The influence of forest age on food resource consumption and preference in invertebrates

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Abstract

Ecological succession refers to the change in species composition in an ecosystem over time. As a forest progresses through successional stages, arthropod diversity tends to increase (Keten, 2014), which may increase food resource consumption by arthropods. The purpose of our study is to determine how invertebrate food resource removal and preference varies across different stages of forest succession. We measured units of plain rice and butter, salt, and sugar coated rice removed from macrofauna-excluding cages in five forests of different ages after 24 hour periods to assess the impact of forest age on food resource removal. Our results indicate that there was a significant difference in the average units of rice removed across the different burn plots. Significantly more sugar-coated and butter-coated rice was consumed on average compared to the salt-coated and plain rice across all burn plots. However, there was no significant difference in rice removal between treatment types across the burn plots. Our findings suggest that the food preferences of arthropods remain constant over different successional stages. In all burn plots, microfauna prefered fat and carbohydrate-coated rice over plain rice and

salty rice. This may have important implications for managing the microfauna communities in forests undergoing reforestation after a disturbance such as a burn or clear cut. Regulating the availability of fats and carbohydrates may enhance the health of microfauna communities and, by extension, assist forest ecosystems in recovery from disturbances.

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Ecological succession refers to the change in species composition in an ecosystem over time. As a forest progresses through successional stages, arthropod diversity tends to increase (Keten, 2014), which may increase food resource consumption by arthropods. The purpose of our study is to determine how invertebrate food resource removal and preference varies across different stages of forest succession. We measured units of plain rice and butter, salt, and sugar coated rice removed from macrofauna-excluding cages in five forests of different ages after 24 hour periods to assess the impact of forest age on food resource removal. Our results indicate that there was a significant difference in the average units of rice removed across the different burn plots. Significantly more sugar-coated and butter-coated rice was consumed on average compared to the salt-coated and plain rice across all burn plots. However, there was no significant difference in rice removal between treatment types across the burn plots. Our findings suggest that the food preferences of arthropods remain constant over different successional stages. In all burn plots, microfauna prefered fat and carbohydrate-coated rice over plain rice and salty rice. This may have important implications for managing the microfauna communities in forests undergoing reforestation after a disturbance such as a burn or clear cut. Regulating the availability of fats and carbohydrates may enhance the health of microfauna communities and, by extension, assist forest ecosystems in recovery from disturbances.

Ecological succession refers to the change in species composition in an ecosystem over time. A forest's successional stage influences microfauna diversity. Forest ecosystems experience rapid succession after a disturbance such as a fire, which can eliminate most of the insect communities that previously existed there (McCullough, 1998). The composition of arthropod species in a forest during different stages of succession is affected by the dispersal and competitive abilities of those species. Insects with high dispersal abilities are the first to occupy a forest after a fire. Older forests tend to be inhabited by arthropod species with limited dispersal abilities (Buddle, 2006). They also may have higher arthropod diversity because it has been found to increase with DBH and tree height (Keten, 2014). An increase in microfauna diversity may correspond to increased food consumption and more variability in food preference among microfauna communities in older forests. Similarly, nutrient-levels tend to increase as succession progresses (Rehkopf, 2003). Microfauna communities may show higher variation in food preferences in older forests compared to younger forests because the more nutrient-rich soils may result in a greater variation in food resources available for invertebrates.

The purpose of our study is to determine how invertebrate food resource removal and preference varies across different stages of forest succession. We placed rice coated in either sugar, salt, butter, or nothing in cages that excluded macrofauna in five forests of different ages on two different days. Units of rice removed from each sample were recorded over a 24 hour period to assess the impact of forest age on food resource removal. A sample from each treatment group and a control were placed within one cm of each other in all replications to control for arthropod species with small ranges, which tend to be found in older forests (Buddle, 2006).

We hypothesized that older forests will have significantly more rice removal on average than younger plots due to an increase in arthropod diversity (Keten, 2014). We also hypothesized that more sugar-coated rice will be removed than the plain, salt-coated, and butter-coated rice because ants prefer carbohydrate-rich diets. This is exhibited by Wilder's (2011) study, where carnivorous arthropods preferred carbohydrates over a protein-rich or combined carbohydrate and protein diet. Lastly, we hypothesized that younger plots will show stronger preference towards the sugar-coated rice than older plots because soil nutrient levels tend to increase with forest age (Rehkopf, 2003).

