Ecology and Bio-economics of Freshwater Apple Snail *Pila globosa* in Natore district of Bangladesh

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Abstract: *Pila globosa* is an economically and commercially valued snail used as food in aquaculture, medicine, and food item in many regions of Bangladesh and other countries. The current study examines the ecology of *Pila globosa* and determines their current bio-economic situation. *Pila globosa* were collected from Singra, Lalpur and, Bagatipara upazila of Natore district. It was found 1.5-fold decline of the snail population in the study areas. *Pila globosa* is an ecological element that actively contributes to preserving a healthy aquatic habitat, which is necessary for biodiversity preservation. On the one hand, snail fauna scientific management is out of date. On the other hand, *Pila globosa* is still being exploited for fish culture, providing the underprivileged with a means of subsistence and the country with foreign income. By easing pressure on the natural population, the scenario justifies the development of supplemental *Pila globosa* culture techniques for commercial use.

Keywords: *Bangladesh, Biodiversity, Bio-economics, Ecology, Pila globosa*

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1. Introduction

Surface and underground water resources are abundant in Bangladesh. The surface water resources include water from rivers in motion and water from still bodies of water like ponds, beels, and haors. The country receives surface water inflows ranging from 140,000 m^3/s in August to a minimum of 7,000 m^3/s in February. These resources are biologically sensitive and fragile areas with solid support for inland agricultural activities and the source of a variety of freshwater fins and shellfishes (Prasad, 2020). In developing countries, the shellfishes like prawns, crabs, and molluscans are significant food resources due to their high protein content and other medicinal and nutritional values (Prabhakar and Ray, 2009; Chutia and Pegie, 2017). Two *Pila* species (*P. globosa* and *P. Virens*) have been discovered in Bangladesh thus far. *P. globosa* is a common snail all over the country. It is widely distributed in the districts of Rajshahi, Naogaon, Natore, Pabna, Sirajganj, Meherpur, Kustia, Chuadanga, Alamdanga, Magura, Rajbari, Faridpur, Madaripur, Sariatpur, Gopalganj, Manikganj, Jessore, Narail, Khulna and Barisal. The natural ecosystem is progressively being destroyed, leading to biodiversity loss. According to Wilson (1998), there are 1.4 million live species worldwide, of which 135,000 are mollusks. Of these, more than 2000 are at risk of extinction (Seddon et al.2000). There have been reports of diminishing juvenile snail populations due to things like harvesting, degradation, agricultural runoff, industrial contamination, and sedimentation. *P. globosa* in Nepal is decreasing due to habitat loss, agricultural intensification, and fish poisoning (IUCN red list). In Bangladesh, the overexploitation of this species is one of the main reasons it diminished.

Saha (1998), Jahan and Rahman (2000), Jahan et al. (2001, 2005), Islam (2006), and Yasmin and Rahman (2015) carried out works on bio-economics, breeding biology, food preference, and commercial farming of *Pila globosa.* However, many researchers work on *Pila globosa* but have not consolidated position on snail biodiversity in the northwestern region of Bangladesh is available. No work on the conservation status of snail fauna is accessible in this region. A Snail is a lower animal, so the defeat of snail diversity cannot construct the interest of general people. It is also one kind of natural resource. But we are not conscious of this resource. So In this study, our main objective was to learn about the ecology and bio-economics of *P. globosa* in Natore district of Bangladesh.

2. Materials and methods

2.1. Study area

Three sampling sites were selected for the present study. These was Singra, Lalpur and, Bagatipara upazila of Natore district. These sites are well-known for *P.globosa* trading. Singra is located at 24°30′N 89°08′E. It has 52851 households and a total area of 528.46 km^2. Singra, with an area of 528.46 km^2, is bounded by Nandigram Upazila on the north, Gurudaspur Upazila on the south, and Tarash and Sherpur (Bogra) Upazilas on the east, Natore Sadar, Atrai and Raninagar Upazilas on the west.

