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Determination of growth and survival rate of juvenile snail *Helix lucorum* Linnaeus, 1758 (Gastropoda, Helicidae)

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Abstract. In this research, the growth and survival rate of juvenile *Helix lucorum* was determined during the eight weeks. Coefficient variation (CV*)* in assessing variability of shell height and live weigth was investigated. One week old juvenile snails with a mean shell height of 6.73±0.03 mm and a mean weight of 0.10±0.01 g were stocked to the three rearing boxes with a density of 13 snails per group at the start of the experiment. At the beginning of the study, the variability of shell height and live weight showed relatively little difference as 9.71% and 28.16% but this gradually increased towards the end of the study. The final variation of shell height and live weight was calculated 20.32% and 59.84%, respectively. At the end of the study, cumulative survival rate was found 97.74%. In conclusion, snails showed high survival rate with high size variation in the study. Initial stocking density is optimal for rearing juvenile *H. lucorum* but after four weeks, stocking density should be decreased and thereby lower size variation and more similar growth pattern might be provided.
Key words: mortality, development, snail, juvenile.

Introduction. Edible land snails are consumed in the worldwide by the rich and the poor since prehistoric times (Murphy 2001). Snail meat is delicious, healthy nutrition and rich in protein (Gomot 1998; Avagnina 2006; Toader-Williams & Golubkina 2009). Helicidae edible snail species are quite abundant population in Turkey because country's topographical structure, humid and not harsh climatic conditions are very suitable compared to neighboring countries whereas the consumption of snail meat is a few in the country. *Helix lucorum* is the most traded among other edible land snails in the country (Baki 2010). Years of overfishing caused the snail stock decrease. Therefore the production does not satisfy the increasing demand. In this case, snail cultivation should be carried out to meet the growing demand in Turkey. To date, there is no known study that investigated land snail culture in the country. Therefore, snail farming experiments are necessary to have knowledge of their behavior, biology and ecology and generate ideas to develop best farming practices.

The juvenile phase is important in the snail's development and generally covers the period from one or two months in farming processing (Cobbinah et al 2008). Special structures are designed for raising snails in their juvenile stage to allow for optimum growth, high survival rate and to provide a safe environment. The growth is mainly affected by genetic factors (Goodfriend 1986), besides many others as food consumption (Iglesias & Castillejo 1999; Roberson & Moorhead 1999), stocking density (Dupont-Nivet et al 2000), environmental conditions (Jess & Marks 1988), competition (Bloch & Willig 2009). Unfavourable circumstance can repress growth for along period of time (Garcia et al 2006). Competitive hierarchies affect proportional food intake that can cause different growth rates and increase high size variation (Peacor et al 2007).

Despite the importance of the subject, studies concerning growth patterns of *H. lucorum* juvenile are deficient. The objective of this work was to investigate factors affecting size variation depending on growth of *H. lucorum* juvenile snails in laboratory conditions. This basic information can serve as base model for future studies on juvenile *H. lucorum*.

Material and Method. The study was carried out in the laboratory of Aquaculture and Fisheries Faculty, Sinop University between March 2014 and April 2014 (eight weeks). The juvenile snails were obtained from adults in the laboratory rearing conditions. The growth and survival rate of juveniles was determined and also coefficient variation (CV*)* in assessing variability of shell height and live weigth was determined.

The temperature and moisture of air was measured by Medifine temperature and humidity meter every week (TFA5013 manufactured by Dostmann-Wertheim, Germany). The study was maintained under natural light conditions, avoiding direct sunlight, at room temperature. The relative humiditiy was regulated by simpler humidification system. The temperature ranged from 18°C to 22°C and humidity ranged from 84% to 92% during the experiment time.

At the beginning of the study, one week old juveniles with a mean length of 6.73±0.03 mm and a mean weight of 0.10±0.01 g were stocked to the three rearing boxes with a density of 13 snails per group. Snails were fed food consisting of corn gluten (13.9%), wheat flour (71.1%), eggshell (14.5%) and vitamin mix (1.5%) that was about 2 g per two days. The rearing boxes which have a volume of 350 mL (high of 5.50 cm and diameter of 10.50 cm), were made of foam. The boxes were cleaned daily to avoid negative effects of excreta and mucus.

