

Research Article

**BIOLOGY OF PUMPKIN FRUIT FLY, *ZEUGODACUS TAU* WALKER  
(DIPTERA: TEPHRITIDAE) IN CUCUMBER IN KATHMANDU NEPAL**

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**ABSTRACT**

The pumpkin fruit fly *Zeugodacus tau* (= *Bactrocera tau*) is a devastating pest of cucurbits such as cucumber, squash, bitter melon and many other solanaceous crops such as tomato. In Asia, damage of this pest in fruits and vegetables recorded up to 90 % in severe conditions. This pest has complete costal band overlapping Radius 2 and 3 and extending into a distinct apical spot at wing spot, Scutum black with large red brown areas located centrally and anterocentrally. Life cycle study of *Z. tau* was carried out in Khumaltar, Lalitpur with mean temperature of 26.79°C and 78.04% RH. Morphometric study revealed that mean length and breadth of *Z. tau* eggs were 1.31 ± 0.010 mm and 0.24 ± 0.0 mm, respectively. Eggs were shiny, smooth and turning brownish dark during hatching. The first, second and third instars maggots were measured (length and breadth) 1.39 ± 0.010 mm X 0.25 ± 0.005 mm, 4.46 ± 0.009 mm X 1.16 ± 0.005 mm and 8.38 ± 0.012 mm X 1.38 ± 0.016 mm, respectively. Female fruit fly was greater in size than male fruit fly with the size of 9.37 ± 0.186 mm X 16.30 ± 0.223 mm for female and 7.32 ± 0.138 mm X 14.4 ± 0.225 mm for male. The egg incubation, I, II, III instar maggots and pupal periods were 1.23 ± 0.058 days, 2.33 ± 0.0875 days, 3.00 ± 0.000 days, 9.67 ± 0.443 days, and 9.67 ± 0.260 days, respectively. Male and female longevity in honey water (1:5) solution was 110.93 days (± 1.419) and 119.46 days (± 2.730), respectively. Life cycle study is important to know their detail ecology and habitat that can support to develop pest management strategy.

**Key words:** *Cucumber, pumpkin fruit fly, life cycle, morphometric and Zeugodacus tau*

**INTRODUCTION**

Fruit flies belong to Tephritidae family and Diptera order. There are more than 500 fruit fly species currently described in the world and widely distributed in tropical and sub-tropical regions of Asia (Choudhary *et al.*, 2014). Six to seven fruit fly species are reported as an economic important fruit fly pest that invade a wide range of vegetable and fruit crops. These species are: *Bactrocera dorsalis* Hendel (mango fruit fly or oriental fruit fly),

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*Bactrocera zonata* Saunders (Peach fruit fly), *Bactrocera cucurbitae* Coquillett (Melon fruit fly), *Bactrocera scutellaris* Bezzi (Cucurbit fruit fly), *Bactrocera tau* (= *Zeugodacus tau*) Walker (Pumpkin fruit fly), *Bactrocera minax* Enderlein (Chinese fruit fly) (Adhikari and Joshi, 2018; Choudhary *et al.*, 2014). Fruit fly species *Dacus longicornis* Wideman is the recently recorded species in Nepal (Adhikari and Joshi, 2018; Sharma *et al.*, 2015).

