NOTE

Special Use Pheromone-Baited Trap for the Red Flour Beetle (Coleoptera: Tenebrionidae)[1]

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Processed and bulk commodities are susceptible to infestation by stored-product insects in all parts of the marketing channel. There is need for the development of effective thorough monitoring systems for both early detection and to judge the duration and effectiveness of management measures. DeCoursey (1931, J. Econ. Entomol 24, 1079-1081) was the first to develop an effective trap for the confused flour beetle, *Tribolium confusum* Du Val. The trap contained no pheromone and consisted of corrugated paper into which various baits were placed. Flour was generally the attractant of choice but, like other food attractants, it was effective only from a short distance. Wilson (1940, J. Econ. Entomol. 33, 651-63) utilized more aromatic bait to attract carpet beetles, *Anthrenus scrophulariae* (L.), to a sticky trap. With the identification of an effective aggregation pheromone for the red flour beetle by Suzuki and Mori (1983, Appl. Entomol. Zool. 18, 134-136), effective traps were developed using a combination of a food attractant and pheromone. Multi-layered corrugated paperboard traps for monitoring stored-product insects were developed by Burkholder (1976, Insect Pheromones and their Application, T. Kono and T. Ishii eds., Pp. 111-112. Japan Protection Association, Nagota and Tokyo), Barak and Burkholder (1976, Environ. Entomol. 5, 111-114; 1984, Agric. Ecosys. Environ. 12, 207-208), and Williams et al. (1981, J. Chem. Ecol. 7, 759-780). These traps were similar to the DeCoursey trap in that they were constructed of corrugated cardboard, taking advantage of the insect's natural need for a place to hide. These traps were an improvement over the DeCoursey trap because they not only incorporated a food attractant and pheromone bait, but also a killing agent. The trap was improved by Barak and Burkholder (1984) when they replaced the killing agent with a plastic pitfall filled with an oil bait food attractant that also functioned as a killing agent. This trap was later modified by Barak (1989, J. Econ. Entomol. 82, 1470-1477) for *Trogoderma granarium* Everts.

Barak and Burkholder (1984) and Mullen (1992, J. Stored Prod. Res. 28, 245-249)

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reported that some insect species are hesitant to walk onto a sticky surface. Mullen (1992) also reported that some glues repelled insects or were not strong enough to hold them. Other factors to be considered are dust resistance and making the traps less obvious so that humans and rodents do not disturb them. Traps must be placed in such a way that they do not interfere with normal warehouse traffic and commodity movement. Therefore, it is sometimes necessary to construct traps for specific uses or placement in areas that other traps might not be suitable.

Mullen (1992) developed a trap for *T. castaneum* (Herbst), FLITe TRAK M^2 (Tre'ce', Salinas, CA) that appears to meet all of the criteria for an effective trap. The trap is a modified pitfall covered by a paperboard sleeve. The plastic pitfall contains the oil food attractant which also serves as the killing agent. The sleeve serves as a dust cover and to hold the pheromone lures. The trap can hold two lures, but we have used three lures effectively (Dowdy and Mullen 1998, J. Stored Prod. Res. 34, 75-80). Like the traps developed by Barak and Burkholder (1984) this trap is designed as a floor mount which makes it susceptible to normal warehouse traffic and commodity movement.

Monitoring is often not done where conventional traps can not be used because of their size or shape. Areas such as electrical panels, behind equipment or in other less accessible places are often overlooked in monitoring programs. These areas provide refuge to pest insects and may be a source of reinfestation. In addition, it was thought that such a trap could be included in a shipping package containing the finished commodity. Upon arrival at its final destination, the package could be opened and the trap checked for insects. The purpose of this study was to develop a trap that can be used in addition to the more expensive conventional traps now available for detecting and monitoring red flour beetle populations.

Trap designs were evaluated in arenas made by taping two sheets of 61-cm wide white butcher paper together to form a square approximately 120 × 120 cm. The perimeter of each square was lined with Tanglefoot® (Tanglefoot Co., Grand Rapids, MI) so that crawling insects could not escape. The traps were constructed from 15-dram snap cap plastic vials 60 × 35 mm (Fig. 1). Using a hacksaw or a small drill, slits were cut through the walls of in each of the vials in one of four configurations: (1) x x x, (2) ///, (3) ●●●, or (4) –___–. The openings were made so that they extended around the circumference of the vial. The outside of the vial was roughened using medium grit sandpaper so that the roughened area extended from the bottom of the vial to just above the openings. The inside of the vial was also roughened in a band sufficiently wide to extend slightly below and above the openings. The internal roughened area increased the probability of the insects entering he trap because it provided a surface for them to walk on. The center of the plastic cap was drilled with a hole large enough to accommodate a rubber septa pheromone lure.

In each replication, 50 red flour beetle adults were released on a paper arena containing a single trap. Traps were baited with a rubber septum RFB/CFB lure (Tre'ce', Inc., Salinas, CA) and the trapping surface consisted of a paper disk cut to fit the inside bottom of the trap. The paper was coated with a food lure and killing agent made from a mixture of wheat, oat, sesame and mineral oil (Tre'ce', Inc., Salinas, CA). Trap counts were made at 1, 4, and 24 h. Tests were conducted at room temperature (23°C) with the lights on. The door was kept closed to minimize air currents. Lures were replaced after every four replications. Each design was replicated 24 times and the data were analyzed as a completely random design (CRD) using an ANOVA (SAS, 1987, SAS Institute, Inc. Cary, NC).

