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Mating suppression of the Mediterranean flour moth (*Ephestia kühniella* Zeller) (Lepidoptera Pyralidae) in a food industry

Summary - Infestation of *Ephestia kühniella* in a food industry was controlled by using laminar and "rubber string" dispensers imbued with a high quantity of TDA. Trials lasted more than two years. The dispensers were placed on the walls and under the machineries in crevices with high infestation. The mating suppression can be obtained when a daily average distribution of 2.5 (±1) $\mu g/m^3$ of TDA for at least 4 months has been mantained.

Riassunto - *Un esperimento di tecnica confusionale su* Ephestia kühniella *(Zeller) (Lepidoptera Pyralidae) in una industria alimentare.*

Vengono riferiti i risultati ottenuti applicando elevate quantità di TDA in un reparto di una industria dolciaria gravemente infestato da *Ephestia kühniella.* Le prove sono state protratte per oltre due anni. Si è riusciti a ridurre l'attacco sino a livelli che possono essere considerati irrilevanti, partendo da una serie di indicazioni scaturite da test precedentemente effettuati in una situazione analoga e utilizzando dosi progressivamente crescenti di TDA, distribuito con erogatori sia laminari che a "fettuccia", disposti sugli impianti e sotto i macchinari infestati. I risultati ottenuti evidenziano che si può ottenere l'inibizione dell'accoppiamento in *Ephestia kühniella,* in ambienti gravemente infestati, con una erogazione media giornaliera pari a 2,5 (±1) $\mu g/m^3$ di TDA protratta per almeno 4 mesi.

Key words: *Ephestia kühniella*, mating suppression, TDA, Mediterranean flour moth.

INTRODUCTION

The infestations of *Ephestia kühniella* are a very frequent problem in all environments where there is wheat flour. The ability of this insect to rapidly multiply in spaces, which are also very limited, makes the screen conveyors, the inspection of the rolling mills, the plan sichters, be transformed in hotbeds of hundreds of insects. They must be regularly and accurately inspected and cleaned, because the moths mate and develop in the crevices and recesses.

If we consider that the production cycles mostly take place without interruptions, this situation becomes almost perfect for the development of the "Mediterranean flour moth". Bakeries, producers of sweet things are not exempt from this scourge.

The components of the female sexual pheromone of *Ephestia kühniella* have been pointed out for time and now there are practical applications of monitoring (Bommer & Riechmuth, 1980; Süss & Trematerra, 1985, Brady *et al.*, 1971; Kuwahara & Casida, 1973).

Later experiences (Trematerra & Battaini, 1987; Trematerra, 1988; 1990; 1994a; 1994b) were aimed, at the possibility of carrying out mass trapping: the fact that it is possible to have success using sticky traps activated with 2 mg of TDA every 260-280 m^3 has been highlighted, but this is only possible where the population density is low and at the same time cleaning drastically both the environment and the machinery.

Further practical applications of the female pheromone are those aimed at inhibiting mating, reaching concentrations so high in the environment to be protected to hinder the males from singling out the females when they call or distracting them from the natural source of pheromone with "false traces" produced artificially. With regards to this, Trematerra & Capizzi (1987) say they have obtained a reduction of the population of *Ephestia kühniella* in mills using 0.2 mg of TDA per cubic metre.

Süss *et al.* (1996) working in the mixing and kneading department of an industrial bakery seriously infested, managed to obtain the inhibition of mating using 1.5 mg/m^3 of TDA with laminar dispensers activated with 50 mg of TDA. On the whole, 3500 mg of TDA in 2300 m^3 of environment were used.

It was noticed, however, that it was necessary at the same time to accurately clean the recesses where the hotbeds of multiplications had taken place as in these places the inhibiting effect of the synthetic pheromone was quite low. Consequently, the individuals present, even if they were a few centimetres from each other managed to single out the natural female call, then mating and repeating the attack.

It is necessary always to remember that in practical conditions the estimate of the density of the population is extremely difficult; especially for *Ephestia kühniella* the risks of attacks are often underestimated. Based on the results previously obtained, we wanted to carry out a new test in a department of sweet industry, infested by *Ephestia kühniella* for some time.

MATERIALS AND METHODS

The experiment, which lasted over 2 years, was carried out in the department "Kneading and chopping" of oven products with a production cycle that never stops. This department is 5200 m^3, conditioned at about 38% r. h. and 21-22°C with a change of air 11 times an hour. In it there is steel machinery with carters obstructing the carrying out of regular and good cleaning.

