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Comparative biology of melon fruit fly, *Bactrocera cucurbitae* in different cucurbitaceous crops

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Abstract
Laboratory studies were conducted to study the comparative biology of fruit fly, *Bactrocera cucurbitae* in different cucurbitaceous crops *viz.* bitter gourd, bottle gourd and watermelon. The significant differences were observed in the life cycle of the pest when reared on bitter gourd, bottle gourd and watermelon. The mean incubation period, total larval period, pre pupal period, pupal period, adult male longevity, adult female longevity, fecundity, hatching percentage, sex ratio and total life cycle for male and female were recorded as 1.28 ± 0.458, 6.08 ± 0.493, 1.08 ± 0.277, 5.88 ± 0.600, 10.33 ± 0.617, 15.10 ± 0.738, 32 to 35 eggs, 92.00%, 1: 0.67, 24.80 ± 1.320, 29.20 ± 1.033 days respectively, for bitter gourd, 1.32 ± 0.476, 8.12± 0.332, 1.12 ± 0.332, 7.16 ± 0.374, 12.81 ± 0.655, 17.22 ± 0.833, 42 to 46 eggs, 88.00 %, 1: 0.56, 30.19 ± 0.750, 35.80 ± 1.814 days respectively, for bottle gourd and 1.36 ± 0.700, 8.08 ± 0.812, 1.08 ± 0.277, 9.40 ± 0.645, 13.11 ± 2.111, 16.86 ± 2.734, 50 to 55 eggs, 80.00 %, 1: 0.39, 32.56 ± 2.382, 38.00 ± 3.512 days respectively, when the larva reared on watermelon.

Keywords: biology, melon fruit, *Bactrocera cucurbitae*, cucurbitaceous

Introduction
Cucurbits, a common name given to a number of crops belonging to family cucurbitaceae which mostly possess trailing habit, are extensively grown all over the tropical and sub tropical countries and include the largest number of summer and rainy season vegetables. Cucurbits in general are a good source of vitamin A and C and various vital minerals. Cucurbitaceous vegetables are consumed in various forms, *i.e.* salad, sweet, pickles, deserts and culinary purpose.

Cucurbitaceous crops are attacked by a number of insect pests and mites but fortunately, in India only fruit flies and few species of beetles are of economic importance; aphids and blister beetles though of regular occurrence, seldom cause severe damage, rest of the insect pests and mites are of minor importance (Butani and Jotwani, 1984) [2]. Fruit flies belonging to dipteran family Tephritidae (Trypetidae) are recognized as one of the most important group of pests of cucurbits. There are over 4000 species of fruit flies in the world (Norrbom *et al*, 1998) [10], of which about 5 per cent occurs in India (Ramani, 1998) [14]. Senior-white (1924) [16] listed 87 species of Tephritidae in India.

Melon fruit fly, *B. cucurbitae* damages over 81 plant species, but plants belonging to the family Cucurbitaceae are preferred most (Allwood *et al*., 1999) [1]. Fruit flies have been identified as one the most serious pests owing to their polyphagous nature and huge economic losses varying from 30 to 100 per cent depending upon the crop and season (Dhillon *et al*. 2005) [3]. This pest is reported to cause 59.5% and 20.20% in bitter gourd and bottle gourd, respectively (Lall and Sinha, 1959) [6]; more than 50% damage to cucurbits (Narayanan and Batra, 1960) [9]; 80% infestation in cucumber and bottle gourd, 60% infestation in bitter gourd (Gupta *et al*., 1992) [4]; while 30% in watermelon, *Citrullus lanatus* Thunberg (Pareek and Kavadia, 1994) [11].

The fruits of cucurbits are picked up at shorter intervals for marketing and self-consumption. In no family of insect pests, the control measures are as difficult as in the Tephritidae. Therefore, it is difficult to rely on insecticides as a means of controlling *B. cucurbitae*. Some weak link in the life history of the pest is exploited by the economic entomologists. Several management techniques are being applied against this pest, because three of its life stages are hidden and the only adult stage is the usual target for its management. Under management option, a number of methods such as field sanitation, soft insecticides with lures, non-chemical bait, and different cue-lure baited traps can be employed to keep the pest population below

economic threshold in a particular crop over a period of time to avoid the crop losses without health and environmental hazards, which is the immediate concern of the farmers. *B. cucurbitae* has become threat to the intensive agriculture. To develop efficient pest management strategies, a thorough knowledge on the biology of this pest and its status during different times provides an important basis especially with regard to management of this pest in farming systems.