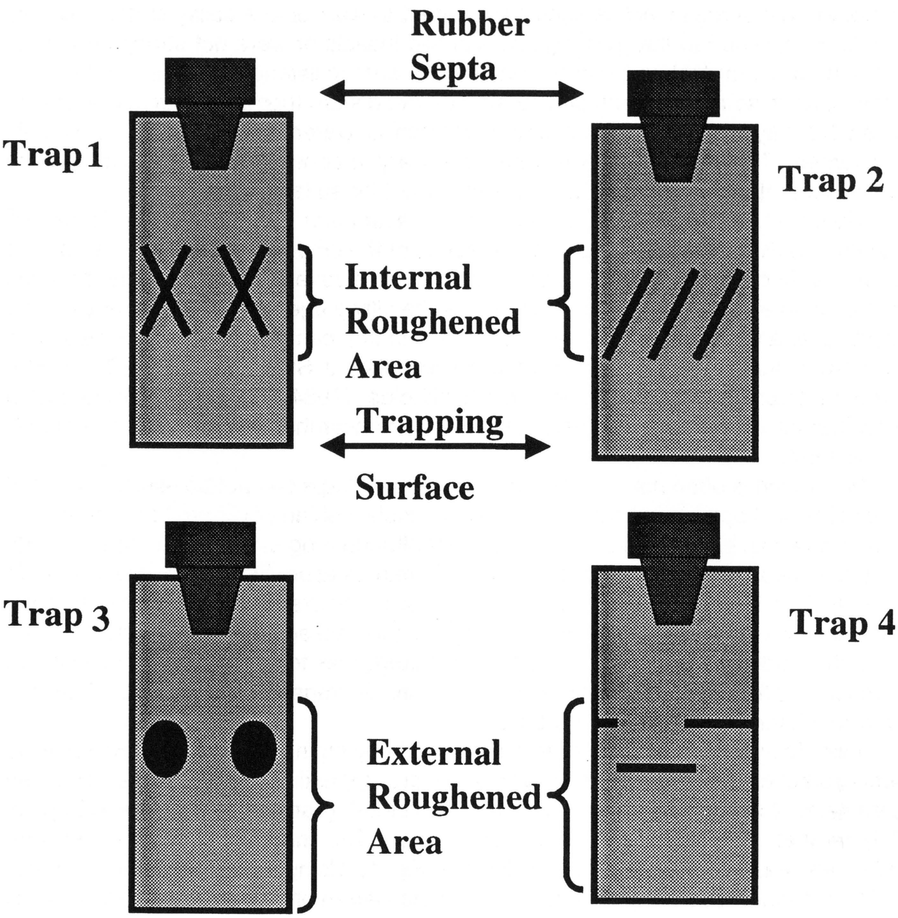

Fig. 1. The four trap designs tested showing the placement of the lure and the internal and external roughened areas that provide a climbing surface. The entry hole patterns are shown for each trap design.

The adult red flour beetles had no problem climbing the vertical roughened surface of the trap and all trap designs were effective (Table 1). After the initial count at 1 h the "X" trap (trap 1) obtained the fewest insects. However, after 4 and 24 h, trap captures were equal. The design of traps 2 and 4 was somewhat different from the others which made it impossible for an insect to climb straight up the trap wall without making a deviation around the openings. In traps 1 and 3 the insects were able to climb straight up the trap and walk between the openings. Once the insects entered the trap, escape was possible, but very rare. Insects that fell to the bottom of the trap were trapped in the oil and could not escape.

This trap was designed for specialized uses and not to replace other traps. It does, however, because of its size and shape, allow areas generally not monitored to be

Table 1. Trap catch in four designs of a disposable pheromone-baited trap for the red flour beetle over time. Data represents mean capture from a population of 50 adult insects in each of 24 replications

	Time in hours		
Trap type	1	4	24
(1) xxx	9.8 ± 1.1 a	20.9 ± 2.5 a	30.8 ± 1.4 ab
(2) ///	15.8 ± 1.6 b	27.3 ± 2.2 a	33.8 ± 1.5 a
(3)●●●	14.5 ± 0.9 b	23.0 ± 1.7 a	29.5 ± 1.4 b
(4) –__–	16.9 ± 1.6 b	27.3 ± 1.9 a	34.2 ± 0.9 a

Means within a column followed by the same letter are not statistically different ($P = 0.05$) using the Waller-Duncan K-ratio *t* test.

checked for refugial populations. The trap meets the requirements for an effective trap as outlined by Barak and Burkholder (1984) and Mullen (1992). The trap is durable, dust proof and nearly escape-proof. The pheromone lure protrudes through the top of the trap allowing the pheromone to disperse more evenly (Mankin et al., 1980, J. Chem. Ecol. 6, 929-950). Because there is no sticky surface, it eliminates the aversion that many insects have to walking on a sticky surface (Mullen 1994, Proc. 6th Intern. Working Conf. Stored-Product Protection, E. Highley et al., eds., 1, 421-424). To increase the usefulness of the trap the design will allow for multiple lures (Dowdy and Mullen 1998).

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