





LIFE TABLE ESTIMATES FOR THE MICRO LAND SNAIL *KALIELLA BARRAKPORENSIS* (REEVE, 1852) (GASTROPODA: EUPULMONATA: CHRONIDAE) OCCURRING IN KOLKATA, INDIA

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ABSTRACT: Life history features of the micro land snail *Kaliella barrakporensis* (Reeve, 1852) (Gastropoda: Chronidae) were estimated under laboratory conditions. We observed the growth, fecundity and life span of *K. barrakporensis* using a fixed number of individuals ($n = 10$) in 10 different cohorts. The maximum life span was observed to be 22 weeks, along with early sexual maturity around 7 weeks, and only one reproductive event. The net reproductive rate (R_0), finite rate of increase (λ), intrinsic rate of increase (r_m) and generation time (T_c in weeks) were 8.54 ± 1.46 , 0.11 ± 0.03 , 1.1 ± 0.02 , and 10.89 ± 0.3 , respectively. Our study showed that *K. barrakporensis* exhibits indeterminate growth, short life span, higher juvenile mortality, early sexual maturity, only one reproductive period and the reproductive strategy that they may retain their eggs and hatch inside their body or give birth to live young. Information on the growth and reproductive strategy of the micro snail *K. barrakporensis* will reflect the adaptive features of the snail in the terrestrial ecosystem.

KEYWORDS: fecundity; Gastropoda; generation time; growth; life history traits

INTRODUCTION

Terrestrial gastropods (Mollusca: Gastropoda) are an important group among the invertebrates, constituting the second largest invertebrate taxa with about 24,000 species (LYDEARD et al. 2004) with extensive variations in their shape, size, body colouration and habitat utilisation patterns (RAHEEM & NAGGS 2006, RAMAKRISHNA et al. 2010). *Kaliella barrakporensis* (Reeve, 1852) (Gastropoda: Chronidae) is one among many “micro-snails”, with shells less than 5 mm maximum dimension (PANHA & BURCH 2005), native to India. It is also found in other countries around the Indian Ocean, and in hot-

houses elsewhere (BLANFORD & GODWIN-AUSTEN 1908, HERBERT & KILBURN 2004, VERDCOURT 2006, PREECE & NAGGS 2014, SOW-YAN & LAU 2020, NURHAYATI et al. 2024). It is typically a species of damp, shady microhabitats such as moist spaces in gardens, detritus, under logs, stones, or other debris. While its distribution and plant preferences are well known (BARMAN & ADITYA 2021), there is little or no information on biological characteristics, including morphology, life-history and reproductive traits of this micro land snail.



While it is not a threatened species, its vulnerability to microhabitat changes, coupled with its ability to spread, passively, beyond its natural range (BARMAN & ADITYA 2021), make it a target for understanding its life history, reproductive capacity and population structure. In this study, we aimed to describe the life history traits and life table parameters based on laboratory observations on *K. barrakporensis*. As factors such as habitat destruction, climate change, and

human activities can significantly impact these traits and the survival of micro snail populations, understanding life history traits is crucial for developing effective conservation strategies and ensuring the sustainability of ecosystems where these snails play a substantial role. In addition, this study addresses a critical knowledge gap by providing baseline information on the biology of *K. barrakporensis*, which has remained poorly studied to date.

MATERIAL AND METHODS

SPECIMEN COLLECTION AND REARING

The micro snail, *K. barrakporensis*, was collected from the gardens in Ballygunge campus, University of Calcutta, India (22°31'37"N, 88°21'46"E), during the rainy season. The specimens were collected by hand-picking and with a wet paintbrush early in the morning and late in the evening. The collected specimens were placed in sample containers (100 ml volume, Tarsons®, India) with moist tissue paper to maintain the higher humidity. The specimens were identified by their external morphological characters (MITRA et al. 2004). The adult snails had thin, pyramidally trochiform, brownish, translucent shells, which were narrowly perforate with six whorls, the last of which has a peripheral keel that is not descending (MITRA et al. 2004). The field collected snails ($n = 50$) were kept in 5 rearing plastic containers each with 10 snails ($6 \times 6 \times 8$ cm, Tarsons®, India) in the laboratory, which were prepared by placing humid soil with a sufficient amount of coco peat at the base. Throughout the rearing period, the snails were fed ad libitum with cucumber slices, and the food and faeces were removed from the container at 24-hour intervals. The rearing containers were kept at ambient temperature (25–27 °C), and the containers were kept moist by spraying the requisite water each day. The field-collected *K. barrakporensis* (F_0) began producing hatchlings after a few days of acclimatisation in the laboratory. The hatchlings were collected and transferred to new rearing containers for the subsequent generations (generation F_1 and F_2 respectively). The progeny of F_2 (F_3) were used in the study.

