to stunted growth^[29]. Age structure, size structure, and growth rates of freshwater mussel populations are used to determine if a population is declining, increasing, or remaining stable. Since mussels living in an environment with abundant resources and few environmental stressors should have a higher growth rate than mussels living in an inhospitable environment, growth rates are also used to assess the long-term health of aquatic ecosystems^[30].

Nutrient loading from agricultural runoff and domestic waste also contributed to degraded water quality. Excess nitrogen and phosphorus inputs promote algal blooms, accelerate eutrophication, and further deplete oxygen^[24,25]. Such processes undermine the ecological role of mussels as natural living filters that maintain water clarity and nutrient balance^[15].

These findings resonate with global concerns. Biodiversity declines in rice agroecosystems are often linked to habitat degradation and chemical pollution^[10]. Freshwater mussels, in particular, are among the most imperiled faunal groups due to their sensitivity to habitat alteration and pollution^[13]. The decline of Tikam in runoff-affected paddies exemplifies how local agricultural practices contribute to the broader biodiversity crisis^[5–7].

At the same time, rice paddies have been recognized as surrogate wetlands supporting rich aquatic biodiversity^[1,2]. A decline in mussel populations threatens this role, with consequences that extend to rural communities. Aquatic organisms harvested from rice fields contribute protein and essential nutrients to local diets^[3,4]. Thus, the

reduced biomass of Tikam in polluted paddies not only reflects ecological stress but also signals a loss of traditional food resources.

5. Conclusions

This study demonstrated that the abundance, biomass, and growth of *Pyganodon cataracta* (Tikam) were significantly higher in spring-fed rice paddies than in those affected by agricultural runoff and domestic waste. These differences are closely associated with variations in environmental conditions. Soil quality differed markedly between sites, with lower pH and higher organic matter in runoff-affected paddies, conditions that may reduce calcium availability essential for shell growth. Water quality factors, particularly elevated temperature and reduced dissolved oxygen, further contributed to the decline of mussel populations in polluted paddies. In contrast, water pH did not differ significantly between sites, suggesting that other physicochemical stressors exert a stronger influence on mussel survival.

Overall, the findings highlight that pollution-driven changes in soil and water properties—characterized by acidity, organic enrichment, warmer temperatures, and lower dissolved oxygen—negatively affect the population size and health of *P. cataracta* in rice agroecosystems. Beyond ecological implications, reduced mussel abundance in polluted paddies also signals a loss of a traditional food resource for local communities. This baseline study therefore underscores the dual importance of Tikam as both a bioindicator of rice paddy ecosystem health and a contributor to rural food security, emphasizing the need for sustainable management of rice agroecosystems in the Cordillera region. The findings of this study demonstrate that the population health and biomass of *P. cataracta* are intrinsically linked to the maintenance of traditional irrigation and land-use practices. Therefore, it is recommended that the Local Government Unit (LGU) of Bontoc and the Barangay Council of Maligcong prioritize policy interventions that focus on establishing buffer zones or natural filtration systems to intercept domestic wastewater and agricultural runoff before it enters the terrace system, thereby mitigating the organic enrichment and oxygen depletion that stunt mussel growth.

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Data Availability Statement

The data supporting the findings of this study are available from the author upon reasonable request.

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Conflict of Interest

The authors declare no conflict of interest.

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