Oviposition and Larval Development of the Indian Meal Moth, *Plodia interpunctella,* on Different Breakfast Cereals

Tanner Liba[1,2], Jamie Aikins[1], Thomas Phillips[1]

[1]Department of Entomology, College of Agriculture, Kansas State University
[2]Department of Biology, College of Arts and Sciences, Kansas State University

Abstract

Plodia interpunctella, the Indian meal moth (IMM), is a common pest of grain products. Adult IMMs lay eggs on a food source and once hatched, the larvae consume the product while leaving behind large amounts of frass and silk [1, 2]. The purpose of this experiment was to identify which kind of grain products are at the highest risk of *P. interpunctella* infestation by using the lab-rearing diet as a comparison to two different breakfast cereals of the same brand: a frosted cereal and a regular non-frosted cereal. Two-choice tests determined if moths prefer to lay eggs on and which of the choices would b for the larva to develop. At the end of the experiment, it was observed that adult *P. interpunctella* preferred to lay their eggs on the frosted cereal diet. The frosted cereal diet also proved to be the better of the two for larval survival and growth. This research suggests that frosted cereals may be preferred by this pest, and that such products need special protection during storage.

Purpose

The purpose of this research was to help understand and predict what kind of breakfast cereals or similar grain products are at the highest risk for infestation by *Plodia Interpunctella.*

Questions, Hypotheses, and Predictions

Question: Which of two common breakfast cereals, one with added sugar and one without, is at the highest risk of infestation by IMM?

Hypothesis: *P. interpunctella* will prefer the cereal with the added sugar over the regular cereal.

Prediction: Adult *P. interpunctella* will prefer to lay their eggs on cereal with added sugar. We also predict that more IMM larvae will infest the sugar-added cereal compared with the regular cereal

Study System

Adult *P. interpunctella* are found either resting on the walls or on the food itself. Females can lay as many as 20 eggs a day and can reproduce year-round (Fig. 1). Larvae are the feeding stages and their diet consists of high amounts of carbohydrates [1]. Larva are a cream-white color with a brown head (fig. 5). Late instar larvae are quite mobile and will chew through thin cardboard and thin plastic bags. Depending on conditions, the larval stage of *P. interpunctella* can last from 2 weeks to a year [2, 3].

Figure 1. (from l to r), IMM larva in lab diet, adult IMM, eggs and a first instar larva on food.

Methods and Experimental Design

Two well-known breakfast cereals were purchased at a local grocery store (Fig.2). Ingredients in each product included oats, corn starch, sugar, salt and other materials. Both products were essentially the same except for the "frosted" variety having over nine times as much sugar as the regular cereal. The laboratory diet for the IMMs consisted of organic yellow corn meal, chick starter mash, hen laying mash, and glycerol. Two experiments were run: a two-choice assay in which the adult *P. interpunctella* were given a choice of which food to lay their eggs on, and a no-choice scenario in which the adults were forced to lay their eggs on a specific diet in a closed jar. Pupae were isolated from cardboard rolls that had been placed in lab culture jars (Fig. 2).

Figure 2. Nutrients and images of the regular cereal (left), and the frosted cereal (right).

Two-day old pupae were separate by sex according to the presence of small bumps corresponding to testes in males, vs. no bumps in females (Fig. 3). A group of 3 males and 3 females were placed together in each individual rep to ensure reproduction. For the no-choice assays, 2 grams of each cereal was placed inside their own individual 120 ml ventilated glass jar and with 6 sexed pupae , 3 females and 3 males, were added to each jar (Fig. 4). There were three replicate jars for each grain product. Each choice experiment used one gram of either powdered frosted cereal or regular cereal vs. the moth lab diet. Each food sample was placed inside a small plastic open dish and taped on opposite sides of a 3.8 l plastic box (30 cm c 10 cm x 15 cm tall) (fig. 5).This was done 3 times for both the frosted cereal and regular cereal. Once both scenarios were set up, the experiments were placed in a humidified room at 27°C and given time for the adults to emerge, mate and lay eggs.

