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Multiple Stored-Product Insect Pheromone Use in Pitfall Traps

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Abstract—Monitoring programs for stored-product insects in warehouses and processing plants are directed at the detection of several species. Pheromone lures for certain species are commercially available, but little is known about the interaction between pheromones from different species used in the same trap. This research examines the effect of the paired interaction of synthetic pheromones used in the same trap on the effectiveness of trapping *Rhyzopertha dominica*, *Tribolium castaneum* and *Trogoderma variabile*. The *Rhyzopertha dominica* pheromone can be used in the same trap with pheromones for *Tribolium castaneum* and *Trogoderma variabile*. The pheromone of *Trogoderma variabile* does not appear to impact adversely on the trap catch of *Tribolium castaneum*, but the opposite is not true. There appears to be a repellent effect caused by *Tribolium castaneum* pheromone on the trap catch of *Trogoderma variabile*, but not sufficient to preclude its use in the same trap. Using a single trap to monitor two insect species will result in reduced cost, associated with the purchase of less traps and reduced labor in maintaining pest surveillance programs.

Key words—pheromones, *Rhyzopertha dominica*, trapping, *Tribolium castaneum*, *Trogoderma variabile*

INTRODUCTION

There are many insect species infesting raw grains and processed cereal foods in storage facilities and processing plants. Often more than one species within a facility requires monitoring. Stored-product insects can be detected with a variety of traps, some using food attractants and synthetic insect pheromones (Vick *et al.*, 1990). Some traps are designed, or can be modified, so that pheromones for more than one species can be used at the same time. However, little information is available on how the presence of multiple pheromones in the same trap influences the effectiveness of that trap for attracting each insect species (Lindgren *et al.*, 1985). Laboratory tests indicate that pheromone for the rusty grain beetle and red flour beetle can be used in the same trap without reducing the attraction to the trap by either species, and there is even a slight cross attraction of the red flour beetle to the rusty grain beetle pheromone (Lindgren *et al.*, 1985).

When sex pheromones are combined in the same trap, there is interaction of the Indianmeal moth with the Angoumois grain moth and of the Indianmeal moth with the almond moth. Vick *et al.* (1979) reported reduced capture of Angoumois grain moth when Indianmeal moth pheromone was also present in the trap, but this interaction resulted in only a moderate loss of trap efficiency. Although the major component of the sex pheromone is the same for the almond moth and Indianmeal moth (Brady *et al.*, 1971), few almond moths were collected in

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pheromone-baited sticky traps when Indianmeal moths were present (Mullen *et al.*, 1991). This is due to a second volatile substance released by female Indian meal moths that inhibits the sex pheromone response of the male almond moth (Sower *et al.*, 1974).

The presence of multiple pheromones in one trap has three possible outcomes on the attraction of each species. First, an insect may be attracted to a trap by its own pheromone regardless of the presence or absence of pheromones for other species. Second, the attraction of an insect to a trap may be greater due to the combination of its pheromone with that of another species. Finally, the attraction to a trap may be reduced due to the repellent characteristics of a pheromone from another species.

The potential for the interaction of multiple sex and aggregation pheromones in the same trap and the resulting influence on the trap catch are important when monitoring for several insect species. Three stored-product insects that commonly occur together, and for which pheromones are available, are the lesser grain borer, *Rhyzopertha dominica* (Fab.) (Williams *et al.*, 1981), and the red flour beetle, *Tribolium castaneum* (Herbst) (Suzuki and Mori, 1983), which use an aggregation pheromone, and the warehouse beetle, *Trogoderma variabile* (Ballion) (Cross *et al.*, 1976), which has a sex pheromone. There is no reported research on the potential interaction of these pheromones and the possible impact on trapping and monitoring programs. Therefore, the objective of this research was to examine the effect of the interaction of synthetic pheromones used in the same trap on the effectiveness of trapping *Rhyzopertha dominica*, *Tribolium castaneum* and *Trogoderma variabile*.

MATERIALS AND METHODS

All insects were reared in the laboratory. *Rhyzopertha dominica* were cultured on whole hard red winter wheat kernels. *Tribolium castaneum* were cultured on whole-wheat flour containing 5% brewers yeast. *Trogoderma variabile* were cultured on a mixture of 50% whole hard red winter wheat kernels and 50% standard laboratory insect diet (McGaughey, 1985). All insects used in the study were about 2 weeks old with a 1 : 1 sex ratio.