Every snail per group was taken every week and measured the shell height (SH) and live weight (total weight of snails, LW) in the morning when the animals were resting. SH was measured to the nearest 0.1 mm with a caliper. LW was measured by weighing live animals. Growth rate (mm/week) was calculated from initial and final shell diameters of each snail for a weekly from the following formula:

$$\text{Growth rate} = (L_1\text{-}L_2)/L_1$$

where L1 and L2 are the mean shell heights at following weeks.

Dead snails in the boxes were counted and removed to determine mortality that was determined from the following formula:

$$\text{Mortality (\%)} = 100(N_t/N_0)$$

where N_t is the number of dead snails removed from the box after t time and N_0 is the number of snail at the beginning.

Data were analysed for significant differences in means using ANOVAs, with significance levels set at $p < 0.001$ and the normality of the variation of data was verified using the software program MINITAB 16 software. The variability of shell height and live weight were analyzed as the coefficient of variation (CV) in Microsoft Office Excell.

Results. SH and LW of each group displayed similar development from one week old until eight weeks old (Table 1).

An one-way ANOVA showed significant differences between SH and LW by weeks ($p < 0.001$). At the end of the study, the SH and LW of snails were 9.81±0.12mm and 0.32±0.01g, respectively. Weekly growth rate in SH and LW of snails at third and sixth weeks were generally higher than other weeks (Figure 1).

At the beginning of the study, the variability of SH and LW showed relatively little difference as 9.71% and 28.16% but this gradually increased towards the end of the study. The final variation of SH and LW was calculated 20.32% and 59.84%, respectively. Figures 2 and 3 show the histogram of individual SH and LW at first and last week of the experiment.

Table 1

Shell height and live weight of snails from one week old until eight weeks old

		Shell height (mm)		
		Group		
Weeks	*1*	*2*	*3*	*Mean*
1	6.73±0.19 (10.41)	6.69±0.19 (10.41)	6.78±0.17 (8.98)	6.73±0.03[a] (9.71)
2	7.20±0.21 (10.53)	6.96±0.22 (11.55)	7.05±0.19 (9.67)	7.07±0.07[ab] (10.37)
3	7.69±0.35 (16.32)	7.86±0.30 (13.64)	7.65±0.21 (9.99)	7.73±0.06[bc] (13.27)
4	8.21±0.42 (18.33)	8.18±0.38 (16.30)	8.02±0.30 (13.60)	8.14±0.06[cd] (14.83)
5	8.33±0.57 (22.51)	8.48±0.37 (15.27)	8.63±0.45 (18.04)	8.48±0.09[cde] (18.09)
6	8.73±0.67 (25.29)	8.96±0.38 (14.87)	9.46±0.5 (18.32)	9.05±0.12[def] (19.95)
7	8.89±0.76 (28.24)	9.03±0.55 (20.99)	9.67±0.61 (20.85)	9.19±0.24[ef] (21.81)
8	10.04±0.92 (25.80)	9.62±0.60 (20.57)	9.75±0.65 (22.10)	9.81±0.12[f] (20.32)
		Live weight (g)		
1	0.09±0.01 (29.39)	0.09±0.01 (32.30)	0.09±0.01 (24.63)	0.10±0.01[a] (28.16)
2	0.11±0.03 (31.22)	0.11±0.01 (32.39)	0.11±0.01 (27.52)	0.11±0.01[ab] (29.66)
3	0.14±0.02 (41.09)	0.15±0.01 (34.61)	0.13±0.01 (30.79)	0.14±0.01[ab] (35.43)
4	0.15±0.02 (51.49)	0.16±0.02 (41.56)	0.15±0.01 (36.76)	0.15±0.01[abc] (43.86)
5	0.19±0.03 (56.50)	0.18±0.02 (42.67)	0.17±0.02 (47.15)	0.18±0.01[bc] (47.65)
6	0.23±0.05 (65.46)	0.22±0.03 (42.24)	0.25±0.03 (48.69)	0.23±0.01[cd] (55.59)
7	0.27±0.06 (74.36)	0.25±0.04 (59.82)	0.21±0.05 (53.23)	0.27±0.01[de] (61.75)
8	0.34±0.07 (61.17)	0.29±0.06 (65.34)	0.32±0.06 (58.70)	0.32±0.01[e] (59.84)

*Mean ± SE (CV); different letter show significant difference ($p < 0.001$).

