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# COURTHSIP BEHAVIOUR IN THE ORIENTAL FRUIT FLY, *DACUS DORSALIS* UNDER SEMI - NATURAL CONDITIONS

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## Abstract

An investigation was carried out to study the distribution and courtship behaviour of the oriental fruit fly, *Dacus dorsalis* under semi-natural conditions using a potted citrus plant held inside a perspex cage. The principal site of assembly for mating in *Dacus dorsalis* on the plant was the under-surface of leaves. When the light intensity was reduced at the 'dusk' period, males aggregated mainly under the leaves and started calling. Majority of male calling, encounters and copulation attempts between flies occurred on the under-surface of leaves. Copulation was always initiated on the foliage and never on the 'fruit'. Females were less receptive to males just after mating. Probing with the ovipositor, which is thought to be an important part of the courtship sequence, was the most prominent female sexual behaviour observed.

Key words: *Dacus dorsalis,* courtship behaviour, encountres, copulation

## 1. Introduction

Mating has received more attention than any other aspect of fruit fly behaviour. Detailed studies of courtship behaviour have been reviewed for several species of Tephritidae including *Ceratitis capitata* (Prokopy & Hendriks, 1979), *Anastrepha fraterculus* (Malvasi et al, 1983), *Rhagoletis pomonella* (Prokopy et al, 1972), *Dacus tryoni* (Tyschen, 1977) and *Dacus cucurbitae* (Kuba et al, 1984). Despite a wide-range of studies such as these, published studies on mating behaviour of the oriental fruit fly based on observations are scant.

Sexual activity of most of the *Dacus* species is restricted to the late afternoon or dusk period (Bateman, 1976). Roan et al (1954) in their studies observed that *Dacus dorsalis* mated only during the dusk period. As dusk approached, the flies became highly active and the males produced a high-

buzzing sound which was followed by copulation. They produced this buzzing sound by vibrating their wings which were presumed to be male calling signals. During courtship, the males release a sex pheromone to which the females are strongly attracted (Shultz &Boush, 1971). According to Bateman (1972), mating activity of *Dacus dorsalis* in nature usually occurs on the foliage and not necessarily on the host plant.

Systematic observations were made to study the distribution and behavioural activities of male and female oriental fruit flies on a caged citrus plant during dusk period.

## 2. Materials and Methods

Experiments were carried out using virgin males together with virgin females and virgin males with recently mated females. The following observations were recorded during their mating period.

(i) Location of flies on various parts of the plant

(ii) Encounters between two flies

An encounter was defined as a meeting of flies inwhich there was discernible recognition by each fly of the other fly's presence as evidenced by the flies'visual attentiveness and movement (Prokopy et al, 1972). i. e. a fly moving towards the other fly and touching each other with their heads.

(iii) Copulation attempts among the flies

A copulation attempt was defined as the leap of a male on to another male or female.

(iv) Successful matings between males and females

A successful copulation was defined as the intromission of the aedeagus into the female opening and the coupled pair staying in the same position for more than one hour.

(v) Incidence of male calling (wing vibration)

(vi) Incidence of female ovipositor probing response

A potted cirtus plant (55cm high) was introduced into a perspex cage (50x50x75cm) with a screen top and sliding front windows. The plant had two main branches with a toal of thirty nine leaves. Two yellow-painted glass flasks (5cm diameter) were hung on each side of the plant, at a height of 30 cm to simulate the fruit. The cage with the citrus plant, was surrounded

by many potted plants and vines. The room was illuminated with atificial light with an intensity of 1500 lux between 6.00 and 17.00 hours and 15-18 lux between 17.00 and 18.30 hours (dusk period). The temperature in the room was maintained at 28±1$^0$C and the relative humidity at 70±10%.

The oriental fruit flies were reared in the laboratory by methods similar to those adopted by Tanaka (1969). Adult flies were maintained on a diet consisting of dry sugar and water supplemented with small quantities of yeast hydrolysate. Adults were sexed within the twenty four hours of emergence and kept in separate cages and rooms. 14-16 day old insects of both sex was used in the experiments. Where mated females were used, females which mated the day before the experiment were selected. Ten male and ten female flies were transferred on to the plant 6-8 hours before the onset of each experiment to allow them to adapt to the new conditions. Experiments were conducted between 17.00 and 18.30 hours under reduced light conditions. The distribution of flies was recorded by counting the number of flies on each part of the plant at 10-minute intervals. Two experiments were carried out with seven replicates each and seven or eight observations were made for each of the replicate. Since only one potted plant was used for the experiments, one replicate was made during each dusk period to prevent contamination. Other behavioural studies related to mating were recorded by counting all the activities that occurred during a 5-minute period with 5-minute intervals between each recording period.

