The effect of food resources on growth and fecundity of the Chinese Mystery Snail, *Cipangopaludina chinensis*

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Abstract

This study focuses on the Chinese mystery snail, *Cipangopaludina chinensis*, which is a non-native viviparid gastropod present in many lakes in Northern Wisconsin and Michigan. Fecundity and growth were studied using three food resources: muck, sand, and spinach. I hypothesize that there will be differences in the fecundity and growth of the snails depending on the substrate, and predict that fecundity and growth will be greatest in muck and least in spinach. I found that fecundity was significantly affected by substrate and that the pattern changed over time. I also found that growth was significantly effected by substrate. The results suggest that muck and sand are the optimal substrates for *C. chinensis*. I also found that *C. chinensis* has an initial reproductive "surge" when in muck. *C. chinensis* living in spinach has low initial fecundity and then has very high fecundity after 2-3 weeks, possibly in response to the deteriorating condition of the adult female snail.

Introduction

The Chinese mystery snail, *Cipangopaludina chinensis*, is a non-native viviparid gastropod present in many lakes in Northern Wisconsin and Michigan (Distler 2003). This species has recently been discovered at several locations on the UNDERC property. *C. chinensis* were imported into live markets in the United States from their native range in East China, Taiwan, Korea, and Japan

(Chiu et al. 2002). Adult *C. chinensis* are larger than any native snail on UNDERC property (Brett Peters, personal communication). Newborn snails are usually between 7 and 8 mm (Jokinen 1984) and must be at least 15.5 mm in order to have babies (Jokinen et al. 1982).

Although *C. chinensis* are widespread throughout the United States, there has been little research on how they affect the ecosystems where they are introduced. Invasive molluscs have been shown to be a threat to native plant and animal organisms (Ricciardi et al. 1998). Fecundity can be used to determine the risk a species poses to its environment and then decisions can be made on how to prevent spread of the species (Keller et al. 2007). There are many aspects of *C. chinensis's* natural history which would greatly further our understanding of how *C. chinensis* invade ecosystems and what the potential impacts of these invasions may be.

The goal of this project is to estimate the fecundity and growth of *C. chinensis* and how these important life-history parameters are affected by different environmental conditions. The information from these experiments will help us better predict which lakes are vulnerable to *C. chinensis* invasions, what possible impact C. chinensis invasions may have, and what adaptations allow them to successfully invade these ecosystems.

I hypothesize that there will be differences in fecundity and growth based on the substrate treatments. I predict that fecundity will be greatest in muck and least in spinach. I also predict that growth will follow the same pattern as fecundity.

Materials and Methods

Study site

This experiment was done in a laboratory setting to ensure the same environment and living conditions for all snails. *C. chinensis* were collected in lakes and streams on the University of Notre Dame Environmental Research Center property and in lakes from the surrounding area.

Fecundity procedure

I first placed snails into individual plastic containers with mesh sides and placed them in larger tanks, in order to determine which snails were female by the presence of babies in the plastic container. Once I obtained 30 female snails I placed them into individual Tupperware (7in x 5in x 5.5in) containers and filled them with 2.2 liters of lake water. Each container was equipped with an air source. Snail food sources (muck, sand, and spinach) were placed into the individual containers. All snails were randomly placed into one of the three substrates. Ten snails received 400 mL muck (detritus), ten received 400 mL sand, and ten received approximately 50 mL spinach. The substrate was changed weekly to ensure an ample food supply for the snail. Less spinach was used than other substrates because initial experiments with 400mL of spinach led to hypoxia and snail death. I checked the tanks weekly and counted number of live-young birthed by each snail.

Growth procedure

Newborn snails were used for growth experiments and were housed in individual plastic containers (5in x 5in x 3in) with an air source and filled with 0.8 liters of lake water. The same three food treatments were applied to 60 newborn snails as were described above in the fecundity methods. All snails were randomly placed into one of the three treatments. 20 snails received 200 mL of muck (detritus), 20 received 200 mL of sand, and 20 received approximately 25 mL of spinach for the same reasons stated above. Snail weight was measured every week to determine growth rate. Each week I changed the water and food source in order to provide unlimited amount of food for the snails.

Statistical Analysis

I used ANOVA tests with repeated measures to account for the measurements made each week. For the growth experiment I used proportional weight gain (from start of experiment) as the response variable to account for differences in snail weights at the beginning of the experiment. For the fecundity experiment I used number of babies born (each week) as the response variable. I also ran an ANOVA for each week separately for both growth and fecundity, and then did a post-hoc Tukey's test to see where the difference was.

