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Growth rates of Manduca sexta on artificial and natural diets
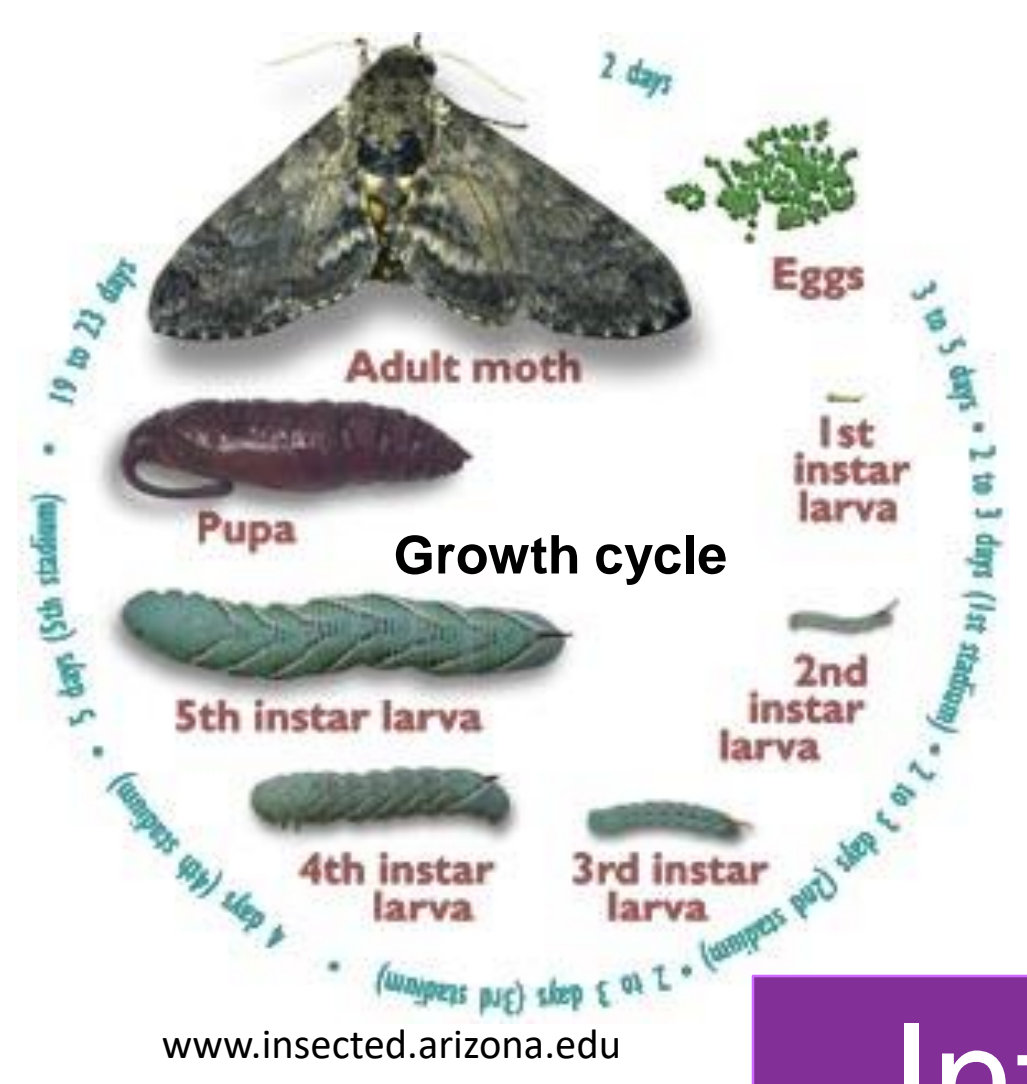
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Growth rates of *Manduca sexta* on artificial and natural diets

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Introduction

- *Manduca sexta* (tobacco hornworms) have an exponential growth rate and a short larval development period of about 18-21 days.
- They are commonly used as model organisms for studies of growth, development, metabolism, and neurobiology.
- These studies can generalize the results found in the laboratory to patterns in nature.
- In the laboratory setting, *M. sexta* are typically fed an artificial wheat germ diet.
- In nature, *M.sexta* feed on the leaves of the tobacco plant, *Nicotiana tabacum.*
- A previous study found no differences in growth rate in the 5th instar based on diet (Reynolds, 1998).
- This study examined a possible difference in growth rate over all 5 instars of the larval development of the organism based on differences in diet.

Methods

Set up
- Eggs were obtained from Carolina Biological Supply.
- Over 10 weeks, 3 cohorts of *M. sexta* were reared individually from hatching to the final wandering stage before pupation.
- Organisms were kept in a laboratory incubator set to 27°C with a 16 Light: 8 Dark Photoperiod.
- Animals were given fresh food daily:
  - 35 were fed an artificial wheat germ diet.
  - 14 were fed a natural tobacco diet.
- Tobacco was grown from seeds at the Brown Family Environmental Center.