Laminar dispensers were installed in the department, as in the previous experiment (Süss *et al.,* 1996), both on the walls and on the machineries, substituted every 4 months (approximately) in a year (Fig. 1).

The number of dispensers used, progressively more during the experiment, is shown in Table 1.

For the control of the efficacy of the method 10 funnel traps were used activated constantly with laminar dispensers like those on the walls. The count of the captures was carried out every week.

In order to evaluate if the inhibition of mating had actually been obtained, a test using 5 traps was carried out, each containing 1 virgin female of *Ephestia kühniella* 2-3 days old, put in a suitable cage, suspended in the trap itself in place of the synthetic TDA dispenser. It was noticed that due to the lack of captures the call naturally emitted wasn't perceived by the males any longer.

During the tests, the industry thought it in any case useful to carry out some treatments with fogging with pyrethrum by a specialised pest control operator, recorded in Table 1.

The results have been submitted to ANOVA.

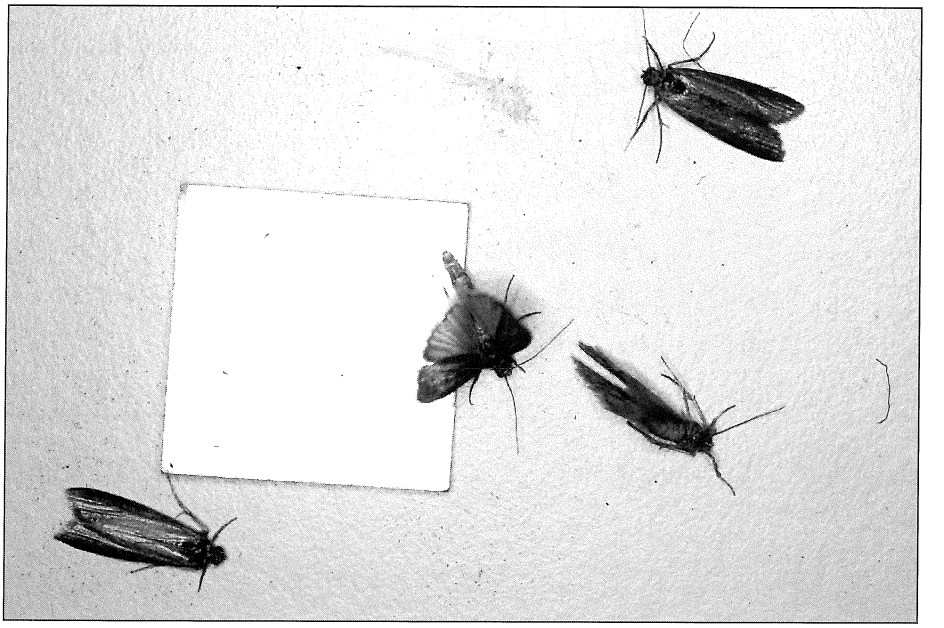

Fig. 1 - Laminar dispenser on the walls with *Ephestia kühniella.*

RESULTS

As can be seen in Table 1, if before the beginning of the use of high quantities of TDA the infestation of *Ephestia kühniella* was quite remarkable, despite the first treatment with fogging machine and the applications of pheromone dispensers, the number of captures has progressively increased in an extraordinary way. Therefore the insect continued regularly its development in the first months of the test independently both from the insecticide treatments and from the artificially created pheromone

Table 1 - Monitoring of Ephestia kühniella *in the "kneading and chopping" department during the test.*

