

12. Stored product pests

12.1 Official examination of consignments 1997

The DPIL examines consignments of grain and other dried plant products intended for export. Based on the result of these examinations, the Plant Directorate of the Ministry of Food, Agriculture and Fisheries issues a phytosanitary certificate. In 1997 a total of 744 consignments were examined: 186 grain lots, 112 lots of malt, 58 consignments of tobacco, 100 lots of dried peas and 291 consignments of other products. Live insects were found in 1.2% of the consignments, mainly in grain lots. The following pest species were detected:

Number of lots	Pest species
3	<i>Sitophilus granarius</i>
3	<i>Oryzaephilus surinamensis</i>
2	<i>Tribolium confusum</i>
1	<i>Ptinus fur</i>

L. S. Hansen

12.2 Allergens from pests in grain stores and milled products

The purpose of the present work was to describe the population dynamics of the mite *Lepidoglyphus destructor* and its production of allergens in stored grain. Results have been presented in previous Annual Reports, and further analysis has been carried out in 1997.

The development of *L. destructor* and its production of a major allergen in whole grain (*lep d 2*, formerly *lep d 1*) was investigated in the laboratory. Under controlled conditions the growth rate for *L. destructor* was found at combinations of three levels of relative humidity (70-90% RH) and four temperatures (5-20°C) for 2-3 mite generations. The development of *L. destructor* was successfully described by a simulation model for each combination of temperature and relative humidity and growth rates were calculated. At 5-20°C the intrinsic rate of increase (r_m) ranged between 0.0009 and 0.13 mites per day. The number of *L. destructor* was analysed by a linear statistical model in which the number of mites is a function of

relative humidity, temperature and time. In subsequent analyses high relative humidity (83-90%) and temperatures of 16-22°C were determined as optimal values.

The development of the stage distribution of the mites through the generations may explain some elements of the population dynamics. At 10-20°C the population was initially characterized by a dominance of adults, which were quickly followed by larvae and protonymphs. These protonymphs could be expected to develop into tritonymphs, but only a few tritonymphs were found. They might have entered the hypopus stage instead, possibly due to exhaustion of the food source. The density of the hypopus stage can-not be determined by the extraction method used in the experiments (Berlese funnel).

A linear statistical model was used for deciding whether the number of mites, relative humidity, temperature and time had an effect on the allergen content of the grain sample. Regression analysis showed that all factors except the relative humidity were highly significant ($R^2=59\%$). However, the ELISA method used for the determination of *lep d 2* needs improvement before it can be put into commercial use.

C. Danielsen's Ph.D. thesis will be submitted in 1998.

C. Danielsen and L. S. Hansen

12.3 Biological control of the Mediterranean flour moth *Ephestia kuehniella*

This project deals with the possibilities of using natural enemies for control of the major pest in flour mills, the Mediterranean flour moth *Ephestia kuehniella*. The total phase-out of methyl bromide in Denmark on January 1, 1998 has forced the mills to consider other methods of pest control. Biological control is one of several options.

A distributed-delay simulation model was developed to describe the population dynamics of the flour moth. Parameters for temperature-dependent development of eggs, larvae and pupae and the lifespan and fecundity of female moths were obtained from published data. The model was validated against three years of pheromone trap catches of male moths in a Danish mill. Outside temperatures with an increase of 5°C were used to drive the model. The overall phenology of the flour moth population

was well simulated and was found to be determined largely by the stipulated mill temperatures and the seasonality of diapausing larvae. The model estimates that the moth realizes 1-3% of its reproductive potential from one year to the next. Reduced fecundity and juvenile mortality seem to be the most likely regulating factors.

A submodel of a natural enemy, the egg parasitoid *Trichogramma pretiosum*, was developed from published life table data. Simulations indicate that if parasitoids are released early in the season, and if they realize their full reproduction potential, the flour moth population can be suppressed considerably during the summer months. However, since little information is available about the present factors regulating *E. kuehniella* in the mills, precaution must be taken when extrapolating from such simulation results to the field situation.

A monitoring programme is being conducted to elucidate actual climatic conditions in industrial flour mills. Temperature and humidity conditions have been monitored in two industrial mills for a year. It appeared that average daily temperatures in some areas are generally about 5°C above the outside temperature, ranging from 3° to 30°C, while in other areas heat coming from machinery maintains temperatures consistently above 15°C. An example of this can be seen in Figure 12a.

This difference in temperature conditions is reflected in the presence of flour moths in pheromone traps: in warm areas, flour moths were found when the monitoring programme started in February, whereas in the cooler areas, pests were not found until May or June.

The monitoring programme included investigations of the presence of egg parasitoids or predators; batches of UV-sterilized *Ephesia kuehniella* eggs were placed in the mills and renewed weekly to check for signs of natural enemies. No activity was found, however.

Investigations are being conducted in chambers with controlled climate conditions to elucidate the effect of temperature on pheromone trap catches. Preliminary results have shown that temperature has an important influence on the catch rates of released male flour moths (<24 hours old). The investigations will be continued to identify upper and lower temperature limits for flight activity.

