Agricultural Sciences Journal
Available online at http://asj.mnsuam.edu.pk/index.php
ISSN 2707-9716 Print
ISSN 2707-9724 Online
https://doi.org/10.56520/asj.v6i1.318

Research Article

LIFE HISTORY PARAMETERS OF MELON FRUIT FLY, *BACTROCERA CUCURBITAE* (COQUILLETT) (DIPTERA: TEPHRITIDAE) ON FOUR ECONOMICALLY IMPORTANT VEGETABLES

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Abstract

The majority of plant species that are used for consumption and medicinal purposes belongs to Cucurbitaceae. These vegetables are attacked by several insect pests including Tephritid flies. Keeping in view, four economically important cucurbit vegetables such as sponge gourd; *Luffa aegyptiaca*, bitter gourd; *Momordica charantia*, musk melon; *Cucumis melo*, and bottle gourd; *Lagenaria siceraria* were selected to investigate the life-history parameters of *Bactrocera cucurbitae* (Coq.) (Diptera: Tephritidae) under laboratory conditions. For this purpose, *B. cucurbitae* was reared in the laboratory on each host vegetable and egg hatchability %, egg incubation period, larval survival (%), duration (days), length and width of larvae, pupal parameters, male-female ratio, and age-specific fecundity were recorded. The results showed no statistical difference in hatchability percentages, larval duration, and pupal survival (%) in all tested vegetables. However, greater length and width of larvae were recorded when the *B. cucurbitae* larvae were provided with bottle gourd. Moreover, maximum pupal recovery was recorded in bottle and sponge gourd among all the tested vegetables. Maximum females were also recorded in bottle gourd. Adult longevity and fecundity were significantly affected by the host. Maximum female longevity (52 days) was recorded when *B. cucurbitae* were provided with bottle gourd and minimum (41 days) on sponge gourd. Similarly, maximum fecundity (823 eggs) was also recorded when maggots were fed on bottle gourd and the lowest (611 eggs) on a sponge gourd. In conclusion, Bottle gourd is the most preferable and nutritious host among all the tested vegetables and needs effective management strategies for *B. cucurbitae*. The output of the present studies would be helpful for the development of an effective integrated pest management (IPM) program for *B. cucurbitae* in a variety of vegetables.

Keywords: *Melon fruit fly; vegetables; biology; longevity; fecundity; IPM.*
(Received: 18-Feb-2024 Accepted: 29-Apr-2024) Cite as: Khuhro. N. H., Abubakar. M., Pirzado. Q. B., Soomro. Q. A., Kubar. M. I., Asif. M. U., Memon. R. M., 2024 life history parameters of melon fruit fly, *Bactrocera Cucurbitae* (Coquillett) (Diptera: Tephritidae) on four economically important vegetables. Agric. Sci. J. 6(1): 49-57.

1. INTRODUCTION

The melon fruit fly, *Bactrocera cucurbitae* (Diptera: Tephritidae) is a serious agricultural pest (Jaleel et al., 2018c; Laskar and Chatterjee, 2010). The adult melon fly is 6 to 8 mm in length and the eggs are elliptical, about 2 mm long, and pure white (Weems et al., 2001). The larva is a cylindrical-maggot shape, elongated, with the anterior-end narrowed a somewhat curved ventrally (Hassan, 2015). The pupae range in color from dull red or brownish yellow to dull white (Njuguna, 2022). The female lays eggs in young fruits, vegetables, and succulent stems of vegetables. The eggs are deposited in cavities created by the female using its sharp ovipositor. Pupation usually occurs in soil. There may be as many as 8 to 10 generations in a year (Weems et al., 2001). In hot weather, they rest on the undersides of leaves and in shady areas (Inskeep et al., 2021). They are strong fliers and usually fly in the mornings and afternoons (Manoukis and Gayle, 2016). *B. cucurbitae* is a polyphagous pest that infests as many as 125 plant species most of which belong to Cucurbitaceae and Solanaceae (Alim et al., 2012; Saeed et al., 2022). It can attack flowers, stems, root tissue, and fruit (Oke, 2008). It is native to India and is distributed throughout the world. In United States, it was the first tephritid fruit fly species established in Hawaii and became a serious pest.