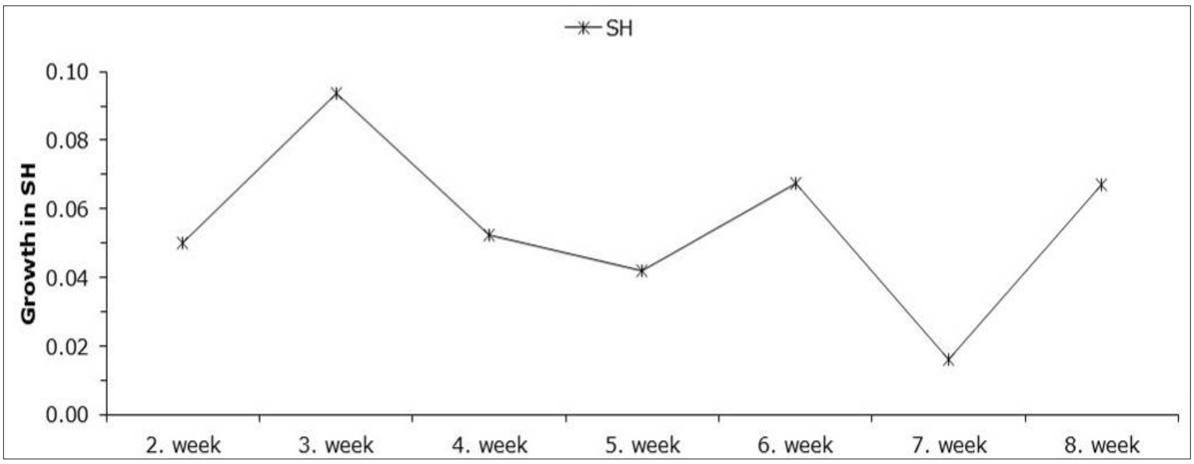

Figure 1. Growth rate in shell height (SH) during the experiment time.

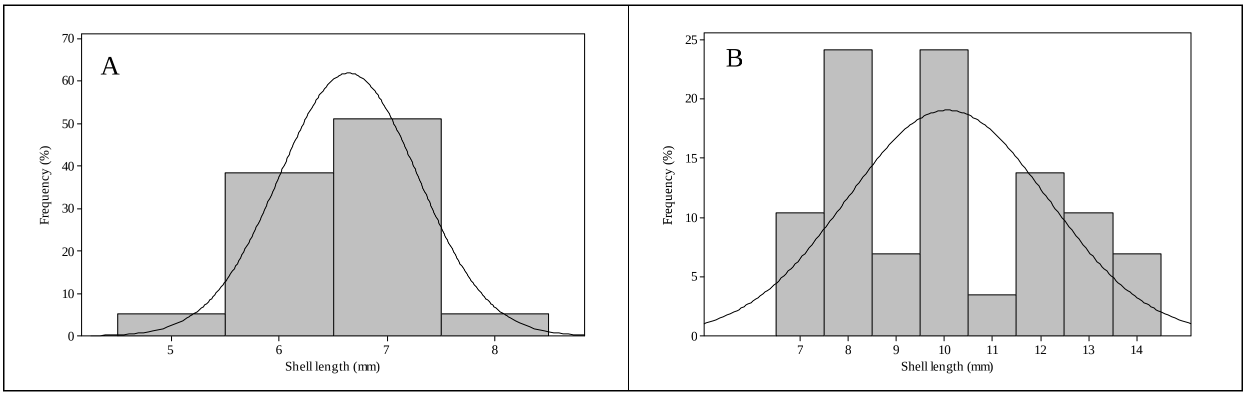

Figure 2. Snail shell height (mm) variation at first week (A) and last week (B) of the experiment.

