Trogoderma variable: a model species for control of Dermestids in museums

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Abstract

Insects of the family Dermestidae are common insect pests of museums and other sites where historical artifacts are displayed and stored. *Trogoderma variabile* (Ballion), the warehouse beetle, is a member of this family, and though it is more commonly associated with processed and finished stored food products, it can be found in museums. There are aspects relating to monitoring and control of *T. variabile* that are relevant to control programs for this species, and may also be more broadly related to the Dermestidae as a whole. Although fumigation, freezing and anoxia are perhaps the dominant control methods, there are alternatives that are being evaluated for stored product insects, which in turn could be adapted for specific situations. In particular, contact insecticides show promise for incorporation into existing control programs for museum pests. In this paper, we discuss recent studies with *T. variabile* and suggest use of this species as a model insect for evaluating control strategies for museum pests.

Keywords: museums, Dermestids, *Trogoderma variabile*, control

1. Introduction

Museums containing historical artifacts, woolen goods, books and paper exhibits, and other irreplaceable items are at risk of infestations by a variety of insect species (Pinninger, 2010), including members of the beetle family Dermestidae (Hansen et al., 2012; Querner et al., 2013). Management of dermestids in museums historically has relied on insecticides as the primary means of insect control, though alternative controls have been investigated and some are quite promising (Linnie and Keatinge, 2000). Methyl bromine and surfuryl fluoride (Vikane) were two common fumigants used for disinfestations of museums. Now that methyl bromide is being withdrawn from use under an international agreement, the Montreal protocol (Fields and White, 2002), alternative controls such as contact insecticides applied as targeted treatments are being evaluated for disinfestations of museums. Generally, museums avoid using residual insecticides but this could change with the elimination of methyl bromide.

Some dermestids can also be important generalist pests of stored food products, and included in this group is the warehouse beetle, *Trogoderma variabile* (Ballion). Although *T. variabile* can be found in museums, other dermestids may be more common and more economically important. However, generating research results regarding susceptibility of dermestid beetles that are specifically limited to museums may be limited due to practical and economic considerations. Thus, *T. variabile* is a cosmopolitan species that can adapt to a variety of food sources, and there are a number of recent studies that could be used as a guide for estimating susceptibility of dermestids in general to various integrated pest management strategies, including specific targeted treatments with contact insecticides. As museums also contain stored products in a sense, this approach could be adapted to the museum situation. This paper presents a review and discussion and will not follow the standard format of a research paper.

2. Rearing Procedures

Here at the USDA-ARS Center for Grain and Animal Health Research (CGAHR), we have developed a standardized method of mass-rearing *T. variable* that potentially could be used for mass-rearing similar dermestid species. Briefly, the diet consists of about 100 grams of protein shake mixed with about 300 grams of commercially available dog food that is ground prior to mixing. The protein shake mix is an excellent diet, but it is relatively expensive, and using the shake-dog food blend is cheaper and still provides the necessary numbers for susceptibility testing. The mixed diet is held in a 0.95 liter glass jar. About 300 adults are placed on the diet for one week, and then removed, and the jar held inside an incubator set at 27°C and 60% relative humidity (r.h.) in constant darkness. Development from egg to adult takes approximately 6-7 weeks at that temperature. Studies with *T. variabile* are also being conducted at the USDA-APHIS- Center for Plant Health Science and Technology in Buzzards Bay, Massachusetts. They rear *T. variable* on a protein shake diet topped with oatmeal. The mixture is about 150 g of protein shake and about 15 g of oatmeal in 0.95 liter glass jars. About 50 adults are put on the mixture, these adults are not removed, and the rearing temperature is 30°C and r.h. is about 45%, and the culture jars are kept in constant darkness.

3. Evaluating insecticide susceptibility

Adults of *T. variabile* live only about 2-3 weeks, in contrast to flour beetles such as *Tribolium castaneum* (Herbst) and *Tribolium confusum* Jacqueline DuVal, which can live for months (Rees, 2003). Therefore, for susceptibility studies with contact insecticides it is essential to use adults of *T. variabile* that are less than 1 week old otherwise mortality results may be skewed. When we conducted our initial studies with *T. variabile* at CGAHR, we immediately noticed excessive mortality of untreated controls if adults were older than one week, especially when studies were conducted on treated surfaces without food material present. Studies at CGAHR and at CEPHAS indicate adult T. variable are about 2 and 3x more tolerant to insecticides than adult *T. castaneum*. In addition, larvae of *T. variabile* are about 2 and 3x more tolerant to insecticides compared to adults. Eggs are the life stage of *T. variabile* that is generally most tolerant to fumigants (Banks and Cavanaugh, 1985).

4. Cold treatments

Studies are being conducted at CGAHR to determine susceptibility of *T. variabile* to cold temperatures. Preliminary results indicate that it takes 3-4 times longer to kill larvae of *T. variable* exposed at -18°C compared to larvae of *T. castaneum*. It takes about 2-3 times longer to kill eggs of *T. variabile* exposed at this temperature compared to larvae. Recent tests show differences among field strains regarding tolerance of *T. variabile* to cold temperatures.

5. Heat treatments

Although heat treatment is a viable option for disinfestations of flour mills in the USA, there are practical considerations and potential inherent risks that must be considered. Although these considerations may be even more important in museums, heat is still considered in some cases to be practical for control of museum pests (Pinninger, 2003). Time-temperature requirements have been developed for different life stages of *T. castaneum* and *T. variabile*, with some differences between the two species regarding the most tolerant life stage, young larvae and old larvae, respectively, are the most tolerant stages (Wright et al., 2002, Mahroof et al., 2003**)**

6. Monitoring

The commercial pheromone used for *T. variabile* is highly effective and can capture males indoors and outdoors (Campbell and Mullen, 2004; Arthur and Campbell, 2008). However, one of the difficulties in monitoring insect species using sex pheromone traps is that pheromones are generally species and sex-specific. Kelley et al. describe the identification and potential synthesis of the odd beetle (2015), which is a dermestid museum pest. An alternative to using pheromone traps is food oil baits in pitfall traps, which can capture multiple insect species, including *T. variabile* (Arthur et al., 2014).

7. Conclusions

Dermestid species can be serious pests in various museum environments, and members of this group will vary considerably regarding susceptibility to insecticides, biology and flight activity, identification and quantification of pheromones for monitoring, and potential for mass-rearing under laboratory conditions. However, recent research with *T. variabile* provides a framework for expanding knowledge of Dermestids in general and in particular those species that are most damaging to museum stores and artifacts

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