## 3. Results

Table I depicts the aggregation of males and females on various parts of the plant. During the dusk period, the majority of both sexes were found

Talbe 1 Distribution of male and female Oriental fruit flies on the citrus plant at 'dusk' period

| Test | Sex (n=10) | Location of flies: Leaf | Fruit | Branches | F-value | Probability level |
|---|---|---|---|---|---|---|
| Virgin male with virgin female | Male | 17.29±2.5$^a$ | 0.57±0.28$^b$ | 1.0±0.53$^b$ | 59.23 | p<0.005 |
| | Female | 11.71±1.53$^a$ | 0.86±0.33$^b$ | 0.00$^b$ | 51.46 | p<0.005 |
| Virgin male with mated female | Male | 34.57±3.98$^a$ | 1.29±0.56$^b$ | 0.43±0.29$^b$ | 69.50 | p<0.005 |
| | Female | 10.43±1.76$^a$ | 4.00±0.69$^b$ | 0.00$^c$ | 22.01 | p<0.005 |

Mean values of seven replicates with eight observations pooled for each replicate; Means in the same row follwed by similar letters do not differ significantly (p=0.01, DMRT)

on the cage wall. Of the flies found on the plant, the highest number was observed on the leaves. More males were observed on the 'fruit' when they were caged with mated females than when they were caged with virgin females. Although no significant difference was found between numbers of virgin and mated females either on the upper or lower surfaces of the leaves, significantly more mated females than virgin females were found on the fruit (Table II). Both males and females (virgin and mated) preferred the lower surface of the leaves to the upper surface (Table III).

Table II The distribution of virgin and mated female Oriental fruit flies on the citrus plant at 'dusk' period

| Test | Location | | | |
|---|---|---|---|---|
| (n=10) | Upper leaf surface | Lower leaf surface | 'Fruit' | Branches |
| Virgin female | 3.14±0.59 | 8.57±7.02 | 0.86±0.33 | 0.00 |
| Mated female | 2.71±0.52 | 7.71±1.84 | 4.00±0.69 | 0.00 |
| t-value | 0.544 | 0.043 | 3.66 | - |
| Probability level | NS | NS | <0.01 | - |

NS-Not Significant (p>0.05)

Table III - Selection of leaf surface by male and female oriental fruit flies on the citrus plant at 'dusk' period

| Sex n=10 | Location | | | |
|---|---|---|---|---|
| | Upper surface | Lower surface | t-value | Probability |
| Virgin male | 1.86±0.63 | 15.43±2.38 | 6.31 | <0.005 |
| Virgin female | 3.14±0.59 | 8.57±7.02 | 4.60 | <0.005 |
| Virgin male | 2.14±0.59 | 32.43±3.67 | 9.89 | <0.005 |
| Mated female | 2.71±0.52 | 7.71±1.84 | 2.60 | <0.005 |

Mean values of seven replicates with observations pooled for each replicate

The first observable sign of mating activity exhibited by the flies was rapid movement (walking and flying) by males and females although this was less in females than in males. Encounters between the two sexes became more frequent with time. Gradually the males assumed a crouched position and vibrated their wings rapidly in short bursts (male calling). During calling, males usually remained in one location except for short walks or flights towards other flies on the same leaf or between leaves.

A receptive female arrived on a leaf where the male was calling and approached the male in short flights or walks. When the female came within a distance of about 2-3 cm, the male oriented towards her in a face to face stance. In this frontal orientation, flies commonly butted each other with their heads. Then the male leapt over the female's head and on to her abdomen. As soon as the male settled on the female's back, it tried to insert its aedeagus into the female opening while vibrating its wings rapidly. A receptive female remained stationary when the male settled on her back. Usually the mounting was done with minimum courtship. The females sometimes flew away before making any contact with a calling male.