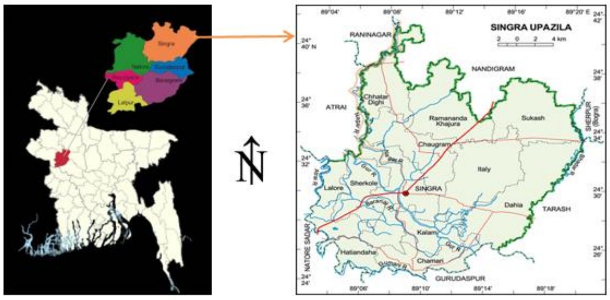

Figure 1: Map of Singra Upazila, Natore

Bagatipara is located at 24.3306°N 88.9444°E. It has an area of 139.37 km^2 and is bounded by Natore Sadar Upazila on the north, Lalpur Upazila on the south, Baraigram Upazila on the east, and Charghat , Bagha, and Puthia Upazilas on the west. The soil of the Upazila is mainly plain; there are few depressions.The main river is Boral.

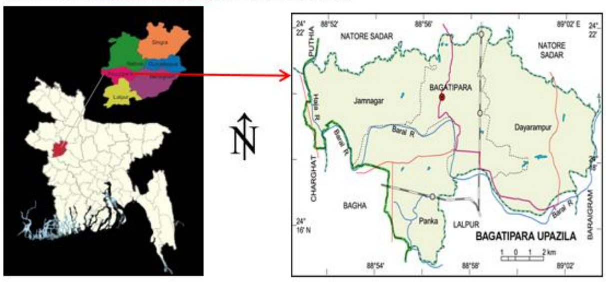

Figure 2: Map of Bagatipara Upazila, Natore

Lalpur is located at 24.1833°N 88.9750°E. It has a total area of 327.92 km^2. 29 km distance from Natore Sadar. Its thana Sadar is situated on the bank of the river of Padma. Lalpur Upazila is bounded by Bagha Upazila on west, little part of Daulatpur Upazila, Kushtia and Bheramara Upazila on south, Ishwardi Upazila on east, Baraigram Upazila and Bagataipara Upazila on north.

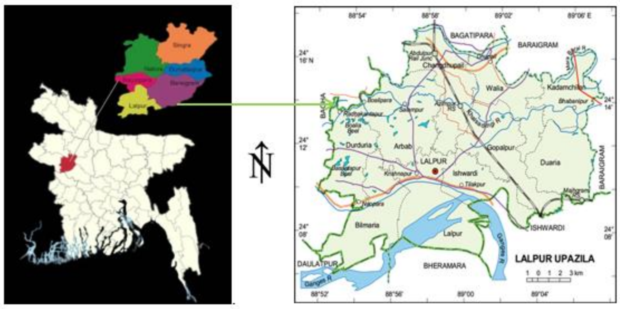

Figure 3: Map of Lalpur Upazila, Natore

2.2. Methodology of sample collection

Sample collection: *Pila globosa* was collected by hand with plastic baskets and a small net. Primarily it is washed with fresh water to remove mucous and then treated ascending grade of ethyl alcohol.

Washing and preservation: A high-grade wash is essential for preservation. Soil, algae, mucous, and other substances were rinsed away in freshwater with NaCl. To wash, use a bucket, brush, and needle. The most suitable amount of ethanol for shell preservation was 70%.

Methodology of identification: The IES (Institute of Environmental Science) lab received the collected materials for identification.

Morphometric: One hundred or more *Pila globosa* were randomly selected from each study site's marketplace sections for the morphological investigation. We used to scale and divider for morphological research. For age determination, shell size is an important parameter. The older the snail, the thicker the lip, the lighter shell color, and the shell surface between the lateral lip bases whiter. By adding the total number of winter breaks to the yearly increments, it is simple to calculate the snail's age. Some of the snails were at least six years old and probably more like eight or nine. Fig: 5 AB denotes shell height, CD indicates shell width, EF indicates operculum height, and GF shows operculum width.

