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Research Article

Hibernation Ecology of *Pila globosa* Swainson in Chalan Beel, Bangladesh

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Abstract

Pila globosa Swainson is the most important aquatic animal which is found in the aquatic environment of Bangladesh. *Pila globosa* is entered in the hibernation due to passing of unfavorable environmental conditions. It is acted as a good bio-indicator and lives in nutrient rich shallow aquatic environments. Different types of phytoplankton, zooplankton, and aquatic plants are used as sources of food such as algae, diatoms, *Vallisneria spiralis* L., *Commelina diffusa* Burm. L., *Enhydra flactuans* Lour., and *Pistia stratiotes* L. etc. It is chosen hibernation period due to lack of sufficient food and environmental conditions. *Pila globosa* is found at Chalan beel area which is the best habitat in the context of Bangladesh. The main aim of the study was to determine hibernation period, edaphic criteria and habitat of *Pila globosa* of the Chalan beel area. The study revealed that hibernation period was started by end of October to November and the peak hibernation period was December and continue to February. *Pila globosa* is normally semi-dormant, but if food and water are available, some individuals may stay active during the hibernation period. The present study was conducted on the following parameters of soil and indicated that calcium, sodium, magnesium, copper, iron, manganese, and electrical conductivity were 44.08 mg/100 g, 0.38 mg/100 g, 5.07 mg/100 g, 4.18 µg/g, 111.48 µg/g, 20.77 µg/g etc. respectively. Water was nature in slight acidic and its pH value was 5.7. The maximum *P. globosa* was found in the shallow waterbodies, where the water level was 3 to 5 inches. It was also found in dense aquatic vegetation areas where food was easily collected and take shelter for laying eggs. Actually, it is identified as an ideal bio-indicator because of their ability to respond oxygen availability and nutrient enrichment. The findings of the study indicates that *P. globosa* is an essential component of the aquatic environment which plays a vital role in improving of sustainable aquatic ecosystem development. Furthermore research is needed to improve the habitats of *P. globosa* for protection and conservation in the whole aquatic bodies of Bangladesh.

Keywords

Bangladesh, Chalan Beel, Ecology, Hibernation, *Pila globosa*

1. Introduction

Bangladesh's freshwater ecosystems are an intricate and essential part of the nation's resources. Chalan beel is one of the most important and the largest freshwater wetlands of Bangladesh and plays a vital role in providing the fish industry, agricultural productivity and the rich biodiversity necessary to sustain life. Many kinds of aquatic animals are found at Chalan beel area which play a crucial role in improving of aquatic environment. Among them, *Pila globosa* Swainson is

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a crucial ecological component and plays a vital role in the nutrient cycling processes and acts as a biofilter and also contribute to sustainable development of aquatic environment [1]. It has also contribution to maintain the balance of aquatic habitats [2]. It contains a valuable nutrient which is used as edible food in different ethnic communities of Bangladesh [3]. The aquaculture of freshwater prawns (*Macrobrachium rosenbergii*) in the southwest of the country uses *P. globosa* meat more frequently [4, 5]. Mollusks make up 135,000 of the world's 1.40 million extant species [6]. Over 2,000 of them are endangered of going extinct [7]. But day by day, *P. globosa* is decreased due to over exploitation, loss of habitats and scarcity of food in Bangladesh. In order to survive harsh climate conditions, the freshwater *P. globosa* exhibits remarkable behavioral adaptation such as hibernation and aestivation.

