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Distribution and Abundance of *Pila globosa* in Biltongi, Natore, Bangladesh

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Abstract: Freshwater snail population numbers and their ecological significance need to be better understood. This study aimed to measure snail abundance in Biltongi-Narayanparabeel in the Natore district. The objective was to establish the population density of snails using the CMR (Capture-Mark-Recapture) method in four sections of the Biltongi-Narayanpara beel between August 2022 and February 2023. Snail samples were collected from four sampling sites, each located in different areas: one near agricultural land, one in the shallows, and one in the middle of the deepest part of the beel. The plot with the highest overall mean population density in terms of CMR for the presence of snails was plot 3 (33.25 ± 2.75), while the field with the lowest density was plot 4(22.75 ± 2.22). The biomass showed only slight variations across the different habitat categories. This is likely due to the presence of many young snails in shallow areas, whereas young snails in nearby regions were nearly nonexistent.

Keywords: *Abundance, Bangladesh, CMR (Capture-Mark-Recapture), Distribution, Habitat, Pila globosa*

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1. Introduction

Freshwater snails are essential to the environment in Bangladesh. Two species of snail have been identified in Bangladesh: *Pila globosa* and *P. virens* (Shathi and Rahman, 2022). *Pila globosa* holds economic and commercial significance in various regions of Bangladesh, where it is utilized as a food source in aquaculture, as well as in traditional medicine and culinary applications. *Pila globosa* is widely distributed throughout the nation and serves as a primary source of nutrition for several freshwater predators. Therefore, the size and species composition of the snail population can have significant top-down effects on the river catchment environment. Various factors, including temperature, food availability, predators, parasites, precipitation, and water composition, influence the distribution and abundance of freshwater snail populations. Additionally, factors such as sunlight, blooming aquatic weeds, an abundance of microorganisms, and high dissolved oxygen levels can affect the number of freshwater snails (Hosea *et al.*, 1998).

Extensive qualitative surveys since the 1930s have shown that hardness, pH, altitude, size of water bodies, temperature, vegetation, and pollution are among the significant factors influencing the distribution and abundance of mollusks (Dillon, 2000). Snails, with their moist bodies exposed during activity, face challenges in temperature management and water balance (Howes and Wells, 1934a,b; Hogben and Kirk, 1944; Dainton, 1954a, 1954b; Russell Hunter, 1964; Machin, 1964, 1965, 1966; Cloudsley-Thompson, 1968, 1970; Vernberg and Vernberg, 1970).

Apple snails exhibit year-round activity in tropical and subtropical regions (Hylton, 1957; Fausto, 1962; Milward *et al.*, 1978). However, in temperate regions, these species display reproductive activity in the spring, with some cases of reproduction in the summer, fall, and winter (Bachmann, 1960; Andrews, 1964; Hurdle, 1973). The diversity of freshwater snails is rapidly diminishing due to various factors, including habitat destruction and parasites. River ecosystems, upon which most species depend, have suffered from siltation, industrial and agricultural pollutants, the elimination of wetland habitats, and other channel changes, resulting in a substantial reduction in habitat diversity. Species diversity refers to the number of distinct species and their relative abundance within an ecosystem (Hussein *et al.*, 2011).

Freshwater snails also play a vital role in public and veterinary health as intermediate hosts for blood fluke trematodes and nematodes (Oloyede *et al.*, 2016). While snail populations contribute to higher trematode diversity, trematodes can affect snail populations by directly reducing egg production or increasing snail mortality rates (Lafferty, 1993). Although the distribution and quantity of freshwater snails have been investigated in Bangladesh, the diversity of freshwater snails in Natore sadar Upazila remains to be discovered, as most research has been conducted in specific districts and did not include this location. We aimed to investigate the environmental factors that may account for the unequal distribution of *Pila globosa* in this area. First, we determined the population size and density of *Pila globosa* in several regions of Biltongi-Narayanpara beel. Then, we investigated the influence of physiochemical factors on the distribution, abundance, and diversity of freshwater snails.

