SEX ATTRACTION IN THE HOUSE FLY, *MUSCA DOMESTICA* L.[1, 2]

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ABSTRACT

Attraction tests have shown that virgin female house flies attract both virgin males and females but the degree of attraction is relatively small. A tentative hypothesis of chemical sex attraction is suggested. The attraction does not appear to be due to moisture, motion, or sound effects.

INTRODUCTION

The development of insect strains resistant to various insecticides has created such serious problems that entomologists have had to consider concepts of insect control that are radically different from any previously devised. Control or eradication by sterilization of pest populations is one such concept that has proved to have considerable merit (Bushland, 1960). Basic research on insect behavior has led to the development of other possibilities, such as the use of insect attractants in combination with insecticides, pathogens, or chemosterilants to increase the efficiency of a control program. Green et al. (1960), Jacobson and Beroza (1963), and Beroza and Green (1963) have reviewed the recent advances in the field of insect attractants. Interest in sex attraction in particular has increased and considerable effort has been given to the discovery and identification of sex lures with the idea of utilizing them in the control of certain species. A discussion of insect sex pheromones is given in the paper by Karlson and Butenandt (1959).

Superficial observations on the mating behavior of the house fly give little indication that chemical attraction is of great importance in the sexual activity of this species. Males often attempt to mate with other males and will do so even in an environment free of females or a female scent (Murvosh et al., 1964). However, this behavior, in itself, does not disprove the existence of a chemical "sex attractant" or copulation stimulant. This paper represents a continuation of our previous studies on house fly mating behavior and gives the results of preliminary investigations in which evidence of the existence of a house fly sex attractant was found.

METHODS

The sex attraction experiments were performed in a large cage-type olfactometer (chemotactometer would be a more precise term, but is still not fully descriptive, since rheotaxis, sound, and motion may also affect the behavior of the test insects). The apparatus and procedure were similar to those used by Gouck et al. (1963) for testing mosquito attractants. Briefly, the unit consisted of an 18-mesh wire cage (6 ft x 3.5 ft x 6 ft) with aluminum frames. At one end of the cage, 2 ft from the top, there were two apertures, 3 in. in diameter, spaced 10 in. apart. Two glass cylinders (3 in. x 8 in.), each containing an inverted wire cone trap, were placed on a wood frame that moved so the glass traps would slide into position over the apertures in the cage. A 16-in. fan, at the opposite end of the cage, was used to draw a current of air through the glass traps and then across the cage. In order to achieve the air stream, it was necessary to seal the whole cage tightly with large plastic sheets, except for the glass trap area and fan sections of the cage. The test was designed to determine the percentage of "responder" flies in the cage

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that entered the glass traps containing the "attractor" flies. Preliminary tests showed that the entrance of responder flies in the traps was dependent upon the presence of both an air stream and attractor flies in the traps.

One hundred attractor flies were exposed in each glass trap; the cage contained 400 responder flies in experiments 1 and 2 and 500 in experiments 3 to 8. Usually, each experiment was replicated 3 times, but some were replicated 5 or 6 times. Each exposure lasted an hour. After each exposure, the glass traps were replaced with others that had been decontaminated in a detergent wash, fresh water rinse, and acetone rinse, and the positions of the traps were alternated to offset the effects of a favorable position. The light falling on the traps was measured with an exposure meter and balanced by moving a series of gooseneck lamps. One ml of water was injected into each trap on the glass surface at the start of each test to equalize any possible moisture effects. All flies were virgin at the time of testing. A supply of food and water was always present in the cage. The temperature and humidity of the test room could not be controlled.

RESULTS AND DISCUSSION

The results are given in table 1. Experiments 1 to 3 were designed to see whether mature virgin males were attracted to either virgin males or females;

TABLE 1

Number of virgin male or female house flies entering traps containing attractor virgin males or females of varying age

Experiment no.	No. of replicates	Responder group		Attractor group		Total no. trapped
		Number	Age	Number	Age	
1	3	400 males	7 days	100 females	7 days	68
				100 males	do.	2
2	3	400 males	8 days	100 females	8 days	43
				100 males	do.	5
3	3	500 males	2 days	100 females	2 days	23
				100 males	do.	3
4	3	500 males	3 days	100 females	1–7 hr	15
				100 males	do.	6
5	6	500 males	7 days	100 females	7 days	133
				do.	1–7 hr	15
6	3	500 males	8 days	100 females	8 days	44
				do.	1 day	9
7	3	500 males	8 days	100 females	8 days[a]	36
				do.	1 day[a]	9
8	5	500 females	7 days	100 females	7 days	165
				do.	1 day	78