The hibernation period was started in the cold weather. It is observed that the minimum hibernation period was started in November and the maximum hibernation was occurred in February. During the aestivation and hibernation phase, when *P. globosa* may live for a long time without water and nutrients, it has been observed that its growth, mobility, and reproductivity activities were remarkable reduced. By lowering metabolic activity, hibernation helps to preserve energy and endure harsh environments [8]. By November or December, they hibernate, and by February, they aestivate. In winter period, they form an epiphragmatic layer to close the aperture opening [9]. As long as water is available, they will continue to perform their functions. In the wild, gastropods that are hibernating or in aestivation frequently rely on anaerobic metabolism to provide energy during trying times. Elevated uric acid is found in several other tissues. During aestivation, uric acid levels rise, may be as a result of oxyradical generation during uric acid synthesis [10]. The bio-economics, ecology and physiology are important for farming of *P. globosa* [11]. Food preference is also essential substance for breeding of *P. globosa* [12]. Actually, breeding capacity depends on ecological habitats [13]. Favorable environment leads to increase breeding and also helps to survive in the local habitats [14]. In order to preserve this natural resource and to aid in *P. globosa* culture and transportation, this study was conducted to monitor the ecology and hibernation activity of the species in Chalan beel area.

2. Materials and Methods

2.1. Study Area

The present study was conducted on chalan beel area of Singra upzila under Natore district of Bangladesh. Singra upzila area is famous for *P. globosa*. There were selected three sites such as Singra point, Kabirganj point and Dahia point etc. The total area of study was 528.46 square kilometers and is situated at 24 ৩0 N latitudes and 89 ৩8 E longitudes (Figure 1). Tarash (Sirajganj district) and Sherpur (Bogura district) upzilas were the east border of Singra upzila and Nandigram upzila (Bogura district) was the north border. Gurudaspur upzila was the south border and Natore sadar and Atrai were the west border of the whole study area.

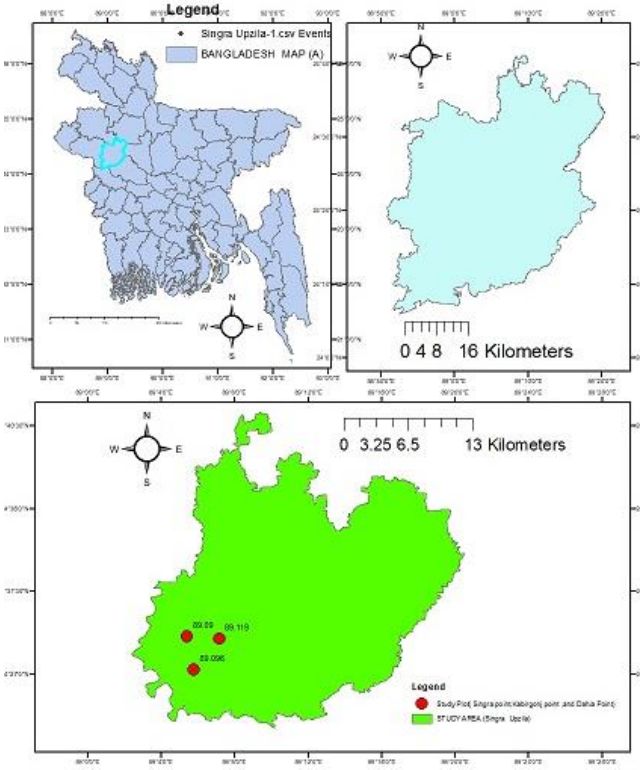

Figure 1. *Location of the study area.*

2.2. Sample Collection

Systematic sampling method was followed for the selection sampling sites with the help of Geographic Information System (GIS). The whole samples were collected from samplings point. The field study and laboratory investigations were done from December, 2023 to June, 2024. The methods are systematically described in the following sections.

2.3. Physiological Parameters

Soil samples were collected from selected sampling points. From each point, three randomly chosen soil samples were collected. The dirt was then combined to make a composite sample. About 500 g soil samples were provided to the Soil Resources Development Institute (SRDI) laboratory in Rajshahi.

