

Around the whorl in 18 days: a comparison of growth rates for four species of *Lavigeria* in the Kigoma area of Lake Tanganyika

Student: Sherry-Ann Todd-Pearson

Mentor: Dr. Ellinor Michel

Introduction

Lake Tanganyika is one of the oldest, largest and deepest lakes (Coulter, 1991). Its formation is the result of tectonic activity of the East African rift system. The high level of species diversity and endemism found in Lake Tanganyika has been credited to its antiquity and rift lake morphology (Cohen, 1995).

The thiarid gastropods of Lake Tanganyika are especially diverse: the genus *Lavigeria* is the most species rich of the lake's endemic snails, consisting of over forty species (Michel *et al.*, 2004; Michel & Todd, in prep.). Because of their interesting ecology and wide distribution within Lake Tanganyika, *Lavigeria* species have been the focus of various research projects. Past studies examined evolution of the species flock (Michel, 2000), distribution and abundance (Michel *et al.* 2004; Barrett *et al.*, 2003), life history strategies (Michel & Kingma, in prep.), predator-prey interactions with an emphasis on co-evolution (Rosales *et al.*, 2002), and morphological changes through ontogeny (Papadopoulos *et al.*, 2004). However, a major component of *Lavigeria*'s basic biology is still poorly understood. Very little is known about the growth rates of the different species that comprise the genus. Growth rates are vital for linking variables to morphological diversification, life history strategies, and population dynamics (Moran, 2000). Therefore, this study aims to determine juvenile growth rates of four *Lavigeria* species: *L. nassa*, *L. grandis*, *L. sp. J* and *L. sp. M* (open nomenclature is used for *L. sp. J* and *L. sp. M* because their taxonomy is under revision, Michel and Todd, in prep.).

The gastropod shell is an ideal tool for documenting the growth throughout the life of the animal. As a snail grows the aperture deposits new calcium carbonate shell material. This shell acts like a bio-recorder of environmental conditions and the individual's development; the entire ontogeny of a mollusk is represented in its shell (Goodwin *et al.*, 2001). It is possible to use analyses of growth lines and stable isotope variation to determine growth rates. However, since Tanganyika is a tropical lake, a temperature dependent method such as isotopic analysis ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) may not be practical due to the lack of seasonality. Furthermore, work in any new system requires groundtruthing. I used mark-recapture methods to estimate species growth rates over short time scales

I tested two hypotheses regarding *Lavigeria* growth rate:

- growth is related to species adult size, so that the species with the largest average adult size will exhibit the fastest growth rate
- growth rate will decrease with age because other gastropod studies have revealed this trend (Brazil Romero, 2004)

Methods

Specimens for this study were collected by snorkeling at depths ranging from 0 to 5 meters from two sites in Kigoma: Hilltop and Jakobsen's Beach. *L. nassa* is found at both sites while *L. grandis* occurs at Jakobsen's Beach. *L. sp. J* and *L. sp. M* were collected from Hilltop. Snails were preferentially taken from juvenile and sub-adult stages, as *Lavigeria* are known to have determinant growth which is indicated by the presence of adult modifications (Papadopoulos *et al.*, 2004). A total of 545 snails were marked and returned to the lake. Of these, 99 *L. nassa* and 100 *L. grandis* were from Jakobsen's Beach; 100 *L. nassa*, 100 *L. sp. M* and 146 *L. sp. J* were from Hilltop.

The specimens were marked with nail polish on the penultimate whorl exactly at the aperture boundary (Figure 6). The snails were then tagged with a unique identification number laser-printed on waterproof paper attached with superglue to a cleaned, dried, buffed shell and coated with a thin layer of clear nail varnish.

Due to the small size and cryptic habits of *L. sp. J* and *L. sp. M* and the poor visibility at the site, the snails collected from Hilltop were placed in three mesh pyramids. Rocks with algae were placed in each pyramid and a plastic bottle was attached as floating markers. The pyramids were carefully lowered by snorkel to a depth of ~ 3 meters and the plastic bottles were suspended within the water column to serve as a means to locating the pyramids.