Date	Number of laminar dispensers in the funnel traps	Laminar dispensers in the department	Neoprene diffuser products (meter)	Total quantity of TDA (g)	Reference number of the funnel trap										Total captures	Average	D.V.	Variability coefficient
					1°	2°	3°	4°	5°	6°	7°	8°	9°	10°				
24/05/96	10			0.5	21	27	141	79	10	70	15	13	13	28	417	41.7	42.5	1.0
31/05/96	10			0.5	9	11	89	61	23	42	7	26	12	25	305	30.5	26.5	0.9
14/06/96	10			0.5	14	25	170	140	30	58	13	27	38	41	556	55.6	54.5	1.0
15/06/96	10			0.5	**Treatment with pyrethrum fogging**													
17/06/96	10	50		3	**Starting of tests**													
03/07/96	10	50		3	28	19	210	49	27	69	20	17	20	27	486	48.6	59.0	1.2
19/07/96	10	50		3	75	46	145	166	39	97	81	29	45	121	844	84.4	47.2	0.6
02/08/96	10	50		3	39	46	109	259	9	71	43	22	34	61	693	69.3	72.2	1.0
16/08/96	10	50		3	45	29	120	215	13	72	70	28	36	58	686	68.6	59.7	0.9
30/08/96	10	50		3	20	26	107	365	14	86	147	63	85	78	991	99.1	102.2	1.0
13/09/96	10	50		3	27	30	61	668	14	161	119	98	93	126	1397	139.7	191.7	1.4
27/09/96	10	50		3	47	13	160	857	11	85	166	58	31	83	1511	151.1	253.9	1.7
11/10/96	10	50		3	26	4	74	232	20	70	91	59	31	83	690	69.0	64.4	0.9
15/10/96	10	110	10	6.5	**Substitution of dispensers**													
25/10/96	10	110	10	6.5	28	5	55	147	14	70	88	28	37	89	561	56.1	43.3	0.8
08/11/96	10	110	10	6.5	11	4	23	171	3	39	37	41	30	69	428	42.8	49.2	1.2
22/11/96	10	110	10	6.5	26	8	48	259	16	27	58	40	57	69	608	60.8	72.4	1.2
06/12/96	10	110	10	6.5	7	0	13	106	11	17	14	18	15	24	225	22.5	30.0	1.3
20/12/96	10	110	10	6.5	8	8	23	136	0	33	23	14	33	48	326	32.6	39.1	1.2
24/12/96	10	110	10	6.5	**Treatment with pyrethrum fogging**													
03/01/97	10	110	10	6.5	0	0	0	0	0	1	0	0	1	0	2	0.2	0.4	2.1
05/01/97	10	110	10	6.5	**Treatment with pyrethrum fogging**													
17/01/97	10	110	10	6.5	0	0	0	5	0	5	0	1	1	1	13	1.3	2.0	1.5
31/01/97	10	110	10	6.5	0	0	1	3	0	3	0	0	0	4	11	1.1	1.6	1.5
14/02/97	10	110	10	6.5	1	2	0	0	1	1	3	0	1	0	9	0.9	1.0	1.1
24/02/97	10	110	10	6.5	**Substitution of dispensers**													
11/03/97	10	110	10	6.5	0	0	3	16	0	5	1	2	2	8	37	3.7	5.0	1.4
24/03/97	10	110	10	6.5	0	0	2	2	0	4	2	5	6	10	31	3.1	3.2	1.0
29/03/97	10	110	10	6.5	**Treatment with pyrethrum fogging**													
11/04/97	10	110	10	6.5	0	0	1	2	0	1	1	3	5	7	20	2.0	2.4	1.2
02/05/97	10	110	10	6.5	0	4	0	3	0	1	1	0	1	1	11	1.1	1.4	1.2
16/05/97	10	110	10	6.5	0	2	1	0	2	0	3	1	0	0	9	0.9	1.1	1.2
30/05/97	10	110	10	6.5	0	0	1	0	1	0	0	1	2	0	5	0.5	0.7	1.4
16/06/97	10	110	10	6.5	1	0	0	2	0	0	0	0	2	3	8	0.8	1.1	1.4
27/06/97	10	110	10	6.5	2	0	0	1	0	0	0	0	0	1	4	0.4	0.7	1.7

(Table 1 continued)

