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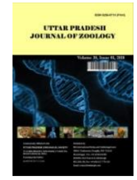

# SHELL MORPHOMETRY AND FECUNDITY OF THE EXOTIC SNAIL *Planorbarius corneus* (Linnaeus, 1758) (Gastropoda: Planorbidae) IN KOLKATA, INDIA

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**AUTHORS' CONTRIBUTIONS**

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

An assessment of the shell morphology and the fecundity of the 'great ramshorn snail', *Planorbarius corneus* (Linnaeus, 1758) (Gastropoda: Planorbidae) obtained from pet market in Kolkata, India was carried out. Using various dimensions of the shell, including shell diameter, and body weight of the living specimens (n=204) and shell weight for dead specimens (n= 306), the correlations and regression equations were framed to portray the shell shape of *P. corneus*. A relationship between fecundity with the shell diameter was also deduced to highlight the reproductive potential of *P. corneus*. In the living specimens, the shell diameter (x) and the body weight (y) fitted with a power regression $y = 0.396x^{2.74}$, $R^2 = 0.987$. Similar observation was made for the dead specimens, where the shell diameter (x) and the shell weight (y) were related as: $y = 0.067x^{2.99}$, $R^2 = 0.973$. All the dimensions of the shell were highly correlated ($P < 0.0001$) and could be related through regression equations. A positive correlation was observed between fecundity and shell diameter but with a low fit to a linear regression equation, indicating sufficient variability in the fecundity for a particular size of *P. corneus*. In continuation with these observations, further studies on *P. corneus* are required to deduce its possible effects as an invasive freshwater species in Indian context.

**Keywords:** Shell morphometry; regression equation; ramshorn snail; invasive species.

## 1. INTRODUCTION

One of the major and growing threats of biodiversity loss is the invasion of non-native organisms [1,2]. The invasive species may have direct or indirect effects on the ecosystem as they can directly compete with the native biota of the respective ecosystem for their resources and can alter the community structure [3]. For example, the introduction of non-native carnivorous gastropod, *Euglandina rosea* (Férussac, 1821) with the aim of controlling the invasive African giant land gastropod *Achatinella mustelina* Mighels, 1845, has adverse effect on the native land snail population of the Hawaiian Island [4,5]. Similarly, it was observed that the non native gastropod, *Pomacea bridgesii* (Reeve, 1856) (Gastropoda: Ampullaridae) consume the eggs of *Indoplanorbis exustus* (Deshayes, 1834) [6] and thereby induce risk to the native fauna. In the recent times, anthropogenic activities are the main factors over the natural causes responsible for the invasion of many freshwater plants, fishes and gastropods [7,8]. With the growing

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popularity of aquarium in the households, the chance of translocation of freshwater organisms around the world is gradually increasing [7-10]. Many gastropod species of Physidae, Planorbidae, Thiaridae and Lymnaeidae are reported to get transported via the water column of aquariums, plants or sediments present in the aquarium and dispersed elsewhere [8,11-12]. The golden apple snails (Gastropoda: Ampullariidae), *Pomacea canaliculata* (Lamarck, 1828) and *Pomacea insularum* (D'Orbigny, 1839), native to South America was introduced in many parts of Asia as a potential protein food source but escaped from aquaculture and get established in natural habitats of South-east Asia [13,14]. Therefore, as mentioned, in spite of their small body size, the invasive gastropods are a matter of great concern. More importantly, these gastropods are sold worldwide as a part of the aquarium trade facilitating the dispersal process [7,8].

The freshwater gastropod *Planorbarius corneus* (Linnaeus, 1758), known as the great ramshorn snail, is commonly found all over the European countries [15-18]. In many of the Asian countries, these snails are being sold in the local pet market without any restriction or caution and are being reared in the aquarium with high interest solely because of its beautiful reddish coloration. As the fecundity of this snail is very high [19-21] and can grow rapidly [20,22], it may be assumed that if *P. corneus* escape from aquarium, they may establish in the natural freshwater habitats, with ease. As a strategy of invasion, an invasive species produce surplus number of propagules which in turn influences the rate of increase in their population. So estimation of the fecundity of a species is considered to be an indicator of their extent of invasion in a newer habitat [23]. An assessment of the shell shape and the size is necessary to predict the possible changes of the snail in the life tenure. The shell shape and size represent the fitness of the gastropod under natural condition and serves as the surrogate to indicate the growth of the specimens [24,25] as observed in *P. corneus* in European regions [19-22]. Thus in the present study an attempt is made to portray the shell morphology and fecundity of *P. corneus.* Appraisal of the shell morphology and the fecundity of *P. corneus* will enable comparison with the studies made from France [19,20] and Russia [22]. The shell morphology and fecundity of *P. corneus* will also provide insight about its potential to invade Indian freshwater.

