The primacy effects of seasonal shifts on the foraging behavior of wild-caught woodland deer mice (*Peromyscus maniculatus gracilis*)

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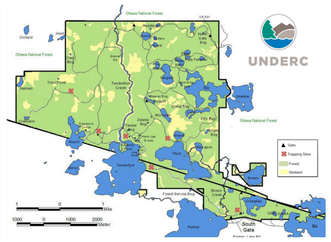
Introduction

Rhythmic changes in foraging are evident through observable behavior; when adapted behaviors vary by annual environmental cycles, they are known as seasonal rhythms. Foraging behaviors, such as preferences for certain food items, could be explained by the need for more energy and increased maximal metabolic rate during colder seasons (Sears et al., 2009). The woodland deer mouse (*Peromyscus maniculatus gracilis)* is an omnivorous generalist that displays selectivity for Red maple (*Acer rubrum*) over Sugar Maple (*Acer saccharum)* seeds (Cramer 2014). Changes to photoperiod and temperature have the potential to alter an animal's normal foraging behaviors and preference for seed type; it is yet unknown what role seasonal photoperiod and temperature shifts play in foraging behavior and what effects are present immediately after these shifts in the environment. Any effects on population dynamics have implications for the vector capacity of *P. m. gracilis* (Lyme and hanta-virus) and the ecosystem(Paull and Johnson, 2014). A similar model for climate change predicts the effect of seasonal confusion on female turtles' ability to shift nesting dates (Telemenco et al. 2013). This study explores the immediate shifts in foraging behavior, measured through seed selectivity and foraging preference, of woodland deer mice (*Peromyscus maniculatus gracilis)* caused by sudden onset of fall climate.

Here we report the effects of a sudden onset of fall temperature and shortened day length on **(1)** the length of the animals' nocturnal activity, **(2)** selectivity for seeds of the genus *Acer*, and **(3)** consumption of high-nutrition, high-handling time seeds (*Acer saccharum).*



Trapping Sites at the University of Notre Dame Environmental Research Center (UNDERC-East). From May 2016 – July 2016, trapping occurred at six sites dominated by trees of the genus *Acer* in Northern Wisconsin and the Upper Peninsula of Michigan.

P. m. gracilis were live-trapped using Sherman traps. Mature males and females that were not pregnant or lactating were included in the study.

Housing unit with food and water *ad libitum*

Temperature/photoperiod controlled incubator—up to five animals at once

Method

1. 3-day acclimation period for wild-caught Peromyscus
2. Selectivity Trial
3. Shifts in Seasonality
   - Preference/ Foraging Index analyzed

Summer Trial 16:8 LD 25°C

Fall Trial 13:11 LD 15°C

Locomotion Activity

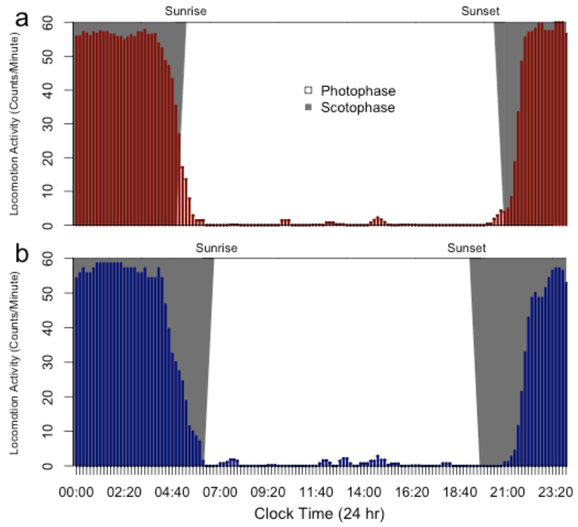
Onset/Offset of Nocturnal Activity

Preference Index

Foraging Index

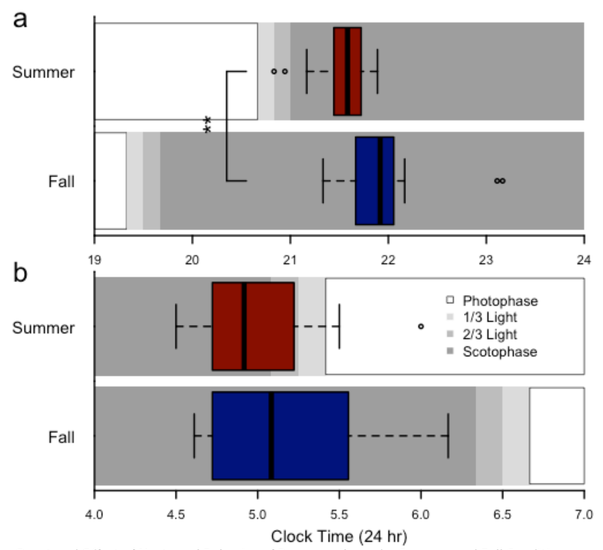
Summer and Fall conditions were determined by June and July averages and included a 0.5 hr dusk transition/onset of night. For more information about trapping methodology and preference index see Cramer 2014.

1 Locomotion Activity for *P. m. gracilis* under summer and fall conditions − 24 hour profile



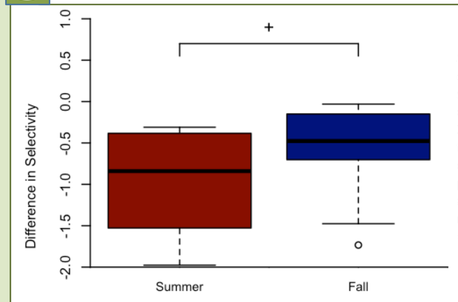
Locomotion Activity of P. m. gracilis. Activity scores were reported in 1-minute bins during the Summer treatment (a, Sunrise 05:00-05:30, Sunset 21:00-21:30) and the Fall treatment (b, Sunrise 06:00-06:30, Sunset 19:20-19:50) every tenth minute from the beginning of the holding period to the beginning of the selectivity trial.