Materials and Methods

The studies on comparative biology of fruit fly, *B. cucurbitae* on bitter gourd, bottle gourd and watermelon was carried out during the month of December to March of 2017-18 in the laboratory of Department of Entomology, N.M. College of Agriculture, NAU., Navsari.

Rearing techniques

To initiate the culture of *B. cucurbitae* in the laboratory, infested fruits (with larvae inside) of different hosts *viz*., bitter gourd, bottle gourd and watermelon grown in the farmer's fields were collected, brought to the laboratory and kept on the 4 cm layer of sieved sand in the galvanized cages (Diameter 30 cm, Height 10 cm) host-wise for pupation. The cage of each host was covered with black cloth duly tightened with rubber bands to prevent the emerging adult from escaping. The pupae from respective host were collected by sieving the sand and kept in the petridish (10 cm diameter and 1 cm height). Petridish with pupae was kept inside a wooden cage (length: 35 cm, breadth: 35 cm, height 35 cm) for the emergence of adult flies. The slices of tender fruit of respective host were placed inside the cage for oviposition. The eggs laid in the fruit's slices were collected and used for further study on biology.

The study was carried out in 3 sets of each life stages. Initially under each set, 25 eggs were placed on fruit slice of respective hosts and reared till end of the life cycle. The fruit slices were placed in a small plastic bowl (Diameter: 12 cm on top and 10 cm at bottom, Height: 5 cm) having blotting paper over laid on wet cottony swab at the bottom. The old fruit slices were changed with fresh fruit slices of respective host at every 2 days interval during development up to pre-pupal stage. As and when larvae became fully developed, the blotting paper and cottony swab in the plastic bowl were replaced with the 4 cm layer of sieved sand for pupation. The observations on developmental period were made stage-wise. The data on different parameters were statically analyzed.

Method of observations on life stages

The eggs were observed under microscope daily in the morning and evening till hatching. The egg was considered as hatched when tiny larva came out from it. Incubation period was calculated from the date of egg laying to the date of hatching. Hatching percentage was calculated from the data on number of eggs hatched out of total number of eggs under observation. The total larval period was calculated from the date of egg hatching to the date of formation of pre-pupa. When fully grown larva stopped feeding and became inactive, it was considered as pre-pupal stage. The pre-pupal period was recorded from the date of inactivation of fully grown larva to date of formation of pupa. Pupal period was calculated from the date of formation of pupa to the date of emergence of the adult from the pupa. The newly emerged adults were sexed based on presence of ovipositor in female and paired. Five pairs of male and female were released in the oviposition cage individually. Fruit juice of respective host soaked in alkathene foam was provided to the adults as food source. The tender fruit slices were also placed inside the oviposition cage for egg laying. The data on duration of pre-oviposition, oviposition and post-oviposition, total longevity of male and female, sex ratio, and fecundity were recorded. Pre-oviposition period was calculated from the date of emergence to the date of starting of egg laying. Oviposition period was calculated from date of starting egg laying to the date of stopping egg laying. Post-oviposition period was calculated from the date of stopping egg laying to the date of death of the female adult. Longevity of male and female was calculated from the date of emergence to the date of death of adults.

Results and Discussion

Eggs

The incubation period varied from 1- 3 days on different hosts. Results presented in Table-1 showed that the incubation period of *B. cucurbitae* eggs ranged from 1 to 2 days for bitter gourd and bottle gourd while, it was 1 to 3 days for watermelon. The incubation period was 1.28 ± 0.458, 1.32 ± 0.476 and 1.36 ± 0.700 days for bitter gourd, bottle gourd and watermelon, respectively. The egg period on bitter gourd was lower than the bottle gourd and watermelon. The report on higher incubation period of *B. cucurbilae* on bitter gourd (1.43 days) than on bottle gourd (1.25 days) reported by Patel (1989) [13] and incubation period of *B. Cucurbitae* 1.20 days on watermelon (Shivakar and Dumbre, 1985) [17] is not accordance with the present finding.