2.4. Habit and Habitat Study

The habitat of *P. globosa* was observed by routine monitoring of sampling locations. Vegetation was also seen to be available. One litre of sample water was transferred to cyl-

inders and combined with 4% neutral formalin and a few drops of Lugol's solution in order to quantify the variety of phytoplankton and zooplankton [15]. During the study period, the ambient temperature varied between 20 and 26.5 ℃. Under a microscope, freshwater plankton species were identified following different literature such as *Daphnia magna* Straus. was identified by [16]. Some freshwater plankton species were identified by [17]. The following species were identified by [18] such as *Commelina diffusa, Eichhornia, Enhydra fluctuans and Ludwigia adscendens* etc.

2.5. Observation of Hibernation Period

Both *In-situ* and *Ex-situ* observations of hibernating times were made. After collection of samples from selected points, 35 samples of *P. globosa* were put in the Institute of Environment Science (IES) research field for overcome hibernation period under controlled conditions. Scientific research on this period was made easier by ensuring that *P. globosa* could hibernate comfortably.

(a) (b)

Figure 2*. (a) Fresh P. globosa; (b) Hibernation condition of P. globose.*

3. Results and Discussion

3.1. Soil Quality of the Study Area

Edaphic criteria are the most important factors for surviving of *P. globosa*. The following parameters of soil were analyzed in the laboratory which are presented in table (Table 1). The present study revealed that Calcium (Ca), Sodium (Na), Magnesium (Mg), Copper (Cu), Iron (Fe), Manganese (Mn), and Electrical Conductivity (EC) were 44.08 mg/100 g, 0.38 mg/100 g, 5.07 mg/100 g, 4.18 µg/g, 111.48 µg/g, 20.77 µg/g etc. respectively. The Electrical Conductivity was 0.24 mS/cm. Water was nature in slight acidic and its pH value was 5.70 (Table 1).

The pH value of Chalan beel was 5.70 which was indicated that slight acidic. The soil composition of the Chalan beel area was indicated that it is the most suitable for the survival and growth of *P. globosa*. Normally, it prefers a neutral to slightly acidic environment and essential components such as calcium (Ca), and Magnesium (Mg) are also available in the study area. Since calcium is necessary for the shell development process, *P. globosa* requires minimum of 44.08 mg/100 g of soil. Increased its populations are typically supported by mollusks such as *P. globosa*, settings with sufficient calcium concentrations and calcium required for shell growth and maintenance [19]. The amounts of magnesium (5.07 mg/100 g of soil) support vital metabolic processes that aquatic animals depend on it for surviving.

Table 1*. Physiological parameters of the study area.*

Parameter	Result	Unit
pH	5.7	-
Calcium (Ca)	44.08	mg/100 g
Sodium (Na)	0.38	mg/100 g
Magnesium (Mg)	5.07	mg/100 g
Copper (Cu)	4.18	µg/g
Iron (Fe)	111.48	µg/g
Manganese (Mn)	20.77	µg/g
Electrical Conductivity (EC)	0.24	mS/cm

The optimal range of essential trace elements are needed to sustain various biotic communities iron (Fe) at 111.48 µg/g, copper (Cu) at 4.18 µg/g, and manganese (Mn) at 20.77 µg/g [20]. For physiological functions including respiration and enzymes activity, iron and manganese are necessary for both plants and animals [21]. The amounts of above chemical substances are promoted the growth of aquatic vegetation which is essential diet of *P. globosa*. Additionally, the sodium content (Na) of 0.38 mg/100 g of soil and the low electrical conductivity (EC) of 0.24 mS/cm produce excellent conditions for freshwater species by lowering salinity stress [22].

3.2. Habit and Habitat

The Chalan beel area is rich in flora and fauna. The study was conducted on habits and habitats of *P. globosa* and revealed that it was found in shallow waterbodies, including rice fields, where the water level was 3 to 5 inches. It was also found in dense aquatic vegetation areas where food was easily available and take shelter for laying eggs. The following plants were found in the habitats of *P. globosa* such as *Vallisneria spiralis* L., *Pistia stratiotes* L., *Jussiacea repens, ottelia ovalifolia, Enhydra fluctuans* Lour. etc. Several scientists have also been suggested that the above species play a vital role for proving shelter. It is identified as an ideal bio-indicator because of its ability to respond some indicators

such as change in habitat structure, oxygen availability, and nutrient enrichment [23].