2 Average (mean) time of onset and offset activity for *P. m. gracilis* under summer and fall conditions



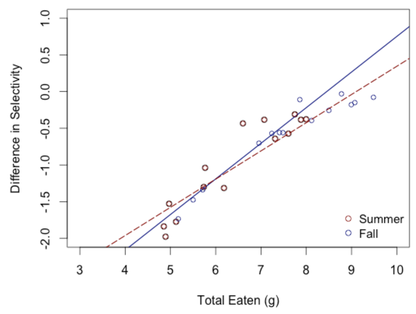
Onset and Offset of Nocturnal Behavior of P. m. gracilis under Summer and Fall Conditions. (a) The onset times of mice in the two conditions varied significantly (W = 33.5, p = 0.003). (b) The offset times of mice in the two conditions did not vary significantly (t = -0.9343, df = 26, p > 0.05).

3 Selectivity index for *P. m. gracilis* vary by seasonal shift

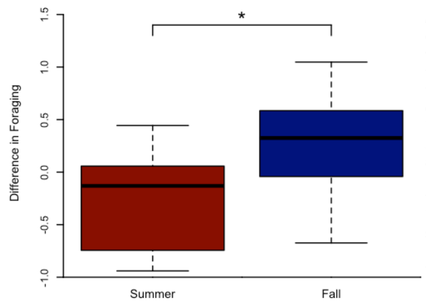


Selectivity Index for Seeds of the Genus Acer. The selectivity index was calculated that a score of 2.0 a complete preference for *A. saccharum*, a score of -2.0 indicates a complete preference for *A. rubrum*, and a score of 0 indicates a neutral selectivity (V = 45, p = 0.062).

Linear Model of Difference in Selectivity versus Eaten Seeds. Plot of difference in selecitivity against total amount eaten with linear regression line for both Summer conditions and Fall conditions. Both conditions demonstrated a positive linear relationship: the difference in selectivity increased with increasing amount eaten (Summer trial (dotted line), W = 0.896, p > 0.05, R^2 = 0.878, p < 0.001; Fall trial (solid line), W = 0.950, p > 0.05, R^2 = 0.914, p < 0.001).

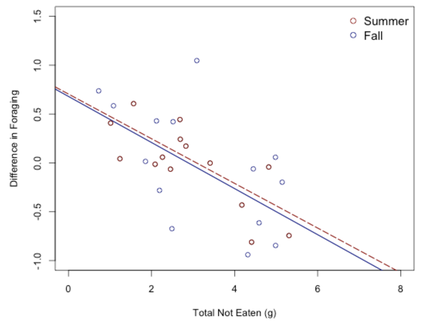


4 Foraging index for *P. m. gracilis* vary by seasonal shift



Foraging Index for Seeds of the Genus Acer. Uneaten seeds were categorized as either foraged or not foraged. The foraging index was then calculated that a score of 2.0 indicates that all uneaten *A. saccharum* seeds were foraged, a score of -2.0 indicates that all uneaten *A. rubrum* seeds were foraged, and a score of 0 indicates no preference for species of foraged seeds . Differences between the two trials approached significance (t = -2.772, df = 25, p = 0.010).

Linear Model of Difference in Foraging versus Uneaten Seeds. Plot of difference in foraging against total amount not eaten with linear regression line for both Summer conditions and Fall conditions. Both conditions demonstrated a negative linear relationship. The difference in foraging decreased with increasing amount uneaten (Summer trial (dotted line), W = 0.958, p > 0.05, R^2 = 0.577, p = 0.002; Fall trial (solid line), W = 0.095, p > 0.05, R^2 = 0.326, p = 0.033).



Conclusions & Discussion

- **The primacy effects of an experimental three day shift can be observed in wild-caught *Peromyscus maniculatus gracilis***. The observed shift during the short 3-day holding period supports the hypothesis that the primacy (immediate) effects of seasonality shifts can be synthesized with this experimental design.
- The selectivity for seeds of the genus *Acer* was affected by the brief shift in seasonality. **The previously observed selectivity for *Acer rubrum* seeds is not conserved under the experimental shift in seasonality.**
- A foraging index derived from a selectivity index from the literature (Cramer 2014) showed that ***P. m. gracilis* show an increased preference to handle *A. saccharum* seeds.** Seeds that were presumably handled by the mice were found in several locations—this may approximate caching behaviors, but more research is necessary.
- The lack of a relationship between amount uneaten and foraging indices (in the linear models) demonstrates that not all aspects of the **complex foraging behaviors** of *P. m. gracilis* are affected by brief seasonal shifts.
- Several aspects of this study indicate that further research is necessary to solidify the effects of seasonal shifts on the foraging behavior of *P. m. gracilis.* **An increased holding period** would ensure that the shift in seasonality is appropriately mimicked, but **it is worth noting the unpredictability in seasonality brought on by climate change could be as brief as 3 days**.
- Future studies should aim to characterize the mechanisms which underlie this observed shift in activity and foraging behaviors. Research should focus upon **hypothalamic activity**, **gene expression** in the circadian pathway, and **hormone levels** implicated with feeding behaviors.

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