commercial lures specifically available for baiting traps. A sexual attractant was identified and described in a Chinese patent, but not commercially available (Lei and Guangwei, 2016). *N. rufipes* larvae and adults were captured with commercial pitfall traps baited with food oil and pheromone lures (not specific for *N. rufipes*) from Trécé, in pet food retail stores (Roesli et al., 2003), but currently there is not a trap specifically set up for *N. rufipes*. This is a weak point for the management of infestations as it is not possible to constantly monitor the presence of the insect in industries, warehouses, pet stores.

Another aspect to take in account is the lack of specific information on control strategies. Only Roesli and Subramanyam (2002) reported that precision targeting using sanitation alone did not have an impact on *N. rufipes* adults, but reduced larval presence. Precision targeting with sanitation followed by cyfluthrin spray greatly reduced both larvae and adults.

We can conclude that the diffusion of *N. rufipes* is actually favored by a lack of specific monitoring traps, by incorrect application of pest prevention tecniques, combined with the incorrect management of storage warehouses and retail stores.

Further researches are needed to better understand food preference and behavior of this emerging pest associated with pet store chain.

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The orientation of *Tribolium castaneum* adults in the presence of aggregation pheromone 4,8-Dimethyldecanal and food oils

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Abstract

Monitoring of *Tribolium castaneum*, the red flour beetle, involves the use of aggregation pheromone 4,8-dimethyldecanal (4,8 DMD) and kairomones such as cereal oils. Despite their present use, certain information which maximizes the efficacy of these compounds is still lacking. These experiments tested the effects of distance from the pheromone and edible oils on the orientation of *T. castaneum* adults. The movement of adults toward the aggregation pheromone was determined by changing the distance from the pheromone or the air flow. The adults released inside a glass apparatus tested their orientation either toward the food oils or the empty vial. The maximum trap catch was recorded at distances up to 60 cm from the pheromone and with the presence of air flow. The oils having botanical origin successfully attracted adults than those of animal origin. It is concluded that the orientation of *T. castaneum* adults varies with the distance from pheromone, air flow and the nature of food oil.

Keywords: Aggregation pheromone, distance, Kairomone, air flow, Tribolium castaneum

1. Introduction

Tribolium castaneum (Herbst), the red flour beetle, is a serious pest of stored agricultural products (Rees, 2004; Trematerra and Sciarretta, 2004). The most popular control measures for stored-product insects include the use of contact insecticides (Ghimire *et al*., 2016) and fumigants (Hill, 1990). Due to the negative impact of the residual effect of insecticides on human and the environment, control methods using compounds other than neurotoxic chemicals are emphasized for stored-product protection.

Male adults of *T. castaneum* release the aggregation pheromone 4, 8-dimethyldecanal (4,8 DMD) that attracts both sexes (Suzuki *et al*., 1984). Commercial pheromone lures use a combination of pheromone and kairomone (Campbell, 2012). However, certain information that maximizes the efficiency of this aggregation pheromone is still lacking. Also limited research has been conducted on the response of *T. castaneum* adults to food volatiles (Campbell, 2012). Therefore, the objectives of this research were to determine the effect of distance from the aggregation pheromone, air movement and food oils on the orientation of *T. castaneum* adults.

2. Materials and methods

One-month-old *T. castaneum* adults (50) were released at distances 30-120 cm from the trap having pheromone 4,8 DMD. From each distance, three replicates were tested. The control experiments were done using only the plastic trap (without pheromone or kairomone). The beetles trapped following releasing was counted. The effect of airflow was tested by using an exhaust fan.

A glass chamber having two holes on the bottom plate and vials underneath was used to test the effect of edible oils on *T. castaneum* movement. The food oils, egg albumin, the commercial kairomone solution (Trece Inc., USA) or two pheromone septa (Trece Inc., USA) was placed inside one vial. Fifty *T. castaneum* adults were released at the center of the chamber, and the number of beetles in each vial was counted.

3. Results and discussion

The attraction of *T. castaneum* adults to pheromone decreased when the distance at which the beetles released was increased (Tables 1 and 2).

Tab.1 *Tribolium castaneum* adults trapped when released at different distances from the trap- presence of air flow.

Distance (cm)	Trapping in control (%)*	Trapping in treatment (%)*
30	0d	21.33a
60	0d	18.66a
120	0d	2.66c

* Percentage trapped followed by the same letter in a column are not significantly different at p=0.05 according to Tukey's test.

Tab. 2 *Tribolium castaneum* adults trapped when released at different distances from the trap- absence of air flow.

Distance (cm)	Trapping in control (%)*	Trapping in treatment (%)*
30	0c	13.33a
60	0c	10a
120	0c	1.33cb

* Percentage trapped followed by the same letter in a column are not significantly different at p=0.05 according to Tukey's test.

Olive oil, kairomone solution (Trece), pheromone solution and Mee oil attracted significantly higher number of adults than their controls. The adults attracted to rice bran oil, corn oil, cod-liver oil, ghee, coconut oil or sunflower oil were not significantly different from their controls. Lowest attraction was shown by the egg albumin and the mustard oil.

Tab. 3 *Tribolium castaneum adults* attracted by different food oils, pheromone or kairomone.

Source	Trapping in Treatment (%)*	Trapping in Control (%)
Olive oil	29edc**	15**
Rice bran oil	21ed	25
Coconut oil	52ab**	8**
Kairomone	44abc**	5**
Pheromone	53ab**	17**
Sunflower oil	36bdc	17
Mee oil	59a**	14**
Mustard oil	29ecd**	26**
Gingelly oil	22ed	21

* Percentage trapped followed by the same letter in a column are not significantly different at p=0.05 according to Tukey's test.

**denotes significant difference from the control.

The aggregation pheromone 4, 8 DMD released from *T. castaneum* adults is dispersed effectively up to 60 cm from the trap. Air flow increases the beetle orientation towards the source. Coconut oil and Mee oil equally attract adult beetles as the synthetic pheromone and kairomone.

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The responses of *Tribolium castaneum* to wheat germ oil and fungal produced volatiles

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Abstract

The red flour beetle *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) is a significant pest affecting a wide variety of different stored products around the Globe. Despite its economic impact, there is evidence that the lures currently used in traps to monitor for this species are largely ineffective. Based on the evolutionary history of *T. castaneum*, and the ecological niche it occupies, the volatiles of wheat germ oil and volatiles produced by grain-associated fungi have the potential to act as attractants for this species. We used electroantennography (EAG) to measure the electrophysiological response elicited by sixty-eight volatile compounds found in wheat germ oil and/or grain-associated fungi in two *T. castaneum* strains; an established lab population (CTC12 strain) and a recently caught wild population. Many volatile compounds from both sources elicited strong antennal depolarisations, and the responses of both strains were highly correlated. We then tested whether the compounds that triggered the strongest antennal depolarisations also elicited behavioural responses by using Y-tube olfactometer bioassays and identified several compounds attractive to both strains. The discovery of novel compounds that elicit strong EAG signals and behavioural responses could prove useful in the design of