The incident of several flies has been occurred in August 2010, in Kern County, California. It has been reported as pests from Asia, Africa, Australia, and South America (Dhillon et al., 2005a). It has been reported by Naqvi (2005) that 10 to 30 % losses of annual agricultural yield of the nation were caused by fruit flies.

The knowledge of the biology of an insect pest on various hosts can provide us with valuable information about the population dynamics and fitness cost of the insect (Cherif et al., 2019). Previously, the biology of various *Bactrocera* species has been studied by many researchers (Abubakar et al., 2021; Jaleel et al., 2018a; Jaleel et al., 2018b; Jaleel et al., 2018c). The ability of fruit flies to acclimate and survive on a variety of plant hosts has clear consequences for agricultural production and pest-management programs (Balagawi et al., 2023). The infestation ability and fitness of fruit flies can be understood by knowing how different plant hosts impact on longevity, fecundity, and other biological parameters of fruit flies (Balagawi, 2006). Through this knowledge, well-organized and effective IPM strategies for a specific host-crop system may be devised using sustainable methods to reduce financial losses.

Different management strategies are used worldwide to lessen the negative impacts of B. cucurbitae on cucurbit crops (Khan et al., 2020). These approaches consist of chemical, biological, cultural, and physical control methods (Dhillon et al., 2005a; He et al., 2023; Jaleel et al., 2018a; Oke, 2008; Vargas et al., 2012; Vargas et al., 2015). Furthermore, understanding the biology of *B. cucurbitae* on various economically important plants can make it easier for us to manage this notorious pest by devising more targeted IPM plans. Therefore, the purpose of this work is to investigate how different hosts affect the biology of *B. cucurbitae* while highlighting the value of fitness studies in comprehending the ecological and agricultural effects of this economically significant pest.

2. MATERIALS AND METHODS

2.1. Insect colony and hosts

The effect of different hosts on the biology of *B. cucurbitae* was determined at Fruit Fly and their parasitoids laboratory of Plant Protection Division, Nuclear Institute of Agriculture, (NIA) Tandojam, Hyderabad, Sindh, Pakistan. Experimental *B. cucurbitae* were already reared in this laboratory from 2005 and were maintained in cages (3 x 2 x 3 ft). Adults had access to sugar, protein hydrolysate, and water-soaked cotton. A larval diet (mixture of wheat bran (70 g), yeast (2 g), and sugar (20 g) in water (140 ml) in an iron tray (12 x 8 x 3 inches) was kept in a cage for egg laying. After one day larval diet was removed from the adult cage and these larval trays were kept in the iron larval chamber (4 x 2.5 x 1 ft) bottom filled with sawdust (1 inch) for pupal medium. After pupation, these pupae were collected and sieved from pupal medium and kept in an adult cage for the next generation. For the experiment, four different vegetables: sponge gourd, bitter gourd, musk melon, and bottle gourd were offered to evaluate their effect on the biological parameters of *B. cucurbitae*. The vegetables used in the experiment were purchased from the Tandojam vegetable market. The whole experiment was conducted at 27 ± 2°C, 65 ± 5% RH, and a photoperiod L:D of 14 h: 10 h. The laboratory environment was maintained by using electric light bulbs, air conditioners (in summer), and heaters (in winter).

2.2. Effect of different hosts on pre-imaginal growth of *B. cucurbitae*

To investigate the pre-imaginal period of *B. cucurbitae*, freshly emerged larvae were transferred with the help of a fine hair brush to different hosts. Each larva was provided with 10g of each tested vegetable. Larval period till pupation was recorded. Freshly pupated 50 pupae fed on each experimental host (sponge gourd; *Luffa aegyptiaca*, bitter gourd; *Momordica charantia*, musk melon; *Cucumis melo*, and bottle gourd; *Lagenaria siceraria*) were kept in small tubes (1 cm in diameter and 5 cm long) to observe the pupal period of *B. cucurbitae.* Observation on the larval period, larval length (3rd instar), pupal period, pupal weight, and pupal length were taken. For larval duration and larval length, 40 larvae/replication of each host were tested. For determining the pupal period, pupal weight, pupal length, and width, 50 larvae/replication were tested.