Table 1: Study area and sample size

Locality	Number of samples	
	Adult	Juvenile
Singra upazila	72	28
Bagatipara upazila	74	26
Lalpur upazila	82	18

Measurement of morphological parameters: Study divider, scale, needle, and slide calipers were used to measure the morphological characteristics (length, breadth, and thickness).

Habit and habitat study: The habit and habitat of *Pila globosa* were observed by routine observation.

Water quality parameters; From each site, surface water was collected for water quality analysis. 1 Litter plastic pot was used for sample collection. Each water sample from the chosen area was handled delicately. Water pH, conductivity, total dissolved solids, and salinity were measured in-situ at each sampling site using a calibrated digital multi-parameter. Dissolved oxygen concentration was measured using a DO meter. Visibility was recorded using a Secchi disk. The biological oxygen demand five days after incubation, chemical oxygen demand, nitrate concentration, and dissolved $CaCO_3$ were analyzed from the central lab of Rajshahi University.

Bio-economics data collection

Primary data: Primary data was collected through field visits and personal interview methods.

Secondary data: Secondary information was collected from journals, books, proceedings, and periodicals.

Methodology of data analysis: MS Excel software was used for data storing. Morphometric analysis was carried out using the SPSS (Statistical Package for Social Science) software.

3. Results and discussion

The snails play an active role as an ecological component in maintaining a healthy aquatic environment, which is a prerequisite for bio-diversity conservation (Jahan et al., 2001). Snail helps to control marine environment pollution through the recycling of residues, serves as an agent of the biogeochemical cycle, and hosts several larval trematode parasites. Population density is an essential factor for the growth and survivability of snails. It has been observed that highly high red tide bloom reduces the population density, and size class reflects its seasonal distribution (Gallagher, 1989). Lower density provides a better survival rate than the higher density, indicating density-dependent survival of the snail (Ahmed, 1996). The availability and quality of food are also crucial for the distribution of *Pila globosa*. The abundance of *Pila globosa* degeneration increased from November to February and from June to October. Snail abundance was very high at the start of its harvest in Bangladesh, but the price of snail increased year after due to its abundance decrease.

3.1. Habit and habitats

Pila globosa is commonly found in freshwater ponds, pools, tanks, lakes, marshes, rice fields, and sometimes even streams and rivers. They occur in areas with a large amount of aquatic vegetation like *Vallisneria* and *Pastia* for food. *Pila globosa* is amphibious, adapted for life in water and on land. The animal creeps slowly by its ventral muscular foot, covering about five cm per minute.

The movement of the animal is like the gliding movement of the planarian. During the rainy seasons, *Pila globosa* comes out of the ponds and makes long terrestrial tours, thus respiring air directly. It can overcome long periods of drought in a dormant condition and buried in the mud. This period of inactivity is called aestivation or summer sleep. The snails can survive in this state for up to three years though typically, their sleep cycles spread over two or three days as opposed to the usual twenty-four-hour process we're wont. Snails can shift into hibernation. The hibernation starts in the early whiter and continues till late winter, while a sudden rejuvenation occurs during April when it rains (Ahmed, 1996). In general, the snails go to hibernation in winter when the temperature is low. It has been observed in the study area that the minimum hibernation takes place in November, and the maximum takes place during February.

Figure 4: View of the study site

Our study area is rich in freshwater rivers and beels. So plenty of snails is enough here. However, *P. globosa* is in short supply because of overexploitation and pollution. The mollusks have been recognized as excellent bio-indicators because of their relative stability or sedentary adult stages, close contact with the bottom sediments and the water column, and capacity to respond to a wide range of anthropogenic impacts, such as nutrient enrichment, oxygen availability, and changes in habitat structure (Bonada et al.,2006; Feio et al.,2007; Mereta et al.,2013) Since the majority of the life cycle of gastropods takes place at the bottom habitats of wetlands, they are constantly in contact with shallow soft sediments and underlying water columns. This position allows them to respond fast to any physical or chemical changes in these environments. Therefore the temporal and spatial variation of abundance, composition, and distribution of the mollusks provide an index of the ecosystem (Barbour et al., 1999). Freshwater gastropods are efficient bioindicators of ecosystem health (Tallarico 2016). They constitute a substantial part of the freshwater biomass and, as primary consumers, a vital link between primary producers (e.g., potentially toxic cyanobacteria) and higher consumers (leeches, crayfish, insects, fish, waterfowl, and mammals) (Habdija et al. 1995; Dillon 2000). Snails are available as usual in these areas. But the others claimed that these are decreasing day by day. Our observation and environmental quality testing suggested that these resources have degraded qualitatively. If large-scale exploitation continues in the foreseeable future, the quality and quantity of these resources will decline.

