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FLIGHT MUSCLE AND FLIGHT ACTIVITY OF MELON FLY, *BACTROCERA CUCURBITAE* (DIPTERA: TEPHRITIDAE)

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Abstract

The flight activity and flight muscle of the melon fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) were observed. The Tethered technique was used to observe the flight activity in this study. The flight activity, and wing and flight muscles were compared between male and female melon flies. The results indicate that the female was relatively better and strong flier than the male. The mean duration of the flight activity of the females was 13.90 min/hour and of the males was 7.12 min./hour. The mean length, width, volume of wings of the males were 6.07 mm, 2.67 mm and 10.99 mm^3, respectively. On the other hand, the mean length, width and volume of the wings of females were 7.07 mm, 2.87 mm and 15.60 mm^3, respectively. In case of wing muscles, the mean volume of dorsal longitudinal muscle (DLM) in male and female was found 5.20 mm^3 and 5.67 mm^3, respectively. The mean length of flight wing muscle of male and female was 2.22 and 2.23 mm, respectively and the mean breadth of male and female was 1.65 and 1.77 mm, respectively.

Introduction

The melon fly, *Bactrocera cucurbitae* (Coquillett) is a fruit fly of the family Tephritidae under the order Diptera. It is broadly distributed throughout the temperate, tropical and subtropical regions of the world(1). The melon fly is well distributed over India and throughout most of southeastern Asia. India is considered as the native home of the flies. It was introduced into the Hawaiian Islands from Japan in 1895(2). It has more than 81 host species and the species can cause 30 to 100% losses of fruits(3). They are major pests of beans, bitter melon, winter melon, cucumber, eggplant, melon, pumpkin and other cucurbit plants. They cause extensive damage to many fruits and vegetables of cucurbitaceae. They attack on bitter melon, reduce the yield, and affect the quality of bitter melon. Therefore, the marketability of the crop is reduced and the infestation turns serious losses in trade value and export opportunity(4).

Flight consumes a large amount of energy that increases the metabolic rate from 50 to 100-fold above the usual state in the animal kingdom(5). The flight behavior of invasive

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insects is particularly important not only for their survival, but also for expanding the scope of their life. To control their risk of dispersal of many areas and many plants their flight capacity needs to know. Flight is prerequisite for long distance migration[6]. Every year many insects are found to engage in long-distance, seasonal mass migrations that have major influence in agriculture, ecosystem services and insect-vectored diseases[7].

In Diptera, flight muscles are attached to the thorax, making it oscillate and indirectly causing the wings to beat [8]. Indirect flight muscles are found in more advanced in the insects [9]. Many researchers have worked on the flight capacity of *Bactrocera* sp. and showed that they have strong flight and dispersal capacity, which helps them to spread the infection in the fruits and vegetables throughout the world [10]. Most of the researches have done with the *B. dorsalis*.

According to Sharp *et al.* (1975), wing beat increases to a maximum for *B. cucurbitae* at 9 days of adult stage[11].

A Tethered Flight Mill system is commonly used to test insect flight behavior. According to Cooter and Armes (1993), three Tethering techniques are traditionally used to monitor flight performance in insects[12]. By the flight mill system, a number of insects, such as the Asian gypsy moth (*Lymantria dispar*), the rice leaf folder (*Cnaphalocrocis medinalis*), the oriental migratory locust (*Locusta migratoria manilensis*), potato beetles (*Leptinotarsa decemlineata*) and the white-backed plant hopper (*Sogatella furcifera*), are investigated regarding their flight capacity[13-16].Therefore, the aim of this study was to understand the flight capacity of *B. cucurbitae*, we tested and compared the flight muscle and duration of the flight movement of both the adult male and female melon flies.

Materials and methods

The research work was conducted in the Entomology Laboratory, Department of Zoology, University of Dhaka at room temperature (30 ± 5°C) and 75% humidity.

The initial culture of *B. cucurbitae* was collected from infested bitter melon which were bought from the Kawran Bazar, Dhaka. The infested bitter melons were kept in a large bowl on a layer of wooden crush in the laboratory to facilitate pupation. The bowl was covered with a piece of cloth in order to give the larvae a dark and cooler environment. After 3 - 4 days, the wooden crush was sieved and newly formed pupae were collected. The pupae were kept in a 10 cm petri dish which was placed inside a rearing cage. The rearing cage had wire (synthetic) mesh in all sides except the wooden board on the bottom (45cm×45cm). There was a round opening at one side of the net that was covered by mosquito netting through which the adult flies were taken out for experimental purpose. After 7-8 days, the adult flies emerged from the pupae. Sugar solution was provided as food for the adult flies and the solution was served in a conical flask kept inside the cage. After 3-4 days of their emergence, the flies were used for experiments.