2.3. Effect of different hosts on hatchability of *B. cucurbitae* egg

To observe the hatchability percentage, the eggs of *B. cucurbitae* were kept on different hosts (sponge gourd, bitter gourd, musk melon, and bottle gourd) with the help of a fine hair brush. In each replication, ten eggs were kept in a Petri dish (9 cm diameter, 1 cm high) on each piece of the vegetable. The observation on the incubation period, egg mortality and number of larvae that emerged were made.

2.4. Effect of different Hosts on longevity and fecundity of *B. cucurbitae*

Freshly emerged adults of *B. cucurbitae* were paired and kept in cages (26 x 20 x 23 cm) and were provided with adult diet as described above for colony maintenance. Different hosts were provided as egg-laying substrates up to the mortality of females to calculate the fecundity of *B. cucurbitae*. Males after death were replaced with new males till female death. In each treatment, 15 pairs of *B. cucurbitae* were used.

2.5. Data Analysis

The analysis of variance (ANOVA) of a completely randomized design (CRD) with four treatments and three replications was applied by using Statistix (version 8.1) analytical software to analyze the life-history parameters data. The means of life history data from all strains were compared using the least significant difference test (LSD) at $p \leq 0.05$. A graph of age-specific fecundity was made by GraphPad Prism software (version 9).

3. Results

3.1. Effect of different hosts on life history parameters of *B. cucurbitae*

The means of different life history parameters are presented in Table 1. The degree of freedom (df) for each parameter is three (df = 3). The hatchability (%) was statistically similar in all treatments/hosts ($p > 0.05$). There was a statistically significant difference ($p < 0.05$) in the incubation period of all the tested vegetables. The maximum incubation period was observed in bitter gourd and minimum in bottle gourd. The egg length of *B. cucurbitae* was significantly affected in all treatments ($P < 0.05$). The egg length in all the treatments was as follows Bottle gourd > Musk Melon>Sponge gourd>Bitter gourd. The larval survival (%) was

statistically different among treatments ($p < 0.05$), and the maximum and minimum larval survival was observed in bottle gourd (79%) and sponge gourd (73%), respectively. The larval duration was not significantly different in all four treatments ($F = 1.17$, df = 03, $P = 0.12$).

The larval length and width were significantly higher in the bottle gourd followed by the musk Melon and sponge gourd than in the bitter gourd ($p < 0.05$).

3.2. Effect of different hosts on pupal parameters and adult emergence

The means of various pupal parameters of *B. cucurbitae* are presented in Table 2 and df = 3 for all parameters. The pupal recovery was significantly low when larvae were reared on bitter gourd as compared to other tested hosts ($p < 0.05$).

In our experiment, a significantly increased pupal period was recorded on the bitter gourd as compared to all other tested hosts ($p < 0.05$). The pupal period of the sponge gourd and the bottle gourd were similar to each other but lower than that of the musk melon. The pupal length, width, and weight ($F = 93.7$, df = 3, $P = 0.03$) were significantly affected in all treatments ($p < 0.05$). Bottle gourd showed the highest while Bitter gourd showed the lowest pupal length, width, and weight. There was no significant difference in pupal survival percentages in all treatments ($p < 0.05$). There was a significant difference in male and female sex ratio when larvae reared on different experimental hosts ($p < 0.05$). A maximum female sex ratio was observed when larvae were fed on a bottle gourd however, minimum females were observed on musk melon. Maximum male recovery was observed when the larvae were fed on sponge gourd and minimum males were collected on bitter gourd.

3.3. Adult longevity and fecundity of *B. cucurbitae*

Adult longevity and fecundity were significantly affected by the host provided to *B. cucurbitae* (df = 03, $p < 0.05$) (Table 3). Maximum female longevity and fecundity were recorded when the larvae of *B. cucurbitae* were

Table. 1. Effect of different hosts on life history parameters (means ± SE) of *B. Cucurbitae*