3.2. Morphometric analysis

Shells of the gastropods contain a rich source of taxonomic information that can be used to interpret evolutionary relationships among taxa and shell morphological characters and are also used as primary guidelines for species identification (Chiu YW et al., 2002). An animal's available biomass depends on the body width, length, and depth. Morphometric traits in terms of shell width (SW), shell length (SL), shell outer lip thickness (SOLT), shell depth (SD), body whorl length (BWL), operculum width (OW), and operculum length (OL), including animal weight (AW), were good predictors for identification.

Table 2: Morphometric of *Pila globosa*

Trait	Singra upazila (Mean±SE)	Bagatipara upazila (Mean±SE)	Lalpur upazila (Mean±SE)
SL(cm)	4.02±1.22	3.99±1.10	3.99±1.04
SW (cm)	3.44±0.91	3.39±0.91	3.42±0.85
OL(mm)	32.78±9.71	33.66±8.63	31.68±9.74
OW(mm)	22.78±9.71	23.66±8.63	21.68±9.74

The mean and standard deviation (SD) were recorded for each of the four morphological traits.Four variables in total—shell length (SL), shell width (SW), operculum length (OL), and operculum width—were chosen for continuous measurements (OW). In the present study, the average SL was recorded as 4.02±1.22cm, 3.99±1.10cm, and 3.99±1.04cm for Singra, Bagatipara, and Lalpur Upazila, respectively. Of our three study areas, Singra Upazila is rich in snails. The snails here are enormous. Their production capacity is high. They have adequate food here, and their roaming area is vast. So their growth is higher than the other two study areas.

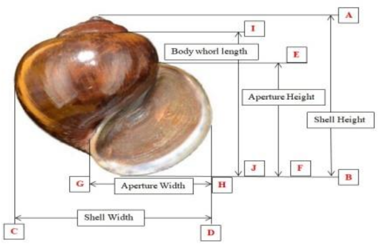

Figure 5: Morphometric study of *Pila globosa*

3.3. Water quality in the study area

Spatial variation of water quality parameters in sampling sites is given in Table 3

Table 3: Water parameter of study area

Parameter	Study area		
	Singra	Bagatipara	Lalpur
pH	8.6	8.1	8.6
EC(mS/cm)	0.14	0.38	0.42
TDS(mg/l)	0.08	0.18	0.24
Alkalinity(mg/l)	68	194	141
CaCO3(mg/l)	51	138	103.5
DO(mg/l)	8.3	8.4	8.1
BOD(mg/l)	0.90	2.90	0.70
COD(mg/l)	1	44.5	25

From January to May 2022, the current study was conducted. The study area's three sampling locations were chosen. The pH of natural waters ranges from 5.0 to 10.0. Other aspects of water quality, including carbon dioxide, alkalinity, and hardness, are reliant on the pH. It can be toxic at a certain level and is also known to influence the toxicity of hydrogen sulfide, cyanides, heavy metals, and ammonia (Klontz, 1993). Below pH 6.5, Physical Parameters, some species experience slow growth (Lloyd, 1992). At lower pH, the organism's ability to maintain its salt balance is affected (Lloyd, 1992), and reproduction ceases. At approximate pH 4.0 or below and pH 11 or above, most species die (Lawson, 1995). In a water body, oxygen is available in a dissolved state. The amount of oxygen consumed varies based on the species, size, feeding rate, and activity level. Environmental factors such as temperature, altitude, and salt can also impact oxygen levels. Any substance suspended or dissolved in water is a whole solid. Everything retained by a filter is considered a suspended reliable, while those passed through are classified as dissolved solids, i.e., usually 0.45µ in size (American Public Health Association, 1998). Concentrations in water are measured as Total Suspended Solids (TSS) and Total Dissolved Solid (TDS), respectively.