Results

Fecundity

Over the three week period the average number of young birthed by snails was 2.4±0.987 babies in muck, was 0.1±0.1 babies in sand, and 1.9±0.458 babies in spinach (Fig. 1). For the repeated measures ANOVA, the difference in number of young birthed by treatment was significantly different (p=0.0354, F-ratio=3.792, df=2) and there was also significant time*treatment interaction (p=0.004, F-ratio=4.363, df=4). Using an ANOVA with a Tukey's post-hoc analysis, the number of young birthed in week one is significantly different between muck and sand (p=0.042) as well as muck and spinach (p=0.042), but no significant difference between sand and spinach (p=1.0) (Fig. 2). In both the second and third week there was only significant difference between sand and spinach (p=0.027 and p=0.053) (Fig. 3 and Fig. 4).

Growth

I found the best way of measuring growth in the baby snails was their weight. In order to account for the bias in initial weight between treatments, I used the proportion of weight from each week over the weight from week one. For the repeated measures ANOVA, the difference in proportion of weight by treatment was significantly different ($p < 0.001$, F-ratio=9.987, df=2) and there was also significant time*treatment interaction (p=0.0175, F-ratio=3.158, df=4).

When looking at the proportions for week two in separate ANOVA's the Tukey's post-hoc analysis shows that spinach growth was significantly less than that of muck ($p < 0.001$) as well as sand ($p=0.002$) (Fig. 5) in week 2. For week three proportions there was only significantly difference between muck and spinach ($p=0.015$) (Fig. 6). Lastly, for week four there is significant difference between muck and spinach ($p < 0.001$) and between sand and spinach ($p=0.001$).

Discussion

Fecundity

My hypothesis that the most babies will be born in the muck treatment was supported by raw data means of babies, but sand rather than spinach had the least number of babies. There were 2.4 babies born in the muck over the three week period, for a total of approximately 42 babies per year. The documented fecundity for *C. chinensis* is 65 babies per female per year, which categorizes the species as benign or having no evident negative impacts (Keller et al. 2007). This data is consistent with the fecundity found in my experiment. However, comparing the fecundity of viviparous snails to the results of Keller et al. 2007 may not be appropriate because Keller et al. used egg laying snails (which have high early-life mortality) in their analysis.

There is a significant interaction of time and treatment ($p=0.004$, F-ratio=4.363, df=4) and when we looked at how fecundity changes over time we see a very interesting pattern. After the first week muck had significantly higher fecundity than both sand ($p= 0.042$) and spinach ($p=0.042$). In the second and third week muck and sand are not significantly different, but sand and spinach are significantly different (p=0.027 and p=0.053). I believe that the snails had high initial fecundity in muck because muck is a good food resource for young snails (Fig. 5-7); whereas, the sand and spinach treatments were not optimal environments. Spinach is a very poor food resource for snails (Fig. 5-7) and after 1-2 weeks it is possible that the females were stressed and invested all of there remaining effort into having babies before they died. We see no real change in the number of babies from the sand treatment. I believe that this is most likely because the substrate is neither optimal (muck) nor sub-optimal (spinach) that it jeopardizes their life. This means snails on sand substrate may have been delaying releasing their offspring until a more optimal substrate was found.

This experiment should be run for a longer period in order to see the full effect of substrate on fecundity. I predict that the number of babies in the sand will eventually peak as the spinach did. I would also expect the number of babies in the spinach to gradually decrease over the next several weeks as the muck did. I would also expect that the adult female snails in the spinach will die soon after week three.

Growth

Baby snails grew best in muck and worst in spinach as expected. Although the results were not significant, the trend shows that snails grew larger in the muck than in the sand. I believe that the baby snails did not eat the spinach which led to them actually lost weight over the time period. It has been previously tested and is evident in my experiment that snail shell morphology can change due to changes in environmental conditions without any genetic variation in the snails (Chiu et al. 2002).

In a growth study done by Stelzer and Lamberti (2002) on *Elimia livescens* snails, they concluded that growth was most effected by the amount of phosphorous in the substrates. Jokinen (1984) also states that an increase in calcium concentrations will lead to greater snail growth, as it is an important factor in repairing and constructing the shell. I did not measure chemical composition of my substrates, but I expect that the spinach has a higher phosphorus concentration than muck, which is mainly carbon. It is possible that the lower growth in spinach was a result of *C. chinensis* not being adapted to chew large pieces of leaf material, or that the larger growth in muck is due to the large calcium concentrations.