Hosts	No. of eggs observed	Hatchability (%)	Egg incubation period (h)	Egg length (mm)	No. of larvae tested	Larval survival	Larval duration ays)	Larval length (mm)	Larval width (mm)
Sponge gourd	313	77.00 ± 7.25a	27.57 ± 0.12b	0.342±0.18b	40	73.00 ± 1b	8.85 ± 0.13a	7.99 ± 0.07b	1.41± 0.1b
Bitter gourd	329	81.00 ± 8.50a	36.35 ± 5.55a	0.305±0.11c	40	78.00 ± 5a	8.65 ± 0.19a	7.43 ± 0.05c	1.27 ± 0.02c
Musk melon	332	76.91 ± 8.24a	27.83 ± 2.5b	0.355±0.17b	40	73.50 ± 4b	8.68 ± 0.14a	8.21± 0.07b	1.45 ± 0.03b
Bottle gourd	391	82.47± 4.39a	26.51 ± 4.34b	0.392±0.16a	40	79.50 ± 4a	8.44 ± 0.16a	8.76 ± 0.11a	1.52 ± 0.02a

Means in the same column followed by different letters are significantly different (LSD test, $P < 0.05$).

Table. 2. Effect of different hosts on pupal parameters and adult emergence (means ± SE).

Host	Pupal recovery	Pupal Period (days)	Pupal Length (mm)	Pupal Width (mm)	Pupal Weight (mg)	N	Pupal Survival (%)	Sex ratio	
								Male	Female
Sponge gourd	178 ± 8.63a	7.85 ± 0.11c	4.31 ± 0.05c	2.0 ± 0.03b	126.53 ± 1.05b	50	90 ± 8.00a	24.0 ± 4.0a	21 ± 3.00b
Bitter gourd	90 ± 5.98c	11.16 ± 0.22a	3.98 ± 0.04d	1.84 ± 0.04c	91.61 ± 1.85c	50	82 ± 6.50a	16.2 ± 2.5b	25 ± 3.25ab
Musk melon	224 ±8.34ab	9.70 ± 0.24b	4.69 ± 0.11b	2.11 ± 0.06b	132.35 ± 5.21b	50	78 ± 5.25a	19.0 ±3.0ab	20 ± 2.75bc
Bottle gourd	260 ± 13.12a	7.78 ± 0.13c	5.31 ± 0.06a	2.28 ± 0.04a	189.79 ± 6.24a	50	92 ± 8.75a	18.2 ± 2.7ab	28 ± 3.25a

Means in same column followed by different letters are significantly different (LSD test, $P < 0.05$).

N = number of pupae tested.

Table. 3. Effect of different hosts on female longevity and fecundity of *B. cucurbitae.*

Host	Female longevity (days)	Fecundity
Sponge gourd	41.23 ± 6.12c	611.17 ± 12.43c
Bitter gourd	47.45 ± 7.11b	728.10 ±17.56b
Muskmelon	50.31 ± 8.15b	778.26 ±19.55b
Bottle gourd	52.63 ± 11.34a	823.35 ±24.23a

Means in same column followed by different letters are significantly different (LSD test, P < 0.05).