## 2. MATERIALS AND METHODS

### 2.1 Study Materials

The specimens of *P. corneus* were collected from the vendors of a local pet market in Kolkata during 2018 and 2019 and reared in the laboratory for seven days prior to initiating the measurement of the shell features and the body weight. In the laboratory the specimens were placed in plastic tray (30 x 25 x 10 cm) and buckets (30 x 30 cm) as available, filled with tap water and maintained in aerated condition at a temperature of 25 ± 1°C and the pH of the water was between 7.4 – 7.6. As food for consumption, the snails were provided with lettuce and few twigs of *Jussiaea repens* L. (Onagraceae) and *Alternanthera philoxeroides* (Mart.) Griseb. (Amaranthaceae) were placed in the containers to simulate the natural conditions. After death of any specimens, the shells were collected and stored for the measurement of the morphology for future. In the buckets and the trays, the density of the snails was 10/l and the water and food was replaced at the end of 24 hours for each instance.

### 2.2 Data Collection

#### 2.2.1 Shell morphometry

From the laboratory maintained culture of the snails, each individual was measured for the snail features and the body weight. Upon death of the snails, the shell morphology and the dead shell weight were measured along with the measurement of the aperture length, aperture breadth, shell width and the values were recorded for analysis. The shell morphological variables were selected comparing published literature [24,26]. The diameter, width and breadth of the shells were measured to the nearest 0.1 mm and the weight to the nearest 0.1 mg. At least 204 living and 302 dead shells were considered for the morphometric analysis.

#### 2.2.2 Fecundity

An assessment of the fecundity of the snails was also carried out by immediately placing a snail alone in a 100 ml plastic container for a day. At the end of a 24 hour period, the number of egg capsule oviposited and the number of eggs in each capsule was recorded against the concerned snail individual. The shell diameter (SD in mm) of the snail was recorded to the nearest 0.1mm against the number of the egg capsule oviposited.