Relevance to UNDERC Lakes

We can conclude from this experiment that the Chinese mystery snail will most likely not be directly harmful to the aquatic vegetation in the lakes at UNDERC. Since the snails grow and reproduce best in muck, it can be predicted that *C. chinensis* will mostly be found in lakes and streams with high muck concentrations.

If this experiment was done again it would be helpful to have it run for a longer period of time as well as more replicates in the fecundity experiment. For future experiments on this topic it would be interesting to test more than just three substrates along with testing the chemical composition of the substrates which could give an indicator to why the snails grow better and have more babies in one environment than another.

Acknowledgements

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Literature Cited

Chiu, Y.W., H.C. Chen, S.C. Lee, and C.A. Chen. 2002. Morphometric analysis of shell and operculum variations in the viviparid snall, *Cipangopaludina chinensis* (Mollusca: Gastropoda), in Taiwan. Zoological Studies. 41(3): 321-331.

Distler, D.A. 2003. Occurrence of the mystery snail *Cipangopaludina chinensis* (Gastropoda:Viviparidae) in the Walnut River basin, Kansas. Transactions of the Kansas Academy of Science. 106: 215.

Jokinen, E.H., J. Guerette, and R.W. Kortmann. 1982. The Natural History of an Ovoviviparous Snail, Viviparus georgianus (Lea), in a Soft-Water Eutrophic Lake. Freshwater Invertebrate Biology. 1(4): 2-17.

Jokinen, E. H. 1984. Periostracal morphology of viviparid snail shells. Trans. Am. Microsoc. Soc. 103(3):312-316

Keller, R.P, J.M. Drake and D.M. Lodge. 2007. Fecundity as a basis for risk assessment of nonindigenous freshwater mollusks. Conservation Biology. 21(1): 191-200.

Ricciardi, A., R.J. Neves, and J.B. Rasmussen. 1998. Impending extinctions of North American freshwater mussels (Unionoida) following the zebra mussel (*Dreissena polymorpha*) invasion. Journal of Animal Ecology 67:613-619.

Stelzer, R.S., and G.A. Lamberti. 2002. Ecological stoichiometry in running waters: periphyton chemical composition and snail growth. Ecological Society of America. 83(4): 1039-1051.

Figures

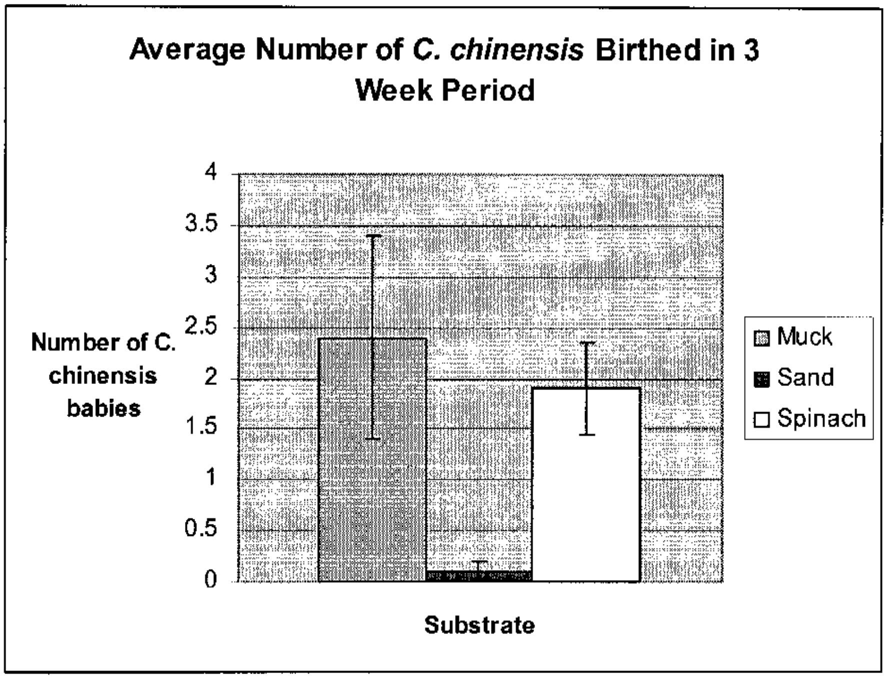

Figure 1. Over the three week period the average number of young *C. chinensis* birthed in muck was 2.4±0.987 babies, in sand was 0.1±0.1 babies, and in spinach was 1.9±0.458 babies. Overall, there is a significant difference between treatment over the time period ($p=0.0354$, F-ratio=3.792, df=2). From the graph it is evident that fecundity in sand is significantly less than both muck and spinach.