2. Materials and methods

2.1. Study area

The study location was in the Natore sadar upazila of the Natore district. The coordinates of our study area are 24.4139°N 88.9300°E. The Natore District is mainly made up of plain land. Rashid (1991) split Bangladesh into seven climatic zones, with the majority of Natore district being located in the western zone, where annual rainfall is typically under 150 cm, and humidity is under 50%. The three seasons of the year in Bangladesh's climate are the hot summer or pre-monsoon (March to May), the rainy season or monsoon (June to October), and the winter with significantly lower humidity. Of all the subzones, the western part of the nation experiences the driest and hottest summers. The hottest month is June (mean = 35 °C), and the coldest month is January (mean = 17°C). The typical temperature throughout the summer is higher than 30°C. According to weather reports from 2005 to 2015, the study region has 1,221mm of yearly rainfall (Ahmed, 1997). Although the studied area meets the humid subtropical climate zone criteria, Bangladesh is mainly classified as being in the global tropical zone by the Köppen-Geiger climatic classification (Köppen *et al.*, 2011). We established each of the four 5m×5m plots. Four plots were situated near localities (plot 1), near agricultural land (plot 2), in the shallows (plot 3) and one in the centre portion of the beel's deepest region (plot 4). This survey was done to guarantee that these plots represented habitats with various environmental characteristics and to select fields with living *P. globosa* for the population density investigation.

Figure 1: Map of Natore Sadar Upzilla

2.2. Snail sampling

In the province of Biltongi-Narayan para beel, a cross-sectional snail sampling survey was done between August 2022 and February 2023. The investigation was conducted during the day from 6am to 2pm. using a net known locally as a "Thelajal," three assistants collected samples of snails. It is a push net with a triangle shape made of polyamide monofilament nylon rope and an extended handle made of two bamboo poles, one longer and fastened at a 30º angle. With a mesh size of 0.2 to 1.0cm, its two arms are 2 to 3 meters long, and its front side is 1 to 1.5 meters long. The net's triangle section is lowered and propelled forward along the bottom of the shallow water zones. One person operates the net during the entire year. The freshwater snails were recognized morphologically to the species level using an identification key.

2.3. Spatial distribution and population density

Mark and recapture is a method commonly used in ecology to estimate an animal population's size when it is impractical to count every individual. A portion of the population was captured, marked, and released. Later, another portion was captured, and the number of marked individuals within the sample was counted. Since the number of marked individuals within the second sample should have been proportional to the number of marked individuals in the whole population, an estimate of the total population size could be obtained by dividing the number of marked individuals by the proportion of marked individuals in the second sample. Other names for this method, or closely related methods, included capture-recapture, capture-mark-recapture, mark-recapture, sight-resight, mark-release-recapture, multiple systems estimation, band recovery, the Petersen method, and the Lincoln method (Kreb, 2009).

We utilized the capture-mark-recapture method (Blinn, 1963; Hansel, Walther and Plachter, 1999; Standish, Bennett, & Stringer, 2002; Parkyn *et al.*, 2014)) to examine the population of *P. globosa* in each plot containing living snails. During many sampling sessions, *P. globosa* were caught and marked with various shades of nail paint (Figure 3). First-stage snails are kept with turquoise green nail polish to ensure accurate marking. Red nail polish is used to mark second-stage snails. During different collection sessions, *P. globosa* specimens were observed with nail polish of multiple hues. The initial sampling occurred on August 15, 2022, and the first recapture occurred on August 22, 2022. All captured snails were returned to their respective plots. We determined the population density *of P. globosa* by counting the living snails in each field during the various CMR (Capture-Mark-Recapture) sessions. The population size of *P. globosa* was approximated using the following calculation based on the given data in the Schnabel index:

N= estimate of the total population size,
S = Size of second sample,
M =Marked individual released,
R = Marked animals recaptured

To produce a more accurate assessment, we employ several marks and recaptures and the Schnabel index (Alcoy, 2013).

$$N = \frac{\sum_{i=1}^{m} MiCi}{\sum_{i=1}^{m} Ri}$$

Where
Mi = the total number of previously marked animals at time *i*
Ci = the number caught at time *i*
Ri = the number of marked animals caught at time *i*

2.4. Physiochemical parameters

Physiochemical parameters impact *P. globosa* spread and density in the study area. Water and soil physiochemical parameters at each site were assessed concurrently with the snail sample. A portable multipara meter measured pH, electric conductivity, and salinity. These physiochemical parameters were selected to influence snail abundance, dispersion, and variety.

2.5. Vegetation data

First, we identified emergent, floating, and submerged aquatic vegetation groups in every four plots of the study area. Then, we found the vital anatomical features that were used to identify aquatic plants. Aquatic vegetation identification was carried out using the Encyclopedia of Flora and Fauna in 2009, and a few species were checked with ICUN in consultation with multi-disciplinary books and journals.

3. Results and discussion

First, a section of the neighborhood beel was chosen for observation. The beel was filled with water during the rainy season, but during the dry season, it became fertile land. The initial part was close to the area where ducks could freely wander about, and the areas utilized water flows that mixed with the beel. This section had a depth of around 1.5 feet.

The second section was near some farmland where paddy was the primary crop grown on much of the land. In designated areas, different chemicals employed on the soil during irrigation might have been combined with the beel water in different ways. This space had a depth of one and a half feet.

The third section was the shallow portion of the beel, inhabited by various molluscs, arthropods, and snails, along with numerous aquatic plants. The location had a depth of two feet.

The fourth component consisted of the deeper portion of the beel, which was more than five feet deep and had an abundance of native fish and mollusc species.

2(A)

2(B)

Figure 2: (A) Rainy season of the study area (B) Dry season of the study area

3.1. Distribution and population density of *P. globosa*

The total number of live specimens were collected during the four CMR sessions. The majority of snails that were marked were sub-adult and adult. The average number of snails during all CMR sessions standard deviation for each 5m^2 plot (Table 1).

Table 1: Population estimates for *P. globosa* based on capture-mark-recapture and the Schnabel index for each plot

Plots	Population density per 5sq/m^2	Population estimation by CMR (number of snails)
Plot 1	22.75 ± 2.22	41.81
Plot 2	29.5 ± 4.20	45.28
Plot 3	33.25 ± 2.75	43.54
Plot 4	32.0 ± 4.24	45.81

The present analysis revealed that plot 3 had the highest population density, while plot 1 had the lowest. This Beel's abundance of *Pistia stratiotes, Vallisnariaspiralis,* and numerous other filamentous algae, which serve as food for *P.globosa*, is believed to be the primary cause of its greater density. In this regard, however, the surface-to-volume ratio is essential; the deeper a water basin, the more water it contains relative to its surface area and the more diluted the nutrient supply. In addition, the photosynthetic transformation of nutrients into an animal-assimilable form by plants can only occur in the top layers of water. Thus, this process is less successful in a deep basin relative to the volume of water than in a shallow bay. Algae production is essential, as these plants serve as the primary food source for numerous species, especially young snails. , A lack of light inhibits algae development, yet, even a tiny amount of light may be sufficient to promote adequate growth to feed young snails. In addition, various species such as bacteria, protozoa, fungi, and decomposing organic waste may provide enough food for newly-hatched snails. Snails typically seek refuge on the undersides of leaves in areas exposed to harsh sunlight, shielded by water plants. There, the temperature may be two to three degrees cooler than in more exposed areas, and the oxygen tension may be more significant, particularly beneath the leaves. In aquatic systems, seasonal fluctuations were documented regarding their influence on the change in species abundance rather than complete species replacement (Brooks, 2000; Mesa, 2012).