Observation of flight activity: The flight activity of *B. cucurbitae* was observed following the Tethered Flight Technique which is a very reliable technique for observing flight activity of flying insects[12]. A table fan of about 1200 RPM (rounds per minute) and a table lamp were used as stimulators to the flies for flight.

To observe the flight activity of the adult flies, 10 male and 10 female adult flies of 3 to 4 days old ages were collected. Each fly was kept at 4ºC in a refrigerator for about 3 - 4 minutes and then the thorax of each fly was glued to a long stick in order that the fly could flap its wings, but could not fly away. After that, the stick was attached to a wooden stand, which had four holes. The wooden stand was kept one meter away from a table fan and a table lamp was kept over the wooden stand. With the help of foam (filled in the holes of wooden stand), the stick was affixed to the wooden stand when the fly became conscious (i.e., gained its sense) and tried to fly. The table fan was started with low speed and the light was switched on. The fan provided wind to the fly and the lamp provided light so that it could realize it as a flying environment. The flight movement of the flies was observed for an hour and a stopwatch was used to observe the duration of flight activity. The length and width of the wings of the flies were also noted. Then, the flies were detached from the stick and kept in 70% alcohol in a glass vial for the observation of their flight muscles.

Observation of flight muscle: The flies were dissected and observed the flight muscle. The thoracic Dorsal-Longitudinal Muscle (DLM) was carefully observed under a stereomicroscope (under 10x magnification) and a picture was taken. The length and breadth of the flight muscle were measured by using 'ImageJ' software. Here, 1mm was set as scale and after 'analysis' the length and breadth were measured.

The formula of volume of a cylinder was used to calculate the volume of flight muscle of the melon fly, and the formula of volume of a cone was used to calculate the volume of wing of the melon fly.

The volume of flight muscle of the melon fly was observed by the following formula:

$$V= \pi r^2 h$$

Here, π= 3.1416, r= Half of breadth of wing muscle, h = Length of wing muscle

Volume of wing of melon fly was observed by the following formula:

$$V= 1/3\pi r^2 h$$

Here, V= volume, π = 3.1416, r = radius (half of breadth of wing), h= height (length of wing)

Results and Discussion

Dorsal longitudinal muscle (DLM) and flight activity of *B. cucurbitae* were evaluated.

Observation of flight activity of the melon fly: The mean time taken during the flight activity of male was 7.12 ± 3.30 min. and of female was 13.90 ± 3.95 min. It showed that

duration of flight activity of the female was more than that of the male. The flight activity significantly ($p > 0.05$) varied between male and female melon fly (Table 1). According to Liu *et al.*[4] and Chen *et al.*[13], *B. dorsalis* showed many flight episodes during its long-distance flight. Sharp *et al.*[11] reported that the maximum distances that individual males of *B. cucurbitae* (8 days old) covering in flight were 9845 m at flight speeds of 96.7% of the time, whereas the maximum distances that individual females (8 days old) flown, were 13,000 m at flight speeds of 98.5% of time. Present study showed that the flies could do long distance flight ability.

Table 1. Flight activity of male and female melon flies.

Observation no (n)	Mean ± SE (min)	
	Male	Female
10	7.12 ± 3.30*	13.90 ± 3.95*

*Significant at $p = 0.05$.

In addition, these tested melon flies belonged to laboratory-reared colonies. Normally, *Bactrocera* flies of the wild colonies could travel better than the artificial rearing[17].

Observation of wings of melon fly: The flight activity was conducted with the wings of melon fly. The mean volume of wing in male and female flies was found 10.99 ± 0.86 mm^3 and 15.60 ± 1.06 mm^3, respectively. As the flight activity, the wing volume of female was larger than male melon fly. The volume of wing varied significantly ($p < 0.05$) between male and female melon fly (Table 2).

Table 2. Length, width and volume of wing of male and female melon flies.