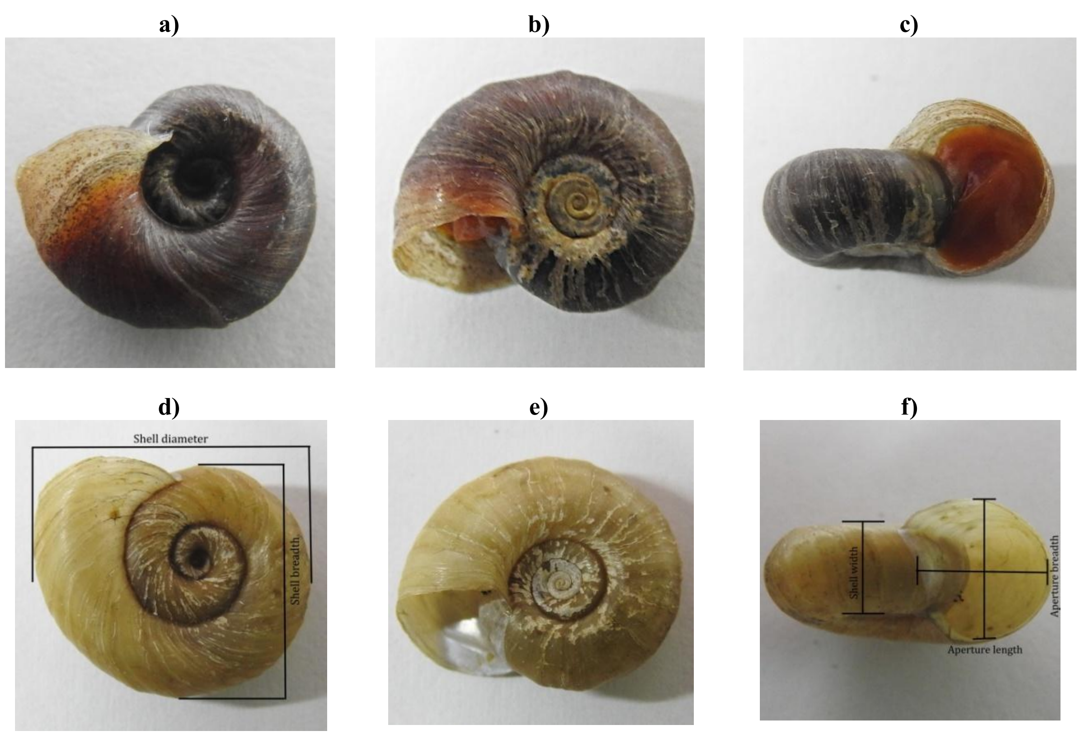
### 2.3 Data Analysis

Data on the morphological variables of the shells and the body weight of the living specimens and the weight of the shell of the dead snails were subjected to linear regression analysis [27]. An extrapolation of the data of the shell diameter and the body weight relationship of the living specimens was used to predict the prospective weight of the soft tissues of the single specimen. For a particular shell diameter, the prospective weight of the snail was used to construct the shell diameter and the fecundity relationship, which was further used as a reference to deduce the weight of the soft tissue of the concerned snail individual. The eggs oviposited by each individual was used to construct a regression analysis [27] to justify the predictive feature of the shell diameter as a variable on the egg laying potential of *P. corneus*.

## 3. RESULTS

The shape of the living *P. corneus* and the shells of the dead specimens in different views and the egg capsules are shown in Fig 1. In the present context, the living *P. corneus* considered for the study ranged between 2 and 16 mm in shell diameter (SD, in mm) and 2.94 and 685. 68 mg in body weight (BW, in mg). The dead specimen of *P. corneus* ranged between 3.5 and 20.3 mm in shell diameter ($SD_{DS}$, in mm) and 1.94 and 612.17 mg shell weight ($W_{DS}$, in mg). An extrapolation of the regression equation relating the SD and BW of the living *P. corneus* was used to deduce the weight of the soft tissue. For the living specimens, a power regression equation, relating BW (y) with the SD (x) [$y = 0.396x^{2.736}$, $R^2 = 0.987$] was found to be the best fit. For the shells of the dead snails, similar regression equation $W_{DS}$ (y) with the SD (x) was observed [$y = 0.067x^{2.99}$, $R^2 = 0.973$]. Replacing the values of the SD with the $SD_{DS}$, the data on the predicted body weight ($BW_P$ in mg) was obtained for the dead snails. The value was further subtracted with the shell weight ($W_{DS}$ in mg) to obtain the weight of the soft tissue ($W_{ST}$ in mg) of the snails. Thus the body weight component could be viewed as the weight of the soft tissue and the weight of the shell. A significant positive correlation was observed for the $BW_P$, $W_{DS}$ and $W_{ST}$ ($W_{ST}$ vs. $W_{DS}$: $r = +0.933$; $W_{ST}$ vs. $BW_P$: $r = +0.991$; $W_{DS}$ vs. $BW_P$: $r = +0.972$). The values of the different variables of the shell shape and the body weight of *P. corneus* and the corresponding correlation coefficients are shown in Table 1. In all instances, the correlation coefficients were highly significant at $P < 0.0001$ level (Table 1). The regression equations of the variables are shown in Fig. 3, showing high significant level ($P < 0.0001$).

The oviposition of 214 *P. corneus* was observed in the laboratory where in almost all instances (212 snails laid single egg capsule and 2 snails laid two egg capsules). Oviposition was observed for a shell diameter of 6.9mm and the highest shell diameter was 18.2 mm. The eggs/ capsule ranged between 6 and 26 (mean 13.12 ± 0.12 SE) for *P. corneus* with corresponding shell diameter of 6.9 and 16.9mm. The fecundity of the snail *P. corneus* shows a significant correlation with the shell diameter, though the regression equation did not show a significant fit (low $R^2$ value of 0.267). An increment in the egg/ capsule was found to increase with the shell length being considered as a discrete variable with distinct size class for each diameter (Fig. 4).