Figure 3: CMR field trial with *Pila globosa*

3.2. Physicochemical conditions of study area and its impact on abundance

Hence, the habitat concept will be restricted to that portion of the environment that more or less directly impacts snails and to which snails respond ecologically and physiologically. In an ecological interaction, both the influence of the environment on the organism and its response to its surroundings is crucial, and it isn't easy to address one without the other.

Temperature, pH, turbidity, dissolved oxygen, calcium, magnesium, and phosphate are regarded to be the most significant physicochemical variables of the water body in the aquatic environment, particularly for freshwater snails (Abbasi *et al.*, 2011). Several physicochemical and biological conditions must be considered concurrently to comprehend the fluctuation of natural populations in a body of water (Dallas, 2004).

The growth and survival of snails can be impacted by different types of soil. For instance, thick soils might be difficult to dig into, while sandy soils can provide a poor foundation for their shells and make it harder for them to move. So we examined soil and water quality of our study area.

Hora and Pillay (1962) reported that the pH variation of water sources is primarily the result of the daily interaction between photosynthesis and community respiration of the biota and is one of the most influential single factors on aquatic output because the pH changes throughout time as a result of temperature variations, it is regarded as an essential ecological component. Marine organisms are influenced by pH since most of their metabolic processes are pH-dependent (Wang *et al.*, 1988). The study system's most crucial variable for land snails was soil pH, which encouraged diverse and abounding snail colonies. It is well known that snails depend on the pH of the soil, particularly in locations with variable soil chemistry (Martin and Sommer, 2006; Ondina *et al.*, 2004;

Wehner *et al.*, 2019). In the present investigation, the soil pH was 7.9, and the water pH was 7.6.

The electrical conductivity (EC) of water with a high concentration of acid, base, or salt rose as its concentration of acid, base, or salt grew (Arya and Mishra, 2015). In the summer, the concentration of salts increases due to increased evaporation, resulting in a higher EC; in the winter, precipitation leads to dilution, lowering the value (Trivedy and Goel, 1984). In the current study, soil salinity was 0.18(ds/m), and water salinity was 0.31(ds/m). Low concentrations of dissolved oxygen may be associated with flowing water and the photosynthetic efficiency of aquatic plants (Singh and Triweri 1979)

Organic matter removal requires a high DO level, often low in summer (Mamta and Ranga, 2012). The organic matter in soil in our study region is 1.87 percent. Thus, physical, chemical, and biological factors can have a substantial impact on the population dynamics of freshwater snails (Barbosa and Barbosa, 1994)

Snails are susceptible to environmental toxins such as heavy metals, pesticides, and fertilizers. They may impact how they develop, reproduce, and maintain their immune systems, leaving them more vulnerable to illness and predators. So we examined heavy metals in the soil, such as Zn, and found 1.12 µg/gm.

The distribution and quantity of freshwater snails differed significantly among the four sites during the same sample period and duration (July to September 2022). The abundance of freshwater snails was most incredible in July and August. During the rainy season, the water was contaminated with organic and inorganic contaminants, such as fertilizers from adjacent farmlands; the alkalinity of the water was low, and the distribution of freshwater snails decreased from November to January due to a lack of precipitation. The maximum number of freshwater snails was found in August at the study location, possibly due to increased rainfall and physicochemical conditions promoting freshwater snails' rapid growth and multiplication. It could be linked to environmental changes, particularly precipitation, and essential physicochemical parameters such as temperature, pH, turbidity, and phosphate, which are required for the growth and survival of freshwater snails. The precipitation began to increase in July, peaked in August/September, and ceased by the end of November. Only calcium was discovered to be strongly related to the abundance and distribution of freshwater snails. The amount of calcium available significantly impacts the density of the snail population. (Gardenfors, 1992; Graveland & Van der Wal, 1996; Skeldon *et al.*, 2007) .Calcium is an essential ingredient for developing freshwater snails. Snails require calcium for the development of their shells and for the provision of eggs during reproduction (Baur, 1994). Our analysis revealed a soil calcium content of 27.58 mg/100gm and a water calcium content of 1.09 mg/100gm.

