POPULATION DYNAMIC OF EPHESTIA KUEHNIELLA ZELLER IN A FLOUR MILL: THREE YEARS OF MASS-TRAPPING.

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Abstract

Results obtained by the practical application of mass-trapping using TDA pheromone, to control the infestation of Ephestia kuehniella Zeller protecting an entire large flour-mill for 3 years are reported.

The experiment indicates that Mediterranean flour moth infestation can be controlled by baiting 67 funnel-traps with 2 mg each of TDA (daily release of 13 µg) and placing one trap every 260-280 cubic meters. Five additional traps were also placed outside the mill, near the loading machinery. The continual presence of traps in the mill caused a marked decrease of the E.kuehniella population during 1988 and 1989, resulting in respective levels of 26% and 16% of the density recorded during 1987. The impressive reduction of the population density of the moth raises the question if insectistasis can be obtained in flour mills by mass-trapping alone. Extrapolation of the data recorded suggests that by using pheromone traps for longer periods of time should further dilute the population density of E.kuehniella . However, it was not possible to eliminate infestation, or even reduce the level of insectistasis, if trapping was not accompanied by careful cleaning of the rooms, particularly in the corners and inside parts of the machinery where the insects can hide and reproduce undisturbed.

Introduction

During recent years interest in manipulating harmful insect population by pheromone has increased, while a tendency to restrict the hitherto excessive use of insecticides became obvious.

In this regard some years ago we obtained permission to carry out long-term observations of insect pest captures in pheromone traps along with coordinated application of insecticides in various large flour mills in northern Italy.

In the Mediterranean region Ephestia kuehniella Zeller, is one of the major pests of flour mills, its infestations, if neglected, can be,

in fact, so abundant as to clog the flux of food products in the machinery. With the aim of finding an alternative to traditional chemical treatments, with 1 or more frequently, 2 fumigations, and several other limited treatments, a year, or in any case, of limiting their use, on-going research has been carried out (Süss and Trematerra, 1986; Trematerra and Battaini, 1987; Trematerra and Capizzi, 1987; Trematerra, 1988a).

Trematerra and Battaini (1987) demonstrated that integrated control of this moth can be achieved by mass-trapping and the limited use of insecticides in flour mills. In their preliminary study, carried out in limited environments, funnel traps baited with (Z,E)-9-12-tetradecadienyl acetate (or TDA) were successfully used to trap many Mediterranean flour moths, and thereby stabilized infestation at levels as low as those observed during months unfavourable to insect development. Subsequently, Trematerra (1988a) reported results obtained by the practical application of mass-trapping using TDA pheromone, to control the infestation of E.kuehniella protecting an entire large flour-mill for one year. The experiment indicates that Mediterranean flour moth infestation can be controlled by baiting funnel-traps with 2 mg each of TDA and placing one trap every 260-280 cubic meters. Additional traps were also placed outside of the mill, near loading machinery. The continued presence of the traps in the mill resulted in a high population reduction of 95-97% of all male specimens noted. The utilization of this methodology has led to a reduction of chemical treatments with one rather than two fumigations of the mill required and to few limited treatments, with consequent economic and qualitative advantages by protecting milling products from pesticide residues and improving the image of the firm.

In this paper the results of long-term mass-trapping trials conducted in a large flour-mill are reported with a view to controlling infestation by E.kuehniella . The survey covering a period of three years was performed by 2 weekly captures of adult Mediterranean flour moths on pheromone-baited traps.

Materials and methods

Experiments were performed in an unclimatized flour-mill situated in northern Italy (Pianura Padana). The mill is a large building of about 20,000 cubic meters and it produces about 2,500 cwt of flour from spring wheat, Triticum aestivum L., a day.

Funnel traps with slow release natural rubber-dispensers baited with 2 mg of TDA (daily release of 13 µg) were used in the test. The dispensers remained effective for about 2.5-3 months when they were replaced (*).

(*) Traps and dispensers were supplied by G. Donegani Institute, Novara, (Italy).

