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BIOLOGY OF *BACTROCERA CUCURBITAE* (DIPTERA: TEPHRITIDAE) ON CUCUMBER

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Abstract

Present studies on biology of melon fruit fly, *Bactrocera cucurbitae* (Coquillett) revealed that the freshly laid eggs were glistening white, slightly curved, tapering at one end while rounded at the other end. The mean length and breadth of the egg were found to be 1.13 ± 0.14 mm and 0.28 ± 0.05 mm. The first and second instars measured 1.49 ± 0.28 and 6.40 ± 0.86 mm in length, respectively, and 0.31 ± 0.07 and 1.21 ± 0.09 mm in breadth, respectively. The third instar was very mobile and measured 9.62 ± 0.87 mm in length and 2.05 ± 0.32 mm in breadth. The puparium measured 5.72 ± 0.13 mm in length and 2.46 ± 0.11 mm in breadth. The length and breadth of male was 8.74 ± 0.32 mm and 11.46 ± 1.16 mm, whereas, the female measured 9.94 ± 0.20 mm in length and 15.92 ± 0.74 mm in breadth. The duration of egg incubation, and the larval, prepupal and pupal periods were 16.8 ± 4.9 hours, and 4.5 ± 1.13, 0.8 ± 0.25 and 8.4 ± 0.51 days, respectively. Pre-oviposition and oviposition periods ranged from 10-15 and 12-28 days. Fecundity varied from 58-92 eggs, while egg viability was 86.1± 0.54. Sex ratio (male: female) was 1.10 ± 0.14. Longevity of adults was extended to 30-52 days for males and 30-60 days for females when fed either water, molasses and honey or water, molasses and proteinex. Lack of access to water led to sudden death of the flies.

Key Words: biology, morphometrics, cucumber

Resumen

Los estudios actuales sobre la biología de la mosca de la fruta del melón, *Bactrocera cucurbitae* (Coquillett) revelaron que los huevos recién puestos son de color blanco brillante, ligeramente encurvado, que se estrecha en un extremo y redondeado en el otro extremo. Se encontró que el promedio de la longitud y la anchura de los huevos son 1.13 ± 0.14 mm y 0.28 ± 0.05 mm. Los primeros y segundos estadios midieron 1.49 ± 0.28 y 6.40 ± 0.86 mm de longitud, respectivamente, y 0.31 ± 0.07 y 1.21 ± 0.09 mm de ancho, respectivamente. Las larvas de tercer estadio fueron muy móviles y miden 9.62 ± 0.87 mm de longitud y 2.05 ± 0.32 mm de ancho. La pupa mide 5.72 ± 0.13 mm de longitud y 2.46 ± 0.11 mm de ancho. El largo y ancho del macho fue 8.74 ± 0.32 mm y 11.46 ± 1.16 mm, mientras que la hembra mide 9.94 ± 0.20 mm de longitud y 15.92 ± 0.74 mm de ancho. La duración de la incubación de los huevos, y los períodos de las larvas, pupas y prepupales fueron 16.8 ± 4,9 horas y 4.5 ± 1.13, 0.8 ± 0.25 y 8.4 ± 0.51 días, respectivamente. Los períodos de pre-oviposición y oviposición variaron de 10-15 y 12 a 28 días. La fecundidad varió de 58-92 huevos, mientras que la viabilidad del huevo fue 86.1 ± 0.54. La proporción de sexos (machos: hembras) fue 1.10 ± 0.14. La longevidad de los adultos fue extendida de 30-52 días para los machos y de 30-60 días para las hembras cuando fueron alimentados por agua-melaza-miel o agua- melaza-proteinex. La falta de acceso al agua llevó a la muerte repentina de las moscas.