Hatching percentage

The hatching percentage differed on different hosts and ranged from 80.00 to 92.00 per cent. It is evident from the data in Table-1 that maximum egg hatching percentage of 92.00 was recorded when reared on bitter gourd while, minimum egg hatching *i.e*. 80.00 per cent was recorded in watermelon and 88.00 per cent on bottle gourd. The observations on egg hatchability are in close agreement with those of Samalo *et al*. (1991) [2], Dhillon *et al*. (2005) [3] and Laskar (2013) [7] who reported that about 83-88 per cent eggs viability. The report on higher hatching percentage of hatching on bottle gourd (89.28) than on bitter gourd (83.97) as reported by Patel (1989) [13] is not in corroboration with present finding.

Maggot (Larva)

The results on maggot revealed that, there were three larval instars of *B. cucurbitae* when reared on bitter gourd, bottle gourd and watermelon. The present finding are in conformity with the observations made by Manzar and Srivastava (2009) [8] who reported the three larval instars of *B. cucurbitae* on bitter gourd.

First instar

The data in Table-1 indicated that the period of first instar development ranged from 1 to 2 days for all the three hosts. However, average minimum period of first instar larva was 1.08 ± 0.277 days for bitter gourd, 1.16 ± 0.374 days for bottle gourd and 1.08 ± 0.277 days for watermelon.

Second instar

The data in Table-1 indicated that the period of second instar development ranged from 1 to 2 days for all the three hosts.

However, the average mean development of second instar larvae were 1.64 ± 0.490 days, 1.72 ± 0.458 days and 1.68 ± 0.476 days for bitter gourd, bottle gourd and watermelon, respectively.

Third instar

Second instar larvae moulted to third instar and become longer than the second instar. The third instar larval period ranged from 2 to 7 days on different hosts. However, the average mean development of third instar larvae were 3.32 ± 0.627 (2 to 5 days), 5.24 ± 0.523 (4 to 6 days) and 5.32 ± 0.802 days (4 to 7 days) for bitter gourd, bottle gourd and watermelon, respectively (Table 1).

Total larval period

The larval period ranged from 6.08 to 8.12 days on different hosts. It is evident from the data presented in Table-1 that the mean larval period were 6.08 ± 0.493 (5 to 7 days), 8.12 ± 0.332 (8 to 9 days) and 8.08 ± 0.812 days (7 to 10 days) for bitter gourd, bottle gourd and watermelon, respectively. Bitter gourd recorded shorter larval period than rest of the hosts. Shorter larval period on bitter gourd (5.27 days) than bottle gourd (6.0 days) reported by Patel (1974) [12] tally with the present finding. However, the report on the shorter larval period on bottle gourd (4.40 days) than on bitter gourd (5.26 days) reported by Patel (1989) [13] differed from present results.

Pre pupal period

The pre-pupal periods of *B. cucurbitae* on different hosts ranged from 1.08 to 1.12 days on different host. There was no impact of host on pre-pupal period of *B. cucurbitae*. The data in Table-1 indicated that the pre-pupal period of *B. cucurbitae* varied from 1 to 2 days and the mean pre pupal period was 1.08 ± 0.277 days for both bitter gourd and watermelon whereas it was 1.12 ± 0.332 days for bottle gourd. Slightly longer pre-pupal period on bitter gourd (0.56 day) than on bottle gourd (0.54 day) reported by Patel (1989) [13] is not in accordance with the present report.

Pupal period

The periods of pupae on different hosts differed significantly from each other and it varied from 5 to 11 days. Results on pupal period (Table 1) showed that the average means pupal period of 5.88 ± 0.600 (5 to 7 days), 7.16 ± 0.374 (7 to 8 days) and 9.40 ± 0.645 days (9 to 11 days) for bitter gourd, bottle gourd and watermelon, respectively. Thus, different hosts serving as food for larvae were found to have significant influence on the pupal period of *B. cucurbitae*. Patel (1974) [12] has reported the shorter pupal period on bitter gourd (9.86 days) than bottle gourd (10.50 days) which tally with the present finding. The reports on shorter pupal period of *B. cucurbitae* on bottle gourd (7.06 days) than on bitter gourd (7.20 days) (Patel, 1989) [13] differ from the present report.