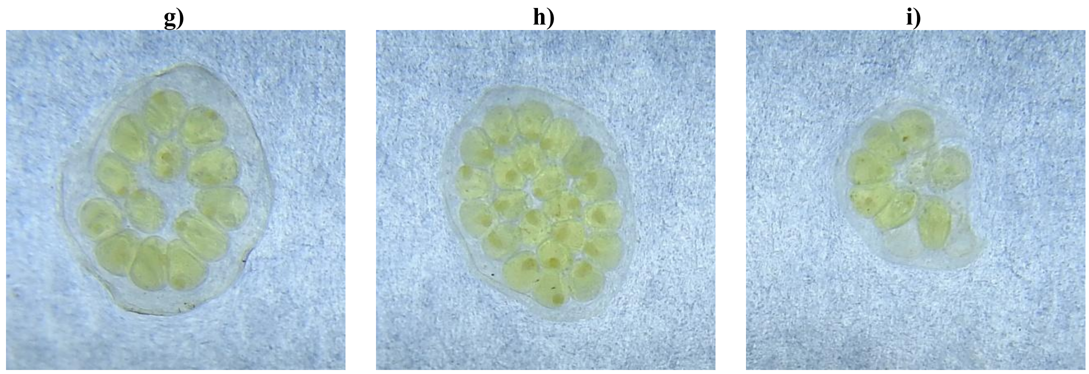



**Fig. 1. Different views of the snail *P. corneus*; live (a-c) and shells of dead individuals (d-f) collected from the local pet shop and reared in the laboratory during 2018 and 2019. Egg capsules (g-i) of the snail *P. corneus* obtained in laboratory culture, with respectively 13(g), 22 (h) and 7(i) eggs**

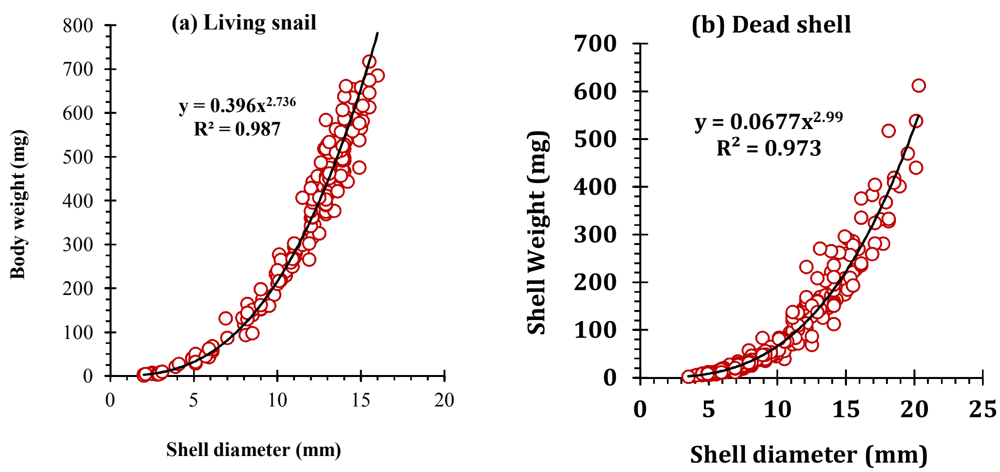
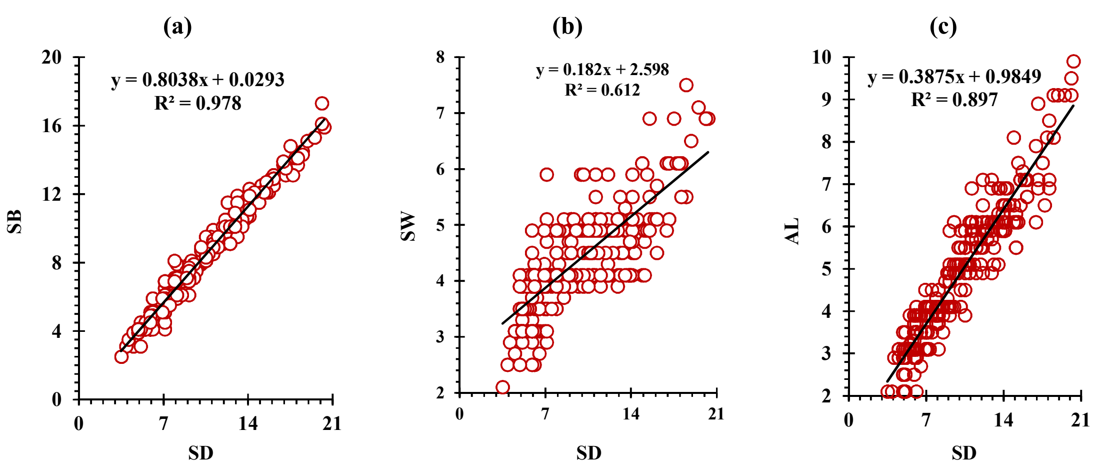