According to the indications of Trematerra and Battaini (1987) and those of Trematerra (1988a) 67 traps were placed in the mill with one trap for every 260-280 cubic meters. The traps were placed from 2 to 2.50 meters from the floor and 2 to 3.50 meters from the walls. Furthermore 5 traps were placed outside of the mill, positioned near loading equipment which is frequently covered with flour.

The pipe unions were opened while the processing was temporarily stopped, allowing the pheromone to act on specimens hiding in the machinery.

Trap capture and residual infestation of adults on the walls and machinery were recorded every 2 weeks. The effect of pheromone treatment was controlled moreover by observing the fluctuations of presences of larvae of E.kuehniella in machinery and the insect fragments in the flour produced in the mill, by filth-test methods.

Experiments were performed from April 1987 to November 1989.

To verify the frequency of natural insect flight, observations were made in a different mill, situated in the same area, using pheromone funnel-traps for simple monitoring.

Results and discussion

The monthly mean temperatures of the mill varied annually between 17°C and 30°C from April to November, and 9°C-16°C from November to March, which implies that the continuous development of E.kuehniella is possible during 8-9 months of the year.

The minimal and maximum temperatures from 1987 to 1989 revealed that the environment within the mill in northern Italy is relatively moderate and constant, if compared with the corresponding outdoor conditions. This is mainly because of the solid costruction of the mill and the fact its doors and windows are usually kept closed.

The Mediterranean flour moth is present in northern Italian mills throughout the year with fluctuations that peak in May-June and between the end of August and early September, but remain low from November through Febrary-March. The insects are abundant during the most favourable months.

Mean fortnightly catches reflecting the population dynamic of the target species in the control mill in 1987 is recorded in figure 1.

In 1987 the total fumigation with methyl bromide, carried out as usual in the last week of April and between August-September, in the pheromone treated mill, led to a rapid decrease of the number of moths caught in traps.

Low numbers of moths were caught in traps for only 2-3 weeks. The treatments were only partially sucessful, and rapid recolonization of the mill occurred by insects present on the outside walls of the building, or by insects surviving the treatment inside the mill, as evident from the peak catches of E.kuehniella in traps; similar observations were revealed in 1988 and 1989.

Total captures carried out in the mill during the three years of

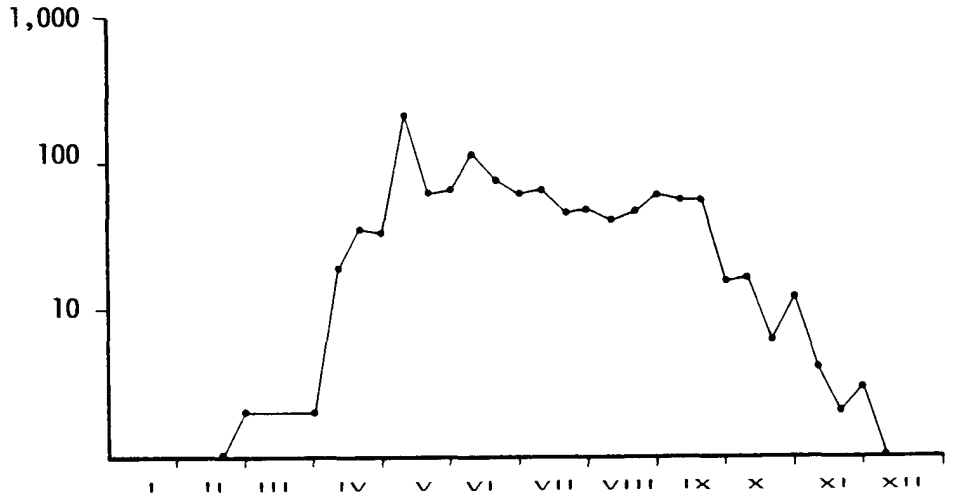

Fig. 1 - Dynamic population of Ephestia kuehniella Zeller in the control mill during 1987.

the trials are reported in figure 2, whereas the captures effected with the traps situated outside the mill are reported in figure 3.