After the insertion of the aedeagus into the female opening, the male released its middle and rear legs from the female's abdomen and attached them to the substratum. However the male held the female's abdomen with its forelegs until the copulation terminated. The mated pair moved to the under-side of leaves or a corner of the cage and stayed still for a few hours, often until day break. However, the act of copulation was not always simple as described. Males were often dislodged many times before they were accepted. A male sometimes appeared to touch the female's ovipositor with its proboscis. When a male encountered another male, it often attempted to mount the other. Occasionally, males were observed attempting to copulate with a mating pair and even remained on the mating pair for several minutes. Probing with the ovipositor was the most overt females sexual behaviour exhibited during their active period.

The majority of male-male encounters occurred on the under-side of the leaves in both experiments (Table IV). Encounters between males and virgin females on the lower side of the leaves were higher than those between males and mated females. Most of the encounters between males and mated females took place on the cage wall and the base. The number of virgin female-virgin female encounters on the under side of the leaves were higher than those between mated females. On the other hand, the number of encounters between virgin females on the fruit were low compared to those between mated females.

Table IV Distirbution pattern and outcome of encounters of male and female oriental fruit files on the citrus plant during 'dusk' period

| Test (n=20) | Location | Encounters | | | Copulation | | |
|---|---|---|---|---|---|---|---|
| | | | | | Attempts | | Success |
| | | Male and Male | Male and Female | Female and Female | Male and Male | Male and Female | Male and Female |
| Virgin males and virgin females | Upper leaf surface | 2 | 3 | 2 | 1 | 1 | 1 |
| | Lower leaf surface | 19 | 34 | 19 | 17 | 18 | 33 |
| | 'Fruit' | 1 | 0 | 2 | 1 | 0 | 0 |
| | Cage wall | 13 | 30 | 29 | 8 | 12 | 15 |
| virgin males and mated females | Upper leaf surface | 12 | 5 | 1 | 10 | 4 | 0 |
| | Lower leaf surface | 96 | 12 | 3 | 91 | 12 | 5 |
| | 'Fruit' | 2 | 4 | 9 | 1 | 2 | 0 |
| | Cage wall | 26 | 42 | 13 | 25 | 41 | 12 |

Combined data of all observations and replicates; Seven replicates with seven observations for each replicate.

In both experiments, most of the male to male copulation attempts were observed on the under surface of the leaves. Male to male copulation attempts were significantly higher when they were caged together with mated females than when they were with virgin females (Table V). Of all the copulation

Table V Activities of male and female oriental fruit flies on the citrus plant during the mating period

| Test (n=20) | Encounters | | | Copulation | | |
|---|---|---|---|---|---|---|
| | | | | Attempts | | Success |
| | Male and Male | Male and Female | Female and Female | Male and Male | Male and Female | Male and Female |
| Virgin males with virgin females | 5.0±0.61 | 9.57±1.0 | 7.43±0.68 | 3.86±0.55 | 4.43±0.81 | 7.0±0.31 |
| Virgin males with mated females | 19.43±4.64 | 9.0±1.21 | 3.71±0.67 | 18.14±4.4 | 8.43±0.9 | 2.43±0.48 |
| t-value | 3.08 | 0.35 | 3.84 | 3.19 | 3.1 | 7.49 |
| probability | 0.01 | NS | 0.01 | 0.01 | 0.01 | 0.005 |

Mean values of seven replicates; NS-Not Significant

attempts observed between males and virgin females, 59% occurred on the under side of the leaves, whereas only 20% of copulation attempts between males and mated females were observed on the under surfaces of the leaves. No mating attempts were recorded on the 'fruit' when males were caged with virgin females. The majority of successful copulations (67%) were observed on the under surfaces of leaves when the males were with virgin females. Copulation success between males and virgin females was significantly higher than between males and mated females (Table V). More males were observed 'calling' when they were caged with mated females than when they were caged with virgin females (Table VI). The majority of virgin female probing was

Table VI Male and female oriental fruit fly activities on the citrus plant during 'dusk' period

| Test | Activity | Location of activity | | | | |
|---|---|---|---|---|---|---|
| | | Upper leaf surface | Lower lear surface | 'Fruit' | Branches | Elsewhere |
| Virgin male and virgin female | Male calling | 5 | 94 | 2 | 5 | 48 |
| | ovipositor probing | 1 | 14 | 0 | 0 | 17 |
| Virgin male and mated female | male calling | 7 | 196 | 8 | 3 | 102 |
| | ovipositor probing | 0 | 4 | 21 | 0 | 16 |

Combined data of seven replicates; seven observations pooled to gether in each replication

observed on the underside of th e leaves while none was observed on the 'fruit'. Mated females probed with their ovipositors mainly on the 'fruit'.