**Fig. 2. (a) Correspondence of the body weight (y) and the shell diameter (x) of living *P. corneus* (n= 204) and (b) correspondence of shell weight and the shell diameter of the shells of dead *P. corneus* (n= 306). The best fit regression equation is represented in the figures**



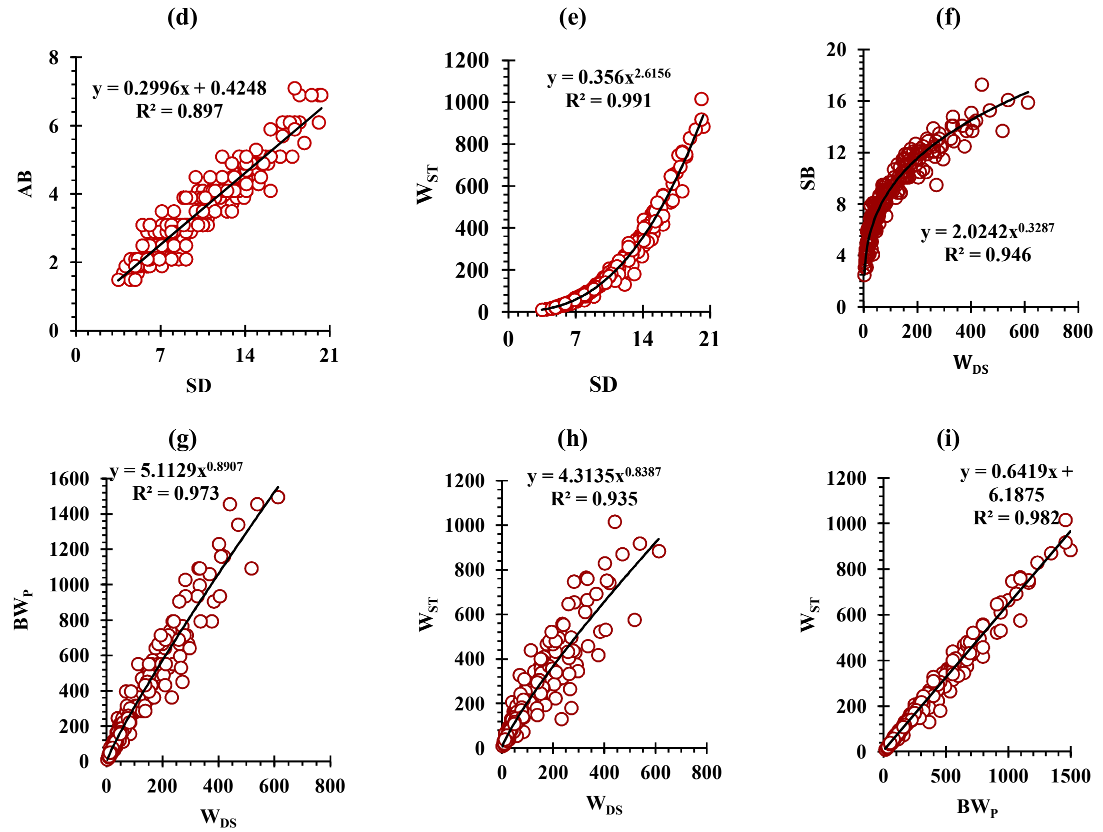


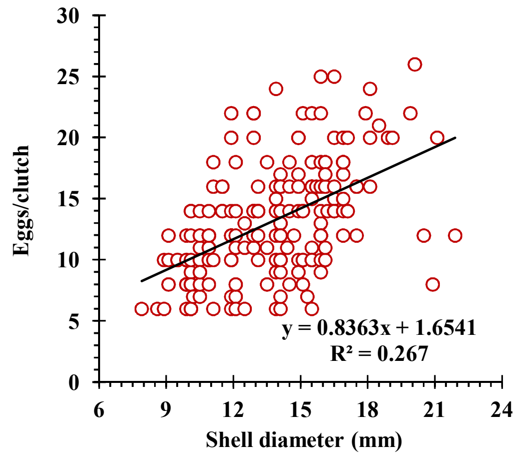

**Fig. 3. The relationship between different variables of shell shape and weight of *P. corneus* represented through a best fit regression equation. Here $W_{ST}$ (in mg) and $BW_P$ (in mg) are derived variables from the extrapolation of the regression equations shown in Fig 1. (SD- Shell diameter in mm, SB – Shell breadth in mm, SW – Shell width in mm, AL – Aperture length in mm, AB – Aperture breadth in mm)**

**Table 1. Values (range, mean ± SE) of different variables related to the shell shape and body weight (BW, in mg) of the living snails and shells of dead individuals of *P. corneus.* The Pearson's product moment correlation coefficient for the different variables representing the shell shape, soft tissue weight ($W_{ST}$, in mg) and the weight of dead shell ($W_{DS}$, in mg) of