Observation no (n)	Observation name	Mean ± SE	
		Male	Female
10	Wing length (mm)	6.07 ± 0.11	7.07 ± 0.21
	Wing width (mm)	2.67 ± 0.093	2.87 ± 0.091
	Volume of wing (mm^3)	10.99 ± 0.86*	15.60 ± 1.06*

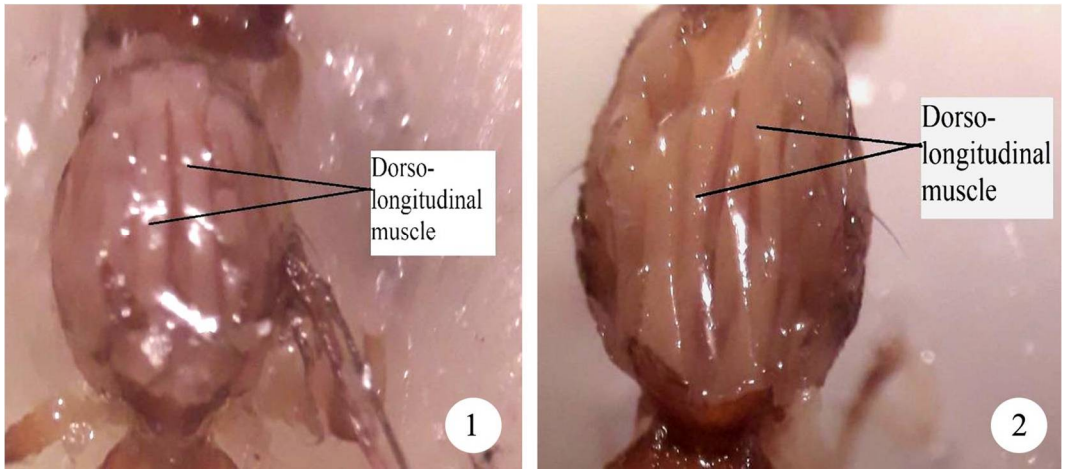
*Significant at $p = 0.05$.

The mean length of male and female wing was 6.07 ± 0.11 mm and 7.07 ± 0.21 mm, respectively. It showed that, the wings of females were larger than the males. The female flies fly longer than the males. The width of wing of male and female was 2.67 ± 0.093 mm and 2.9 ± .091 mm, respectively (Table 2).

In general, females are bigger than males in tephritid flies[18]. As expected, wing sizes of females were larger than males in the *B. cucurbitae*. Based on flight mill experiment,

Sharp *et al.*[11] found that *B. cucurbitae* females were better fliers and their flight abilities were varying with adult day ages[11].

Observation of flight muscle: The wing is the most important organ for the insects that can fly. Beside wings, flight muscles are also important organ for the flight capacity. In this study, the flight muscle of the flies was observed to understand their flight capacity. The main flight muscle, DLM was observed (Figs 1-2) and the measurements were taken with the aid of an 'ImageJ' software. The mean volume of flight muscle of male was 5.20 ± 0.49 mm³ and of female was 5.67 ± 0.43 mm³ (Table 3). It showed that the volume of the muscle of female was quite larger than the male melon fly.



Figs 1-2: 1. Flight muscle of male *B. cucurbitae.* 2. Flight muscle of female *B. cucurbitae.*

Table 3. Flight muscle of male and female melon flies.

Observation no (n)	Observation name	Mean ± SE	
		Male	Female
10	Muscle length (mm)	2.22 ± 0.073	2.23 ± 0.057
	Muscle breadth (mm)	1.65 ± 0.069	1.77 ± 0.055
	Volume of muscle (mm³)	5.20 ± 0.493	5.67 ± 0.0.432

The volume of muscle of wing did not vary in male and female melon fly ($p > 0.05$). The mean length and breadth of the wing muscles of melon flies measured were 2.22 ± 0.07 mm and 1.65 ± 0.07 mm, respectively for male and 2.23 ± 0.06 mm and 1.77 ± 0.06 mm, respectively for female (Table 3). The muscle of the female was relatively larger than the male. As the flight muscle of females found quite stronger and larger than the males

during the experiment, it can be said that, these criteria allow the female to fly longer than the male.

Melon fly, *B. cucurbitae* is a serious pest of cucurbit plants and vegetables in our country. To control their risk of dispersal in many areas and in many plants, their flight capacity needs to be controlled. In this study it has been revealed that the females had relatively larger length, breadth and volume of wing muscle than the males. It also showed that females have higher flight capacity than the males and the females were stronger flier than the males.

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