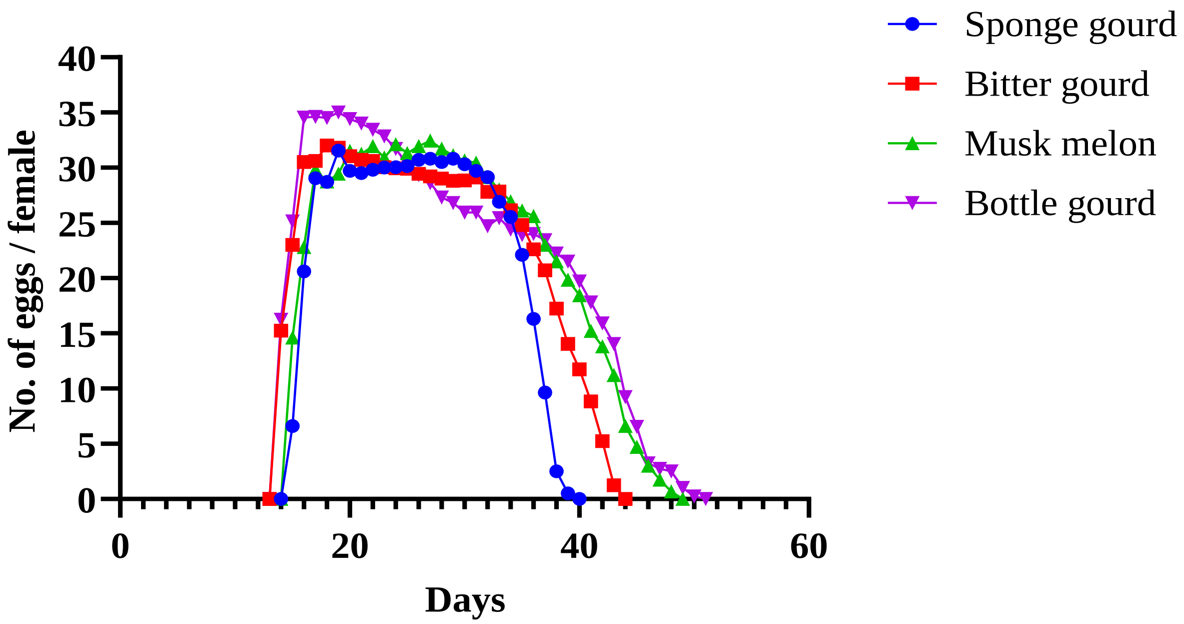

Figure 1 Age specific fecundity of Bactrocera cucurbitae reared on different hosts in laboratory.

reared on a bottle gourd while the minimum was on a sponge gourd.

3.4. Age-stage-specific fecundity on different host

Age-specific fecundity of *B. cucurbitae* females reared on sponge gourd, bitter gourd, musk melon, and bottle gourd is plotted in Fig. 1. The females of *B. cucurbitae* reared on the bottle gourd showed high reproductive potential and can lay maximum of 35 eggs/day when the adult female was 20 days old after that its fecundity was gradually decreased. The correlation of fecundity with female adult longevity is presented in Fig. 2. There is a direct relation between adult longevity and fecundity as female adult longevity increases, the number of eggs laid also increases.

4. Discussion

This study investigated the influence of different host plants on various life history parameters of *B. cucurbitae*. The maggots of *B. cucurbitae* can feed on different hosts including Indian squash, bitter gourd, musk melon, watermelon, bottle gourd, cucumber, brinjal, and ridge gourd (Amin et al., 2011; Dhillon et al., 2005b; Smith-Pardo, 2013). Some species of the above-mentioned hosts could be optimal for the development and reproduction of *Bactrocera* species and result in better biological parameters (Amin et al., 2011). This study provides information on preimaginal development and adult longevity of *B. cucurbitae*, on four hosts which has never been studied together before, despite its economic significance. Our results will be