Date	Number of laminar dispensers in the funnel traps	Laminar dispensers in the department	Neoprene diffuser products (meter)	Total quantity of TDA (g)	Reference number of the funnel trap										Total captures	Average	D.V.	Variability coefficient
					1°	2°	3°	4°	5°	6°	7°	8°	9°	10°				
11/07/97	10	110	10	6.5	1	1	0	0	1	0	0	1	0	0	4	0.4	0.5	1.3
21/07/97	10	110	10	6.5	**Substitution of dispensers**													
14/08/97	10	110	10	6.5	0	0	0	1	0	0	0	0	4	1	6	0.6	1.3	2.1
29/08/97	10	110	10	6.5	0	0	3	1	0	0	0	0	0	3	7	0.7	1.3	1.8
12/09/97	10	110	10	6.5	1	0	0	0	0	1	0	1	5	1	9	0.9	1.5	1.7
03/10/97	10	110	10	6.5	0	3	0	0	0	1	0	1	1	0	6	0.6	1.0	1.6
27/10/97	10	110	10	6.5	1	2	1	0	0	0	1	0	0	1	6	0.6	0.7	1.2
10/11/97	10	110	10	6.5	0	1	1	0	0	1	0	0	0	1	4	0.4	0.5	1.3
24/11/97	10	110	10	6.5	0	0	1	1	0	0	0	1	0	0	3	0.3	0.5	1.6
04/12/97	10	110	10	6.5	0	0	1	0	0	1	1	0	1	0	4	0.4	0.5	1.3
02/01/98	10	110	10	6.5	0	1	0	0	1	0	0	0	1	0	3	0.3	0.5	1.6
16/01/98	10	110	10	6.5	0	1	0	1	0	0	1	0	0	1	4	0.4	0.5	1.3
30/01/98	10	110	10	6.5	0	0	1	1	0	1	0	1	0	0	4	0.4	0.5	1.3
16/02/98	10	110	10	6.5	1	0	0	0	1	1	0	1	1	0	5	0.5	0.5	1.1
26/02/98	10	110	10	6.5	0	1	1	1	0	0	1	0	0	1	5	0.5	0.5	1.1
16/03/98	10	110	10	6.5	0	1	0	1	1	0	0	1	0	0	4	0.4	0.5	1.3
30/03/98	10	110	10	6.5	1	0	1	1	0	1	1	0	0	1	6	0.6	0.5	0.9
16/04/98	10	110	10	6.5	1	0	1	1	1	0	1	1	0	0	6	0.6	0.5	0.9
04/05/98	10	110	10	6.5	1	1	0	1	2	1	1	0	1	1	9	0.9	0.6	0.6
25/05/98	10	110	10	6.5	0	1	1	0	1	0	0	1	0	1	5	0.5	0.5	1.1
08/06/98	10	110	10	6.5	1	0	1	0	1	1	0	0	1	0	5	0.5	0.5	1.1
22/06/98	10	110	10	6.5	0	0	1	1	0	1	1	0	1	1	6	0.6	0.5	0.9
16/07/98	10	110	10	6.5	0	0	2	1	1	0	1	0	1	1	7	0.7	0.7	1.0
17/07/98	10	110	10	6.5	**Substitution of dispensers**													
05/08/98	10	110	10	6.5	2	0	0	2	2	0	2	1	3	2	14	1.4	1.1	0.8
25/08/98	10	110	10	6.5	1	1	0	3	1	3	1	0	2	1	13	1.3	1.1	0.8
14/09/98	10	110	10	6.5	3	0	1	1	0	1	2	0	1	1	10	1.0	0.9	0.9
05/10/98	10	110	10	6.5	2	1	0	2	1	0	1	1	0	0	8	0.8	0.8	1.0
Data analysis referred to all test				Total captures	451	324	1574	3964	272	1102	1018	605	654	1083	11047			
				Average	8.4	6.0	29.1	73.4	5.0	20.4	18.9	11.2	12.1	20.1				
				D.V.	15.4	11.4	54.1	162.4	8.9	35.3	38.8	20.5	21.0	33.7				
				Variability coefficient	1.8	1.9	1.9	2.2	1.8	1.7	2.1	1.8	1.7	1.7				

concentration. In the environmental conditions of the department, the moth manages to evolve one generation every 2 months approximately. It has to be added to this that between May and June there is usually a natural increase of the emergence from the cocoon, due to that part of the population, that overwinters as mature larvae or crysalids.