Methods

Baits containing a cage and four petri dishes, each with ten grains of rice of a different treatment, were set up in five UMBS Burn Plots to explore what nutrients may be limiting for microfauna in forests of different successional stages. We coated 250 grains of cooked long-grain rice in 60 mL powdered sugar, 250 grains in 60 mL butter, and 250 grains in 60 mL table salt. We left 250 grains uncoated for a control. These petri dishes were labeled to identify the manipulation, site, and replication number it corresponds to. Cages to exclude macrofauna from our samples were constructed by cutting chicken wire into squares with sides six inches long. Squares with one inch sides were cut from each corner. The chicken wire was then folded to create 6 in x 5 in x 1 in cages.

At 8:00 AM on August 4th, 2015, we set up 20 baits in five forest plots that each experienced a natural or human-induced burn during a different year (1911, 1936, 1954, 1980, and 1998) to compare the resource preferences of microfauna in forests of different ages. We placed each cage over four petri dishes, one control and one of each manipulation, in a square formation with petri dishes no more than one cm apart. Cages in each burn plot were placed two meters apart from each other. The number of rice grains in each petri dish was recorded at 1:30 PM, 9:15 PM, and 11:30 PM on August 4th, and at 7AM the following day. This experiment was replicated on August 9th, 2015, for a total of 200 replicates. Baits were set up at 12:30 PM on August 9th, and the number of rice grains in each petri dish was recorded at 5:30PM and

10:30PM on that day, and at 8AM and 1:30PM the following day. We conducted a two-way ANOVA analysis between rice units of each treatment removed and forest age to determine whether there were significant differences in rice removal from each treatment group in each burn plot. We also performed a regression analysis on SPSS with the mean units of rice removed for each forest age to determine if there is a significant relationship between rice removal and forest age.

Results

We conducted a two-way ANOVA between rice units of each treatment removed and forest age. The ANOVA test showed an F statistic of $F_{4,180} = 9.403$ for the mean rice removed overall and the forest age. The p-value was 0.000, which suggests that there was a significant difference in average units of rice removed across the different burn plots. The mean rice units removed in the 1911 plot and the 1954 plot was not significantly different (p-value=0.396). The 1980 and 1998 plots were also not significantly different (p-value= 0.255). Similarly, the average amount of rice removed in the 1936 plot was not significantly different from the 1980 or 1998 plots (p-value=0.439 and 0.057, respectively). However, the mean rice removed from the 1911 plot was significantly different from the 1936, 1980, and 1998 plots (p-value= 0.018, 0.002, and 0.000 respectively). The average rice removed from the 1954 plot was significantly different from the 1936, 1980, and 1998 plots (p-value= 0.001, 0.000, and 0.000 respectively). To summarize, the 1911 and 1954 plots were not significantly different, and the 1936, 1980, and 1998 plots were not significantly different; however, the 1911 and 1954 plots differed significantly from the 1936, 1980, and 1998 plots. Significantly less rice was removed on average from the 1954 plot and the 1911 plots compared to the 1936, 1980, and 1998 plots (*Fig 1*). We also performed a regression analysis on SPSS with the mean units of rice removed in each burn plot. The regression showed an R^2 value of 0.078, which suggests that only 7.8% of rice consumption can be explained by forest age. This finding was not significant, however, it is noteworthy that rice removal tended to decrease with forest age in our samples (*Fig 2*).

The previous ANOVA analysis also determined that the F statistic for the mean units of rice removed and treatment type was $F_{3,180} = 2.340$, with a p-value of 0.075. This result indicates no significant difference in rice removal across all treatment types. The average units of rice removed in the control group was significantly different from the butter and sugar treatments (p-value=0.036 and 0.017, respectively), however, the control group was not found to be significantly different from the salt treatment (p-value=0.084). Significantly more rice units were removed on average in the butter and sugar treatment groups compared to the control group (*Fig 1*). The mean rice removal from the butter treatment group was not significantly different from that of the salt and the sugar treatment groups (p-value= 0.707 and 0.764, respectively), and neither was the difference in the salt and sugar treatment groups (p-value=0.499). The F-statistic for the average amount of rice of each treatment removed and forest age was $F_{12,180} = 1.605$. The p-value was 0.093, showing no significant difference in rice removal between treatment types across the burn plots.