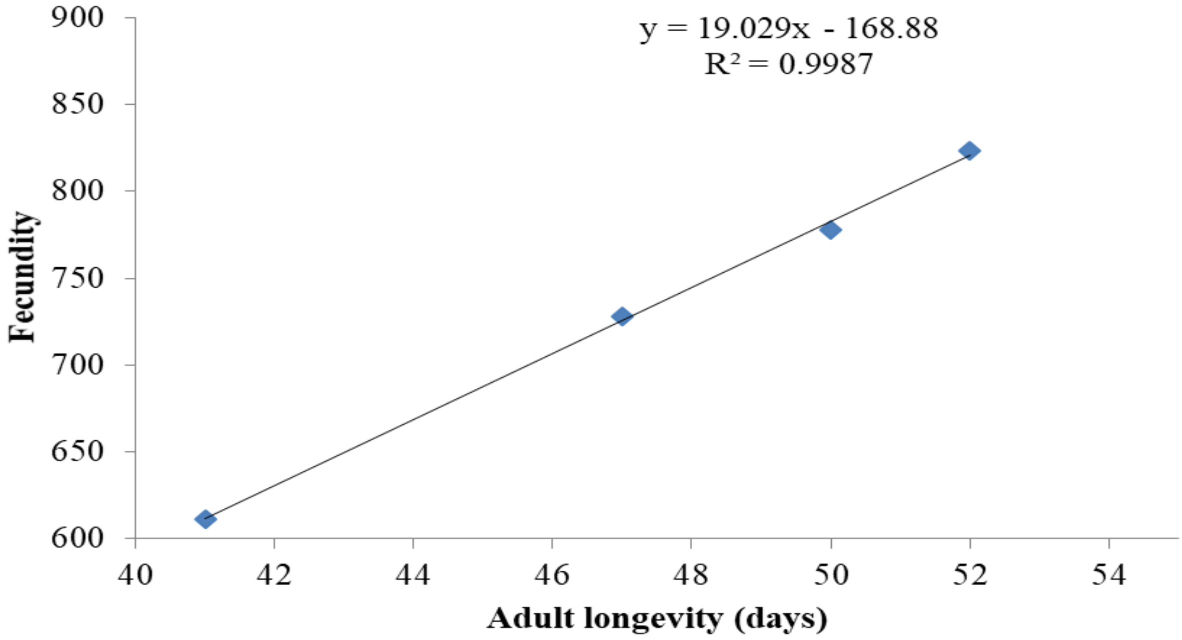

Figure 2. Correlation between adult longevity and fecundity.

helpful in the management of *B. cucurbitae* in the field and the rearing of this pest in the laboratory for experimental purposes. This research underscores the complex interplay between *B. cucurbitae* and host plants, with implications for its reproductive success and development.

The host species influences both the adult behavior and the development of the fruit fly's early instars (Sarwar et al., 2013). In the present research, hatchability (%), larval duration, and pupal survival (%) of *B. cucurbitae* were statistically similar when reared on four experimental hosts. Consistent with our findings, Amin et al. (2011) reported that the hatching rate and larval period of *B. cucurbitae* were similar on ash gourd, bitter gourd, and sweet gourd. Significantly higher larval survival and larval length were observed on those larvae that feed on bottle gourd might indicate adaptation to this host vegetable (Weems et al., 2012). Significantly lower pupal recovery was recorded on bitter gourd as compared rest of the tested hosts which might indicate that this is not a suitable host for *B. cucurbitae* among the tested four hosts. The reduced pupal period supplied with bottle gourd and sponge gourd is according to the results of Zain-ul-Aabdin et al. (2014). Likewise, higher pupal length and pupal width were recorded on bottle gourd which showed adaptation to this vegetable. Previously, Vayssières et al. (2008) reported that the survival percentages of *B. cucurbitae* remained unaffected due to feeding on different vegetables. Potential factors influencing these variations may include nutritional disparities among hosts and their impact on developmental processes (Hamby et al., 2016; Prager et al., 2014).

Host plants significantly influenced adult longevity and fecundity of *B. cucurbitae*. Age-stage-specific fecundity showed that females reared on Bottle gourd exhibited robust reproductive potential, peaking at 35 eggs/day around 20 days of age. The positive correlation between adult female longevity and fecundity highlighted their interdependence, where increased longevity led to high egg-laying capacity. Similar to the present study, Wu et al. (2011) reported a higher fecundity of B. cucurbitae on bitter gourd than that of the sponge gourd. The possible reason for these variations may be nutritional differences in experimental host plants (Bernays and Chapman, 2007) e.g., bottle gourd might be providing more nourishment than other host plants for better survival and reproduction of fruit flies. These findings exposed complex interactions between the reproductive performance of *B. cucurbitae* and host plants that highlights the need of more targeted IPM strategy based on these ecological interactions.

5. Conclusion

The present findings showed that the most suitable host among all tested vegetables for the survival and reproduction of *B. cucurbitae* is bottle gourd. The importance of the host plant in *B. cucurbitae* reproduction and fitness is confirmed by significant differences in characteristics of various life history parameters. This information on host preferences and their effects plays a vital role in devising a targeted pest control strategy. Farming practices can be adjusted to make the best use of less preferred hosts and lessen the prevalence of more preferred hosts by highlighting the implication of host-plant selection in the regulation of *B. cucurbitae* population. Additionally, the strong association between fecundity and longevity of *B. cucurbitae* proposes that a longer female's lifespan possibly will lead to higher reproductive output. These findings provide useful information for the development of a better and more refined IPM strategy. However further studies on the physiological mechanisms underlying the observed trends could be more helpful in the management of this notorious pest that will ensure the sustainable farming of cucurbit vegetables.

6. Conflict of Interest

The authors have no conflict of interest.

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