Experiments were conducted in three 6 m × 3 m × 2.5 m insulated buildings maintained at 28 ± 1°C and ambient humidity (70 ± 10%). Each building had only one door and no windows. The floor, ceiling and walls were covered with plywood and the seams were sealed with caulking. The temperature was maintained with a wall-mounted heater/air conditioner placed about 1.5 m above the floor. The placement of the air unit at this height resulted in little air movement at floor level.

Table 1. Analysis of variance for the interaction between the numbers of insects collected in traps containing pheromone for paired comparisons of *Rhyzopertha dominica*, *Tribolium castaneum* and *Trogoderma variabile*

Pheromone pair	Species tested	Time post-release (h)	*F*	df	*P*
Rhyzopertha dominica and *Tribolium castaneum*	*Rhyzopertha dominica*	24	0.08	1, 96	0.78
		48	0.21	1, 96	0.65
	Tribolium castaneum	24	0.07	1, 96	0.79
		48	0.42	1, 96	0.52
Rhyzopertha dominica and *Trogoderma variabile*	*Rhyzopertha dominica*	24	0.59	1, 41	0.45
		48	0.24	1, 41	0.63
	Trogoderma variabile	24	0.50	1, 41	0.48
		48	0.01	1, 41	0.91
Tribolium castaneum and *Trogoderma variabile*	*Tribolium castaneum*	24	1.68	1, 41	0.20
		48	0.79	1, 41	0.38
	Trogoderma variabile	24	0.53	1, 41	0.47
		48	0.59	1, 41	0.45

Table 2. Analysis of variance for the number of insects collected in traps containing pheromone for paired comparisons of *Rhyzopertha dominica*, *Tribolium castaneum* and *Trogoderma variabile*

Pheromone pair	Species tested	Time post-release (h)	F	df	P
Rhyzopertha dominica and *Tribolium castaneum*	*Rhyzopertha dominica*	24	14.16	3, 96	0.0001
		48	18.31	3, 96	0.0001
	Tribolium castaneum	24	25.80	3, 96	0.0001
		48	29.96	3, 96	0.0001
Rhyzopertha dominica and *Trogoderma variabile*	*Rhyzopertha dominica*	24	8.55	3, 41	0.0002
		48	4.37	3, 41	0.01
	Trogoderma variabile	24	8.43	3, 41	0.0002
		48	9.39	3, 41	0.0001
Tribolium castaneum and *Trogoderma variabile*	*Tribolium castaneum*	24	18.61	3, 41	0.0001
		48	20.64	3, 41	0.0001
	Trogoderma variabile	24	3.34	3, 41	0.03
		48	3.83	3, 41	0.02

In each building, four FlitTrak M^2 (Mullen, 1992) beetle traps were placed on the floor using an incomplete Latin square design such that, among all replicates, each of the four pheromone treatments was positioned next to every other pheromone treatment. One trap contained no pheromone, one trap contained pheromone for two beetle species and the other two traps each contained a single pheromone for the beetle species being tested. Traps were placed through the center of each building at a distance of 1.5 m from the side walls, 1.2 m from the end walls and 1.2 m between each trap. All pheromones were acquired from Trécé, Inc. (Salinas, CA) as impregnated rubber septa. Two species were tested at a time to examine the influence of pheromone combinations on the trap catch. There were nine replications for the *Rhyzopertha dominica* with *Tribolium castaneum* combination. Four replications each were conducted for the *Rhyzopertha dominica* with *Trogoderma variabile* and *Tribolium castaneum* with *Trogoderma variabile* combinations. One replication consisted of the four pheromone treatments tested simultaneously in each of the three buildings. For each replication, 125 insects of each of two species were released from the rearing container onto the floor, halfway between the traps and walls in each building. The buildings were aired out for 24 h between replications. The numbers of insects in each trap were removed and recorded 24 and 48 h after release. All data were subjected to $\log_{10}(x + 1)$ transformation to normalize the variance and analyzed using PROC GLM (SAS Institute, 1995) to test for significance among the traps. Means were separated using a least significant difference test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

There were no significant interactions ($P > 0.05$) for the number of each species collected in the traps for the three pheromone pairs tested at either 24 or 48 h post-release (Table 1) when the data were analyzed in a 2×2 factorial design. Therefore, the presence of pheromone for one species did not influence the attraction of the other species to the traps. Because there is no significant interaction, we would expect as many *Rhyzopertha dominica* in a trap baited with its pheromone plus pheromone for either *Tribolium castaneum* or *Trogoderma variabile* as in a trap baited with only *Rhyzopertha dominica* pheromone. This same situation is also expected for *Tribolium castaneum* and *Trogoderma variabile*.