EXPERIMENTAL DESIGN

The < 1-day-old hatchlings of *K. barrakporensis* (F_3) were considered to estimate the life history traits and life table parameters of *K. barrakporensis* (F_3 hatchlings were used to ensure that all individuals originated from laboratory-acclimatised lineages, thus minimising any possible bias due to field-collected parental stress). Ten cohorts with a fixed number of hatchlings ($n = 10$) were set up in the conditions

mentioned earlier. The snails were fed with sliced cucumber, and the containers were cleaned regularly to remove the faecal material and dead individuals.

The shell height and body mass of randomly selected 30 individuals ($n = 30$; 3 from each of the 10 replicates) were measured using a stereo microscope using an ocular micrometre (Erma®, Japan) and an electronic balance (Afcoset®, India) to the nearest 0.1 mg, respectively, after every two weeks, since initiation of the experiment. The data on the life history traits, such as the age at sexual maturity (in days), fecundity and mortality, were recorded till the death of all individuals in all cohorts.

DATA ANALYSIS

The mean (\pm SE) shell height (mm) and body mass (mg) of *K. barrakporensis* at every two-week intervals were assessed by descriptive statistics, and the growth pattern was estimated by fitting the shell height and body mass to the age of *K. barrakporensis*.

The age-specific survivorship (l_x) and life expectancy (e_x) were estimated using the formulas:

$$l_x = \frac{n_x}{n_0}$$

and

$$e_x = \frac{L_x}{l_x}$$

respectively, where l_x = proportion of the individuals that survived the age x , n_x = number of individuals at age x , n_0 = total number of individuals at the start of the experiment, e_x = life expectancy at age x and $L_x = (n_x + n_{x-1}) / 2$ (STILING 1996, KREBS 1999, SMITH & SMITH 2001).

The fecundity (m_x) was measured using the observed number of hatchlings by snails in laboratory conditions each week, and the age-specific fecundity table was calculated by estimating the following life history characteristics. The net reproductive rate (R_0), i.e., the average number of offspring produced

by individuals during their life was estimated using the following formula:

$$R_0 = \sum_{x=0}^k l_x m_x,$$

where m_x is the total number of hatchlings produced by *K. barrakporensis*. The cohort generation time (T_c) was calculated as:

$$T_c = \frac{\sum x l_x m_x}{R_0}$$

and the intrinsic rate of increase (r_m) was calculated as:

$$r_m = \frac{\log_e R_0}{T_c}$$

(SMITH & SMITH 2001). Additionally, the age-specific reproductive values (V_x) were calculated as:

$$V_x = \frac{e^{rx}}{l_x} \sum_{y=x} e^{-ry} l_y m_y$$

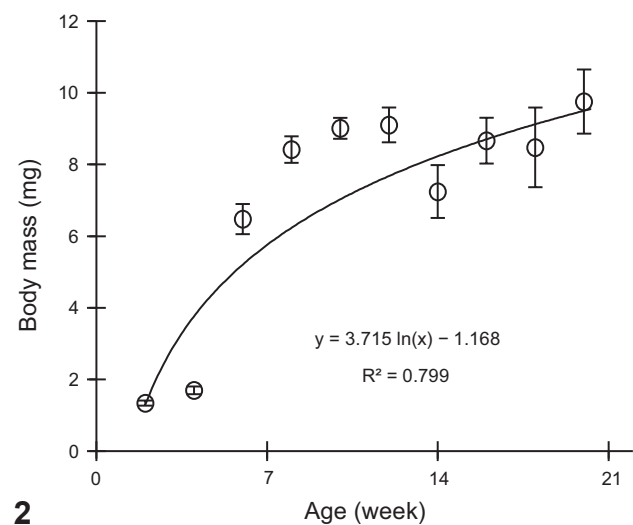
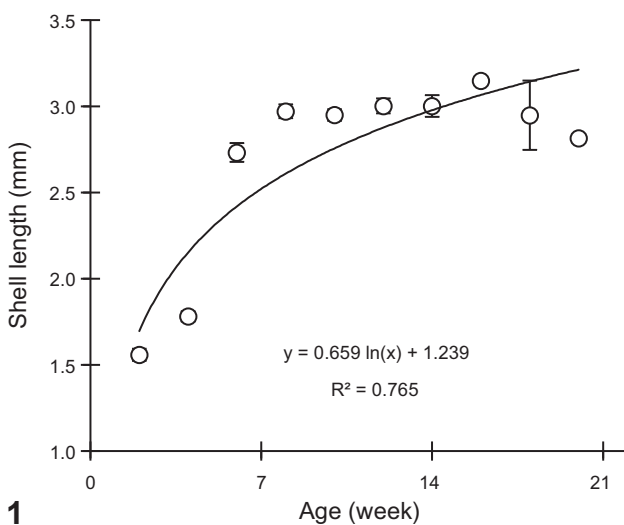
where y is the age of all individual snails passing through from age x (SMITH & SMITH 2001), and the finite rate of increase (λ) was estimated as $\lambda = e^r$.

