

PHEROMONAL COMMUNICATION AND ORIENTATION OF THE GRANARY WEEVIL,
SITOPHILUS GRANARIUS (L.) (COLEOPTERA:CURCULIONIDAE)

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Abstract

A "Dual-Choice-Olfactometer" was designed for testing the behavior of virginal and mated males and females of *Sitophilus granarius* towards its aggregation pheromone. Preferences were examined between several odor/pheromone source alternatives. These alternatives were potential pheromone sources (virginal and mated males as well as frass-contaminated wheat) and inactive sources (virginal and mated females as well as fresh wheat).

Virginal males were very attractive to virginal and mated granary weevils of both sexes. Attractiveness of mated males was observed only in some cases. Only the virginal females were significantly attracted by mated males. In virginal females the pheromonal threshold to cause reaction is probably very low. The attractiveness of frass-contaminated wheat depended strongly on the physiological conditions of the perceptor weevils and the given alternatives.

Using pheromone baited traps for monitoring of *Sitophilus granarius* seems promising, since mated and unmated weevils were strongly attracted by the aggregation pheromone.

Introduction

Usually control of the granary weevil, *Sitophilus granarius*, is performed with phosphine. Reflecting the steadily growing pressure on the environment caused by conventional pest control, where possible, the protection of stored products should be turned also to biological control methods. For monitoring purpose pheromone baited traps are already accepted (Reichmuth et al., 1978) and lead in this direction.

S. granarius males produce an aggregation pheromone which attracts both sexes, males and females, to suitable sites of feeding, mating and breeding (Faustini et al., 1982). The pheromone is only produced when food is available (Burkholder, 1982). The closely related species of *S. granarius*, the rice weevil, *S. oryzae* (Phillips and Burkholder, 1981) and the maize weevil, *S. zeamais* (Walgenbach et al., 1983) have the same strategy to lure and attract the sexes. "Sitophilate" was found to be the main component of the granary weevil's aggregation pheromone (Phillips et al., 1987). There is a remarkable similarity to the rice and maize weevil's pheromone, "Sitophinon", which was identified by Schmuff et al. (1984).

Although there are a lot of other biological and abiological factors, successful trapping of weevils in pheromone baited traps depends on the physiological conditions of the percipients. Positive reactions toward the aggregation pheromone of *S. zeamais* were tested with weevils of different ages, mating status and saturation points (Walgenbach and Burkholder, 1986). In this work similar experiments were carried out done with *S. granarius*. Virginal males and females as well as mated males and females were tested, to discover whether or not they act differently towards a potential pheromone source. It was also examined, whether or not males reduce or stop pheromone production after mating. Frass-contaminated wheat (wheat on which virginal males fed for several days) was tested for attractiveness towards granary weevils.

Materials and methods

A Y-shaped "Dual-Choice-Olfactometer" was designed (Fig.1). A pump generated an air-stream which passed through a charcoal-filter and then was divided into two separate air-streams. The air volumina were adjusted using flow-meters and kept at 50 l/h. Both air-streams passed another charcoal-filter, and then were moistened by a NaCl-solution to 70-75% r.h. at a temperature of 25°C (Winston and Bates, 1960). In the glass-vessels the air was loaded with odor or pheromone molecules. This depended upon whether just wheat substratum or weevils were kept in the glass-vessels (see below). The air-streams were combined again in the Y-shaped glass tube and departed from the olfactometer at the entrance area where the test insects were introduced. The speed of air in the Y-shaped glass tube was calculated to be 0.56 m/s at the base and 0.28 m/s in the wings. All insects had access to food at all times. Weevils in the glass-vessels were kept on wheat. Wheat kernels were placed in the Y-shaped glass tube and test insects were reared on wheat until shortly before experiment.

The Institute for Stored Products Protection of the Federal Biological Research Centre in Berlin, Germany provided the *S.granarius* weevils. They were reared at constant conditions of 21°C, 65-70% r.h., in darkness on 600 cm³ wheat in 2000 cm³ glass-jars.

In order to obtain virginal weevils, single infested wheat kernels were isolated. After hatching from kernels the adults were sexed by the criteria of Halstead (1968) and afterwards, were isolated on wheat. Tested virginal weevils were 6-10 days old. Tested mated weevils were taken directly from rearing-jars.

For different choice combinations the glass-vessels of the olfactometer were filled with potential pheromone donors (virginal or mated males), virginal or mated females, frass-contaminated wheat or fresh wheat, respectively (Table 1).

Olfactometer experiments were performed in a separate room at 25°C, 70-75% r.h. and under red light conditions.