The traps removed males from the populations of E.kuehniella so as to prevent an increase in the residual free population which remained limited. In fact the effectiveness of mass-trapping, judging from the percentage of males trapped as compared to those free in the environment in the course of the experiments, was about 90-95%. It follows that the prolonged presence of the traps in the flour-mill, particularly during periods when the climatic situations are favourable to the development of the insect, led to a drastic reduction of insect presence in all departments of the mill; including where processing does not take place, such as the stairs, stock yards, sales office, etc.

The pheromone traps generally attracted a high number of male moths: a total of 16,108 of Mediterranean flour moths were trapped in the mill during 1987; 4,158 moths were trapped in 1988, and 2639 in 1989. In this regard, it is interesting to note that 1,813 males were also trapped in the 5 traps situated outside the mill during the experiments carried out in 1987; 871 were trapped in 1988, and 670 in 1989.

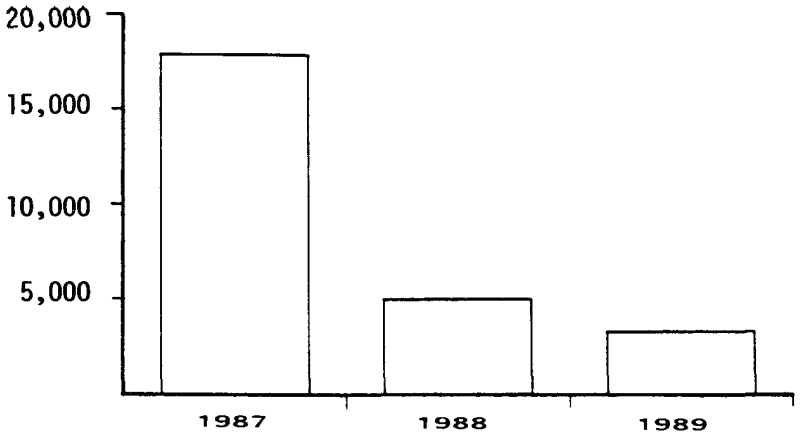

Fig. 2 - Total captures carried out during the three years of the trials.

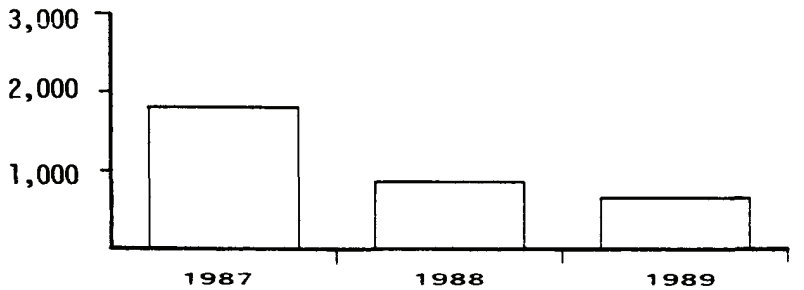

Fig. 3 - Captures effected outside the mill during the three years of the trials.

The annual catches of E.kuehniella in traps in mill reveal a conspicuous decrease in population density (25.8%) in 1988 as compared to 1987, a further decrease in the population density (16.3%) in 1989 as compared to 1987, and one of 63% as compared to 1988. The population density of E.kuehniella outside the mill decreased to a level of 48% in 1988 and subsequently to 36.9% in 1989 as compared to the density level of 1987, and 77% as compared to 1988 (table I).

The control capacity of the program proposed here made a second fumigation of the mill unnecessary, which is usually required, as mentioned, between August and September of 1988 and 1989. The use of the attractant substance was accompanied by careful cleaning of the rooms and, above all, of the machinery. These procedures reduced the possibility of insect reproduction in areas where food is present.

Table I - Number, percentage, and ratio of population decrease of Ephestia kuehniella Zeller.