Discussion

Our results indicate that there was a significant difference in average units of rice removed across the different burn plots. Contrary to our hypothesis, rice removal decreased with forest age, with the exception of the 1954 plot (*Fig 2*). Older forests tend to have larger vegetation which provide shade and cools the local environment. Therefore, albedo is higher in younger forests than in older forests. Increased albedo and local temperature corresponds to an increase in ecosystem metabolism (Enquist, 2000), which may explain why rice removal tended to decrease with forest age. Additionally, the average amount of rice consumed in the 1954 plot was similar to that in the 1911 plot, with a mean rice removal value significantly smaller than the 1936, 1980, and 1998 plots (*Fig 1*). Kosek's (1988) study on insect succession in the UMBS burn plots found fewer ant species in the 1948 plot compared to the 1911 and 1980 plots. Smaller ant species richness in the forest plots of intermediate age may explain the smaller amount of rice consumed in the 1954 burn plot.

As hypothesized, the sugar-coated rice was preferred over the salt treatment group and the control group. Significantly more sugar-coated and butter-coated rice was consumed on average compared to the salt-coated and plain rice. However, there was no significant difference in the average units of rice removed in the sugar and butter treatment groups, suggesting that butter and sugar were equally preferred by microfauna in the burn plots. Butter, like sugar, is an energy-rich food source. Our findings suggest that arthropods select more energy-rich food sources over other resources. Treatment preference by microfauna did not significantly differ amongst the burn plots, implying that microfauna communities in all five burn plots preferred butter and sugar-coated rice equally. This contradicts our hypothesis that younger plots will show stronger preference for sugar-coated rice, while microfauna communities in older plots will consume treatment groups more equally. Therefore, it is suggested that even as soil nutrient levels increase with forest age (Rehkopf, 2003), food resource preference among microfauna remains constant.

Increased arthropod diversity in older forests does not appear to increase resource consumption. This is consistent with Youngsteadt's (2014) study, which found that species identity, not diversity, predicted consumption of human food by arthropods. Further research is necessary to understand how microfauna species composition in forests of different ages impacts resource removal by microfauna. Additionally, our findings suggest that the food preferences of arthropods remain constant throughout different successional stages. In all burn plots, microfauna prefered fat and carbohydrate-coated rice over plain rice and salty rice. This may have important implications for managing the microfauna communities in forests undergoing reforestation after a disturbance such as a burn or clear cut. Regulating the availability of fats and carbohydrates may enhance the health of microfauna communities and, by extension, assist forest ecosystems in recovery from disturbances.

Citations

Buddle, C. M., Langor, D. W., Pohl, G. R., & Spence, J. R. (2006). Arthropod responses to harvesting and wildfire: implications for emulation of natural disturbance in forest management. *Biological Conservation*, *128*(3), 346-357.

Enquist, B. J., Economo, E. P., Huxman, T. E., Allen, A. P., Ignace, D. D., & Gillooly, J. F. (2003). Scaling metabolism from organisms to ecosystems.*Nature*, *423*(6940), 639-642.

Keten, A., Beskardes, V., Kumbasli, M., Makineci, E., Zengin, H., Özdemir, E., ... & Anderson, J. T. (2014). Arthropod diversity in pure oak forests of coppice origin in northern Thrace (Turkey). *iForest-Biogeosciences and Forestry*, 566.

Kosek, S. (1988). Insect succession in Established Burn Plots of Different Ages in Northern Lower Michigan. *Deep Blue*.

McCullough, D. G., Werner, R. A., & Neumann, D. (1998). Fire and insects in northern and boreal forest ecosystems of North America 1. *Annual review of entomology*, *43*(1), 107-127.

