## Behaviour of the Khapra Beetle *Trogoderma granarium* Towards the Assembling Scent Released by the Female

Olfactory responses of *Trogoderma granarium* Everts (*Dermestidae*) were first observed by VOELKEL[1] in 1924. More recently BAR ILAN et al.[2] recorded that virgin females of this species release a scent capable of attracting Khapra beetles of both sexes. Therefore we have classified it as an assembling scent, though its attractivity for unmated males is definitely higher than for virgin females[3,4]. The composition of the scents of *T. granarium*[5] and of the closely related *T. inclusum*[6] has been reported in part. The scent was shown to have a number of functions resulting in aggregation of *T. granarium* on rough surfaces. The latter will eventually elevate the concentration of assembling scent and therefore increase the influx of Khapra beetles to the assembly.

We have investigated the orientation of individual, male and female Khapra beetles in more and less steep gradients of assembling scent volatilized from living females at constant temperature (30 °C). Our studies revealed the following results:

1. In neutral air, beetles of either sex walk, changing course from time to time, without attempting to survey the area in any systematic manner. Antennal sense organs inform the beetles sooner or later – according to steepness of gradient – on assembling scent drifting into the neutral air. The insects will then orient against the direction of the scented air current and proceed by a more or less curved path towards the scent source. Thus they appear to adapt to gradually increasing concentrations of the scent.

2. When approaching the origin of the scent, unmated males often change the position of their antennae and walk in a zigzag pattern. Their 'search' becomes then progressively restricted to a smaller and smaller area (Figure 1). At maximal scent concentration, male beetles move rather rapidly (Figure 2), rise their body frequently and vibrate the antennae. Finally they touch several times the female beetle with antennae and palpi, extend the aedeagus and start to copulate. It is noteworthy that sight does not play any appreciable role in locating the female.

Male beetles are merely retained in air containing assembling scent, the time of their retention being dependent on the attractant concentration (Figure 3). In the scented air, they attempt copulation even with dead females from which the scent has been removed by previous extraction with ether. After approximately 20 matings, male beetles cease to react to the female scent, whereas unmated males remain responsive to it throughout life.

3. Female Khapra beetles are in general more sessile and less sensitive to the assembling scent than males. Accordingly, their response to the attractant is slower and the retention time is briefer than that of males. Yet upon approaching the scent source, virgin females display moderate antennal vibration, while at maximal scent concentration they contract and relax their abdomen from time to time and come to temporary standstill. In presence of a female beetle (or the cuticle of its last larval instar), the above stops become extended to prolonged immobilization resulting from supporting tactile responses. It is rather interesting that the interaction between tactile and olfactory stimuli is synergistic in enhancing the retention of female Khapra beetles (Table). After mating of female beetles, their olfactory responses decline considerably.

4. The scent emitted by a single female is located usually within 3.0 min by males and 7.0 min by females. The average retention times are 2.5 min for males and

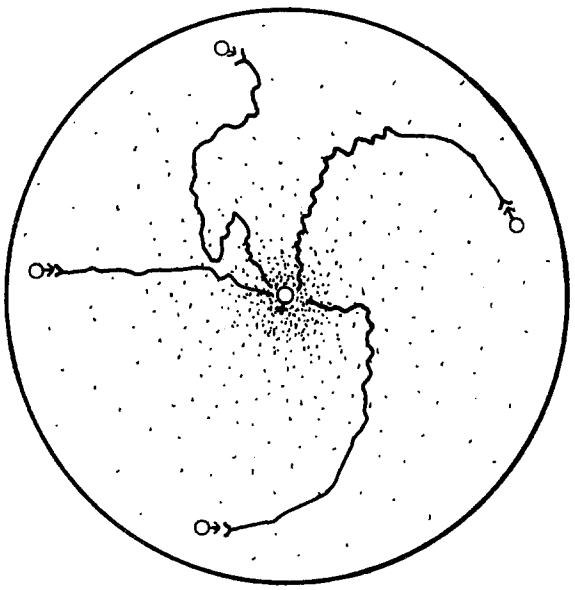

Fig. 1. Mode of attraction of male Khapra beetles to the scent emitted by virgin females. The scent is carried through a chimney to the centre of a circular paper arena (radius, 30 mm). The direction of beetles approaching the former appears to be controlled by scent microcurrents. The tracks shown cover periods of 9–36 sec.

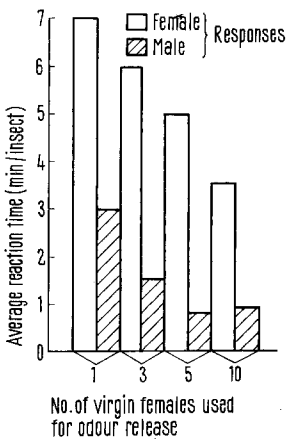


Fig. 2. Velocities of attraction of unmated male and female *Trogoderma granarium* to graded levels of assembling scent. Each bar in Figures 2 and 3 represents 20 individual insects.

[1] H. VOELKEL, Arb. biol. Reichsanst., Berlin *13*, 129 (1924).
[2] A. BAR ILAN (FINGER), V. STANIC and A. SHULOV, Riv. Parassit. *26*, 27 (1965).
[3] H. Z. LEVINSON and A. R. BAR ILAN, Riv. Parassit. *28*, 27 (1967).
[4] H. Z. LEVINSON and A. R. BAR ILAN, J. Insect Physiol., *16*, 561 (1970).
[5] R. IKAN, E. D. BERGMANN, U. YINON and A. SHULOV, Nature *223*, 317 (1969).
[6] J. O. RODIN, R. M. SILVERSTEIN, W. E. BURKHOLDER and J. E. GORMAN, Science *165*, 904 (1969).