RESULTS

The growth pattern of *K. barrakporensis* (in terms of shell height and body mass) was found to be asymptotic, as growth rate was rapid initially (till 7–9th week), and then became slower, becoming negligible in the last weeks of life (Figs 1–2). The mean (\pm SE) shell height and body mass of *K. barrakporensis* were 1.56 ± 0.03 mm and 1.34 ± 0.07 mg at the age of 2 weeks and 2.71 ± 0.1 mm and 9.75 ± 0.89 mg at the age of 20 weeks.

The maximum life span of *K. barrakporensis* was observed to be 22 weeks under laboratory conditions. The mortality rate was higher at the younger stage, while the mortality rate slowly decreased at the older stage. The survivorship (l_x) and life expectancy (e_x) of *K. barrakporensis* is depicted in Fig. 3. The age of *K. barrakporensis* at attaining sexual maturity was 44 ± 0.88 days. During the laboratory rearing, no eggs were seen, but hatchlings were present in all

rearing containers, which indicated that this species is either viviparous or ovoviviparous. During their life cycle, *K. barrakporensis* had a 6 week pre-reproductive period, 10 ± 0.66 weeks reproductive period, and 1 week post-reproductive period. The age-specific fecundity (m_x) varied with age, ranging from 0 to 2.3 hatchlings per individual, and the maximum number of hatchlings were laid in the 8th week (Fig. 4), which were 2.39 ± 4.74 and the minimum number were laid in the 18th week, which were 0.3 ± 0.3 . The total number of hatchlings laid by all the individuals was 802. The reproductive values (v_x) were maximum in the 7th and 8th weeks and declined until their death (Fig. 4). The net reproductive rate (R_0), generation time (T_c in weeks), finite rate of increase (λ) and intrinsic rate of increase (r_m) of *K. barrakporensis* were 8.54 ± 1.46 , 10.89 ± 0.3 , 0.11 ± 0.03 , and 1.1 ± 0.02 , respectively (Table 1).



Figs 1–2. Graphical representation of changes in growth of the snail *Kaliella barrakporensis* in terms of shell length (mm) (1) and body mass (mg) (2)

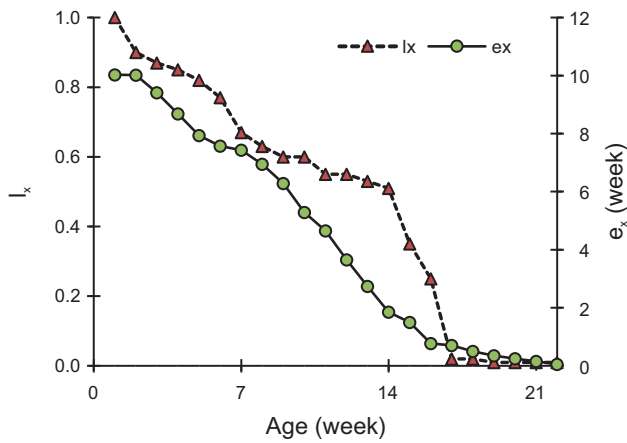


Fig 3. The survivorship (l_x – the proportion of surviving individuals) and life expectancy (e_x) of *Kaliella barrakporensis*, reared under laboratory conditions