Nicotiana tabacum

Data collection
- Organism weight was measured once or twice daily.
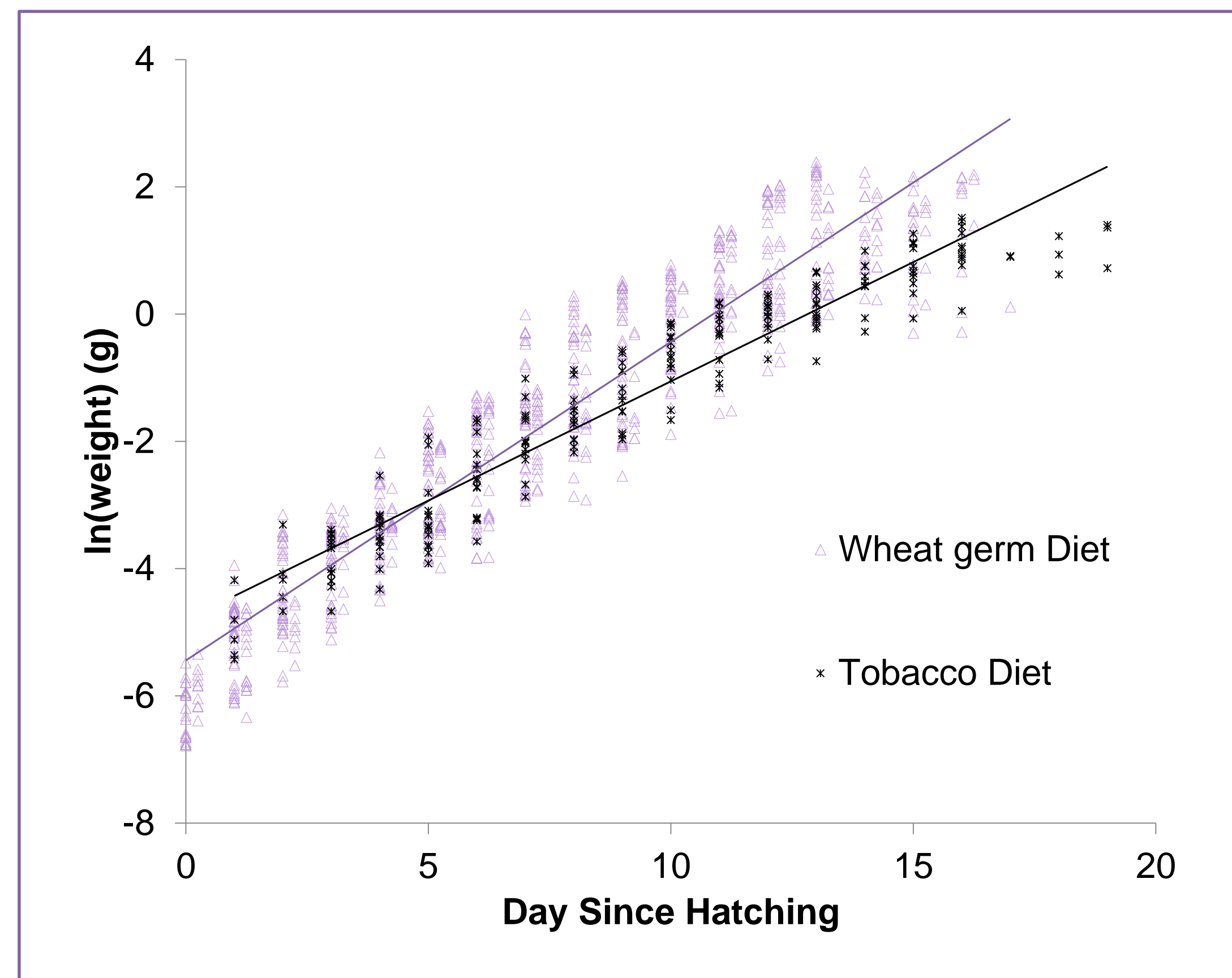- Frass was also collected daily from organisms.

Results

Figure 1. Natural Log mass vs. day since hatching for both diets. (ANCOVA, $F_{day} = 4342.51$, $F_{diet} = 23.85$, $F_{diet*day} = 89.74$, $P_{day} = 0.00$, $P_{diet} = 0.00$ $P_{diet*day} = 0.00$).

Comparison (Figure 1)
- Difference in diet had a significant effect on the growth rate of the organism.
- Tobacco-fed organisms, on average, grew at a slower rate and had a lower final weight than those on the artificial diet.
- The growth rate of the animals on the wheat germ diet leveled off earlier.

In general (Figure 2)
- Regardless of diet, the organisms grew exponentially.
- Growth slowed or ceased shortly before the final wandering stage.

Acknowledgments

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References

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Goodman, W.G., R.O. Carlson & K.L. Nelson. 1985. Analysis of larval and pupal development in the tobacco hornworm (Lepidoptera: Sphingidae), Manduca sexta. *Ann. Entomol. Soc. Am.* 78: 70-80.

Reynolds, S.E., Yeomans M.R., and W. A. Timmins. 1986. The feeding behavior of caterpillars on tobacco and on artificial diet. *Physiological entomology*, 11:39-51.