Common plants in these habitats, such as *Vallisneria spiralis*, *Pistia stratiotes*, *Jussiacea repens*, *Ottelia ovalifolia*, *Enhydra fluctuans*, *etc*. not only provide food but also serve as shelter. *P. globosa* can burrow and prefers to stay in shallow, often found in stagnant or nutrient-rich water bodies, as the slow-moving waters keep them near soft sediments.

Figure 3. *Habitat of aquatic vegetation of Pila globose.*

These aquatic habitats serve a vital role in reproduction, as *P. globosa* deposits its eggs in gelatinous clusters affixed to plant life above the water's surface. This investigation revealed congruence with the present findings [24]. During the rainy season, the snail can venture out of the water onto land, relying on direct respiration through its pulmonary sac. This adaptation allows the species to survive the periods of low water availability or poor water quality. Normally, the habitats are soft, nutrient rich sediments at the bottom, where it burrows and feeds.

3.3. Feeding Behavior

Several environmental parameters, including mean sea level(msl), geology, habitat vegetation, microvegetation, pH, calcium concentration, watercolor, and temperature affect the prevalence and distribution of snails. Food quality and availability have a significant impact on *P. globosa* dispersion within a Beel ecosystem. The feeding behavior has been observed under natural environmental conditions during January and February in Chalanbeel. It is rich in *Pistia stratiotes* L., *Vallisnaria spiralis* L., *Commelina diffusa* Burm. f., *Eichhornia crassipes* (Mart.) Solms., *Enhydra fluctuans* Lour., *Ludwigia adscendens* L., *Lemna minor* L., and many other filamentous algae which serves as food for *P. globosa* and it is to be the main cause of the species increased population in the study area. *P. globosa* is an omnivorous, herbivorous, and detritivores and it consumes a broad range of foods. It plays a vital role in the nutrient cycle and maintains the balance of sound aquatic ecosystems by consuming a wide range of plant materials and organic wastes. Several scientists have also been suggested the similar opinion [25]. It uses its unique radula, a rasping organ with tiny teeth that allows it to scrape and consume soft plant tissues and algae, as part of its feeding strategy. This method of feeding allows it to exploit the abundant plant matter and detritus found in its natural habitats, particularly in shallow waterbodies. The radula scrapes up food particle and the jaw cut off larger pieces of food, to be rasped as by the radula [26]. The diet of *P. globosa* predominantly consists of submerged aquatic plants such as *Vallisneria spiralis* and *Pistia stratiotes*, both of which are commonly found in the Chalanbeel area. A similar finding about food quality is made by [27], who states that it prefers clear water with succulent aquatic plants such as *Pistia stratiotes* L., and *Vallisnaria spiralis* L. These vegetations are the main food items and provide essential nutrients for *P. globosa*. It feeds the dead material of plants which speeds up the decomposition process and releases nutrients back into the water bodies for another different organism. This nutrition recycling process increases the productivity of the ecosystem and helps to the proliferation of aquatic vegetation and algae.

Table 2*. Abundant of Aquatic Vegetation in different spot.*

Spot	Available vegetation	Vegetation (%)	No. of *P. globosa*
Spot-1	Pistia stratiotes L.	51.40	6
	Commelina diffusa Burm. f.	11.83	

Spot	Available vegetation	Vegetation (%)	No. of *P. globosa*
	Eichhornia crassipes (Mart.) Solms	14.86	
	Enhydra fluctuans L.	5.95	
	Ludwigia adscendens L.	7.96	
	Unidentified	8.00	
	Lemna minor L..	46.29	
	Oryza sativa L.	39.67	
Spot-2	*Ludwigia repens.* Forsts.	2.20	4
	Commelina diffusa Burm. f.	1.84	
	Unidentified	10	
	Enhydra fluctuans Lour.	23.33	
	Ottelia ovalifolia L.	26.67	
	Vallisneria spiralis L.	23.33	
Spot-3	*Jussiacea repens* L.	10.00	3
	Eichhornia crassipes (Mart.) Solms	7.00	
	Unidentified	9.67	