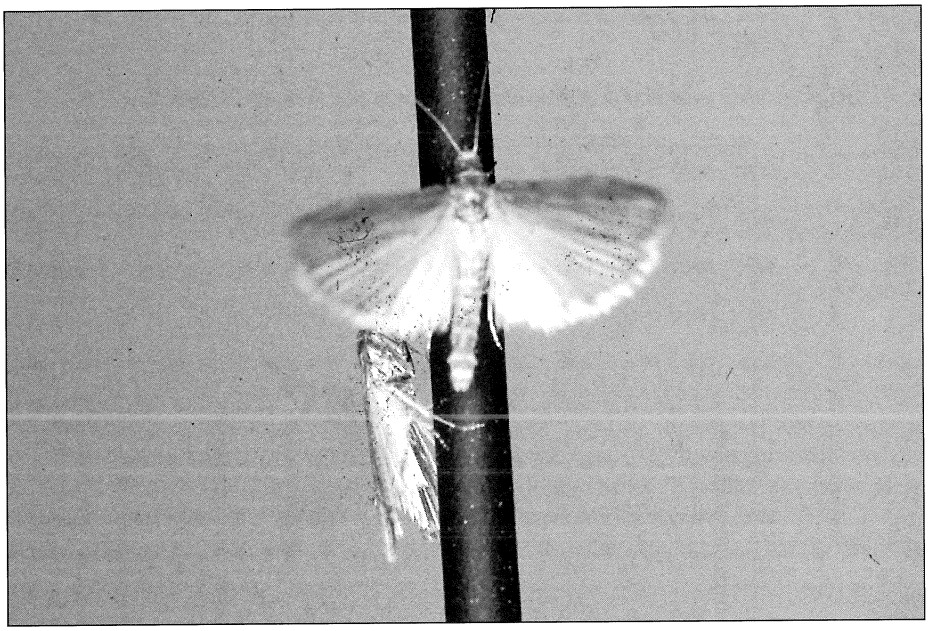

Fig. 2 - *Ephestia kühniella* on the dispenser made of cylindrical neoprene drawn product.

On the basis of these results, noticing that at least half of the high number of captures took place constantly in the two traps corresponding to machinery with "critical points", as they were almost inaccessible, the number of dispensers was doubled. At the same time a new type of dispenser made of a cylindrical neoprene drawn product (3 mm in diameter) activated with 50 mg of TDA per linear metre was installed under the above mentioned machinery. The drawn product was tied to the support legs of the machinery to the ground for a total of 10 metres (with about 50 mg of TDA). Already after a few minutes after the application, many males started to frenetically move, coming out of the nesting recesses, leaning on and moving continually along the dispenser (Fig. 2). After about 3 months from the application of the new concentration and with the use of this dispenser, there was a fall in captures with an almost total disappearance of the infestation. After there were some interventions using fogging with pyrethrum that we did not consider necessary, but which the management of the factory had programmed. Their lack of influence on the

progress of the captures can be seen. Overall, after 2 years from the start of the experiment *Ephestia kühniella* has almost disappeared, despite the fact that the environmental conditions have not changed and the equipment still cannot be inspected and the substitution of the dispensers has been reduced slowly in time.

CONCLUSIONS

As it has been illustrated, the uselessness of carrying out treatments with insecticides against adults has been highlighted. In the previous experiments the inhibition of mating was obtained in a highly infested environment using 3.5 g of TDA in 2300 m^3 with dispensers of 50 mg which, based on their ability to release about 80-90 µg each daily, led to an average concentration of 2.5 µg/m^3.

In this experiment the total quantity of TDA used in the last phase was 6 g.

The fact that the two different types of dispensers used have a different release capacity has to be taken into account. The neoprene drawn product is clearly faster in its efficacy and the quantities progressively distributed are greatly reduced in 3-4 months. The laminar dispenser which release TDA more slowly, last much longer. In any case, the dispersal is influenced by the structure of the dispenser, by the way it is impregnated, as well as by the temperature of the environment where it is applied and by the movement of air. Based on the data supplied by the producer it can reasonably be stated that the cylindrical neoprene drawn product activated with 50 mg/m of TDA, free daily 200-220 µg/m for 3-4 months.

The laminar dispensers, always activated with 50 ng free about 80-90 µg daily for over 4 months. Therefore, calculating the total number of dispensers of the two types used from the moment it was treated successfully on a great population of *Ephestia kühniella*, the result can be obtained when a daily average distribution of 17·000-18·000 µg/day of TDA for at least 3-4 months has been maintained in the department. (there was an oscillation between 22000 µg at the start and about 15000 µg after 4 months). This average quantity corresponds about to 2.5 µg/m^3 of the volume of the environment. As can be seen, the value reached almost corresponds to the one obtained in the previous test.

Such an indication is then considered valid, when there are largely dense populations of *Ephestia kühniella*. What can be hypothesised though, is that if the colonisation of an environment is reduced, it can be treated with lower quantities that still must be decided, as it happened in 1998, when the infestation had almost been eradicated.

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