On the other hand, dissolved solids (DS) include materials dissolved in the water, such as bicarbonate, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. These ions are essential in sustaining aquatic life. However, high concentrations can damage the organism's cells (Mitchell and Stapp, 1992), water turbidity, reduced photosynthetic activity, and increased water temperature.

3.4. Snail harvesting in the study area

During our investigation, we noticed that the number of giant snails is meager. The scarcity of their habitat, food crisis, and some natural and artificial factors are hindering their average growth. While young snails are plentiful, their concentration is high, which could be a significant factor in the extinction of the entire snail species.

Figure 6: Harvesting of *Pila globose*

From the below figure, it can be determined that the number of snails collected each year from the study area decrease daily and varies from place to place because of the availability of food to avoid environmental hazards and obtain compatible physiological condition. We have created data on snail depletion in the light of previous data. The total amount of snails is reduced considerably from 2006 to 2021 due to over-harvesting, their stock has also decreased, and the destruction of young and brood feeding and spawning grounds of desired snails. In 2000 the harvesting amount of snails was 75000 M T, but in 2021 it has come down to only 900 MT.

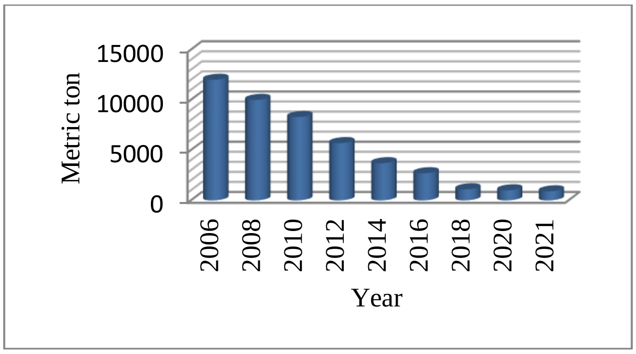

Figure 7: Total amount of snail harvesting within 15 years

Many researchers (Jahan et al.,1998 and 2007; Nath et al., 2013) noted that the amount of available snails has decreased by 50% between 1995 and 2011 in the Chanda Beel. SRLI assessments 2012 suggest that worldwide an estimated 29% of freshwater molluscs species are threatened with extinction. In Bangladesh, over-harvesting this snail from nature for poultry feed and lime production may threaten this species.

3.5. Price trend of snail meat and shell

Humans do not consume snails within the Muslim community of Bangladesh. Saha (1998), however, identified 29 groups of tribal people that consume snail flesh. Snail meat is instead more extensively used in freshwater prawn (*Macrobrachium rosenbergii*) farming in the south-western part of the country (Baby et al., 2010), which (prawn) is one of the significant export earning sectors in Bangladesh (DoF, 2011). With excessive fishing pressure and a lack of regulations, drastic reductions in wild snail populations have occurred in Bangladesh (Nath et al., 2008). Regulating the collection of snails is difficult as it is an essential livelihood for poor people (Jahan et al., 2001). Compared to 1995, the cost of snail flesh and shells grew by 800%, 325%, and 315%, respectively (raised rates are based on BDT (to comprehend the actual growth rate), and the amount is based on US$). The exchange rate of one US$ to BDT varied in different years, which was 40 in 1995, 50 in 2000; 60 in 2005; 70 in 2010; and 74 in 2011 (gocurrency.com, 2011).In our study area, people have not consumed it, but they used snail meat as food for their fish farming and poultry farming. From June to November, local people have taken snail harvesting as a seasonal occupation. Survey information from Singra Upazila, it is observed that snail harvesting has a significant effect on the income of local people. Ten years ago, each harvester earned about 150 taka/day when the price per kg of snail was 3-5 taka. But the cost of snail per kg has increased to 5-8 takas. The daily income has decreased to 50 taka/day because they cannot harvest more than 40-50 kg daily. Snail traders get orders from various districts for processed snail meat, which sells for about Tk. 300 per kilogram. Snail shell is used in the lime industry. For lime production, the yearly average is 294.9 tons; for fish culture and poultry feed, *P. globosa* shells were used with an annual average of 11565 tons. So total average of 5929.95-ton shells was used yearly from the natural field. CARE Int'l. (1999) estimated that the annual harvest of *Pila globosa* from various beel, canals, and rice fields was 365849 Metric Ton.