Pistia stratiotes L. was the most dominated plant within the aquatic vegetation, comprising an impressive 51.40% of the total vegetation. In this case, *Commelina diffusa*, *Eichhornia, Enhydra fluctuans and Ludwigia adscendens* were 11.83%, 14.86%, 5.95% and 7.96% respectively. The total number of *p. globosa* was only six in the spot -1(Table 2). About 8.00% was dead materials which was unidentified.

The present study was revealed that *Pistia stratiotes* was the most preferable food item for the apple size of *P. globosa*. The following species were found in the second spot (Spot-2) such as *Lemna minor* L., *Oryza sativa* L., *Ludwigia repens* L., and *Commelina diffusa* Burm. f etc. and their percentages were 46.29%, 39.67%, 2.20% 1.84% respectively (Table 2). The total *P. globosa* was only 4 which was the second position of whole the study area. About 10% were dead materials which were also unidentified along with four *P. globosa* where *Lemna* minor *L.* (46.29%) and *Oryza sativa* L. *(*39.67%) were dominant. Only four *P. globosa* were recorded in this location. It was highlighted that the primary plant may be needed for its survival, and may serve as viable, albeit secondary food source for the snails and contribute to the overall ecological balance. Normally there were three study spots and the following species were found in the third spot (spot-3) such as *Enhydra fluctuans* (23.33%), *Ottelia ovalifolia* (26.67%), *Vallisneria spiralis* (23.33%), *Jussiacea repens* (10.00%), and *Eichhornia crassipes* (7.00%) etc. respectively (Table 2). Only three *P. globosa* were found in the third spot (Spot-3).

Unidentified materials were recorded about 9.67% of the study area. The findings of the present study indicated that *P. globosa* prefers more diverse habitat for food and distribution.

The diverse aquatic vegetation of Chalanbeel establishes a stable microhabitat by enhancing oxygen levels and water quality, offering a variety of food sources, shelter egg-laying sites, and ideal conditions for the reproduction of *P. globosa*. This dense plant diversity acts as a buffer against seasonal temperature changes and helps to endure its semi-dormant phases during drier or colder months. This favorable environment is closely linked to the high abundance of *P. globosa* in Chalanbeel.

Table 3*. Availability of Zooplankton, Phytoplankton and Aquatic Fauna in different spot.*

Spot	Zooplankton		Phytoplankton		Fauna	
	Available Zooplankton	Quantity (%)	Available Phyto-plankton	Quantity (%)	Available aquatic Fauna	Quantity (%)
Spot-1	Daphnia	30	Spirogyra	28	Fish	35

Spot	Zooplankton		Phytoplankton		Fauna	
	Available Zooplankton	Quantity (%)	Available Phyto-plankton	Quantity (%)	Available aquatic Fauna	Quantity (%)
	Cyclops	27	*Volvox*	25	Mollusks	27
	Moina	18	*Nostoc*	23	Insects	11
	Chydorus	14	*Microcystis*	17	Frog	13
	Unidentified	11	Unidentified	7	Kuchiya (snake like reptile)	5
					Carb	9
	Notholca	10	*Clostridium*	17	Fish	46
	Keratell	5	Diatom	38	Carb	21
Spot-2	*Daphnia*	41	*Nostoc*	13	Mollusks	10
	Cyclops	35	*Microcystis*	22	Leech	7
	Unidentified	9	Unidentified	10	Frog	16
	Asplanchna	21	*Spirogyra*	29	Fish	37
	Cyclops	33	*Nostoc*	18	Mollusks	17
Spot-3	*Daphnia*	12	*Anabaena*	25	Insects	23
	Lacane	19	Diatom	17	lobster	13
	Unidentified	15	Unidentified	11	Unidentified	10