Average Number of C. chinensis Birthed per Treatment for Week One

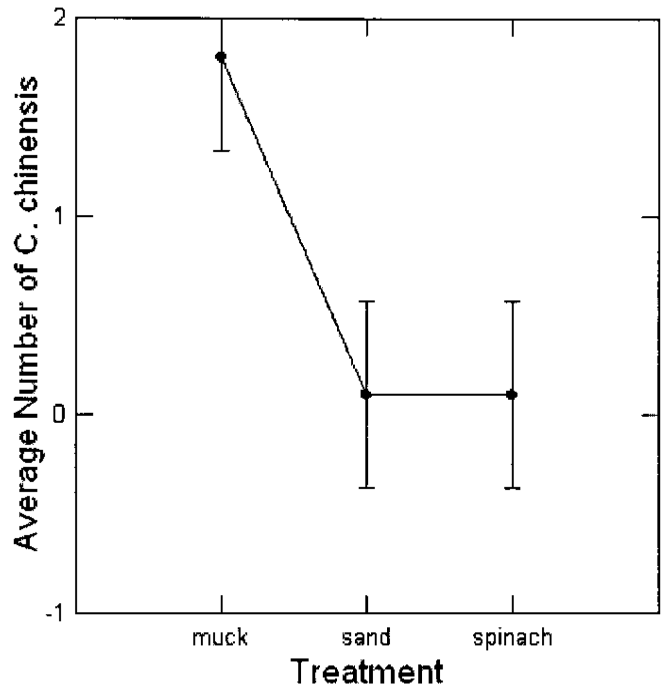

Figure 2. ANOVA results for the number of snails birthed for week one showed that there was significant difference between muck and sand ($p=0.042$) as well as muck and spinach ($p=0.042$).

Average Number of C. chinensis Birthed per Treatment for Week Two

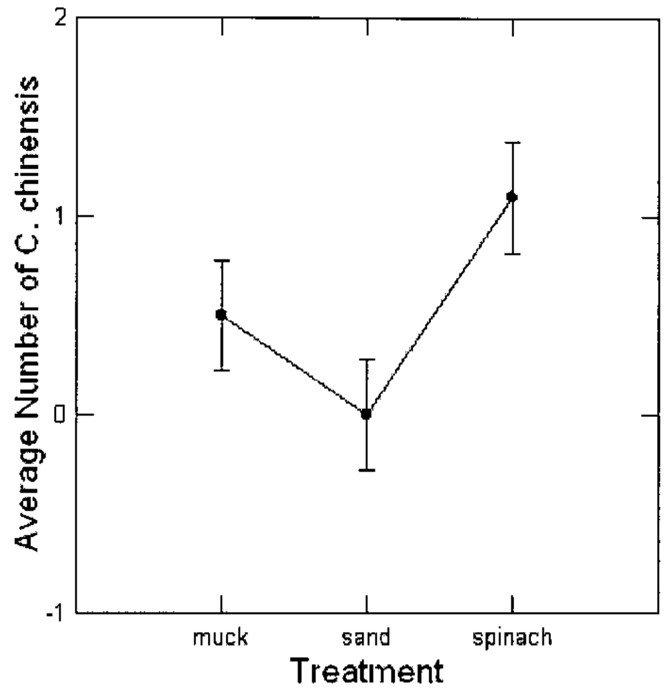

Figure 3. ANOVA results for the number of snails birthed for week two showed that there was only a significant difference between sand and spinach (p=0.027).