Rehkopf, Linda. "Succession." *Environmental Encyclopedia*. Ed. Marci Bortman, Peter Brimblecombe, and Mary Ann Cunningham. 3rd ed. Vol. 2. Detroit: Gale, 2003. 1354-1357. *Gale Virtual Reference Library*. Web. 2 Aug. 2015.

Wilder, S. M., Holway, D. A., Suarez, A. V., & Eubanks, M. D. (2011). Macronutrient content of plant-based food affects growth of a carnivorous arthropod. *Ecology*, *92*(2), 325-332.

Youngsteadt, E., et al (2015), Habitat and species identity, not diversity, predict the extent of refuse consumption by urban arthropods. Global Change Biology, 21: 1103-1115.

Appendix

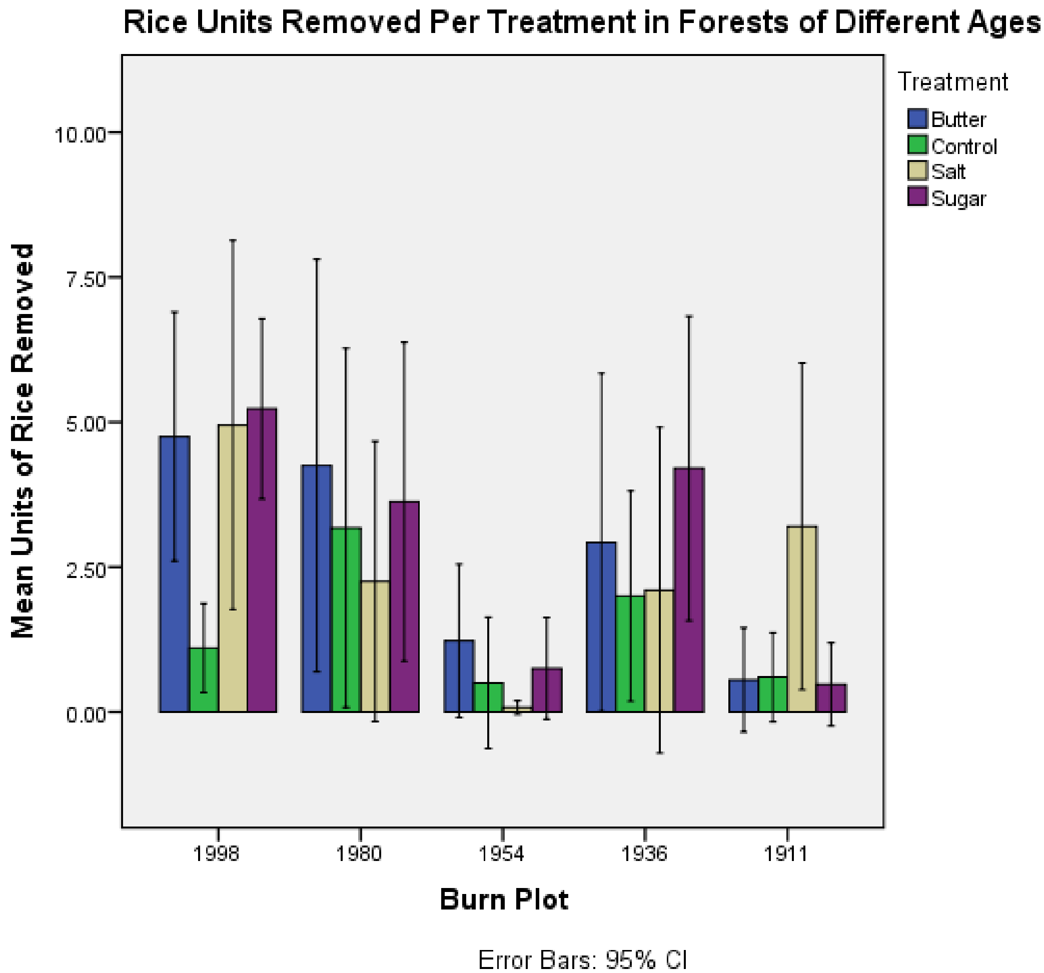

Fig 1. Significantly less rice was removed on average from the 1954 and 1911 plots compared to the 1936, 1980, and 1998 plots. Differences in rice removed from the 1911 and 1954 plots were not significant. Average rice removed from the 1936, 1980, and 1998 plots were not significantly different.