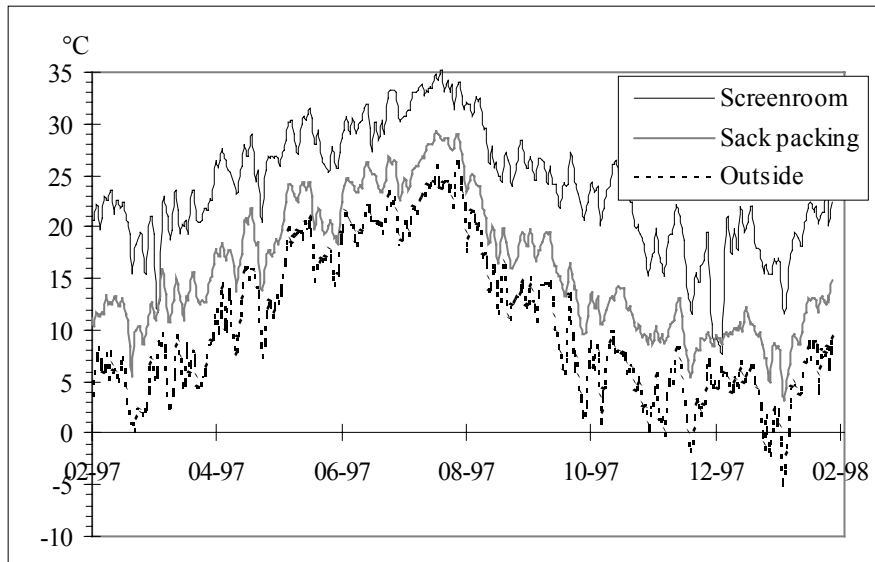


Figure 12a. Examples of mean daily temperatures from an industrial flour mill, compared with the temperature recorded outside the mill. The screenroom area illustrates temperatures in warm mill areas, while the sack packing area is cooler.

Two species of natural enemies have been chosen for further studies: a predatory mite, *Blattisocius tarsalis*, and an egg parasitoid *Trichogramma evanescens*, the “Lager” strain, which is a strain that has given promising results against stored product moths in investigations conducted at the BBA, Institute for Stored Product Protection, Berlin. Both species attack the egg stage of *Ephestia kuehniella*, which is considered essential in the present context, for the following reasons: (i) it is important to avoid development of larvae and their webbing; (ii) the eggs of *E. kuehniella* are laid on top of accumulations of flour and are thus more accessible than the larvae which burrow into the food medium.

Both species of natural enemies have been established in the laboratory.

Blattisocius tarsalis was found on adult *E. kuehniella* collected in a flour mill; this phoretic mite obviously occurs naturally in Denmark. *B. tarsalis* has been studied intensively during 1997. The relationship between temperature, prey abundance and predation rate has been studied in the laboratory. At temperatures as low as 15°C the predation rate is 1.5 moth

eggs per female mite per day, which supports the supposition that this mite is a promising candidate for biological control of *E. kuehniella*. All age groups of *E. kuehniella*-eggs are attacked by adult *B. tarsalis*. *B. tarsalis* is a surface predator and does not penetrate into the flour.

L. S. Hansen, N. Holst, C. Nansen,
P. S. Nielsen, and H. S. Pedersen

12.4 The effect of low oxygen pressure on museum pests

The possibilities of controlling various museum pests, mainly dermestid species, by means of modified atmospheres, such as low oxygen pressure, are being investigated. The investigations are carried out in collaboration with the DPIL, J.-E. Bergh, PRE-MAL, Sweden and P. Væggemose Nielsen, Danish Technical University.

The following species, if possible in all stages, are being used for the experiments: *Attagenus woodroffei*, *At. smirnovi*, *Anthrenus museorum*, *An. verbasci*, *Reesa vespulae*, *Trogoderma angustum*, *Tineola bisseliella* and *Ptinus tectus*. Test specimens are exposed to <0.3% oxygen at 25°C, 55% RH for exposure times of 6-72 hours. The first two test series indicate that *An. verbasci*, *P. tectus* and *T. angustum* are more tolerant than *Ant. museorum*.

L. S. Hansen

12.5 Implementation of integrated pest management (IPM) in industrial flour mills

Due to the fact that methyl bromide will be totally prohibited in Denmark from 1 January 1998, the Danish Environmental Protection Agency has in December 1997 financed a project on the introduction of IPM strategies in three Danish flour mills. The project is carried out by the mills and a PCO-company under the supervision of the Danish Pest Infestation Laboratory.

In the past the Danish flour mills relied on a pest control strategy, which includes fumigation with methyl bromide once or twice a year in order to prevent problems with primarily *Ephestia kuehniella* and *Tribolium*-species. As now the mills have to base their pest control on a combination

of other methods it was found relevant to use the IPM concept in the flour mills.

The goal of the project is to design individual IPM strategies in each flour mill and to initiate the implementation of these strategies. Although various IPM strategies are used in mills world-wide, these strategies often rely on methyl bromide, and there are only few documented investigations on IPM in food processing factories available in the literature.

P. S. Nielsen