Palabras Clave: biología, morfometría, pepino

The melon fruit fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) is widely distributed throughout the temperate, tropical and subtropical regions of the world (Fletcher 1987). It is the only tephritid species in India that is uniformly widespread, attacking a large array of cucurbit fruits. It has more than 81 host species, in which fruit losses can range from 30 to 100% (Dhillon et al. 2005). Cucumber (*Cucumis sativus* L.; Cucurbitales: Cucurbitaceae) is one of the most preferred hosts of melon fruit fly. The female fly punctures the soft and tender fruits with her ovipositor and lay eggs below the exocarp of the fruit. The maggots that hatch from the eggs bore into the fruit and feed on the placenta and other structures. The melon fruit fly is considered a federal quarantine pest in India and many other countries, due to its highly invasive nature as majority of them cause extensive damage to many fruits and vegetables especially cucurbitaceous vegetables. They have been reported as the major limiting factor in obtaining high yields and good quality fruits of cucurbits. Their attack on cucumber not only reduces the yield but also affects the quality of cucumber and as a result, the marketability of the crop is reduced and the vegetable growing enterprise is

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rendered unprofitable. In addition to direct losses, fruit fly infestation can result in serious losses in trade value and export opportunity due to strict quarantine regulations imposed by most importing countries. (Chen & Ye 2007).

The knowledge of biology and different life stages of insect pests is helpful in developing efficient management strategies that will prevent ill effects of insecticides. This study was undertaken to gain precise knowledge of the morphometrics of the various developmental stages, their duration, adult longevity, pre-oviposition and oviposition periods, fecundity and the effect of diet on adult longevity. This investigation was conducted under laboratory conditions.

Materials and Methods

The initial culture of *B. cucurbitae* was collected from infested cucumber fruits from the experimental area of the Central Institute of Temperate Horticulture, Srinagar, Jammu and Kashmir, India. The infested fruits were infested fruits were kept in 20 × 20 × 8 cm plastic trays on a 5 cm-thick layer of sieved moist sand to facilitate pupation. After every 3- 4 days, sand was sieved and newly formed pupae were collected. The pupae were kept in 10 cm-diam petri dishes (50 pupae/petri dish) lined with moist filter paper.

The newly emerged adult flies were collected and placed inside the rearing cages each 35 × 30 × 35 cm. Each rearing cage had wire mesh on 3 sides, glass on the top and a wooden door at one side. A round trap door was provided in the wooden door to facilitate collection of adult flies for experimental purpose and also to provide food and water. The male and female flies were identified according to Drew & Raghu (2002). On the bottom of each cage there was a 2 cm-thick layer of sieved sand with 5% moisture. A glucose solution (10% W/V) was provided inside the cage for adult feeding. This glucose solution was kept in a 50 mL beaker and a thumb sized water-soaked cotton swab was laid in such a way that half of it was immersed in glucose solution and remaining half stayed above rim of the beaker to keep the solution in reach of adult fruit flies. Slices of cucumber were kept inside each breeding cage for oviposition. These slices were replaced by fresh ones daily to avoid decay. The entire fruit culture was maintained at mean temperature of 23.97 ± 0.66 °C and 16.17 ± 0.81 °C with mean relative humidities of 66.39 ± 1.66 and 74.07 ± 1.63%, respectively. A binocular microscope was used to note the number of eggs present in each cucumber slice. This procedure was repeated until the death of the ovipositing females. The eggs collected were placed in 10 cm diam-petri dishes (50 eggs per petri dish) with moist filter paper at the bottom to prevent desiccation of eggs. After egg hatch, fresh cucumber slices were kept in each petri dish for feeding the young larvae. After 24 h cucumber slices were replaced by fresh ones until all the eggs had hatched. The cultures so established was used in biological studies.

Morphometric study of different life stages of *B. cucurbitae* was carried out by taking 10 replicates of each stage, viz., egg, freshly lst instars, 2nd instars, 3rd instars ("fully grown larvae"), pupae and adults for linear measurements. In addition to the above parameters color, shape, size and periods of eggs, maggots, pupa and adults were also recorded. The study was conducted during Jul through Oct 2012.