Average Number of C. chinensis Birthed per Treatment for Week Three

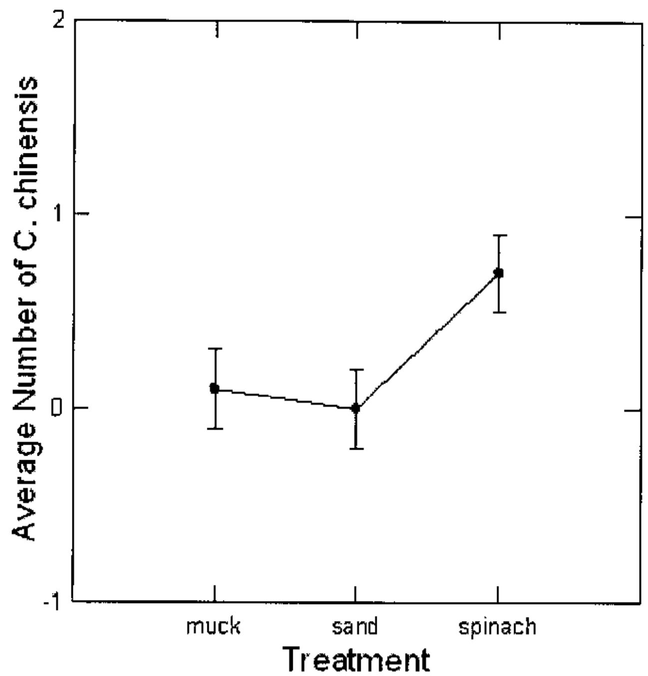

Figure 4. ANOVA results for the number of snails birthed for week three showed that there was only a significant difference between sand and spinach ($p=0.053$). The trend as the weeks progress shows that spinach in week three is greater than muck, where as spinach is less than muck in week one (Fig. 2). Muck is also decreasing in the number of young birthed as the weeks progress.

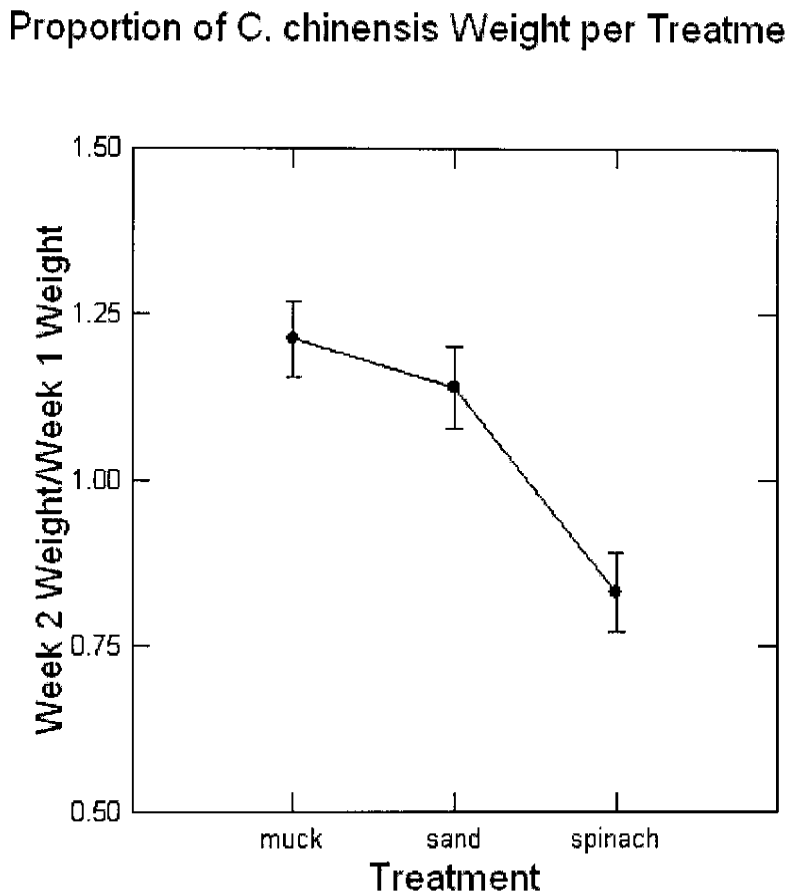

Figure 5. ANOVA results for the proportion of weight of *C. chinensis* baby snails for week two over week one. There is a significant difference between muck and spinach ($p < 0.001$) as well as sand and spinach ($p = 0.002$). There is an overall trend where weight in the muck is the greatest and least in the spinach.