The presence of zooplankton, phytoplankton, and fauna have notable ecological variations in Chalanbeel. According to the results, the distribution of zooplankton, phytoplankton, and aquatic fauna among the three locations may have an impact on the habitat suitability for *P. globosa* (Table 4). Among zooplankton and phytoplankton Spot-1 is dominated by *Daphnia magna* Straus. (30%) and *Spirogyra abbreviata* Zheng. (28%) and the most abundant fauna are different types of fishes (35%) and Mollusks (27%), with rare species like *Monopterus cuchia* Hamilton(5%) appears to provide a rich and diverse food web, potentially favorable for *P. globosa*. At Spot-2, Fish comprise 46% of the fauna, while carbs (21%) contribute significantly. *Chaetoceros* sp. (38%) and *Daphnia magna* (41%) are the dominant phytoplankton and zooplankton, respectively. The well-balanced flora and fauna composition of Spot-3 is dominated by *Cyclops bicuspidatus* Michigan (33%), *Spirogyra abbreviata* Zheng (29%), and different types of fishes (37%), with notable contributions from Insects (23%) and the uncommon presence of Lobsters (13%). This distribution highlights the different environmental preferences and ecological interactions among the locales.

The presence of phytoplankton, diatoms, and other algae species in *P. globosa*'s gut, as revealed by microscopic examination, highlights the opportunistic feeding habits of this species [23]. The snail consumes the algae and diatoms that the radula scrapes off from submerged surfaces. The snail usually acquires food from microbes and larger plant components, which aid in its growth and reproduction. The feeding habits of the snail are not selective, they depend on the availability of food. They also rely on debris and other organic matter for food in areas with fewer nutrients [13, 16].

3.4. Hibernation Period

Hibernation in *P. globosa* typically begins in early winter and lasts until late winter, with a sudden revival occurring in April following the first rains [28]. Generally, the snails enter hibernation during winter when temperatures drop. In the study area, it has been observed that the snails begin hibernating by the end of October or early November, with the peak of hibernation occurring in December. The hibernation period in this study was carried out in December, January, and February. The hibernation behavior of *Pila globosa* is a survival strategy under harsh environmental conditions. Such behavior highlights several important ecological and physiological adaptations. In the rice fields of Chalan beel, particularly along the margins of watersheds with humus-rich soils, *P. globosa* was observed burrowing 1 to 4 inches below the surface during hibernation.

Table 4. Depth required by snails in the soil for hibernation in different habitat.

Spot	Snail hibernation depth (inch)		
	Sample-1 (inch)	Sample-2 (inch)	Sample- 3 (inch)
Spot-1. Peddy field	2	3	4
Spot 2. Bank of the beel	1	1	2
Spot -3. A little far from the water	2	2	3

Location-based preferences were seen in data on *P. globosa* hibernation depths across several locations. The findings of the study revealed that *P. globosa* prefers shallow deep areas such as paddy field where water deep is 2 to 4 inches. The high moisture is the most important environmental factor for surviving of *P. globosa*.

A little far from the waterbodies, the hibernation depths in the soil varied from 2 to 3 inches. This depth may maintain a balance between stability and moisture. This finding suggests that the hibernation depth of *P. globosa* may depend on soil type and moisture availability in the study area. Chalan beel offers perfect microenvironments that provide protection and moisture retention, shielding the snails from temperature during their hibernation period. One of the most critical aspects of *P. globosa*' s hibernation strategy is its reliance on thermal acclimation, a characteristic typical of poikilotherms. *P. globosa* displayed typical pre-hibernation activities before hibernation began, including decreased eating and movement, which were probably signs of physiological preparation for dormancy. These actions imply that the snails were entering a physiological adaption known as hypometabolism, which reduces energy consumption. In hibernating period. *Pila* seals itself by closing its operculum, form an additional structure called the epiphragm, a thin, mucous layer that hardens and further seals the shell opening. Like other species that encounter seasonal temperature variations, *P. globosa* exhibits a marked decrease in metabolic activity during the cold months [29, 30]. Additionally, individual *P. globosa* arose from hibernation at different times, exhibiting a staggered pattern of arousal. Microenvironmental variables, soil temperature, and moisture content all affect this slow waking [31]. Several scientists suggested that other mollusks such as *Helix pomacella* L. was awakened from hibernation, completing (100%) by the 3rd day, while *Eobania vermiculata* L. fully emerged (100%) by the 7th day [32].