Results and Discussion

Egg

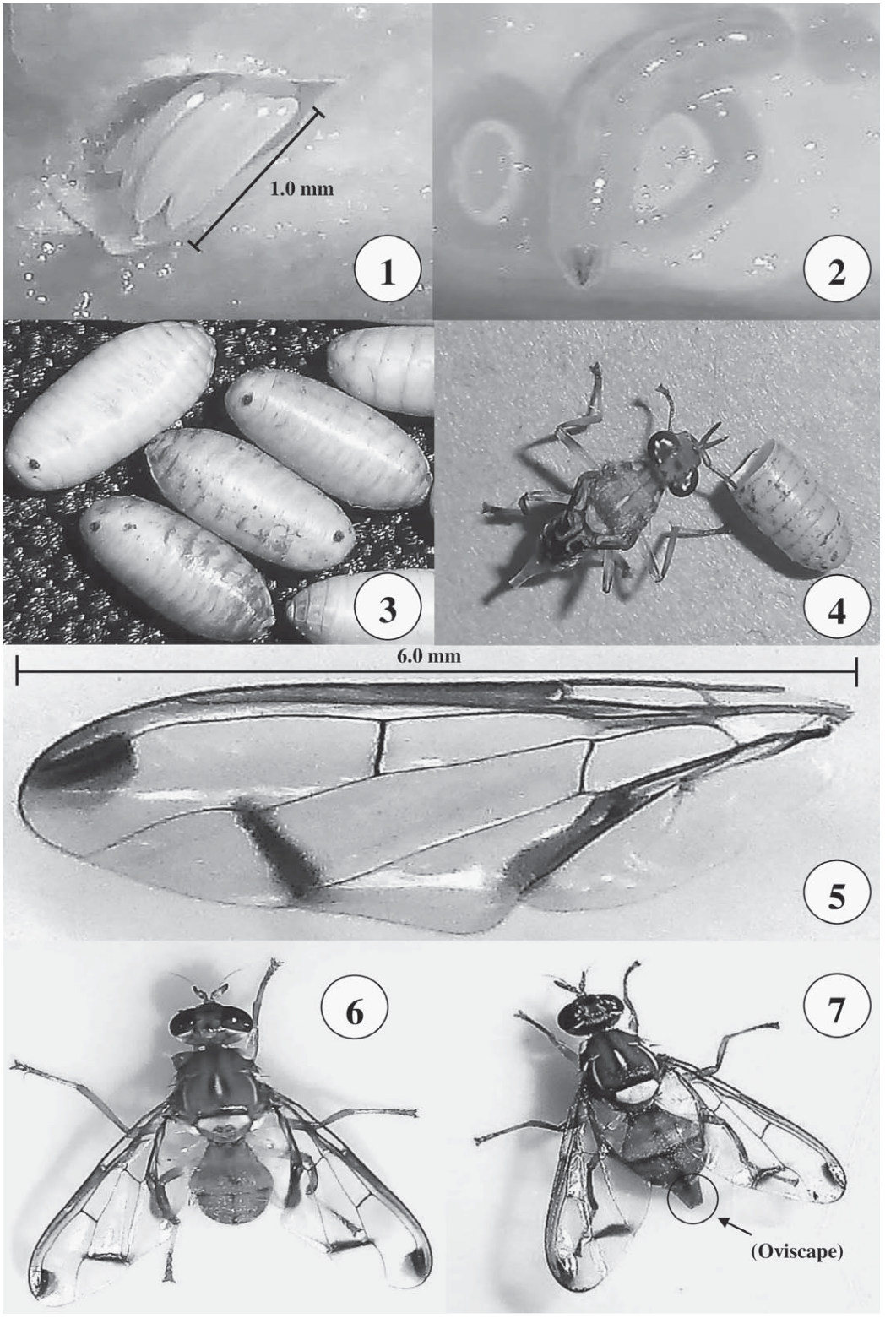
The eggs of *B. cucurbitae* were glistening white, slightly curved, elongated and tapering at one end while rounded at the other end. The posterior extremity was broadly rounded while the anterior end appeared more pointed. The eggs are embedded vertically or slightly slanting and touching each other (Fig. 1). The eggs are laid singly or in clusters of 4 to 10. Morphometric observations revealed that the length of egg varied from 0.98 to 1.28 mm with a mean of 1.13 ± 0.14 mm, and the breadth varied from 0.21 to 0.34 mm with a mean of 0.28 ± 0.05 mm, respectively (Table 1).