Modeling Growth Rates

The exponential growth rate of *M. sexta* can be modeled in the following manner:

$$w = c\, e^{rt}$$
$$\ln(w) = \ln(c) + rt$$

(where w = weight, r = growth rate, t = time (day since hatching), c= constant)

The observed growth rates for the organisms can be modeled by the following equations:

Artificial Diet Growth Rate:
$$w_{artificial\ diet} = 0.0043\, e^{0.501t}$$

Tobacco-Fed Growth Rate:
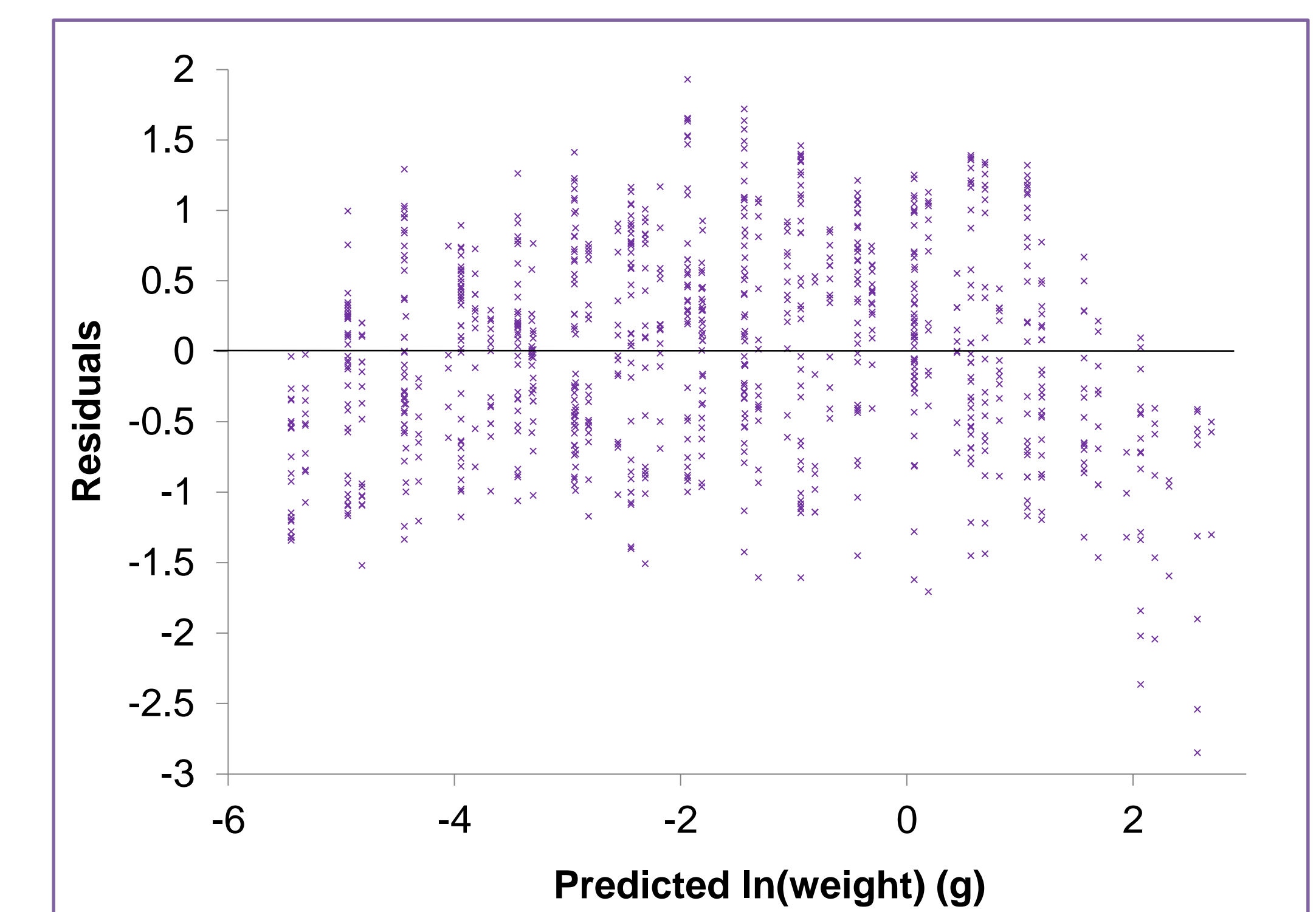$$w_{natural\ diet} = 0.0082\, e^{0.375t}$$

Figure 2 . Residual plot of predicted ln(weight) from models.

Discussion

Possible Explanations
- It is likely that the differences in growth rate were due to the nutritional content of the diet.
  - This can be quantified by the carbon to nitrogen ratio (C:N).
- The tobacco fed-organisms had the added necessity of processing the nicotine in their diet, possibly changing energy allocation and metabolism.

Future Directions
- Future work will analyze frass samples collected this summer to investigate the effects of the C:N ratio of frass and food on growth rates and metabolism.