the snail *P. corneus*. The values in bold indicate significance at P < 0.0001 level. (SD- Shell diameter in mm, SB – Shell breadth in mm, SW – Shell width in mm, AL – Aperture length in mm, AB – Aperture breadth in mm; $BW_P$ predicted body weight in mg)**

| Living snail | | Dead snail | | | |
|---|---|---|---|---|---|
| **SD** | **BW** | **SD** | **SB** | **SW** | **AL** |
| 2 – 16 | 1.23 – 717.41 | 3.5 -20.3 | 2.5 – 17.3 | 2.1 – 7.5 | 2.1- 9.9 |
| 10.61 ± 0.27 | 323.64 ± 14.36 | 9.61 ± 0.22 | 7.75 ± 0.17 | 4.35 ± 0.05 | 4.70 ± 0.09 |
| | | **AB** | **$W_{DS}$** | **$W_{ST}$** | **$BW_P$** |
| | | 1.5 – 7.1 | 1.94 – 612.17 | 10.25 – 1016.152 | 12.19 – 1496.25 |
| | | 3.30 ± 0.06 | 90.98 ± 6.20 | 180.40 ± 10.90 | 271.38 ± 16.83 |

| Variables | SD | SB | SW | AL | AB | $W_{DS}$ |
|---|---|---|---|---|---|---|
| SB | **0.989** | | | | | |
| SW | **0.783** | **0.771** | | | | |
| AL | **0.947** | **0.936** | **0.809** | | | |
| AB | **0.947** | **0.938** | **0.765** | **0.925** | | |
| $W_{DS}$ | **0.924** | **0.909** | **0.751** | **0.894** | **0.899** | |
| $W_{ST}$ | **0.947** | **0.930** | **0.735** | **0.884** | **0.898** | **0.933** |

(a)




(b)

