Sexual behavior of mutant strains of the medfly
_Ceratitis capitata_ (Diptera: Tephritidae)

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Abstract: Males of the mutant strains (blind, vestigal-winged) of the Mediterranean fruit fly (medfly), _Ceratitis capitata_ (Wiedmann) showed differences in behavior compared with control (mass-reared) males. Mutant males made fewer mating attempts and achieved fewer matings than control males. Vestigal-winged females copulated less frequently with both mutants. Blind males climbed rather than jumped onto females and copulated in very low numbers compared with control and vestigal males. Blind females copulated normally with control, males and in very low numbers with both types of mutant males.

Key words: Courtship behavior, medfly, _Ceratitis capitata_, mutants.

Males of the Mediterranean fruit fly, _Ceratitis capitata_, produce an array of stimuli that the female can detect before accepting or rejecting the male. Courtship begins with the release of pheromones and continuous wing vibration, followed by intermittent wing buzzing (possibly combined with the release of pheromones) and head rocking that causes the male’s aristae to tap those of the female (Briceño and Eberhard 2000); these can be display several dimorphic characters of the male, which include eye and face colors, and the capitate bristles (Feron 1962, Webb _et al._ 1983, Briceño _et al._ 1996, Mendez _et al._ 1998).

The stimuli involved in the courtship behavior of _Ceratitis capitata_ that induce acceptance by the female are only poorly understood (Eberhard 1999). There is only fragmentary experimental evidence addressing intraspecific visual, acoustic and chemical communication. When male wings were removed, the percentage of females inseminated after three days dropped by about half (Keiser _et al._ 1973). Mating was inhibited almost totally when both antennae were removed from female medflies (Nakagawa _et al._ 1973) but this could alter visual, auditory and chemical stimulation of the female. Removal of female aristae resulted in less frequent mounting and copulation (Miranda 2000). The aristae are associated with movement and sound reception (Wigglesworth 1965, Bennet-Clark 1971, Ewing 1989) and probably also tactile stimuli (Briceño and Eberhard 2002). Visual communication was modified by genetic alteration of male eye color (with the apricot gene) which resulted in reduced male mating success (Rössler 1980). Elimination of all visual stimuli by keeping flies in darkness reduced insemination rates by a factor of more than 10 (Keiser _et al._ 1973) but the possible roles of males and females in this reduction were not checked. When the capitate anterior orbital bristles of males flies were removed, presumably modifying the visual stimuli received by the female, the female was more likely to attack males and avoid mounting (Mendez _et al._ 1998).
The study of mutations that affect phenotypic traits can be useful in understanding animal behavior (Hall 1994), and studies using mutant flies in Tephritidae are lacking to date. The study of flies with point mutations that affect either emission or reception of signals promises to improve our understanding of cues which trigger different behavior patterns during courtship. This paper reports on the effects on sexual behavior of vestigal wings and blind mutations in *C. capitata*.

**MATERIALS AND METHODS**

The flies were from strains kept in the rearing facilities of the International Atomic Energy Agency in Seibersdorf, Austria. The collection and rearing of mutants from natural populations was begun more than 10 years ago (Röessler 1992).

The mutant strains used were derived from two recessive mutants in field material in Israel, and initially reared in the Cohen Institute for Biological Control (CMBI): white eye (we) located on chromosome 5 found in 1989, and vestigial wings (vg-wp) located on chromosome 4 found in 1990. The control flies were from the Egypt II strain (egII).

The adults were separated by sex 24 hours after emergence, and kept for 4-6 days prior to initiating the experiments in small plastic boxes (16 cm long x 19.5 high x 10.5 wide containing about 100 flies fed with hydrolyzed protein. In the first series of experiments, a pair of virgin flies was placed in a petri dish (13.7 cm diam., 1.8 cm deep). The petri dishes were placed on a glass plate that could be rotated, and the flies were observed from below under artificial illumination, at 24 ºC (10 pairs were observed simultaneously). The male of each pair was placed in the dish 5 min before the female. Observations were initiated at 9 AM and ended at 3 PM. A small microphone (Senheiser system MZK 802V) was inserted through a hole in the ceiling of the chamber to detect sound production.

Courtship, mounting and copulation behavior of all flies was noted. In the second series of experiments each petri dish contained one female and two males of different strains. Chi squared tests were used for statistical analyses.