YEAR	TRAPS		NUMBER trapped	NUMBER average	POPULATION DECREASE compared with 1987	POPULATION DECREASE compared with 1988
1987	inside	67	16,108	240.4		
	outside	5	1,813	362.6	-	-
	Total	72	17,921	248.9		
1988	inside	67	4,158	62.0	0.26:1	
	outside	5	871	174.2	0.48:1	-
	Total	72	5,029	69.8	0.28:1	
1989	inside	67	2,639	39.3	0.16:1	0.63:1
	outside	5	670	134.0	0.37:1	0.77:1
	Total	72	3,309	45.9	0.18:1	0.65:1

Furthermore it has the advantage of minimizing pesticide residue on the flour and reducing the frequency of costly treatments, with consequent economic and qualitative advantages.

In this regard, high levels of the infestation occurred in rooms where flour silos or bran silos were present; in these environments the possibility for E.kuehniella to find residues of flour and other goods was greater (figure 4).

During the three years of experiments on different floors of the mill, a more abundant presence of the Mediterranean flour moth was always observed on the ground floor where it is easier for the gravid female to enter from outside the mill and colonize the environment. Investigations on the appearance of moths of the genus Ephestia and Plodia outside of warehouses and food processing factories were reported in Germany by Wohlgemuth et al. (1987) and in Italy by Trematerra (1988a); the results of the investigations show that moths which are harmful to food supplies, are be found out of doors. The well-founded assumption that they might reinfest appropriate goods should be taken into consideration with respect to storage, especially since it has hitherto been taken for granted that an infestation can only arise from the storage of infested products.

Assuming that a highly efficient trapping system has been designed and an adequate trapping regime established, the problem still remains of accurately assessing the effects of the treatment. With regard to this experiment, the residual infestation of adults on the walls and machinery, as proposed by Trematerra and Battaini (1987),

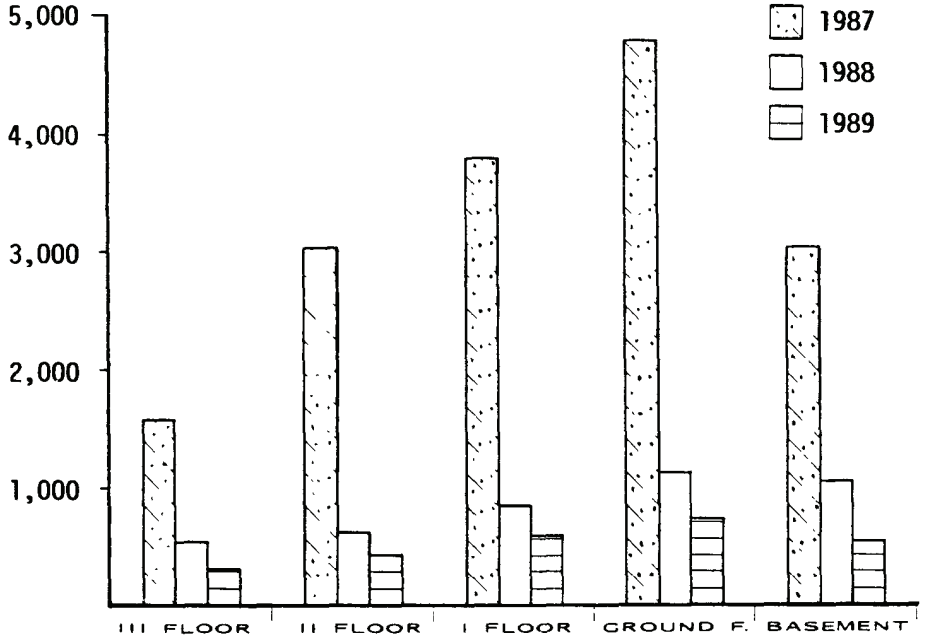

Fig. 4 - Insect presence in the departments of the mill during the three years of the trials.

during the three years of the trials, was controlled as well as the fluctuations of the presence of larvae of the Mediterranean flour moth in the machinery and the variations in the presence of fragments of this insect in the flour by filth-test methods carried out monthly.