Duration of development between laying and hatching, i.e., the incubation period was 12 to 24 h with a mean of 16.8 ± 6.19 h (Table 2). These results are in the close agreement with those of Waseem et al. (2012) who reported that incubation period on cucumber lasted from 24.4 to 38 h. Similarly, Khan et al. (1993) reported approximately the same incubation period as reported herein. Shivarkar & Dumbre (1985) found an incubation period of *B. cucurbitae* of 1.2 days on watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai (Cucurbitaceae). Koul & Bhagat (1994) found the incubation period of *B. cucurbitae* on bottle ground, *Lagernaria siceraria* (Molina) Standl. (Cucurbitaceae) to be 1.0 to 5.1 days.

Maggot (1st, 2nd and 3rd instars)

The apodous maggot passed through 3 instars. Freshly emerged 1st instars were translucent and white in color, whereas the 2nd instars were translucent, elongate and ellipsoidal in shape and creamy white in color. The fully grown 3rd instar had a pointed head with well-developed mandibular hooks and anterior and posterior spiracles (Fig. 2). The 3rd instar had a conspicuous dark transverse line extending between intermediate areas of the caudal segment and exhibited a peculiar habit of curving itself and springing into the air to a lateral distance of 15-20 cm by the sudden relaxation of certain muscles. In this way the 3rd instar displaced itself 6 to 8 inches (15-20 cm) from the fruit to the site of pupation. The 1st, 2nd and 3rd instars

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Figs. 1-7. Life stages of *Bactrocera cucurbitae*. 1. Eggs, 2. Third instar maggot, 3. Puparia, 4. Emergence of adult from puarium, 5. Wing showing venation, 6. Male habitus and 7. Female habitus. Photos by S. H. Mir.

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TABLE 1. MORPHOMETRICS OF DIFFERENT LIFE STAGES OF *BACTROCERA CUCURBITAE* REARED ON CUCUMBER.

	Length (mm)		Breadth (mm)	
Stage	Range	Mean ± SD	Range	Mean ± SD
Egg	0.98-1.28	1.13 ± 0.14	0.21-0.34	0.28 ± 0.05
I instar	1.17-1.92	1.49 ± 0.28	0.22-0.39	0.31 ± 0.07
II instar	4.87-7.49	6.40 ± 0.86	1.06-1.35	1.21 ± 0.09
III instar	8.24-10.65	9.62 ± 0.87	1.73-2.72	2.05 ± 0.32
Prepupa	6.22-6.70	6.46 ± 0.14	1.98-2.06	2.00 ± 0.02
Pupa	5.46-5.91	5.72 ± 0.13	2.32-2.68	2.46 ± 0.11
		Adults (with expanded wings)		
Male	8.05-8.74	8.74 ± 0.32	10.00-12.69	11.46 ± 1.16
Female	9.50-10.2	9.94 ± 0.20	14.88-16.90	15.92 ± 0.74

All measurements are the means of 10 observations.

measured 1.49 ± 0.28, 6.40 ± 0.86 and 9.62 ± 0.87 mm in length, respectively, and 0.31 ± 0.07, 1.21 ± 0.09 and 2.05 ± 0.32 mm in breadth, respectively (Table 1). The developmental period of the 1st, 2nd and 3rd instars were 0.7 ± 0.26, 1.5 ± 0.40 and 2.3 ± 0.47 days, respectively; and their total developmental periods were 4.5 ± 1.13 and 6.45±1.38 days, respectively (Table 2). Other workers also observed the larval period as 5 to 22 days (Renjhen 1949), 5 to 11 days (Singh & Teotia 1970), 3 to 8 days (Doharey 1983) and 15 days (Shivarker & Dumbre 1985)

Prepupa

In this stage, the mature maggots of 3rd instar were slightly bent in position, became sluggish and stopped feeding and remain stationary. The length and breadth of prepupa was 6.46 ± 0.14 mm and 2 ± 0.02 mm respectively. The average duration of prepupal stage was 0.8 ± 0.25 days (Table 2).