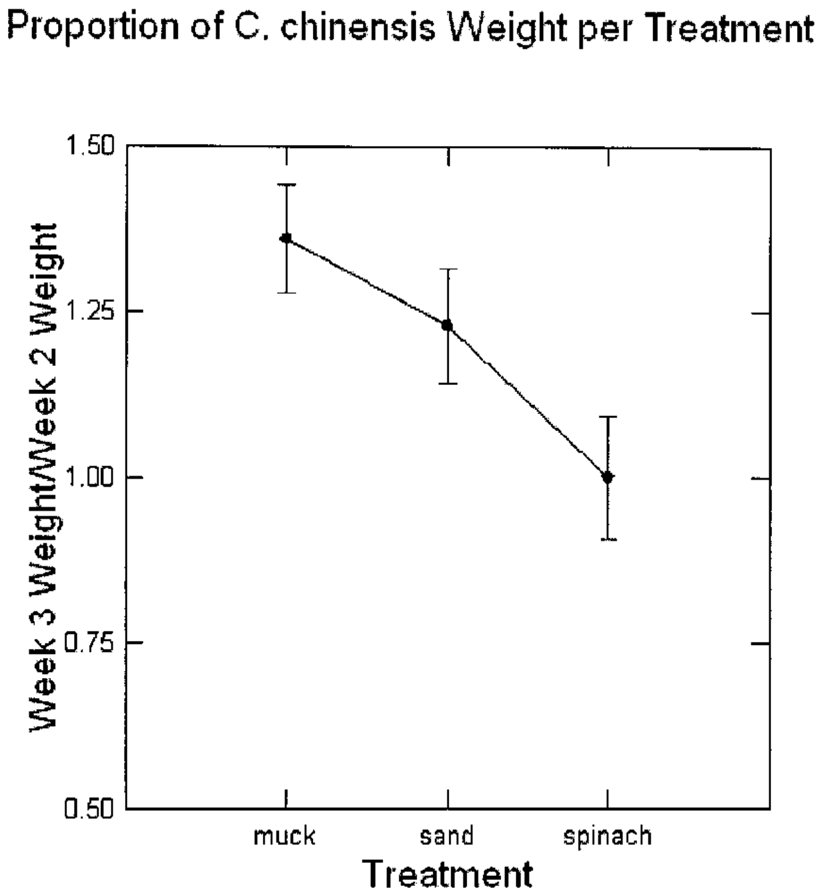

Figure 6. ANOVA results for the proportion of weight of *C. chinensis* baby snails for week three over week one. There is only a significant difference between muck and spinach (p=0.015), but the overall trend hold that muck is greater than sand and spinach is less than sand.

Proportion of C. chinensis Weight per Treatment

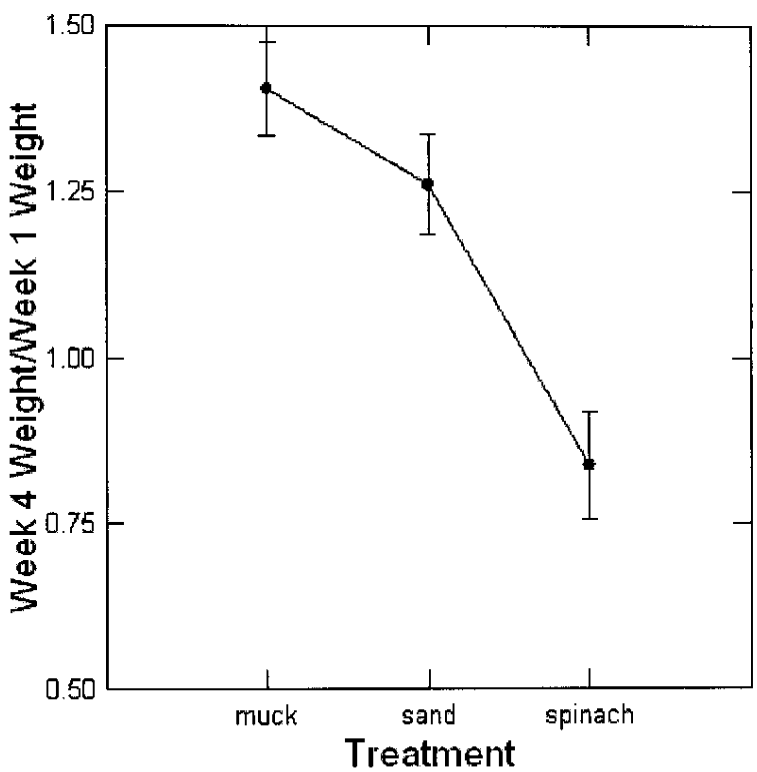

Figure 7. ANOVA results for the proportion of weight of *C. chinensis* baby snails for week four over week one. There is a significant difference between muck and spinach ($p < 0.001$) as well as sand and spinach ($p = 0.001$). The expected trend hold true for week four as well. Muck has the greatest weight proportion and spinach has the least.