0.3 min for females. It can be seen from Figures 2 and 3 that both velocity of attraction and duration of retention of males as well as females depend in fact on the number of females releasing assembling scent. A filter of 25 mm³ active charcoal placed between the scent source and the path of insects will readily abolish their attraction. Ether extraction of virgin females yields a relatively effective scent solution, of which an aliquot of $2.5 \times 10^{-3}$ female equivalent still attracts 60% of exposed males.

5. Interestingly enough, male *Trogoderma granarium* were found to be attracted also by the scent of female *T.*

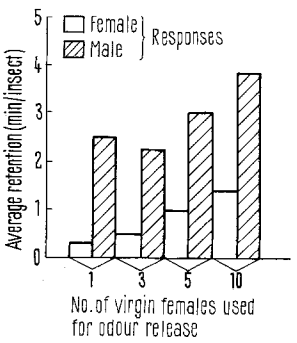


Fig. 3. Retention time of unmated male and female *Trogoderma granarium* in air containing graded concentrations of assembling scent.

Synergistic interaction between olfaction and thigmotaxis upon female *Trogoderma granarium*

| Type of stimulation | Synonym | Attracted females (%)[a] | Average retention time (min/insect)[a] |
|---|---|---|---|
| Olfactory, assembling scent of 1 virgin female | o | 60 | 0.3 |
| Tactile, 1 dummy offered[b] | t | 20 | 0.2 |
| Combined stimuli | o+t | 75 | 3.4 |

[a] 60 Virgin females, 2 days after emergence, were tested individually in a circular and uniform arena at 30°C.
[b] A single cork dummy mimicing the female shape was placed in the centre of the arena.

*inclusum* or *T. glabrum*, but not by those of *Anthrenus vorax, Attagenus megatoma* or *Dermestes maculatus* belonging to the same family[4]. Moreover, male *T. grassmani, T. simplex, T. glabrum, T. sternale* and *T. parabile* respond as well to the scent of female *T. inclusum*[6]. Hence the action of *Trogoderma* scents appears to be genus-specific, and the isolation of the above species must depend on mechanisms other than olfaction. It should be recalled that crossmatings among the species of *Trogoderma* do not produce viable offspring[7]. It is noteworthy that we were unable to demonstrate the release of any intraspecific attractant by male *T. granarium*.

It may be concluded that the assembling scent of the female Khapra beetle guides the population to the site of reproduction and serves as an efficient support for survival of the species. The scent acts both as hetero- and homosexual attractant as well as arrestant, to which male and female beetles respond with differential sensitivity. Moreover, its sex attractant function for unmated males[3,8,9] is accompanied by a marked aphrodisiac effect on the latter and the assembling of females due to scent action is strongly synergized by contact stimulation[10]

*Zusammenfassung.* Es wird nachgewiesen, dass der Duft virginer Käfer der Gattung *Trogoderma granarium* als hetero- und homosexuelles Attraktans, als Arrestans sowie bei den Männchen als Aphrodisiacum wirkt. Die Weibchen werden weniger stark angelockt und überdies wirken taktile Stimuli synergistisch zum olfaktorischen Stimulus. Lockstoffe verschiedener *Trogoderma*-Arten werden nur von weiblichen und nicht von männlichen Käfern abgegeben und sind höchstwahrscheinlich gattungsspezifisch.

H. Z. Levinson and A. R. Bar Ilan

*Laboratory of Insect Physiology,*
*Department of Organic Chemistry,*
*University of Jerusalem (Israel), 28 January 1970.*

[7] R. S. Beal and G. H. Spitler, Proc. Entomol. Soc., Washington *61*, 1 (1959). – R. G. Strong and R. G. Arndt, J. Econ. Entomol. *55*, 445 (1962).
[8] U. Yinon and A. Shulov, J. Stored Prod. Res. *3*, 251 (1967).
[9] C. Adeesan, G. W. Rahalkar and A. J. Tamhankar, Entomologia exp. appl. *12*, 229 (1969).
[10] Thanks are due to Prof. W. E. Burkholder, University fo Wisconsin, for providing extracts of some Dermestidae and to Pest Infestation Laboratory, Slough, Bucks., for supplies of most of the species used in this study.

## Red Blood Cell Electrolytes in Essential Hypertension

Many investigations of the sodium ion metabolism have attempted to elucidate the role of this cation in the control of blood pressure and in the pathogenesis of arterial hypertension. As the ionic composition of the extracellular fluid in hypertension is normal, studies have also included the intracellular compartment. Increased concentrations of sodium have been found in various tissues, both in human[1] and in experimental hypertension[2]. It has also been suggested that a high sodium content of vascular smooth muscles is responsible for the increased tone of the arteries by rendering them more sensitive to vasoactive pressor-amines[3].

Although the red blood cells represent only a small fraction of the intracellular space, endowed with a rather specialized function, they are easily available and therefore their composition has been studied in a great variety of diseases. The electrolyte content of the red blood cells in hypertension has not been examined extensively. Recently, Losse et al.[4] reported high sodium and potassium concentrations in the erythrocytes in hypertensive patients, and also in normotensive subjects with a family history of hypertension[5]. Furthermore, they have found the influx of $Na^{24}$ into the erythrocytes to be increased in these groups[6]. They regard this as evidence of an