Fig.1: Dual-Choice-Olfactometer

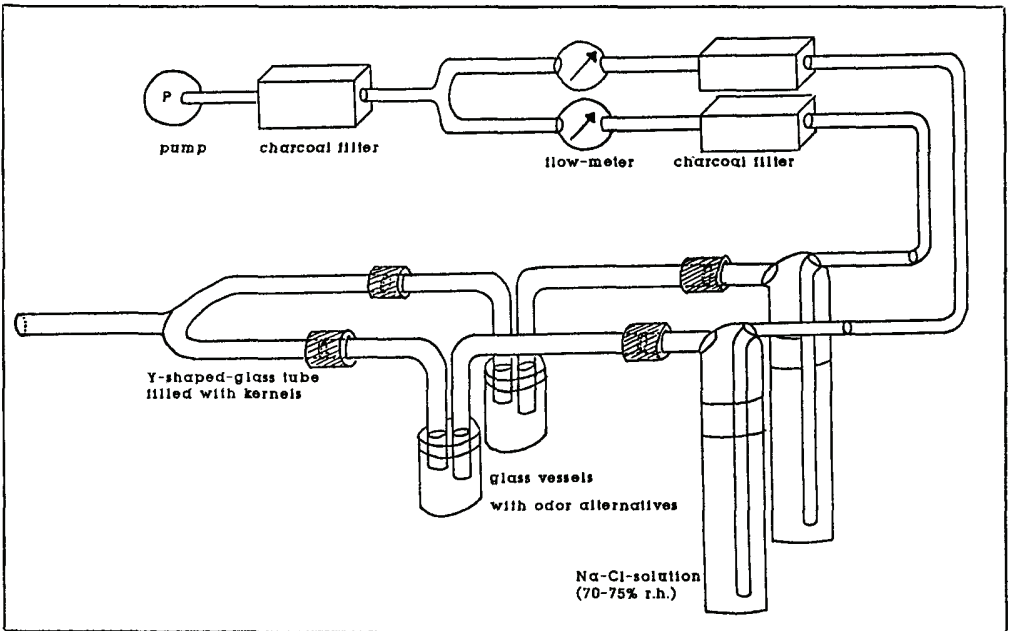


Fig.1: Dual-Choice-Olfactometer

Results

Several odor combinations were tested on virginal males. As expected, regardless of the offered odor alternative, these males were strongly attracted by the pheromone of other virginal males (Tab.2) . In test series A to C the orientation preferences were highly significant at $P \leq 0.01$. Frass-cont. wheat was noticeably preferred ($P \leq 0.05$) when offered in comparison to pheromonal inactive virginal females (Tab.2D). Only a small difference was found in virginal male weevil's orientation between frass-cont. wheat and mated males (Tab.2F); no difference was detected between frass-cont. wheat and virginal males (Tab.2H). This indicated a certain attractiveness of frass-cont. wheat when no stronger pheromone source is offered.

When offered as one alternative, virginal females chose virginal males ($P \leq 0.01$, Tab.3 A-D). The virginal males were also preferred to frass-cont. wheat; whereas virginal males did not distinguish these two alternatives (see above). When frass-cont. wheat was offered in combinations with lesser odor sources (Tab.3 E: fresh wheat, G: mated males; H: virginal females) it was preferred. Virginal females also distinguished ($P \leq 0.01$) mated males (Tab.3F).

Mated males were attracted also ($P \leq 0.01$) to virginal male's pheromone (Tab.4 A-D). In addition frass-cont. wheat was preferred predominantly (Tab.4E). Why neither mated males (Tab.4G) nor mated females (Tab.5H) differentiated between frass-cont. wheat and virginal females is not clear. Perhaps the stimulus in these cases was not strong enough to attract mated weevils.

Strong stimuli from virginal males also attract mated females (Tab.5 A-C). Although the pheromone of mated males was somewhat preferred (Tab.5 E-F) but preferences were not significant.

Tab.1: Tested weevils of *Sitophilus granarius*
to different pheromone/odor alternatives

Tested weevils

- a) virginal males
- b) virginal females
- c) mated males
- d) mated females

Different alternatives

- a) virginal males (15 a.e.)
- b) virginal females
- c) mated males
- d) mated females
- e) fresh wheat
- f) frass-cont. wheat
(virginal males before
experiment removed)

a.e.=animal equivalents

Tab.2: Orientation of virginal males towards given alternatives		
offered choice	responded weevils %	s.d. %
A) fresh wheat virginal males	24,5 75,5	0,9
B) mated males virginal males	32,0 68,0	8,7
C) virginal females virginal males	67,1 32,9	3,7
D) virginal females frasscont. wheat	60,1 39,9	3,1
E) fresh wheat virginal females	42,8 57,2	6,3
F) mated males frasscont. wheat	45,7 54,3	8,8
G) mated males virginal females	46,0 54,0	3,7
H) frasscont. wheat virginal males	46,7 53,3	1,5

