Patch Utilization by the Red Flour Beetle (*Tribolium castaneum*)

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Question

Do female red flour beetles, *Tribolium castaneum*, make optimal oviposition decisions in a patchy environment?

Introduction

- The red flour beetle, *Tribolium castaneum*, is a major pest of flour mills and other food processing and storage facilities.
- The landscape of food processing and storage structures is a patchwork of unfavorable habitats and favorable habitats of varying quality and persistence.
- The spatial configuration of resource patches strongly influences the abundance and distribution of individuals in a landscape and this in turn influences pest management.
- The behavioral ecology of red flour beetle in patchy landscapes is not well understood. We investigated how patch quality influences oviposition behavior and the fitness consequences of different oviposition decisions.

Materials and Methods

- **Four patch experiment**

Artificial patches (2 glass slides separated by gasket material with flour and yeast mixture placed between the slides) were created to provide food, shelter, and oviposition substrate. Patches were placed near each of the four corners of 41 by 32 cm trays. Three treatments were compared: one patch with flour (0.4 g of flour in one patch); four equal patches (0.1 g of flour in each patch); four different patches (0.25, 0.1, 0.04, 0.01 g of flour in each patch, respectively). Fifteen replicates were setup for each treatment. Pairs of male and female *T. castaneum* were added to trays and after 7 days the number of eggs in each patch was determined.

- **Choice experiment.**

Artificial patches, one per dish, were placed in inverted 90 mm petri dishes with bottom lined with filter paper. The following amounts of flour in the patches were used: 0.00, 0.005, 0.01, 0.02, 0.04, 0.08, 0.10, 0.20, 0.40, and 1.00 g. Twenty replications were performed for each amount of flour. Single females were placed in dish and after 48 hrs the number of eggs in each patch was determined.

- **No choice experiment.**

Artificial patches, two per dish, were placed in inverted 150 mm petri dishes with bottom lined with filter paper. One patch contained 0.10 g flour and the other contained either 0.01, 0.02, 0.04, 0.10, 0.20, or 0.40 g flour. Twenty replicates were performed of each combination. Single females were placed in dish and after 48 hrs the number of eggs in each patch was determined.

- **Fitness consequences.**

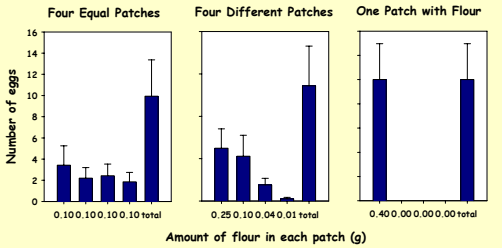
All combinations of amount of flour (0.005, 0.01, 0.02, 0.04, 0.08, 0.10, 0.20, 0.40, 0.80 and 1.00 g) and number of *T. castaneum* eggs (1, 2, 4, 8, and 12) were set up in 30 ml cups (5 replicates of each combination). The total number of adult progeny after 10 weeks is presented here.

Conclusions

- Females adjusted the number of eggs that they laid in a given patch as a function of amount of flour present.
- Females visited multiple patches and the allocation of eggs among patches was influenced by the amount of flour in the patch.
- There was a good correlation between the number of eggs laid and the optimal number of eggs to maximize offspring survival to adulthood.
- Understanding patch use behavior will help improve the management of pest populations in food processing and storage facilities.

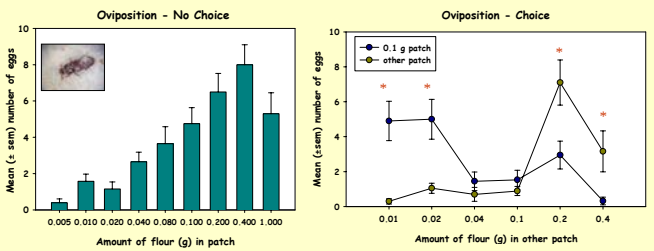
Results - Four Patch Experiment

- No difference in the total number of eggs laid among the different flour distributions (GLM; $F=0.51$; $df=2,37$; $P=0.607$).
- When patches contained equal amounts of flour, the distribution of eggs among patches was not different from uniform (Goodness of fit test; $\chi^2=7.7$; $df=3$; $P>0.05$).
- When patches contained different amounts of flour, the distribution of eggs among patches differed from uniform (Goodness of fit test; $\chi^2=100.9$; $df=3$; $P<0.001$).



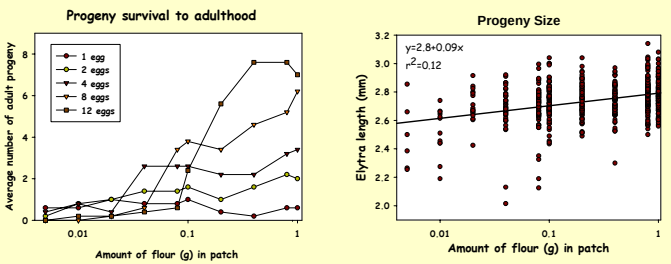
Results - Choice & No Choice Experiments

- Number of eggs laid increased with amount of flour (no choice experiment) (ANOVA; $F=10.23$; $df=8,170$; $P<0.001$).
- Females tended to lay more eggs in patch with more flour (paired t-tests; $P<0.05$ indicated by star) and were able to discriminate differences as small as 0.1 g in the amount of flour in patch (choice experiment).



Results - Fitness Consequences

- Number of progeny that could develop from egg to adult increased with amount of flour in patch.
- Only in patch sizes $\geq$ 0.2 g did increasing the number of eggs consistently correspond to an increase in number of adults.
- The effect of amount of flour present during the larval stage on adult size was minimal.



Relationship Between Oviposition and Fitness

- There was a good correlation between the number of eggs laid in a given amount of flour and the optimal number of eggs for that amount of flour.
- Optimal number of eggs was estimated by determining the minimum number of eggs that provided the maximum average number of adult progeny for a given amount of flour.
- Mechanism used to assess patch size and the influence of other patch quality factors on oviposition will be investigated.