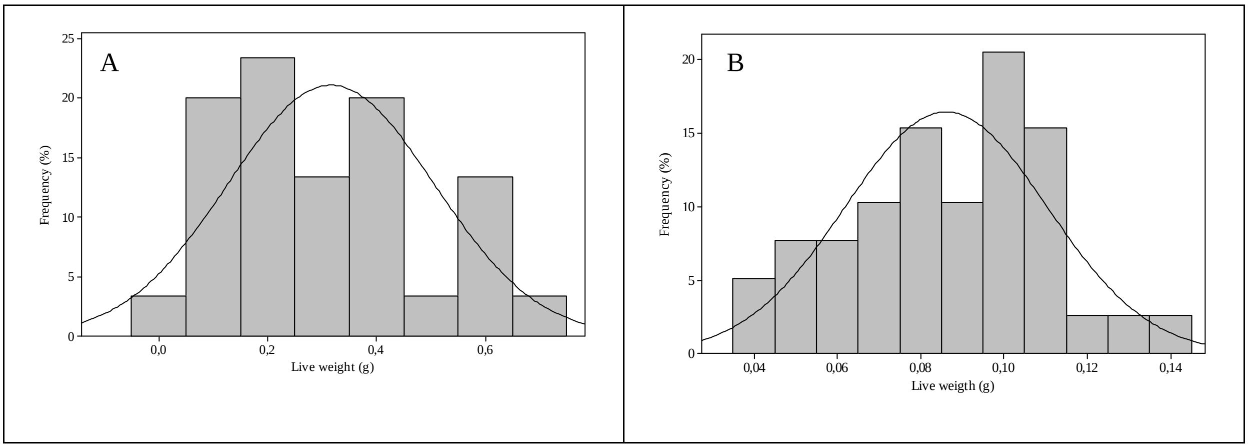

Figure 3. Snail live weight (g) variation at first week (A) and last week (B) of the experiment.

Survival rate was determined high during the experiment period. At the end of the study, cumulative survival rate was found 97.74% (Table 2).

Table 2

Snail survival rate (%)

Weeks	*Group* 1	2	3	*Weekly survival rate (%)*	*Cumulative survival rate (%)*
1	0	0	0	100.00	100.00
2	0	0	0	100.00	100.00
3	0	0	0	100.00	100.00
4	0	0	0	100.00	99.00
5	2	1	1	99.47	98.47
6	0	0	0	100.00	98.47
7	0	0	1	99.87	98.00
8	3	1	0	99.47	97.47

Discussion. Growth of molluscs is affected by several environmental factors such as temperature, food supply, humidity, density (Karayücel et al 2010). Competition may lead to lower growth rates and reduction in the survivorship (Tanaka et al 1999). Increased competition can lead to increased size variation (Peacor et al 2007).

In the present study, it was determined that some snails grew faster and depressed the growth of others. The mean variation of growth in LW and SH were between 20% and 22%, 55% and 62% at last three weeks of the experiment, respectively. When juveniles grew, the rearing area might become insufficient and then increased competition for living area and food. Because of diminishing growing area, the increase in the number of individuals per square could probably induce sensitivity and stress. This situation might lead to develope social hierarchy among individuals and cause to increase size variation. Approximately 30 percent of juvenile snails reached 12-14 mm at the end of the study. The gradually increase in size variation with increasing stocking density occurred stress on smaller snails and raised the effects of competition for food (Yousif 2002). Bloch & Willig (2009) declared that social hierarchy within snail population was determined, the smaller snails were inhibited from feeding adequately due to the physical presence of larger snails because of disproportionate food consumption that could be cause size hierarchy. Within population, larger snails may have a competitive advantage over smaller ones and large snails may provide no further food for small individuals (Baur & Baur 1990). In addition, the authors reported that chemical cues in mucus trail might cause growth inhibition (Baur & Baur 1990; Cook 2001).

Snails are hardy animals which have developed mechanisms that allow them to survive in conditions of drought, scarcity of food, high or low temperatures, and excessive sunshine and/or wind (González et al 2009). However if the habitat of snails in captivity is unsuitable, growth is inhibited and the survival rate decreases (Perea et al 2006). The present study showed that although juveniles are extremely fragile, *H. lucorum* in juvenile stage were essentials hardy animals. Survival rate was very high and cumulative survival was 97.47% at the end of the study. The survival rate generally slightly increased for all groups towards to end of the study because of increasing stocking density.

Conclusions. Size variation depending on growth and survival rate of *H. lucorum* juvenile snails was revealed and determined high survival rate with high size variation. Therefore initial stocking density of 485 individuals per m^2 is optimal for rearing juvenile *H. lucorum* but after four weeks, stocking density should be decreased and thereby creating a more-healthy environment and supplying balanced food among individuals. Thus, lower size variation and more similar growth pattern might be provided.

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