Pupa

The pupae were 11 segmented, barrel shaped or cylindrical and yellowish white to deep brownish yellow when freshly formed. Later on, the colour changed into light brown to brownish grey. The pupa had a single black dot on posterior portion that distinguished it from the pupae of other species (Fig. 3). The average length and breadth of pupae were 5.72 ± 0.13 mm and 2.46 ± 0.11 mm, respectively (Table 1). The duration of pupal stage varied 8 to 9 days with a mean of 8.4 ±

TABLE 2. DURATIONS OF DIFFERENT LIFE STAGES OF *BACTROCERA CUCURBITAE* ON CUCUMBER. EACH DATA POINT IS THE MEAN OF 10 OBSERVATIONS.

	Jul-Aug 2012	
Stage	Range	Mean ± SD
Egg (Incubation period) (Hours)	12-24	16.8 ± 6.19
	Larval Duration (Days)	
1st Instar	0.5-1.0	0.7 ± 0.26
2nd Instar	1-2	1.5 ± 0.40
3rd Instar	2-3	2.3 ± 0.47
Total maggot period (Days)	3.5-6.0	4.5 ± 1.13
Prepupal period (Days)	0.5-1	0.8 ± 0.25
Pupal period (Days)	8-9	8.4 ± 0.51
Mating period (Hours)	2-4	3.5 ± 0.84
Pre-oviposition period (Days)	10-15	12.4 ± 2.36
Oviposition period (Days)	12-28	18.2 ± 5.61
Fecundity	58-92	75.8 ± 12.49
Hatching percentage	83-88	86.1 ± 0.54
Sex ratio (Male: female)	0.95-1.25	1.10 ± 0.14
Temperature °C	13-35.5	23.97 ± 7.36
Relative humidity (%)	36-96	66.39 ± 18.52

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0.51 days, respectively (Table 2) The earlier reports on pupal period of melon fly by Narayana & Batra (1960), Agarwal et al. (1987), Dhillon et al. (2005), Shivayya et al. (2007), Waseem et al. (2012) and Langar et al. (2013) are in close agreement with the present findings who observed that pupal period lasted for 8-9 days on cucumber.

Adult

The maximum number of adults was found to emerge from the puparia between 8.00 to 10.00 am (Fig. 4). The freshly emerged adult flies were inactive, pale yellow with wings stuck to their bodies; and each flies required 25-35 min to gain the appearance of a fly. The flies attained their normal reddish brown with lemon yellow curved vertical markings on the thorax and fuscous shadings on the outer margins of the wings (Fig 5.) after 2-3 h. A few min after eclosion, the flies spread their wings and developed color on the wings and thorax. Adults were moderate in size; female flies were larger than males, and the females were easily distinguished by their tapered abdomens that ended in pointed ovipositors (Figs. 6 and 7). The length and breadth of the male with expanded wings was 8.74 ± 0.32 mm and 11.46 ± 1.16 mm, respectively, whereas, the female with expanded wings measured 9.94 ± 0.20 mm in length and 15.92 ± 0.74 mm in breadth; thus the males were smaller than the females (). The findings corroborate those of Lall & Sinha (1959) and Narayanan & Batra (1960). Minor deviations in morphometrics may be attributed to the variation in environmental conditions.

Mating Period

Males pursued their female counterparts for a long time for sexual copulation, but in majority of the encounters the female rejected the males and mating did not occur; similar observations were recorded by (Koul & Bhagat 1994). The period of copulation period was prolonged as was by Vishva (2005), Shivayya et al. (2007) and Waseem et al. (2012), who found that a mating period of more than 30 min was required for sperm transfer to occur, and the amount of sperm transferred increased progressively up to 4 h. In the present study a mating period of 2-4 h was recorded and found to be sufficiently for sperm transfer to occur.

Pre-oviposition and Oviposition Periods

The pre-oviposition period was of 12.4 ± 2.36 days and varied from 10 to 15 days, whereas the oviposition period was 18.2 ± 5.61 days and ranged from 12 to 28 days (Table 2). The durations of these were observed with melon flies reared on cucumber, and they are in fairly close agreement with the respective range of 10 to 15 and 12 to 28 days reported by others (Hollingsworth et al. 1997; Khan et al. 1993; Koul & Bhagat 1994; Langar et al. 2013).