The traps removed a high percentage of males from the mill so as to prevent an increase in the population of E.kuehniella which remained limited and constant, consequently the presence of larvae and the damages in all departments was diminished. The number of fragments revealed in the filth-tests were also negligible.

As observed in the other mill controlled with a mass-trapping method (Trematerra and Battaini, 1987), the exiguous number of E.kuehniella females present in the residual infestation was of special interest. This number, compared with all the specimens observed in the environment, indicates an extremely low percentage which was repeatedly found throughout the tests. The pheromonal substance present in the treated environment could induce females of the species to leave the environments of the mill for other areas, or the absence of males could stimulate dispersal. High concentrations of synthetic sex pheromone caused an increased flight activity among gravid females, a fact that may indicate an increase in dispersal.

Regular inspection of catches in pheromone traps and in rooms revealed the periodic appearance of a summer generation of the Indian meal moth, Plodia interpunctella Hb., and Angoumois grain moth, Sitotroga cerealella Olivier, but their population density was negligible.

The presence of Colidium (=Tribolium) castaneum (Herbst) and other Coleoptera in the mill in August was controlled by using a localized treatment as customary.

Conclusions

The continual presence of pheromone traps in mill caused a marked decrease of the Mediterranean flour moth population during 1988 and 1989, resulting in levels of 26% and 16% respectively of the density recorded during 1987.

The impressive reduction of the population density of E.kuehniella raises the question if insectistasis, as reported by Levinson and Levinson (1985), can be obtained in flour mills by mass-trapping alone (Trematerra, 1988b). Extrapolation of the data recorded suggests that the use of pheromone traps in each mill for a longer time should further dilute the population density of E. kuehniella .

However, it was not possible to eliminate infestation, or even reduce the level of insectistasis, if trapping was not accompanied by careful cleaning of the rooms particularly in the corners and inside parts of machinery where the insects can hide and reproduce undisturbed. If such preventive measures are not observed, the pheromone will only reduce the number of insecticidal operations, which in such cases remain indispensable.

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DYNAMIQUE DES POPULATIONS D'*EPHESTIA KUEHNIELLA* ZELLER DANS UNE MINOTERIE : TROIS ANNEES DE PIEGEAGE DE MASSE

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Résumé

Nous présentons les résultats obtenus par l'application pratique du piégeage de masse en utilisant la phéromone TDA, pour éliminer l'infestation d'*Ephestia kuehniella* (Zeller) et protéger une grande minoterie dans son intégralité.

L'expérience montre que l'infestation par la mite méditerranéenne de la farine peut être éliminée en appâtant 67 pièges à entonnoir avec 2 mg de TDA chacun (ce qui donne une diffusion quotidienne de 13 mg) et en disposant un piège pour 260 à 280 m^3. Cinq pièges supplémentaires ont aussi été placés à l'extérieur de la minoterie, à côté du dispositif de chargement. La présence continuelle de pièges dans la minoterie a fait chuter la population de *E. kuehniella* au cours des années 1988 et 1989, donnant des densités respectives de 26 % et 16 % par rapport à celles enregistrées au cours de l'année 1987. La réduction impressionnante de la densité de population des mites soulève la question de savoir si l'arrêt de multiplication des insectes (insectistasis) peut être obtenue en minoterie seulement par piégeage. L'extrapolation des données recueillies suggère que l'emploi de pièges à phéromones pendant des durées plus longues devrait encore diminuer le densité de *E. kuehniella*. Cependant, il n'aurait pas été possible d'éliminer l'infestation, ou même de réduire le niveau d'insectistasis, si le piégeage ne s'était pas accompagné d'un nettoyage méticuleux des salles, surtout dans les angles et les parties intérieures des machines et appareils, là où les insectes peuvent se cacher et se reproduire sans être dérangés. Si de telles mesures préventives ne sont pas entreprises, la phéromone ne fera que réduire le nombre de traitements avec des insecticides, qui dans ce cas, demeurent indispensables.