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Stored-product insects in botanical warehouses

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ABSTRACT

Insect pests infesting six stored botanicals were sampled monthly in two Egyptian warehouses over 12 months. The plants sampled were; roselle (*Hibiscus sabdariffa*), mogat (*Glossostemon bruguieri*), coriander (*Coriandrum sativum*), anise (*Pimpinella anisum*), chamomile (*Matricaria chamomilla*) and marjoram (*Origanum majorana*). The warehouses were located in northern Egypt in Mansoura and Bilqas. *Lasioderma serricorne* and *Stegobium paniceum* were the most common insect pests in warehouses. The beetles *Tribolium castaneum*, *Tribolium confusum, Trogoderma granarium* and *Cryptolestes ferrugineus* had lower and similar levels of infestation. The moths, *Plodia interpunctella* and *Sitotroga cerealella*, had the lowest infestation levels. There were small differences in infestation by the most common insects, *L. serricorne* and *S. paniceum*, among the six botanicals. In general, *M. chamomilla* and *O. majorana* had the lowest level of infestation. The other plants, *H. sabdariffa* and *C. sativum* had higher levels of infestation. The warehouse in Bilqas had higher populations than the warehouse in Mansoura. In Bilqas, the temperature and relative humidity were slightly higher and the warehouse was older and had open windows, factors that may have contributed to higher insect infestations.

1. Introduction

Most research in stored-product protection focuses on cereals, as cereals are the most common commodity in storage, and there are several insects and moulds that can reduce the quality and quantity of cereals in storage. However, all agricultural products are stored for some time before consumption, and they can also be infested by insects and moulds in storage. Dried plants, roots, stems, leaves, seeds and flowers, have been used from the dawn of history for medicine and as spices for cooking (Craker, 2007). Recently, there has been an increase in the popularity of herbal remedies in North America and Europe. However, there is a growing need to understand the problems in storing botanicals. Botanicals are also attacked in storage by several insects. The most common insects found in botanicals are *Lasioderma serricorne* (F.) and *Stegobium paniceum* (L.) (Lefkovitch, 1967; Tawfik et al., 1984; Awadallah et al., 1990; Arbogast et al., 2002). These insects are even able to develop on *Acorus calamus* L. rhizomes (Srivastava and Saxena, 1975), a plant that has essential oils that are toxic to several stored-product insects (El-Nahal et al., 1989). There are a number of other insects found in stored botanicals (*Araecerus* fasciculatus (Degeer), *Tenebroides mauritanicus* (L.), *Tribolium castaneum* (Herbst), *Oryzaephilus mercator* (Fauvel), *Ahasverus advena* (Waltl), *Thaneroclerus buqueti* Lefebvre and *Thorictodes heydeni* (Reitter) (Abraham, 1975; Tawfik et al., 1984; Basak, 1991)). There have been several studies examining insects in stored botanicals worldwide; Egypt (Kamel, 1958; El-Halfawy, 1977), India (Abraham, 1975; Basak, 1991), Germany (Schmidt and Graebner, 1987), Korea (Toh, 1998) and USA (Arbogast et al., 2002).

Egypt is a major producer of botanicals. Each year, Egypt exports 7000 to 15,000 t of botanicals (Lange and Mladenova, 1997). These plants are grown in southern Egypt, harvested from June to August, dried, then placed in 50 kg jute bags and stored for 2–10 months in warehouses before being shipped to processing facilities in Egypt, Europe and USA. As in other countries, the two most common insects in botanicals in Egyptian warehouses are *L. serricorne* and *S. paniceum* (Tawfik et al., 1984; Awadallah et al., 1990). These and other stored-product insects cause significant damage during storage. To reduce the damage, bag stacks are covered with a tarp and fumigated with phosphine derived from aluminum phosphide (Bond, 1984) once or twice during storage. However, there is an increased demand from customers in Europe and USA for organic production, which does not allow the use of phosphine. Yet there are very low tolerances for insect damage, live insects and insect fragments in stored botanicals.

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Previous studies on insects in botanicals have described life-histories and losses caused by insect infestation during storage. Previous studies in Egypt have listed the insect pests and their natural enemies. The goal of this study was to sample quantitatively a wide variety of plants in storage throughout an entire year.

2. Material and methods

2.1. Warehouses

Sampling was conducted at two warehouses in the Delta region of Egypt; Mansoura (31°00'N, 31°19'E) and Bilqas (31°31'N, 31°21'E) containing stored botanicals. The warehouse in Bilqas was older, had wooden floors and it was open to the environment; its area was approximately 240 m^2. The warehouse in Mansoura had wooden floors and was sealed from the outside environment with walls and windows; its area was approximately 120 m^2. Samples were taken once a month from June 2005 to May 2006. Six dried plants were sampled; *Hibiscus sabdariffa* L. (roselle) fruits, *Glossostemon bruguieri* (Dsef.) (mogat) roots, *Coriandrum sativum* L. (coriander) seeds, *Pimpinella anisum* L. (anise) seeds, *Matricaria chamomilla* L. (chamomile) flowers and *Origanum majorana* L. (marjoram) leaves. A sample of approximately 2.5 kg of each botanical was taken in five locations in each warehouse (north, south, east, west and center).