When the data were analyzed as a randomized complete block design with four treatment combinations, there were significant differences in the numbers of insects collected in the traps for each of the three pheromone pairs tested at 24 or 48 h post-release (Table 2). Significantly more *Rhyzopertha dominica* and *Tribolium castaneum* were collected in traps containing their own pheromone than in traps without their pheromone (Fig. 1). For these two species, the numbers of insects in traps containing only the other insect's pheromone were not significantly different from the numbers of insects collected in the control traps with no pheromone.

When *Trogoderma variabile* was tested in combination with *Rhyzopertha dominica*, the number of *Trogoderma variabile* in traps containing only *Rhyzopertha dominica* pheromone was not significantly different from the number collected in the control traps without pheromone (Fig. 2). However, when *Trogoderma variabile* was tested in combination with *Tribolium castaneum*, the numbers of *Trogoderma variabile* collected in traps baited with the pheromone of *Tribolium castaneum* only were less than the numbers collected from traps with no pheromone after 48 h (Fig. 3). This may indicate repellency imparted by the *Tribolium castaneum* pheromone that is not evident when the pheromones are used together. There was no significant difference between the numbers of *Trogoderma variabile* collected in the traps baited with its pheromone and the traps with no pheromone. In addition, more *Rhyzopertha dominica* and *Tribolium castaneum* were

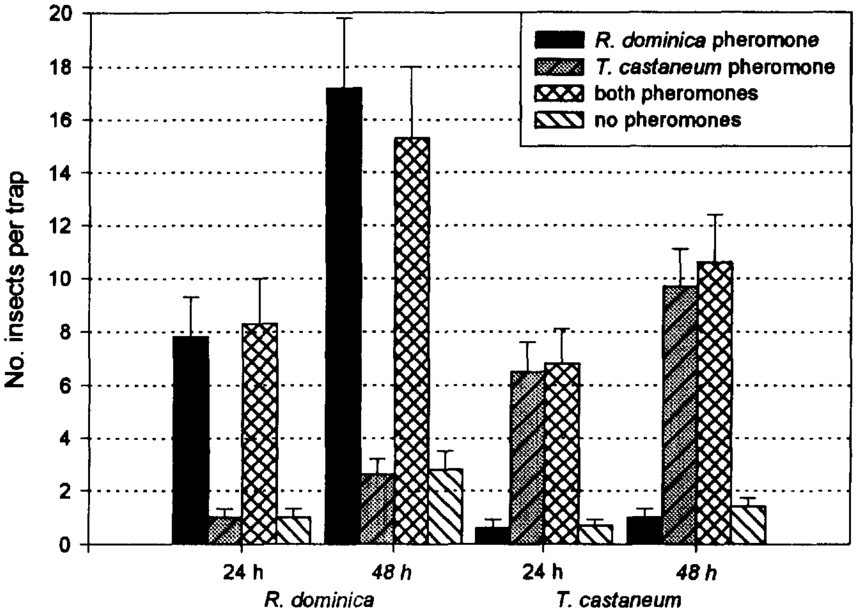

Fig. 1. The number of *Rhyzopertha dominica* and *Tribolium castaneum* collected 24 and 48 h after release in traps with and without pheromone of one other insect species.