## 4. Discussion

The results indicate that the principal site of assembly for mating in *Dacus dorsalis* is the underside of leaves. The underside of leaves may offer some advantage over other locations, for example predation may be lower and the insects are shielded from the direct sunlight.

One of the most characteristic sexual activities of the oriental fruit fly is wing vibration. Only males were noted to engage in this activity which is usually restricted to the dusk period. The wing fanning is thought to propel the pheromone towards the female. Also it is known to produce an auditory signal (Webb et al, 1984) which might be an important part of their courtship sequence.

During mating it was observed that the male exhibited two types of wing vibration. One type occurred before mounting accompanied by short rhythmic beats on the abdomen with the rear legs. The other type was observed as the male settled on the female's back. This involved longer periods of wing vibrations, often lasting for several seconds. It was the female which invariably flew towards the male rather than the male pursuing a female. The male usually stayed in the same position, normally on the underside of a leaf, and continued its wing vibration, probably releasing the pheromone.

Usually males succeeded in copulation at the first mounting but sometimes more than one attempt was needed for a successful mating. Some females were observed flying away without any contact while males were vibrating their wings. Furthermore, some females mated successfully with certain males while being unresponsive to others. This is similar to the behaviour observed in the melon fly, *D, cucurbitae* (Iwahashi et al, 1986). These observations suggest that each female may exert a 'choice'. Males moved about the tree frequently attempting copulation regardless of the sex. Attempted mounting between males may be due to the poor ability of males to discriminate between the sexes prior to contact (Morgante et al, 1983) or it might be that the males use copulation attempts as agonistic behaviour to defend their territory.

The majority of male calling, encounters and copulation attempts between flies occurred on the under-surfaces of the leaves. Copulation was usually more successful between males and virgin females than between males and mated females. Most of the matings with virgin females were initiated on the under side of leaves and never on the 'fruit'. Similarly it was reported that in *D. cucurbitae* (Kuba et al, 1984),*D. tryoni* (Tyschen, 1977) and *Anastrepha fraterculus* (Morgante et al, 1983) copulation is always initiated on the foliage but not on fruit.

The results show that female *D dorsalis* are less receptive to males just after mating. The mated females often tried to dislodge males that were trying to mate, by walking, flying and rapidly kicking the male. The increase of copulation attempts of males with mated females may be related to the frustrated attempts of males to copulate with unreceptive females. Christenson & Foote (1960) stated that in *D. dorsalis*, the males mate more frequently but females may mate at 4-5 day intervals and in between they are unreceptive to males. It has been suggested that a male factor might be transferred to the female during copulation and could be responsible for switching off female's

receptivity for sometime (Tzanakakis et al, 1968). It has also been suggested that a single mating normally ensures production of fertile eggs for life but more frequent mating appear to be required to sustain maximum fertility (Christenson and Foote, 1960).

The most prominent female sexual behaviour observed during mating was the probing of the plant (leaf, fruit etc.) with the ovipositor in a manner very similar to the normal ovipositional behaviour. It is believed that this probing behaviour is a sexual response in virgin females (Tyschen, 1977). During this period, females may by checking the presence of the male pheromone on the leaves with the receptors on their ovipositors, or when the virgin females detect the presence of the pheromone they may be probing with their ovipositors to indicate that they are receptive to the male. Probing of mated females on the fruit is probably related to ovipositional behaviour as there is a marked absence of probing by virgin females on the fruit. Therefore, it can be suggested that on the fruit, mated females use probings of their ovipositors to detect the fruit volatiles.

The ovipositor porbings of virgin females were observed only during dusk, while mated females probed fruit as well as the cage wall throughout the day. The restriction of female responsiveness to the dusk period is brought about by the interaction of light intensity and a circadian rhythm of responsiveness (Fletcher & Giannakakis, 1973). This may serve as an important function i.e. synchronizing maximum female responses with the period when the males are sexually active, releasing pheromone which is also during the dusk period.

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