P. globosa is semi-dormant, yet some individuals may stay active in the hibernation period if water are available. This behavior implies that *P. globosa* can benefit from favorable circumstances even during the hibernation phase, which runs counter to the conventional idea of complete dormancy in hibernating snails. If providing food and water during colder months can enhance *P. globosa* survival and promote potential growth, even in semi-dormant states, this will be helpful for snail culture and trading purposes, as understanding hibernation patterns can improve the management and growth of snails during colder months.

Because there was a scarcity of food and water in our research field, *P. globosa* took a long time to come out of hibernation. Approximately 95% of the snails were found to require over a month to emerge from their hibernating state. This implies that the hibernation recovery process is greatly impacted by resource shortage, which slows down the shift to full activity.

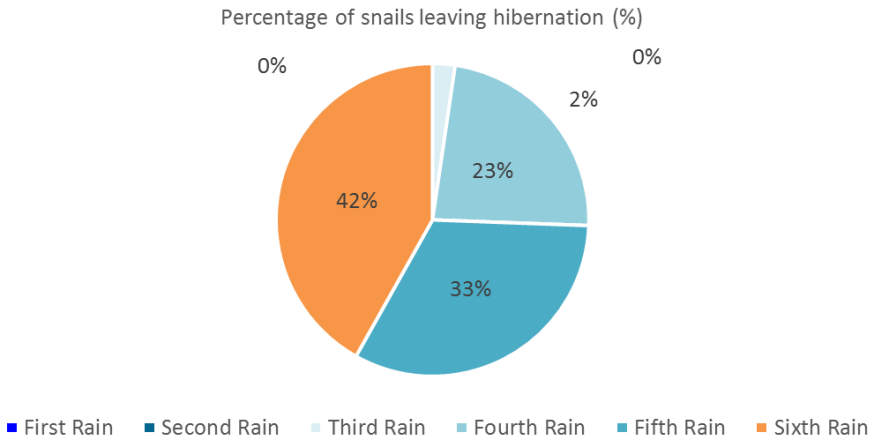

Figure 4. Leaving period from hibernation of P. globosa during rainy season.

4. Conclusion

This study highlights the physiological adaptability of *P. globosa* in Chalan beel area. This species along the coastline of Bangladesh possesses considerable socio-ecological importance for both consumable and non-consumable applications, including serving as a food source and contributing to the production of poultry and fish meal, in addition to its use in ornamental practices. It prefers shallow, nutrient-rich habitats and feeds on phytoplankton, zooplankton, and aquatic plants. Hibernation is their strategy to survive in cold temperatures but some individuals may stay active during the hibernation period in case of water availability which indicates *P. globosa* can profit from favorable conditions even during the hibernation period. Although the demand for snails is increasing daily for consumable and non-consumable applications, snail farming practices are still hardly available in our country. So, the preservation and proper maintenance of *P. globosa* resources in the hibernation period for their proper growth and reproduction are necessary. The development of intensive snail culture farms is important to ensure a steady supply for fish farms and the survival of these useful creatures' natural populations. As *P. globosa* hibernates cold temperatures, special methods for preserving snail products are needed to ensure that low-income communities have a steady source of animal protein.

Abbreviations

MSL	Mean Sea Level
EC	Electrical Conductivity
Mn	Manganese
Mg	Magnesium
Ca	Calcium
Na	Sodium

Conflicts of Interest

The authors declare no conflicts of interest.

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