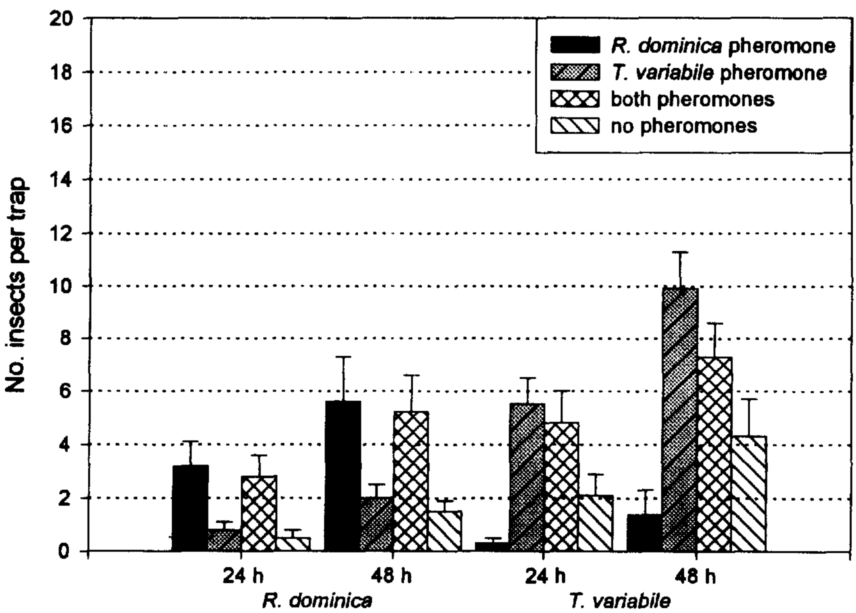

Fig. 2. The number of *Rhyzopertha dominica* and *Trogoderma variabile* collected 24 and 48 h after release in traps with and without pheromone of one other insect species.

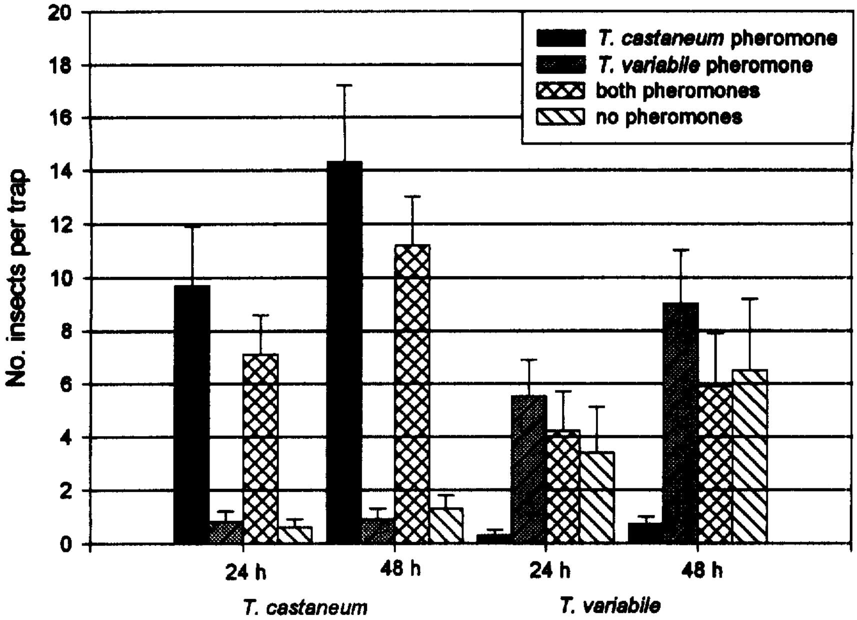

Fig. 3. The number of *Tribolium castaneum* and *Trogoderma variabile* collected 24 and 48 h after release in traps with and without pheromone of one other insect species.

collected in traps containing their own pheromones and in combination with *Trogoderma variabile* than in traps without their pheromones (Figs 2 and 3).

There are alarm pheromones produced by both sexes of *Tribolium castaneum* that act as repellents to conspecifics (Mondal and Port, 1993). If traps are left unserviced for extended periods of time, the alarm pheromones may be released by beetles prior to death, thus potentially reducing the trap efficiency relative to clean traps. Trematerra *et al.* (1996) reported that, although the presence of live *Tribolium castaneum* in traps was attractive to untrapped *Tribolium castaneum*, dead beetles could be repellent due to the residual alarm pheromones. We observed no repellent effect in this study, probably because trapped beetles were removed at 24 h intervals or because the beetles were immersed in the food-bait oil on entering the trap and any alarm pheromone may have been absorbed into the oil.

CONCLUSIONS

For the three insect species examined, the use of pheromones for two species in one trap does not influence the effectiveness of the trap. Although there was inhibition caused by *Tribolium castaneum* pheromone on *Trogoderma variabile* when presented alone, this should not impact adversely on the ability of the two pheromones to be used effectively in the same trap in a monitoring program. For insect monitoring programs in food processing plants and warehouses, separate traps may not be necessary for the detection of multiple pest species. Additional research is necessary on the use of more than two pheromone lures in the same trap. This will result in reduced cost associated with the purchasing of less traps and reduced labor in maintaining a pest surveillance program.

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