Snails were re-collected by snorkel and diving after a growth period ranging from 11 to 18 days. Shell measurements were taken for all specimens that were recaptured alive and had an identification tag attached. Measurements taken were: overall height, overall width, aperture to top, and lip thickness (categorically) (Figure 5). Growth rate was calculated as a ratio of the linear distance from the aperture to the nail polish mark and the days of growth.

Results

Jakobsen's Beach had the highest percentage of snails recovered with visible growth (Fig. 1 & Table 1). Between the two species studied at Jakobsen's Beach, *L. grandis* had a higher percentage of snails (85.54%) recovered with new growth compared to *L. nassa* (80.49%). Despite the cages, Hilltop had the lowest percentage of snails recovered showing new growth. (*L. nassa* 54.55%, *L. sp. J* 22.22%, *L. sp. M* 15.79%).

Jakobsen's Beach also showed the highest mean growth rates of the two sites (Fig. 2 & Table 1) although this combines results from several species. At Jakobsen's Beach, *L. grandis* had the highest mean growth rate of 0.2144 mm/day compared to *L. nassa*, which had a mean growth rate of 0.0783 mm/day. At Hilltop *L. nassa*'s mean growth rate of 0.0518mm/day was the highest, followed by *L. sp. J* with a mean growth rate of 0.0516. *L. sp. M* showed the lowest mean growth of 0.0324 mm/day for specimens collected from Hilltop.

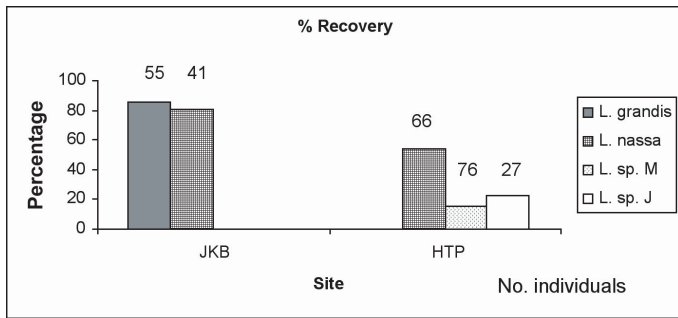


Figure 1: Percent of individuals recovered for each species for each site. Total recovered are indicated above each bar

The species with the maximum individual growth rate was *L. grandis* with a calculated growth rate of 0.418 mm/day. The minimum individual growth rate was recorded for *L. sp. M* at 0.021 mm/day (Fig. 3).

The data indicated a statistically significant correlation ($R^2 = 0.711$) between mean height and mean growth across species for both sites (Fig. 4). However, there was no correlation when individual height was plotted against individual growth rate ($R^2 = 0.001$) for all specimens recovered.

Discussion/Recommendations

The preliminary results, which indicated that mean height is positively correlated with mean growth for all *Lavigeria* species studied here, supports the hypothesis that the species with the largest overall size will have the highest mean growth rate (Figure 4). For the specimens sampled, *L. grandis* and *L. nassa* had the two highest overall size and also the highest growth rates, while *L. sp. M* and *L. sp. J* at Hilltop exhibited smaller overall size and also lower growth rates. *L. nassa* collected from Hilltop had a mean height that is similar to *L. nassa* from Jakobsen's Beach, but has a lower growth rate. A previous study that compared the effects of sediment impacts on snails from Hilltop and Jakobsen's Beach (among other sites) showed that *L. nassa* are larger at the un-impacted, or pristine site of Jakobsen's Beach compared to those at Hilltop, which is sediment impacted (McIntyre *et al.*, 2005). The results of this study suggest that the reason the individuals are larger at Jakobsen's Beach compared to Hilltop is because *L. nassa* is

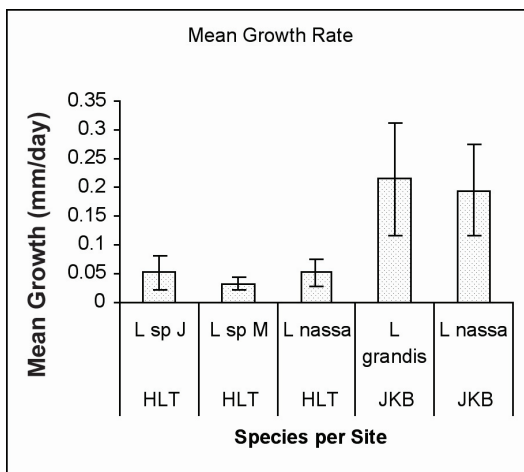


Figure 2: Mean growth for each species for each site

growing faster at Jakobsen's Beach. This may bring full circle the link of the quality of foodstuffs available to the benthic fauna at sites of conservation concern.