Pre-oviposition

The data presented in Table-1 indicated that the females had a pre-oviposition period of 9 to 13 days. However, the mean pre-oviposition period was recorded to be 11.00 ± 0.667 (10 to 12 days), 11.67 ± 0.500 (11 to 12 days) and 11.57 ± 1.272 days (9 to 13 days) for bitter gourd, bottle gourd and watermelon, respectively. The present investigations are mostly is in agreement with the findings of Koul and Bhagat (1994) [5] who also found it to range between 10- 15 days. The reports on longer pre-oviposition period on bitter gourd (12.00 days) than on bottle gourd (11.30 days) [Patel, 1989] [13] differed from the present results.

Oviposition

It is evident from the Table-1 that significant difference in the oviposition periods of female *B. cucurbitae* when reared on all the three hosts. The oviposition period ranged from 2 to 5 days with the mean oviposition period of 2.80 ± 0.632 (2 to 4 days), 3.67 ± 0.707 (3 to 5 days) and 3.29 ± 1.254 days (2 to 5 days) for bitter gourd, bottle gourd and watermelon, respectively. The longer oviposition period on bitter gourd (2.20 days) than on bottle gourd (7.20 days) as reported by Patel (1989) [13] is in agreement with the present results.

Post oviposition

It was observed that female fly lived for 1 to 3 days after completion of egg laying on all the three hosts (Table 1). The mean post-oviposition period of 1.60 ± 0.699, 1.89 ± 0.782 and 2.00 ± 0.577 days was recorded for bitter gourd, bottle gourd and watermelon, respectively. The longer post-oviposition periods on bitter gourd (0.50 day) than on bottle gourd (1.20 days) reported by Patel (1989) [13] are in corroboration with the present finding.

Longevity

Results (Table 1) showed that female lived for longer time than the male when reared on all the three hosts. The female longevity varied from 12 to 20 days with an average of 15.10 ± 0.738 (14 to 16 days), 17.22 ± 0.833 (16 to 19 days) and 16.86 ± 2.734 days (12 to 20 days) for bitter gourd, bottle gourd and watermelon, respectively. Likewise, the males lived with a range of 9 to 16 days and mean longevity was 10.33 ± 0.617 (9 to 11 days), 12.81 ± 0.655 (11 to 12 days) and 13.11 ± 2.111 days (10 to 16 days) for bitter gourd, bottle gourd and watermelon, respectively. Sisodiya (2007) [18] reported shorter period of male adult on bitter gourd (10.60 days) than bottle gourd (12.00 days) is in accordance with the present report. However, Patel (1974) [12] has reported shorter period of female adult on bottle gourd (65.60 days) than bitter gourd (73.40 days) and male adult on bottle gourd (61.40 days) than bitter gourd (67.80 days) which are not in tally with the present finding.

Fecundity

The female of *B. cucurbitae* deposited their eggs inside the epi- or mesocarp region of ripening fruits. The females have an extremely slender and long aculeus that allowed them to gain access to a particular area for egg deposition. It becomes clear from the Table-1 that number of eggs laid by females when reared on bitter gourd, bottle gourd and watermelon varied considerably. The fecundity of females ranged from 32 to 35 eggs (5-15 in cluster) with a mean of 33.40 ± 1.342 eggs per five females on bitter gourd, 42 to 46 eggs with a mean of 44.40 ± 1.517 eggs per five females under study in case of bottle gourd and 50 to 55 eggs with a mean of 53.00 ± 2.000 eggs per 5 female in case of watermelon, however the fly did not lay eggs regularly during her life span, but at intervals of 1-5 days. Sisodiya (2007) [18] has reported lower fecundity on bitter gourd (32.10 eggs) than bottle gourd (44.26 eggs). However, Patel (1974) [12] has reported higher fecundity on bitter gourd (95.20 eggs) than bottle gourd (61.60 eggs) does not tally with present finding.

Sex ratio

The adults emerged from pupae were critically examined and sexed by observing presence or absence of pointed ovipositor. Under laboratory conditions, sex ratio of male and female was 1: 0.67, 1: 0.56 and 1: 0.39 when *B. cucurbitae* larvae reared on bitter gourd, bottle gourd and watermelon crop, respectively (Table 1). Sisodiya (2007) [18] reported the lower sex ratio on bitter gourd (1:1.28) than on bottle gourd (1:1.04) which tally with the present finding. However, Patel (1989) [13] has reported the lower sex ratio on bitter gourd (1:0.89) than on bottle gourd (1:0.95); which differed from the present report of lower sex ratio on bottle gourd (1: 0.56) than on bitter gourd (1:0.67).