**RESULTS**

Males of all strains raised the tip of the abdomen with the everted rectal epithelium in

<table>
<thead>
<tr>
<th>Cross</th>
<th>Female</th>
<th>Male</th>
<th>#mounts/</th>
<th>#copula/</th>
<th>% copulation</th>
<th>N (Pairs)</th>
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<tbody>
<tr>
<td></td>
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<td>#mounts/pairs</td>
<td>#mounts</td>
<td></td>
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</tr>
<tr>
<td>Vestigal</td>
<td>X Vestigal</td>
<td>17</td>
<td>5</td>
<td>0.81</td>
<td>0.29 g</td>
<td>23.8a</td>
</tr>
<tr>
<td></td>
<td>X Blind</td>
<td>0*</td>
<td>2</td>
<td>0</td>
<td>-</td>
<td>10.9b</td>
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<tr>
<td></td>
<td>X Control</td>
<td>31</td>
<td>31</td>
<td>0.97</td>
<td>1.00 g</td>
<td>96.9 a,b</td>
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<tr>
<td>Control</td>
<td>X Vestigal</td>
<td>39</td>
<td>1</td>
<td>1.77</td>
<td>0.026 h</td>
<td>4.5 c</td>
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<td></td>
<td>X Control</td>
<td>49</td>
<td>36</td>
<td>1.29</td>
<td>0.73 h</td>
<td>94.7 c,d</td>
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<tr>
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<td>X Vestigal</td>
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<tr>
<td></td>
<td>X Control</td>
<td>55</td>
<td>29</td>
<td>1.9</td>
<td>0.52</td>
<td>100 e,f</td>
</tr>
</tbody>
</table>

*: male climb the female

**TABLE 1**

Successful jumps and copulations when the female was confined with a single male.

Frequencies followed by the same letter are significantly different (p<0.00001 with x² test)
the pheromonal calling position (Feron 1962) and all except blind males turned toward females when they passed nearby. Vestigial-winged males did not, however, produce the sustained wing vibration produced by the other strains, although they did lower their abdomen and direct the tip anteriorly like the others. Vestigial-winged males also moved their relatively small wings forward and backward, as did control flies during the succeeding stage of normal courtship; there was intermittent wing buzzing but no sound accompanying these movements was detected by the microphone.

Blind individuals of both sexes did not show any response to other flies moving nearby and males did not “track” the female, as was common in the other strains. Blind males did perform continual wing vibration and intermittent wing buzzing, suggesting that these behaviors do not always need visual stimuli to be released. Head rocking behavior, which normally accompanies buzzing, was absent. Blind males never attempted to jump onto females (Table 1), but they did occasionally climb onto females. Blind females copulated in normal numbers with control males.

The two series of experiments (Table 1, 2) produced similar results, though significance levels were lower in the 2nd series, presumably due to small sample sizes. Both control and vestigial males mounted all three types of females more often than blind males, and vestigial males mounted fewer females than normal males (Table 1). Control males were more likely to mate after mounting than vestigial males.

**DISCUSSION**

The visual signals emitted by females (direction of movement, distance and angle with respect to a male) appear to activate and direct male courtship behavior (Briceño et al. 1996, Briceño and Eberhard 2000). The sharply reduced mounting and copulation rate of blind males may thus be due to lack of visual stimuli from the female. Although blind males sometimes courted, lack of proper...
orientation and timing, may reduce rates of 
female approach and acceptance. In 
*Drosophila* the white eye mutant and optomo-
tor blind males (omb) court in a mediocre man-
ner, largely the result of their poor visual 
responses are probably important in medfly 
courtship because they promote female orien-
tation and attraction to the nearly immobile 
male. The effect of lack of visual stimuli in the 
female is quite different. Blind females copu-
lated at the same rates with control males as 
did other females. Presumably other stimuli 
from those males (possibly chemical, auditory, 
tactile and air flow) compensated for the lack 
of visual stimuli perceived by these female.

Female preference for control males over 
vestigial males could have been due to any one 
of several differences in stimuli including 
visual, auditory and chemical (mutant males 
would be less able to waft odor toward the 
female).

The vestigial-wing mutation is thought to 
also reduce or abolish development of the tho-
racic muscles responsible for raising the wing 
(Rössler and Rosenthal 1988), and this may be 
the reason why the males of this strain did not 
perform sustained wing vibration, and why 
they did not produce sound.

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**RESUMEN**

Machos mutantes (ciegos, alas vestigiales) de la 
mosca del mediterráneo *Ceratitis capitata* (Wiedmann) 
mostraron diferencias en conducta comparados con los 
machos testigo (cria masiva). Los machos mutantes, 
realizaron menos intentos por aparearse y lograron menos 
apareamientos que los machos testigo. Las hembras con 
alas vestigiales, copularon menos con ambas clases de 
mutantes. Los machos ciegos, subieron en lugar de saltar 
sobre las hembras y copularon en números muy bajos 
comparados con los machos testigo y con los de alas ves-
tigiales. Las hembras ciegas, copularon de forma normal 
con los machos testigo y en números muy bajos con ambos 
tipos de machos mutantes.

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