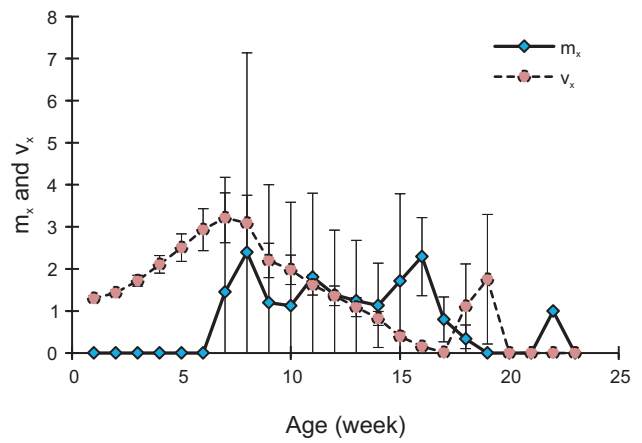


Fig 4. Reproductive values ($v_x \pm SE$) and hatchlings per individual ($m_x \pm SE$) of the snail *Kaliella barrakporensis*

Table 1. Age specific reproductive table of *Kaliella barrakporensis*. The cumulative data of ten cohorts ($n = 10$) were considered for construction of this reproductive table [x – age in weeks, l_x – proportion of the individuals that survived the age x , m_x – age specific fecundity]

Age in weeks (x)	l_x	m_x	$l_x m_x$	$x l_x m_x$
1	1	0	0	0
2	0.90 ± 0.04	0	0	0
3	0.87 ± 0.04	0	0	0
4	0.85 ± 0.05	0	0	0
5	0.82 ± 0.06	0	0	0
6	0.77 ± 0.07	0	0	0
7	0.67 ± 0.05	1.45 ± 2.72	1.07 ± 1.06	7.47 ± 2.06
8	0.63 ± 0.06	2.39 ± 4.70	1.66 ± 1.65	13.24 ± 4.01
9	0.60 ± 0.06	1.20 ± 2.80	0.89 ± 0.88	8.00 ± 2.74
10	0.60 ± 0.06	1.12 ± 2.45	0.72 ± 0.72	7.22 ± 2.73
11	0.55 ± 0.06	1.81 ± 1.99	1.02 ± 1.02	11.24 ± 3.08
12	0.55 ± 0.06	1.39 ± 1.53	0.79 ± 0.78	9.47 ± 2.06
13	0.53 ± 0.06	1.25 ± 1.43	0.68 ± 0.67	8.81 ± 2.57
14	0.51 ± 0.05	1.13 ± 1.00	0.70 ± 0.70	9.80 ± 3.71
15	0.35 ± 0.05	1.71 ± 2.07	0.44 ± 0.44	6.67 ± 2.63
16	0.25 ± 0.04	2.29 ± 0.92	0.47 ± 0.46	7.47 ± 1.43
17	0.02 ± 0.04	0.80 ± 0.53	0.09 ± 0.08	1.51 ± 0.99
18	0.02 ± 0.01	0.33 ± 0.33	0.03 ± 0.03	0.60 ± 0.60
19	0.01 ± 0.01	0	0	0
20	0.01 ± 0.01	0	0	0
21	0.01 ± 0.01	0	0	0
22	0.01 ± 0.01	1 ± 0	0.1 ± 0.1	2.20 ± 0.00
			R_0	8.54 ± 1.46
			T_c	10.89 ± 0.39
			r_m	1.1 ± 0.02
			λ	0.11 ± 0.03

DISCUSSION

The life history strategies of snails exhibit significant variations in terms of growth, survival, and reproduction due to the changing environments and different modes of reproductive strategy (DILLEN et

al. 2009, D’ÁVILA et al. 2018). Due to their limited mobility and specific habitat requirements, micro snails are effective bioindicators of environmental changes and anthropogenic impacts (DOUGLAS et