Figure 8: Lime production from shell

The *P. globosa* are edible to tribal people. They are used to prepare their curries with the flesh and viscera of *P. globosa* in various forms such as *ghati*, soup, wet fried, and fried. Sometimes the meat is taken with vegetables like's potato, arum, tomato, etc. for the preparation of curries. The excellent result reported by Baby et al., 2010 and analysis of the nutrients in the flesh of *P. globosa* contained a moderate source of protein (8.277 %) but a negligible source of fat (0.725 %). Whereas mineral composition in ordinary flesh has calcium (721.44), phosphorus (1360.23), Iron (60.56), Sodium (200.67), and Potassium (60.55) found in mg/100g. *Pila globosa* can be fed live, freshly dead, or processed. Live snails are eaten directly by fish and ducks in ponds and rice fields. Collected *Pila globosa* can be fed whole or without shells (snail meat). Live snails are a good feed for ducks, used in rice fields for natural apple snail population control (Pantua et al., 1992). Fish such as black carp and tilapia have been tested as potential control agents (Caguan & Joshi, 2002; Halwart, 2006). *P. globosa* is being expensively utilized in freshwater prawn (*Macrobranchium rosenbergii*) and the salty water prawn (*Penaeus monodon*) culture in the south-western part of the country.

Figure 9: Using snail in fish farming and duck farming

3.6. Threatened of *Pila globosa*

Information on population sizes and levels of exploitation is so poor to determine whether or not particular species are being seriously over-exploited. Data on the life history, abundance, productivity, and exploitation rates from specific localities are required for every species involved in the shell trade. There are several reports of over-collecting freshwater Mollusca in different areas where collectors concentrate their efforts to meet customers' demands. Various activities connected with shell collecting can alter or degrade habitats. The standard type of disturbance includes trampling and rock removal. Flow modification of rivers for the construction of the dam and other purposes is a threat to freshwater mollusks in Bangladesh. Slightly attention has been paid to the consequences of selective removal of shells from the ecosystem as a whole, but problems exist. It has been remarked that the number of freshwater mollusks is reducing at an alarming rate which sites were polluted (Verma and Saksena 2010; Waghmare et al., 2012). *Pila globosa* plays an essential role in the wetland ecosystem and inhabits an intermediate position in the food chain consuming phytoplankton, algae, aquatic plants, and insects. As the snail population decreases daily, the marine ecosystem is losing its spontaneity, which could be one of the causes of the biodiversity crisis.

4. Conclusion

In comparison to the previous twenty years, we saw an almost 1.5-fold decline in the snail population during our observation. We observed that the snail is now smaller than it was previously. One of the leading causes of snail species decrease is overharvesting and habitat damage. Rising pollution and shifting seasons also interfere with their way of life. Snail species are essential to maintaining aquatic biodiversity. A catastrophe for the ecology could result from changes in the total marine biodiversity brought on by the extinction of snail species. So the preservation and proper maintenance of the various animal resources for the protection of an ecologically balanced environment and harmonious upliftment of the national economy are necessary. Firstly it is an urgent need to develop intensive snail culture farms so that a constant supply for the fish farms could be assured and the natural population of these beneficial animals could exist. Secondly, as gastropod undergoes aestivation during the dry season, specific techniques must be developed to preserve the snail products for the constant supply of animal protein to the low-earning groups of people.

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