2.2. Insect sampling

The plants are harvested from April to June each year. Farmers dry and store plants for a few weeks to a few months before delivering to a warehouse in June, July or August. Samples of plants were taken with a spear sampler, then placed in paper bags and transferred to the laboratory. In the laboratory, the samples were sieved twice with 1.40 mm and 0.850 mm openings and any adult insects identified and counted. To estimate the immature stages, the plant material was held at 30 ± 1 °C, and sieved again after 2, 4 and 6 weeks and any adult insects identified and counted. The total number of insects, both adults and immatures, in the sample was used in the data analysis. In general, there were more adults than immatures in the samples. Air temperature and relative humidity (r.h.) data were from Stevenson Screens at weather stations at Bilqas and Mansoura, maintained by the weather service of Dakhalia region. On the day of sampling, warehouse air temperature was recorded each hour from 12 midnight for 24 h. Average temperatures are reported. Samples were taken at approximately 12 noon.

2.3. Data analysis

We used a one-way ANOVA to compare the total number of all insect species from all plants during the entire year from two warehouses in Bilqas and Mansoura, Egypt, and a two-way ANOVA to compare the total number of *L. serricorne* and *S. paniceum* collected during the entire year from six different plants in two warehouses in Bilqas and Mansoura, Egypt. All means are reported with standard error of the mean (SEM).

3. Results

3.1. Seasonal abundance of insects

All insect species were present throughout the year on all plant material, in both warehouses (Fig. 1). There was a low level of infestation at the beginning of the sampling. This increased gradually and reached the maximum in July and August in Mansoura and in September and October in Bilqas. In Bilqas, the mean total number of all eight insect species collected during the twelve months of study was 2.0 ± 0.04 insects/kg. This was a significantly higher level of infestation than in Mansoura, which had 1.7 ± 0.03 insects/kg (one-way ANOVA, $F_{1,58} = 200.3$, $P < 0.001$).

3.2. Insects pests

In Mansoura, *L. serricorne* was the most common insect found, followed by *S. paniceum*. In Bilqas, the *L. serricorne* and *S. paniceum* were more abundant than other species (Table 1). Other beetles, *T. castaneum*, *Tribolium confusum* du Val, *Trogoderma granarium* Everts and *Cryptolestes ferrugineus* (Stephens) occurred at the rate of approximately 0.24 individuals/kg in Bilqas and 0.12 individuals/kg in Mansoura. The two moths, *Plodia interpunctella* (Hübner) and *Sitotroga cerealella* (Olivier) were the least common insect pests found in Bilqas.

3.3. Botanicals

There were small differences in infestation by the most common insects, *L. serricorne* and *S. paniceum*, among the six botanicals. In general, *M. chamomilla* and *O. majorana* had the lowest levels of infestation. Of the other plants, *H. sabdariffa* and *C. sativum*, had higher levels of infestation (Table 2).

3.4. Temperature and humidity

Temperature in both warehouses increased gradually from a minimum of approximately 13 °C in January, to a maximum of 26–29 °C in September. Bilqas was warmer than Mansoura; the average annual temperature in Bilqas was 21.4 ± 1.4 and in Mansoura it was 18.8 ± 1.2 (paired *t*-test, $P < 0.001$, $t = 7.07$) (Fig. 2B). The r.h. was relatively constant through the year and was between 55% and 75%. Bilqas was more humid than Mansoura; average annual r.h. in Bilqas was $69.1 \pm 1.3\%$ and in Mansoura it was $66.1 \pm 1.5\%$ (paired *t*-test, $P = 0.002$, $t = -3.95$) (Fig. 2A). For all insect species in both Mansoura and Bilqas, there was a positive correlation between the average air temperature at the weather station and the insects found in botanicals in the warehouse (Table 3). In general, there was no correlation between r.h. and the number of insects. However, *C. ferrugineus* and *P. interpunctella* in Mansoura showed a significant positive correlation between r.h. and the number of insects (Table 4).

4. Discussion

The insect population levels were different at the two locations. There are several possible reasons for these differences. The warehouse in Bilqas was older and was open to the environment compared to the newer, closed warehouse in Mansoura. Also, the warehouse at Bilqas had more debris and broken bags on the floor than in Mansoura. Sanitation can play an important role in reducing pest populations and in preventing outbreaks (Imholte and Imholte-Tauscher, 1999). Initial populations may have been the same in the two locations, but the poorer sanitation conditions in Bilqas may have allowed for the much higher populations seen in September and October. Finally, the temperatures and r.h. were slightly higher in Bilqas, which would increase the rate of development and survival (Birch, 1953; Howe, 1957; Lefkovitch, 1967), and would lead to higher insect populations. Other possible reasons for the differences are the number of fumigations, the effectiveness of fumigations, use of contact insecticides and duration of storage. Both warehouses fumigated their stocks with phosphine, but we did not examine the efficacy of fumigations. Further studies would