al. 2013, GHEOCA et al. 2021). Therefore, evaluating the life history traits of micro land snails is crucial for understanding the ecosystem health (HODGES & MCKINNEY 2018), as well as biodiversity and conservation strategies (SEN et al. 2012). In the Indian context, life history patterns of various land snails and slugs, including *Allopeas gracile* (SUBBA RAO et al. 1981, NANDY & ADITYA 2022a, 2022b), *Cryptaustenia ovata* (CHAKRABORTY et al. 2024), *Achatina fulica* (RAUT & BARKER 2002, SARMA et al. 2015, KUMAR et al. 2021), *Glossula gemma* (SUBBA RAO et al. 1985, RAUT & MITRA 1985), *Succinea daucina* (RAUT et al. 1997), *Semperula birmanica* (PANIGRAHI 1995, 1998), *Laevicaulis alte* (NAGABHUSHANAM & KULKARNI 1971), *Mariella dussumieri* (BARMAN et al. 2022), and *Deroceras laeve* (GUPTA et al. 2024) were observed. In the global context, several studies were conducted on the observations of life history traits of micro land snails, including *Lauria cylindracea* (HELLER et al. 1997), *Habroconus semenlini* (SILVA et al. 2009) and several vertiginid micro snail species (MYZYK 2011). However, apart from the taxonomy and distribution of micro land snails in India (ARAVIND et al. 2008, BARMAN & ADITYA 2021, BARMAN et al. 2023), little or no information is available regarding their life history traits.

In the present study, *K. barrakporensis* showed an indeterminate growth pattern, which is similar to other land snails such as *Subulina octona* (D'ÁVILA et al. 2018), *H. semenlini* (SILVA et al. 2009), *A. gracile* (NANDY & ADITYA 2022a, 2022b), and *C. ovata* (CHAKRABORTY et al. 2024). Indeterminate growth in snails refers to a growth pattern where individuals continue to grow after sexual maturity (HELLER 2001). The growth of *K. barrakporensis* was rapid till the 8th week and then gradually slowed to a steady state until all individuals died. Compared to another micro land snail, *H. semenlini* (SILVA et al. 2009), which had an average shell height of 2.51 ± 3.69 mm, *K. barrakporensis* has 3.05 ± 0.09 mm of shell height at the adult stage.

This study shows *K. barrakporensis* has a short life span of around 22 weeks, while the life span of other Indian land snails, such as *A. gracile* (NANDY & ADITYA 2022a, 2022b) and *C. ovata* (CHAKRABORTY et al. 2024), was observed to be 27–53 weeks and 29 weeks, respectively. Despite the absence of egg-laying in *K. barrakporensis*, hatchlings were observed in every rearing container, suggesting that the species is either viviparous or ovoviviparous. However, histological examinations of the species are required to confirm the reproductive strategy (HELLER 2001). In the case of *K. barrakporensis*, sexual maturity was observed around the 7th week, similar to *H. semenlini*, *A. gracile* and *S. octona*, which showed their first oviposition on about the 8th, 4th and 8th weeks, respectively (D'ÁVILA et al. 2018, NANDY & ADITYA

2022a, 2022b). In contrast, a few terrestrial snails took a much longer time to attain sexual maturity, such as *Bradybaena similaris* (CARVALHO et al. 2008), *Archachatina marginata* (EGONMWAN 2004) and *Limicolaria flamea* (EGONMWAN 2004), which need 160 days, 19 months, and 5 months to attain sexual maturity, respectively.

The results of the present study indicate that *K. barrakporensis* has only one reproductive event, has higher mortality at the juvenile stage, and produces live young rather than laying eggs. Considering all observed traits, the present study indicates that *K. barrakporensis* is an r-strategist species. Similarly, the life cycle of *K. barrakporensis* in terms of longevity, survivorship and reproductive period indicates that it is a semelparous species. Several studies showed the semelparous nature of land snails, such as *Arion vulgaris* (RABITSCH & ESSL 2006), *Habroconus semenlini* (SILVA et al. 2009), *B. similaris* (CARVALHO et al. 2008), in contrast with the other iteroparous land snails, such as *Cornu aspersum* (NICOLAI et al. 2010) and *Allopeas gracile* (NANDY & ADITYA 2022a, 2022b). These life history traits of *K. barrakporensis*, when combined with its adaptability to modified habitats, reinforce its invasive potential and justify the need for closer ecological monitoring in its non-native regions.

Considering the potential effects of rapid environmental changes on the adaptive capacities and survival of micro land snails, which may lead to population declines or local extinctions, understanding their life history traits may help to protect their native habitat and develop targeted management strategies that enhance the survival of vulnerable species. Further studies can be carried out to observe the changes in the life history traits of *K. barrakporensis* under various food, density, and temperature conditions.

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AUTHORS' CONTRIBUTION

SM: Investigation, Visualisation, Writing – original and final drafts; NKG: Visualisation, Writing – original draft; PP: Visualisation, Writing – original draft; HB: Visualisation, Writing – original draft; GA: Conceptualisation, Supervision, Validation, Writing – original and final drafts

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