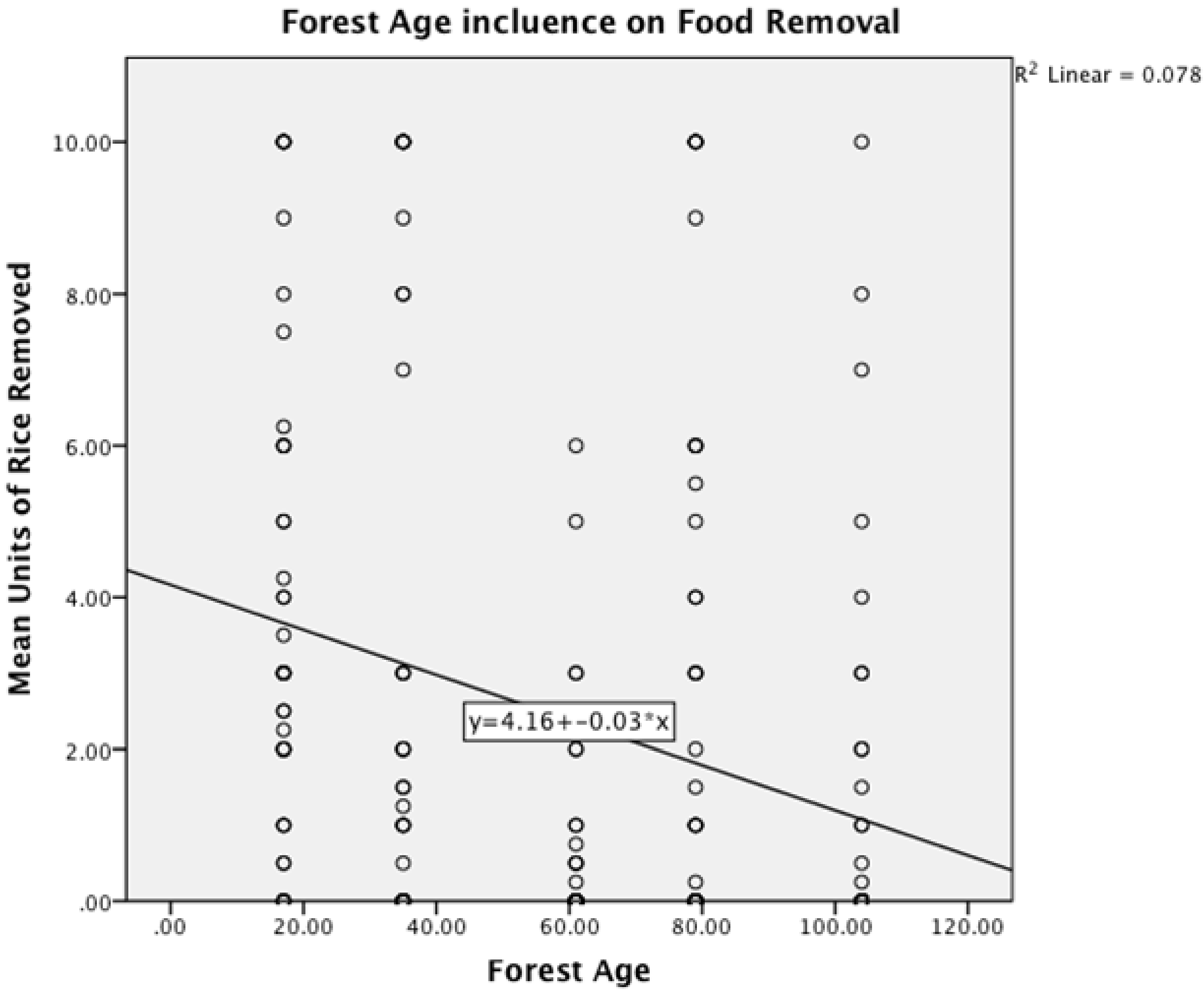

Fig 2. Overall, average rice removal decreased with increased forest age (in years).