Total life cycle

The adult periods for female differed significantly on various hosts. The period from egg to the death of adult occupied by females was 29.20 ± 1.033 (28 to 31 days), 35.80 ± 1.814 (34 to 38 days) and 38.00 ± 3.512 days (32 to 42 days) on bitter gourd, bottle gourd and watermelon crop, respectively (Table 1). The reports on shorter period of female on bitter gourd (14.70 days) than bottle gourd (19.70 days) [Patel, 1989] [12] which tally with the present finding. However, Patel (1974) [12] has reported shorter period female adult on bottle gourd (65.60 days) than bitter gourd (73.40 days) does not tally with present finding.

The adult periods for male also differed significantly on different hosts. The period from egg to the death of adult occupied by males was 24.80 ± 1.320 (22 to 27 days), 30.19 ± 0.750 (29 to 32 days) and 32.56 ± 2.382 days (29 to 37 days) on bitter gourd, bottle gourd and watermelon crop, respectively (Table 1). Thus, a total life period of male was shorter than female recorded during present investigation. The report on shorter period of male adult on bitter gourd (10.10 days) than on bottle gourd (17.20 days) as reported by Patel (1989) [13] tally with the present report. However, Patel (1974) [12] reported shorter period of male adult on bottle gourd (61.40 days) than bitter gourd (67.80 days) are not in accordance with the present finding.

Table 1: Complete life cycle of of *B. cucurbitae* on bitter gourd, bottle gourd and watermelon

S. No.	Life stage	Bitter gourd			Bottle gourd			Watermelon		
		Period (Days)			Period (Days)			Period (Days)		
		Min	Max	Mean ± S.D.	Min	Max	Mean ± S.D.	Min	Max	Mean ± S.D.
1	Egg	1	2	1.28 ± 0.458	1	2	1.32 ± 0.476	1	3	1.36 ± 0.700
2	**Larva**									
	I instar	1	2	1.08 ± 0.277	1	2	1.16 ± 0.374	1	2	1.08 ± 0.277
	II instar	1	2	1.64 ± 0.490	1	2	1.72 ± 0.458	1	2	1.68 ± 0.476
	III instar	2	5	3.32 ± 0.627	4	6	5.24 ± 0.523	4	7	5.32 ± 0.802
	Total	5	7	6.08 ± 0.493	8	9	8.12 ± 0.332	7	10	8.08 ± 0.812
3	Pre-pupa	1	2	1.08 ± 0.277	1	2	1.12 ± 0.332	1	2	1.08 ± 0.277
4	Pupa	5	7	5.88 ± 0.600	7	8	7.16 ± 0.374	9	11	9.40 ± 0.645
5	**Adult**									
	Pre oviposition	10	12	11.00 ± 0.667	11	12	11.67 ± 0.500	9	13	11.57 ± 1.272
	Oviposition	2	4	2.80 ± 0.632	3	5	3.67 ± 0.707	2	5	3.29 ± 1.254
	Post oviposition	1	3	1.60 ± 0.699	1	3	1.89 ± 0.782	1	3	2.00 ± 0.577
6	**Longevity**									
	Male	9	11	10.33 ± 0.617	12	14	12.81 ± 0.655	10	16	13.11 ± 2.111
	Female	14	16	15.10 ± 0.738	16	19	17.22 ± 0.833	12	20	16.86 ± 2.734
7	Fecundity	32	35	33.40 ± 1.342	42	46	44.40 ± 1.517	50	55	53.00 ± 2.000
8	Hatching%	92.00			88.00			80.00		
9	Sex Ratio	1 : 0.67			1 : 0.56			1 : 0.39		
10	**Total life cycle**									
	Male	22	27	24.80 ± 1.320	29	32	30.19 ± 0.750	29	37	32.56 ± 2.382
	Female	28	31	29.20 ± 1.033	34	38	35.80 ± 1.814	32	42	38.00 ± 3.512

Each data point is the mean of 25 observations

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