Fecundity and Hatching

Fecundity, i.e., the egg laying capacity of a sexually mature adult female, was 75.8 ± 12.49 and varied from 58-92 (Table 2). However the flies did not lay eggs regularly during their life span but at intervals of 1-4 days. Mean hatching percentage was 86.1± 0.54 (Table 2). The variations in oviposition may have been affected by different genotypes of cucumber, fruit stage and size. Our findings on fecundity of the melon fly under laboratory conditions agree closely with those of Atwal (1986) and Langar et al. (2013) who recorded 58-95 and 50-91 eggs per female during her entire life span, respectively.

Sex Ratio

Newly emerged adults were critically examined and sexed by the presence or absence of a pointed ovipositor. The sex ratio was 1.10 ± 0.14 (mean ± S.D.), which varied from 0.95-1.25 (male: female).The present results are in conformity with Laskar (2013) who reported that the sex ratio of *B. cucurbitae* varied from 1.102 ± 0.136 on bitter gourd (*Momordica charantia* L.) and 0.976 ± 0.104 on pumpkin (*Cucurbita pepo* L.). The differences in sex ratio do not appear to be statistically significant, but they may be affected by the interplay of factors like seasonal fluctuation and type of availability of food material.

Adult Longevity

When adults were provided neither food nor water immediately after their emergence (Table 3), they died after 1.4 ± 0.54 days, range of 1.0 to 2 days. The longevity of adults was extended up to 2-3 and 3-4 days by access to water only. When provided with water and honey (1:1), flies lived 12-35 days. When supplied with water, molasses and proteinex, males lived 40.4 ± 2.95 ranging from 30-52 days, and females lived 48.6 ± 3.51 days ranging from 32-60 days. The longevities of females in treatment #6 (water + molasses + Proteinex) and treatment #7 (water + molasses + honey) were not significantly different, but they were significantly longer than in any other treatment. The longevities of males in treatment #5 (water + honey + proteinex), treatment #6 and treatment #7 were not significantly different, but they were significantly longer than in any other treatment. These findings of longevity agree closely with those of Shivayya et al. (2007) and Waseem et al (2012), who also reported that carbohydrates greatly extended the longevity of adult melon flies.

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TABLE 3. ADULT LONGEVITIES (DAYS) OF THE MELON FRUIT FLY, *BACTROCERA CUCURBITAE* ON VARIOUS FOOD SOURCES.

	Adult longevity (Days)			
	Male		Female	
Treatments	Range	Mean ± SEM	Range	Mean ± SE
T_1-Water only	2-3	2.8 ± 0.13 a	3-4	3.6 ± 0.16 a
T_2-Water + Honey (1:1)	12-35	23.6 ± 2.65 b	15-30	23.0 ± 1.69 b
T_3-Water + Proteinex (1:1)	21-42	29.2 ± 2.43 b	26-48	34.4 ± 2.96 cd
T_4–Water Molasses (1:1)	15-40	30.2 ± 2.83 bc	28-40	31.6 ± 1.42 bc
T_5-Water +Honey + Proteinex (9:0:5:05)	28-40	32.6 ± 1.45 bcd	30-42	33.2 ± 1.49 bc
T_6-Water+Molasses +Proteinex (9:0:5:0.5)	30-52	40.4 ± 2.95 d	32-60	48.6 ± 3.51 e
T_7-Water + Molasses + Honey (9:0.5:0.5)	30-52	39.4 ± 3.22 cd	30-60	44.2 ± 4.35 de
T_8-No Food or water	1-2	1.4 ± 0.16 a	1-2	1.4 ± 0.16 a
Temperature	17-33		(27.22 ± 0.69)	
Relative Humidity	64-95		(81.03 ± 1.41)	

Values (mean ± SE followed by the different letter within the column are significantly different (Tukey post-hoc test, $P < 0.05$)
*Mean of 5 observations.

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