My results do not support the second hypothesis that there is an inverse relationship between size (measured as overall height) and growth rate (Figure 4). There is no correlation between individual size and growth rate across species and sites, suggesting that growth in *Lavigeria* may be constant until adulthood is attained.

At Jakobsen's Beach there were a substantial number of marked snails that were preyed upon, leaving shards and numbers around the area (J. Sapp and G. Kazumbe, pers. comm.). This observation should be examined more closely to determine if marking the shells of specimens increases their risk of predation. The mesh pyramid used at Hilltop prevented

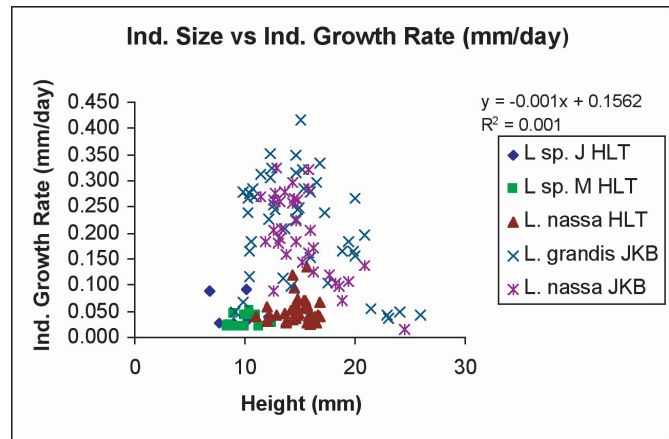


Figure 3: Individual growth rate versus height for all specimens recovered

predation attacks on those specimens but there was a mean mortality rate of 35.2% for recovered specimens compared to Jakobsen's Beach, which had a mortality rate of 16.4%. Although the pyramid may act to prevent predation, there may be some other disadvantages associated with this method, such as low individual per area ratio, higher competition for food, and an increased risk for the spread of disease and parasites.

There are several considerations that should be addressed if this study is repeated: smaller species such as *L. sp. J* and *L. sp. M* are more difficult to tag and there is a problem with glue getting into the inside of the shell, especially for the smaller individuals. I observed that both recaptured snails that had glue inside the shell had died in the field. Therefore, better methods for tagging and marking the snails should be employed for future growth studies. Secondly, smaller snails are more difficult to measure and the calipers easily break their shells, especially when a measure of lip thickness is attempted. I expect that experimental error increases as specimen size decreases.

There was a problem with holes in the pyramids that resulted in the snails from Hilltop being returned to the lab for two additional days until the pyramid was repaired. These snails suffered the highest mortality and this may be related to the fact that they were out of their natural habitat the longest. In the future, it would be ideal to limit the number of days the

specimens are in the lab and to ensure that they are kept in optimal conditions.

There is still an opportunity to determine the growth rate of individuals that are newly released from the brood. This data is necessary in obtaining the growth rate through ontogeny for the *Lavigeria* species studied here.

These results reported here are preliminary because this study is ongoing, with recaptures planned for late August and October.

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Site Name	Lavigeria Species	% Recovery with Growth	% Mortality	Mean Growth Rate (mm/day)	Mean Height (mm)
HLT	<i>nassa</i>	80.49	25.3	0.0518	14.75
HLT	sp. J	22.22	67.9	0.0516	
HLT	sp. M	15.79	12.4	0.0325	9.33 9.98
JKB	<i>nassa</i>	80.49	18.9	0.1953	15.25
JKB	<i>grandis</i>	85.45	13.8	0.2144	15.11

Table 1