Characteristics of Indian Meal Moth

Monitoring the population with pheromone traps is important.

Anyone who is involved in storing or processing grains has seen or heard about the Indian meal moth. This species is implicated in most infestation complaints in finished and packaged products, especially at the retail level.

This is not surprising, since the Indian meal moth has been reported in 48 different countries and is associated with 177 stored commodities. This pest has been found in bakeries, grain processing facilities, warehouses, retail stores, homes, and outdoors in urban and grain processing environments.

The moth has characteristic markings on the wings, which are dark reddish brown at the tips and whitish gray closer to the body. The total wing span is about 2 cm. Soon after emerging from the pupal stage, the male and female moths can mate readily.

After emergence, the female releases a sex pheromone (*cis*-9, *trans*-12-tetradecadienyl acetate), which is very attractive to male moths. This pheromone has been synthesized and is used as a lure in sticky traps for monitoring this species.

Presence of Pheromone

The males also are known to produce a pheromone that makes females more receptive to male mating attempts. Delaying mating results in a reduction in number of eggs laid, and delaying mating for five days results in nonfertile matings (no eggs are produced/laid). Males can inseminate several females, and females can receive several males.

However, a single mating is necessary for the female moths to fertilize and lay its full complement of eggs. The number of eggs laid by a female is usually around 200 to 300 but can vary from 40 to 400 depending on temperature, larval food, and size of moths. The moths live for about six to eight days, and females lay a majority of the eggs during the first four days after mating.

The eggs are white, oval, and 0.3-0.5 mm long. The females lays eggs loosely, directly on the food. Stress such as expo-

Pest Management

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Indian meal moth. Photo by USDA/ARS.

sure to carbon dioxide also makes the females lay eggs.

The larvae go through five to six instars before pupation. Larvae weave a web around food particles or grains, feeding within, and the presence of silken threads are good indicators of larval infestation on commodities.

Damage to commodities is done only by larvae, and the larvae are capable of feeding on dried fruits, nuts, dried flowers, stored grains, grain byproducts, and many types of seeds. Mature larvae are capable of penetrating packaged products, whereas the tiny larvae are capable of entering through small package openings.

Factors that Affect Life Stages

Indian meal moth overwinters as a fully grown larvae when exposed to low temperatures, short day length, or under high population pressure to survive adverse environmental conditions. Overwintering larvae are usually found in farm bins holding grain during winter months. Larvae turn into light brown pupae, and adults emerge from pupae eventually.

The total egg-to-adult development time varies with temperature. At 17.5, 20.0, 22.5, 25.0, 27.5, 30.0, 32.5, and 35.0 degrees Centigrade, the egg-to-adult development time is 150.9, 99.3, 67.3, 48.1, 37.9, 34.9, 38.4, and 49.1 days, respectively (see **Figure 1**).

Figure 1 also can be used to find egg-to-adult development time for other temperatures within this range (e.g., 26 or 31 degrees C).

The moisture content of foods or the ambient relative humidity, which has an influence on food moisture, is not a major factor affecting development, because these moths do well at humidity as low as 30%.

Indian meal moth life stages are highly susceptible to temperatures above 35 degrees C.

Irrespective of the temperature, the percentage of time spent in the egg, larval, and pupal stages is 8%, 77%, and 15%, respectively. These percentages can be used to calculate the egg, larval, and pupal stages at these temperatures.

For example at 17.5 degrees C, the percentage of time spent in the egg, larval, and pupae stages is: 150.9 days x 0.08 = 12.1 days for eggs; 150.9 days x 0.77 = 116.2 days for larvae; and 150.9 days x 0.15 = 22.6 days for pupae. The total development time is 12.1 + 116.2 + 22.6 = 150.9 days. Such calculations may be important in addressing infestation issues.

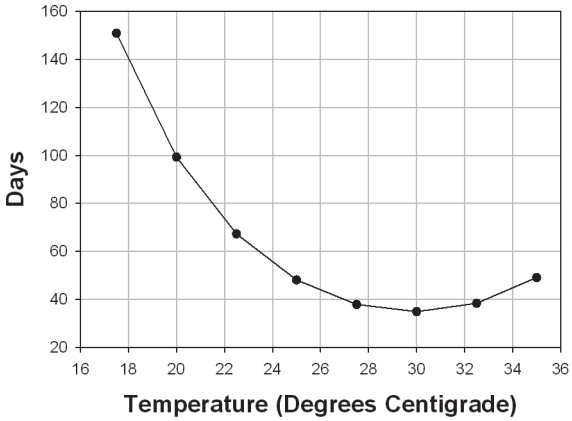

Figure 1. *This shows egg-to-adult development time in days, as a function of temperature. As tempertures decrease, development time increases. Indian meal moth life stages also are impacted when temperatures rise above 35 degrees Centigrade.*

The moths are generally inactive but are active for short time periods especially during early morning and late evening hours. Typically, the moths are observed resting on various surfaces (walls, bags, grain, packages, etc.) in storage environments.

The moths are strong fliers, and one easy way to measure distance flown is by using pheromone traps containing the female-produced sex pheromone lure, where captures of only male moths are characterized.

Moths have been observed outside of flour mills in the United States, but infestations inside flour mills are rare. However, this doesn't mean that they do not infest flour mills in certain parts of the world. Therefore, it is important to close doors and windows to prevent moths from entering mills.