[a]Killed.

the males were attracted to females, but not in meaningful numbers to males. Results of experiment 4 indicated the same effect; but very young attractor flies were used in this test, and the difference in attractiveness between males and females, although consistent in 3 replicates, was small, indicating that age had some bearing on the degree of attractiveness. In experiments 5, 6, and 7, the attractor flies consisted of 2 groups of females of different ages. The data from experiment 5 showed that mature males were attracted to older females (7 days old) but not to newly emerged females (1 to 7 hr old). Newly emerged flies, however, are not very active on the day of emergence and the greater activity of the older females may have influenced the responder males. However, this explanation seemed doubtful in view of the results of the two following experiments. The two attractor

groups of experiment 6 were 1 and 8 days old and no activity differential was apparent, but still the males continued to respond in greater numbers to the older females. So as to eliminate the possibility that motion and sound were controlling factors in some of these studies, the females in both traps in experiment 7 were killed by a 15-min exposure to ether before being tested. As in the other comparisons, the males in this experiment were more attracted to the older females.

Experiment 8, of a different nature, was set up to investigate the attraction of females by females. It was found that when females were used as responders, they were attracted to other females and more were attracted to old than to young females.

Exploratory experiments resulted in other observations which raised interesting questions. Male flies did not respond to females in two 30-min tests that were performed in a dark room. This behavior appeared unusual since house flies will mate in cages that are placed in a dark environment. In another preliminary test, it was found that nonvirgin males (taken from a cage of 5-day-old mixed males and females) attracted as many males as did nonvirgin females taken from the same cage. This behavior, if observed in repeated testing, would indicate that males can become contaminated with an attractive substance when caged with females.

Although the numbers of trapped responder males were relatively small (never higher than 7 per cent for a 1-hr period), the behavior of the flies was slightly more dramatic than the results indicated. For example, at the beginning of each exposure, the response of males to the attractor females was quite fast; some males always entered the trap within a few seconds. Also, there was always a concentration of responder males near the entrance of the most attractive trap even though many of those did not enter the trap. If the trap door was then closed, the distribution of the males became random.

The results of our tests, therefore, appear to justify the following generalizations:

1. The female house fly emits a chemical substance with a low order of attractiveness to both males and females. A tentative hypothesis of chemical sex attraction is suggested. The attraction of females to females requires further study, but it is to be noted that the female American cockroach *Periplaneta americana* (L.) responds to her own sex attractant (Boeckh et al., 1963).
2. The degree of attractiveness to some extent depends on the age of the attractor female.
3. Virgin males do not attract males.

The nature of the attractant is obscure, and some effects observed may have been due to sound, motion, and moisture. The importance of moisture in these attraction tests should not be minimized. Barnhart and Chadwick (1953) previously postulated the existence of an unknown substance termed "fly factor" in *Musca domestica*, i.e., food that was fed on by flies became more attractive to other flies. Dethier (1955) reported the presence of a similar substance in experiments with the black blow fly, *Phormia regina* (Meigen). Acree et al. (1959) showed, in a series of experiments, the increased attractiveness of sugar that had been fed on by house flies was probably due to an increase in the moisture content. In our experiments, the microclimate of the glass traps holding the older females may have differed from that in the traps containing the younger females with respect to moisture, because of different rates of metabolism in the two ages of flies. Whether the addition of water to the glass traps in our tests compensated for any moisture effects is not definitely known, but may be resolved in further experimentation testing homogenates of tissue suspected of producing the attractant.

Our studies support the results of Rogoff et al. (1964) who, a few months before we began our experiments, obtained evidence for the existence of a house fly sex attractant in tests using an ingenious device called the "pseudofly." A pseudofly is a knot of black thread about fly-size. Live males in petri dishes will

attempt copulatory strikes at it. Pseudoflies impregnated with benzene extracts of female flies stimulated more sexual leaps than those impregnated with solvent only or extracts of male flies.

Extension of these results to a field population is difficult. Our laboratory colony has been inbred in cages for 20 years and sex attraction, under these conditions, may have little selective value whereas natural selection for such a factor as a sex attractant may be more pronounced in a natural population. Tests with field-collected females could prove interesting. In general, however, attraction in house flies appears to play a minor role in bringing the sexes together, since they naturally congregate in areas of available food supply such as dairy barns, poultry houses, or garbage dumps.

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