Tab.3: Orientation of virginal females towards given alternatives		
offered choice	responded weevils %	s.d. %
A) fresh wheat virginal males	20,4 79,6	5,7
B) virginal females virginal males	30,0 70,0	5,0
C) mated males virginal males	30,0 70,0	13,2
D) frasscont. wheat virginal males	33,5 66,5	13,9
E) fresh wheat frasscont. wheat	34,8 65,2	9,0
F) virginal females mated males	36,7 63,3	12,6
G) mated males frasscont. wheat	39,4 60,6	9,5
H) virginal females frasscont. wheat	44,5 55,5	5,1

Tab.4: Orientation of mated males towards given alternatives		
offered choice	responded weevils %	s.d. %
A) frasscont. wheat virginal males	19,2 80,0	8,1
B) mated females virginal males	25,8 74,2	10,5
C) mated males virginal males	31,8 68,2	3,2
D) fresh wheat virginal males	32,3 67,7	7,7
E) mated males frasscont. wheat	36,0 64,0	5,3
F) frasscont. wheat virginal females	49,4 50,6	3,3

Tab.5: Orientation of mated females towards given alternatives		
offered choice	responded weevils %	s.d. %
A) virginal females virginal males	17,9 82,1	10,7
B) mated males virginal males	31,0 69,0	6,9
C) frasscont. wheat virginal males	37,5 62,5	6,8
D) frasscont. wheat mated males	40,0 60,0	5,0
E) fresh wheat mated males	42,1 57,9	7,0
F) virginal females mated males	43,3 56,7	7,6
G) mated females mated males	47,6 52,4	7,5
H) virginal females frasscont. wheat	47,9 52,1	0,1

Discussion and conclusion

Walgenbach and Burkholder (1986) illustrated that mated weevils of *S. zeamais* (age of tested weevils 1 week or older) did not react to pheromone sources. However, the behavior of *S. granarius* is quite different. Regardless of their age and mating status males and females all react significantly to the aggregation pheromone of virginal males.

At least periodically after mating males do reduce pheromone production. Only to virginal females were the mated males significantly attractive. More than likely the threshold to cause reaction towards the pheromone is very low in virginal females.

The attractiveness of frass-cont. wheat strongly depends on the given alternative; it is preferred when no stronger impulse is available and on the physiological conditions of the percipients. Mated weevils did not prefer frass-cont. wheat as did the virginal weevils. This may be due to lower activity after mating.

In an olfactometer pheromone molecules are carried by air towards the percipient. The aggregation pheromone causes reaction, orientation is anemotaxic. Under natural warehouse conditions directed air-streams are very unlikely. Experiments to investigate the orientation of *S. granarius* in bulks of grain under natural conditions are in progress. Concentration gradients or trail-following behavior on pheromone contaminated wheat kernels may play an important role.

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COMMUNICATION PAR PHEROMONES ET ORIENTATION DU CHARANCON DES
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RESUME

Les mâles du charançon des greniers produisent une phéromone d'agrégation qui attire les deux sexes vers les sites qui conviennent à leur alimentation, à leur accouplement et à leur multiplication. Les femelles ne produisent pas de phéromones. En utilisant des pièges appâtés aux phéromones, il est intéressant de savoir, dans le contrôle des déprédateurs, si la faculté d'attirance de la phéromone d'agrégation du charançon varie en changeant les conditions physiologiques (âge, accouplement).

Nous avons conçu un "olfactomètre à double choix" pour étudier le comportement des mâles vierges et accouplés ainsi que des femelles du *Sitophilus granarius* envers la phéromone. Nous avons étudié leur préférence entre différentes odeurs, qui représentaient des sources potentielles de phéromones (mâles vierges et accouplés ainsi que du blé défraîchi contaminé) et des sources inactives (femelles vierges et accouplées ainsi que du blé frais).

Les mâles vierges attirent beaucoup les charançons vierges et accouplés des deux sexes. L'attirance des mâles accouplés n'a été observée que dans de rares cas. Les femelles vierges sont les seules à être attirées par ces mâles déjà accouplés. Dès lors, le seuil phéromonal nécessaire pour provoquer une réaction chez la femelle vierge doit être très bas. L'attirance du blé contaminé défraîchi dépend fortement des conditions physiologiques de perception des charançons et de l'alternative donnée.

L'utilisation de pièges à phéromones dans l'élimination de *Sitophilus granarius* semble prometteuse parce que les mâles, accouplés ou non, ainsi que les femelles, sont fortement attirés par la phéromone d'agrégation.