Figure 3, l to r; jar with wandering larvae; cardboard rolls placed in jars in which larvae had pupated; a pupa with arrow at diagnostic segment; location of male-specific testicular bumps.

The adults were removed from boxes at 14 days and another w7 days was given to allow the laid eggs to hatch and develop into larva that were large enough to count. More time would be given to the frosted and regular cereal diet to allow the larva to develop in order to count the larva.

Figure 4. No-choice experiment jars

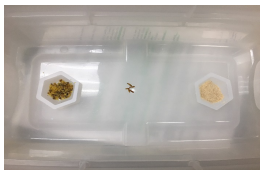

Figure 5. Choice experiment container

Results

In all experiments, there were more eggs laid in the lab diet compared to either of the two cereals. In the no-choice study we found an average of 89 larvae per jar of the frosted cereal compared to an average of 44 larvae per jar on the regular cereal (fig . 6). The two-choice experiment found that larval numbers in the lab diet were quite high, at 100-200 larvae, as expected. In boxes comparing lab diet to a test cereal, the proportion of larvae was higher for the frosted cereal, at 17%, compared to 8% for the regular, unfrosted cereal (Fig. 7).

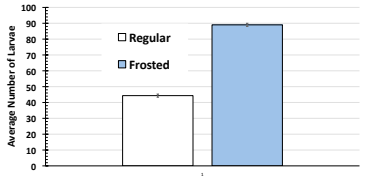

Figure 8. Graph showing the results of the no-choice experiment

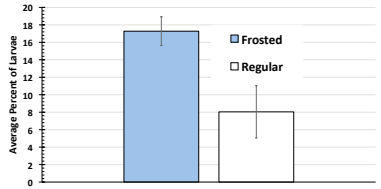

Figure 9. Graph showing results of the two-choice experiment

Conclusions

These results show that out of the two breakfast cereals, the sugar frosted cereal was the most likely to be infested by *P. interpunctella*. Not only was there considerably more larva in each rep of the choice scenarios, the larva actually proved to be more developed in the no-choice scenarios when raised on the frosted cereal diet. This coincides with our hypothesis that the grain-product with the highest amount of carbohydrates would attract more *P. interpunctella* and that it would also prove to be most nutritious for their larva. This can lead us to the conclusion that *P. interpunctella* and other pests prefer grain products that are high in carbohydrates, which can be useful in production industries, inside grocery stores, and inside your home as well as being useful in developing systems of pest control and prevention.

Future Directions

To continue this research, I would like to see the addition of a few different kinds of grain products and possibly the addition of dried fruits. If possible, the eggs would be counted or at least observed once the adults were released so that numbers wouldn't rely on the amount of larva alone. Once the larva have emerged from the eggs, their progress would be monitored much more closely as they develop and their numbers would be counted over time, for larva will sometimes resort to cannibalism if food quality and quantity is too low. Larva could also be starved for a number of days and then released in another choice scenario in which they move towards the diet they prefer.

References

[1] Borzoui, et al. "Dietary Protein and Carbohydrate Levels Affect Performance and Digestive Physiology of Plodia Interpunctella (Lepidoptera: Pyralidae)." *OUP Academic*, Oxford University Press, 18 Jan. 2018, academic.oup.com/jee/article-abstract/111/2/942/4816347.

[2] Jacobs, S. B. and D. Calvin. 2001. "Indian Meal Moth (Department of Entomology)." Department of Entomology (Penn State University), Penn State, ento.psu.edu/extension/factsheets/indian-meal-moth

[3] Bouayad, Noureddin, et al. "Journal of Stored Products Research." *10th Edition*, Mosby, 15 Feb. 2008, www.elsevier.com/locate/jspr.

Acknowledgements

Special thanks to Dr. Jeremy Marshal for giving T.L. the chance to participate in this program. Wu Xiaoli and Jacqueline Maille gave valuable assistance with this project.