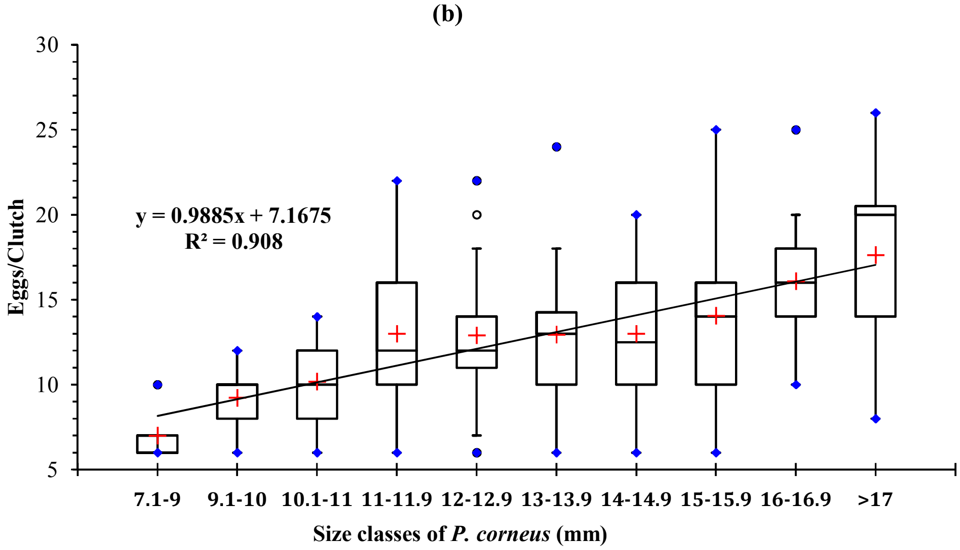



**Fig. 4. The relationship between eggs/clutch and the shell diameter of the snail *P. corneus* collected from local aquarium pet shop and reared in the laboratory - (a) the shell diameter is considered as a continuous variable and (b) the shell diameter is classified into categories of discrete size classes. The best fit regression equation is shown in the figures**

## 4. DISCUSSION AND CONCLUSION

The great ramshorn snail *P. corneus* is extensively distributed in the European continent and in selected regions in northern Asia [16,18]. *P. corneus* is a hermaphrodite snail inhabiting various freshwater bodies of Europe featured with prolific breeding habit [17]. Being omnivore, feeding both on detritus and plants, *P. corneus* is common along with the other two congenerics *P. corneus* and *P. thiolierei* in Europe. The biology of the snail from the British islands indicates that completion of the life history requires more than one year time period [28]. As observed in British lentic system, the cohorts born on a particular year continues to grow for more than a year [28], similar observations have been made for the natural populations in France [19,20] and Russia [22]. The life span of *P. corneus* is observed to be more than 113 weeks depending on the temperature [19,20]. A maximum longevity of 231 weeks was observed at a temperature of 15°C, though the optimal temperature for growth and survival of *P. corneus* is 20.5°C. Shell diameter decreases with the increase in temperature, though the snail lives for a longer period under low temperature [19,20]. The temperature of the ambient condition bears high impact on the life history traits and the life cycle of *P. corneus*, aptly suggesting influence of the climate on the life history of the snail [19]. Apart from the growth, the activity, the embryonic development of *P. corneus* is varies with the temperature conditions [15,21]. In laboratory conditions, *P. corneus* lived between 49 and 110 weeks reaching a weight of 0.7 and 1.7 gm and with a shell diameter of 14 to 21 mm, when maintained at a constant temperature of 20°C [22]. In the present observation, the shell diameter and the shell shape remained within the range observed in these earlier studies [19, 20, 22]. An individual *P. corneus* with shell diameter of 20.3mm was observed with a predicted body weight of 1.5 gm. The shell features bear similar correlations as observed for other planorbid [29,30,26] and non-planorbid gastropods [24,31,25]. The fecundity of *P. corneus* vary with the temperature with numbers of eggs per egg capsule varying between 8 and 14.8 and the maximum number of eggs per egg capsule between 27 and 48 [19,20]. Complying with these observations the variations in the fecundity remained between 6 and 26 with $13.12 \pm 0.3$ numbers of eggs per egg capsule for *P. corneus* in the present instance. Although the cohort based fecundity was not observed, the individual based oviposition indicated about the high fecundity and fertility of *P. corneus*, which may favour its colonization and establishment in new habitats.

*P. corneus* is common in Europe [32] but invasion in New Zealand is also known [33]. Comparing the distribution of the snail in Europe and selected regions of Asia, the involvement of the birds in geographical range expansion has been projected, among the various possibilities [16]. However, the availability of *P. corneus* in India and other regions of the world, excepting Europe and Northern Asia, are perhaps through the aquarium trade [7, 8]. In the pet market, as observed in Kolkata, India, the snail *P. corneus* is an emerging species for sale along with the different indigenous and exotic fish and the macrophytes. Apparently, in the aquarium trade, *P. corneus* is competing with *P. diffusa* and is equally a concern for its possible invasion in the natural ecosystems of India. Considering the ability of the snail *P. corneus* to tolerate the dry sediment conditions for more than 50 days [34], as well as the ability to produce huge number individuals with 1600 newly hatched produced per single generation at 20°C [19]. Whereas, the cohort based fecundity were not assessed, still the risk of invasion by the snail *P. corneus* remains, considering the steady oviposition observed in laboratory conditions. The fecundity of the snails is a key factor in colonization and subsequent establishment in the newer habitats [23]. Thus further studies should be continued inclusive of the life history features and the fecundity schedule of the snail *P. corneus.*

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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