Table 2: Soil quality of Biltongi-Narayanpara beel

Elements	Results
pH	7.9
OM (%)	1.87
K(mg)	0.49
Ca(mg)	27.58
Mg(mg)	3.88
Na(mg)	0.13
Zn(µg)	1.12
Salinity(ds/m)	0.18

Table 3: Water quality of Biltongi-Narayanpara beel

Elements	Results
pH	7.6
K(mg)	0.03
Ca(mg)	1.09
Mg(mg)	0.30
Na(mg)	0.02
Salinity (ds/m)	0.31

3.3. Relationship between *P. globosa* abundance and vegetation

Water snails consume a variety of foods found in their natural habitat. In such circumstances, they consume all the necessary vitamins and minerals for a healthy existence. In the four plots, twenty taxa of aquatic vegetation were identified. For thirteen species, identifications were obtained. Seven species could not be positively identified.

The most widespread and readily available aquatic plants are water hyacinth, kolmi, and sheola. A water lily is a typical vegetable that grows throughout the nation during the rainy season. According to Table 4, plot 3 has a greater concentration of aquatic plants. The reason why there are more snails in this location is assumed to be due to this. However, whether snails employ these aquatic plants for food or refuge is still being determined.

According to Huq *et al.*, (2000), *P. globosa*'s general abundance in Beel Chanda decreased from November to February and increased from February to April. Beginning in early winter and lasting until late winter, hibernation is followed by a rapid rebirth in April when it rains. Snails typically hibernate during the winter months when the temperature is low. In Chalan Beel, it has been noted that hibernation occurs most frequently in February and least frequently in November.

Table 4: Available aquatic plant species of study area

Local name of the Plants	Scientific name	Availability of plot			
		Plot 1	Plot 2	Plot 3	Plot 4
Water Lilly	*Nymphaea L.*				■
Water Hyacinth	*Eichhornia crassipes*			■	■
Sheola (Algae)	*Pithophora*	■	■	■	■
Keshordam	*Ludwigia adscendens*		■	■	
Water Fern	*Ceratopteris thalictroide*	■	■		
Chinese Arrow-head	*Sagittaria trifolia*			■	
Kolmi	*Ipmoea aquatica*	■		■	
Helencha	*Altermanthera philoxeroides*			■	
Maidencane	*Panicum hemitomon*		■	■	
Kachu	*Colocasia esculenta*	■			
Panikhola	*Ottelia alismoides*			■	■
Khudipana	*Lemna trisulca*		■	■	■
Guripana	*Wolffia arrhiza*	■	■	■	

3.4. Other variables that may influence snail distribution and density

Microclimatic variables (air and soil temperature, humidity), predators, and other factors that were not examined in this study could have impacted the distribution and density of *P. globosa*. Snail communities may have been influenced by soil and water temperature (Baur and Baur, 1993; Baur *et al.*, 2014). The patterns of snail density distribution may have also been related to predation pressure (Abramsky *et al.*, 1992; Meyer and Cowie, 2010; Gerlach *et al.*, 2020). Unfortunately, the study did not provide information on predator life cycles or population densities.

4. Conclusion

Snails' ability to survive and reproduce can be significantly impacted by a variety of environmental conditions. To more effectively manage and protect snail populations in their natural environments, it is crucial to comprehend these variables and how they interact. However, the short duration of our study and the lack of additional components of the beel and night time activities of snails limited its scope. After this exploratory study, we propose a more targeted, hypothesis-driven investigation to ascertain: (1) how variations in microclimates affect the activities of freshwater snails during the day and night; and (2) how ground temperature and specific species of aquatic plants may be positively associated with snail abundance.

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