Flying Distance of Indian Meal Moths

Only one paper (Arbogast, R.T., Chini, S.R.; and McGovern, J.E. 2005. *Journal of Economic Entomology*, Vol. 98 (2), pages 326-333) reported that in retail stores and warehouses, the number of male ►

moths captured was inversely related to distance from the source, meaning that more moths were captured closer to the source where moths were emerging, but as the distance increased, fewer and fewer moths were captured.

Experiment Conducted at Retail Store

The author of this article conducted an experiment at a retail store location, which was used by a major company as a training facility. This experiment was initiated on Dec. 19, 2000.

Male pupae of Indian meal moth were extracted from corrugated paper spools placed in culture jars. A total of 250 pupae were collected from culture jars from KSU's Department of Grain Science and Industry.

Additional pupae (250) were collected from culture jars sent from the Department of Entomology, Oklahoma State University, Stillwater.

At the retail facility, 36 commercial sticky traps with Indian meal moth sex pheromone lures were distributed as follows: 20 traps were located inside the retail store area, where actual commercial products were displayed on shelves, 10 were inside the loading dock (receiving) area, and six were placed outside of the retail store.

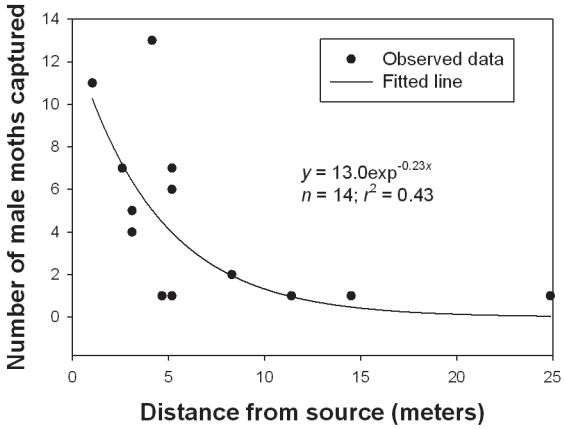

Figure 2. *This model shows that the number of male moths captured decreased with an increase in distance from where the pupae were placed (source).*

At each of the five release stations (four corners inside the store and one in the receiving area), 100 pupae were spread on a brown paper towel and sprinkled with a thin layer of fluorescent marker dust (dye). For each release station, a different colored dust was used. Pupae were rolled gently in these dusts to ensure coverage. It was anticipated that adults emerging from pupae would pick up the dust.

Since, the release points and trap locations were at known distances from release points, based on trap catches one would be able to calculate the linear distance traveled by the male moths in response to the pheromone odor. Generally, moths do not fly in a linear fashion to an odor source.

The temperature at the 36 trap sites, which was measured on Dec. 19, 2000, fluctuated between 18.2 to 22.8 degrees C. The wind speed at 31 out of the 36 trap sites was 0 kilometers per hour (kph), and ranged from 0.5-0.6 kph at five sites. The relative humidity was variable among the 36 locations and ranged from a low of 1% to a high of 34%. These environmental conditions did not change during the entire period of study.

The traps were checked on Jan. 2, 2001, 14 days after placing pupae on paper towels.

All the moths captured in traps had colored dusts, because the store did not have any existing infestation of Indian meal moth. Releasing male moths also will not result in establishing new infestations, because there were no females present in the facility to mate with these male moths.

Table 1. *Linear distance traveled by male moths coated with each fluorescent dust.*

Color	Distance (feet)	Distance (meters)	Number of moths captured
Green	3.40	1.04	11
	27.20	8.29	2
	17.00	5.18	1
Yellow	13.60	4.15	13
	37.40	11.40	1
Pink	17.00	5.18	6
	10.20	3.11	4
	81.60	24.87	1
	15.30	4.66	1
Orange	47.60	14.51	10
	8.50	2.59	7
	15.30	4.66	1
	47.60	14.51	1
Light green	10.20	3.11	5
	17.00	5.18	7

Results

Across all five stations, 315 adults emerged out of the 500 pupae (63% emergence). The emergence at each station (100 pupae per station) was as follows: pink–72%; green–63%; orange–52%; yellow–63%; light green–65%.

A total of 76 male moths were captured out of the 315 that emerged, representing a capture rate of 24.1%. Of the 76 males, 30% were marked with green dust, 22.2% with yellow dust, 16.7% with pink dust, 36.5% with orange dust, and 18.5% with light green dust. The linear distance traveled by male moths of each color from the source is shown in **Table 1** (at right).

Generally, more males were captured in traps close to the source, except in the case of the males marked with the orange dye and in the trap placed at 14.51 meters away (47.60 feet), which captured 10 insects. (This particular data point was deleted, and an exponential decay model was fitted to the remaining data.)

The model fit the data well (see **Figure 2** on page 40) and showed that the number of male moths captured decreased, with an increase in distance from where the pupae were placed (source).

Conclusions

The temperatures during the 14-day experiment period were cooler, and this may explain why only approximately 24% of the 315 moths, which emerged from the pupae, were captured in traps. Warmer temperatures (greater than 25 degrees C) may have improved the trap capture by allowing the odor plumes from the pheromone to permeate the store better.

These results show that the capture of male Indian meal moths in pheromone traps was inversely related to distance from where they emerged from pupae (source).

Indirectly, this information can be used when several traps are used for monitoring this species in a room (not the entire facility).

Consistent higher captures in certain traps and low captures in traps farther away should help pest managers inspect high-capture areas carefully to identify the infestation source.

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