*Zeugodacus tau* is an economically important and devastating pest of cucurbits and solanaceous crops in the world (Shen *et al.*, 2014) as well as in Nepal. In cucurbit crops, *Z. tau* has been reported as a crop limiting factor that reduces quality and quantity of fruits. This species was first reported by Walker in 1849 from China (Walker, 1849). It is widely distributed in South and South East Asia (Drew *et al.*, 2007; Sumrandee *et al.*, 2011) including India, China and Taiwan (Choudhary *et al.*, 2014). In Nepal, for the first time this species is collected from bottle gourd crop from Kathmandu Valley in 1968 (Joshi and Manandhar, 2001) and also recorded in citrus orchard in Sindhuli district (Adhikari and Joshi, 2018). This pest damages the fruits of cucurbitaceous crops such as cucumber, summer squash, pumpkin, bitter melon (Huque, 2006) and solanaceous crops such as tomato (Sharma *et al.*, 2015). It has been reported more than 80 types of vegetable and fruits (An *et al.*, 2011). This pest has also reported in many fruit crops such as citrus, mango etc (Singh *et al.*, 2010). *Zeugodacus tau* is a quarantine pest in Australia, the USA, Japan, and China (An *et al.*, 2011) that can restrict to entry the *Z. tau* infected fruits and vegetables from fruit fly infected regions (Choudhary *et al.*, 2014). *Zeugodacus tau* (formerly known as *Bactrocera tau*) has distinct morphological features that can help to differentiate them from other fruit fly species. This species has pectin present on third abdominal tergum of males, medial post sutural vitta present, scutum orange brown or black, wings without markings along cross veins, complete costal band overlapping R2 and 3 vein and extending into a distinct apical large spot at the wing spot (Gautam *et al.*, 2015). Scutum black with large red brown areas located centrally and anterocentrally (Yang *et al.*, 1994). Lateral and median post-sutural yellow vittae present (Jaleel *et al.*, 2018). Scutellum entirely yellow with four setae (Choudhary *et al.*, 2014).

*Zeugodacus tau* demonstrate complete life cycle which contains egg, maggots, pupa and adult. Maggots have three different stages called instars. Male and female fruit flies have distinct morphological features. Female fruit fly punctures the soft and tender fruits with the help of ovipositor (Sumrandee *et al.*, 2011; Wang *et al.*, 2009). Eggs after hatching produce maggots and feed placenta of cucumber and damage fruits (Singh *et al.*, 2010; Yang *et al.*, 1994). However, researcher have their own opinion and findings on the life cycle of *Z. tau*. A very limited studies have been done regarding *Z. tau* (White and Elson-Harris, 1992). Their biology, ecology and management practices are poorly recorded in South Asia including Nepal. The information regarding morphometric information's as well as their life cycle are lacking (Liu and Lin, 2000). Hence a laboratory study was carried out in Khumaltar Nepal to address all these hypotheses. Life cycle and morphometric

information's in this study will be useful to develop an effective integrated pest management protocol.

## **MATERIALS AND METHODS**

Fruit fly infested cucumbers (*Cucumis sativus* L.) were collected from Godawori, Lalitpur, Nepal. Cucumber fruits were kept inside the insect rearing cage (1.0 X 0.3 X 1.0 m), made from wood and fine mesh. Fruits were kept until the emergence of adult fruit fly. The newly emerged fruit flies were carefully observed to confirm the fruit fly species. Majority of fruit flies collected from the infested fruits were *Zeugodacus tau*. After species confirmation, ten pairs of male and female *Z. tau* were released into another insect rearing cage (1.0 X 0.3 X 1.0 m) along with 2-3 cucumbers (20 g each), cotton-soaked honey water (1:5) solution and commercially available pollen. Pollen (10g) and cotton-soaked honey water solution (10 ml) were kept in each Petri dish.

Cucumbers maintained inside the cage were carefully observed daily to confirm the egg of *Z. tau*. Brown spot on the epicarp (outer skin) of cucumber along with released some sticky substances on fruits confirmed the *Z. tau* infected fruits. The infected portion of the cucumber were marked and carefully observed the eggs of fruit flies. The collected egg mass was transferred to each Petri dish (5 cm diameter) at the rate of one egg / Petri dish which contained chopped piece of cucumber (2 g). Total 100 Petri dishes which containing one egg/Petri dish along with a piece of cucumber (2g) were maintained for the life cycle study. Old pieces of cucumber (2 g) were replaced by the same size of fresh cucumber in every two days. The fruit fly life stages in each dish was carefully transferred to the fresh cucumber. Incubation period of egg, duration of I, II and III instars of maggots, pupal duration, male and female longevity were observed regularly. Some eggs were not hatched, and some life stages were dead during the study time. Hence only 30 samples (30 Petri dishes; n = 30) which demonstrated complete life cycle were only considered for the life cycle study. For pupal duration observation, the prepupal stage (at the end of third instars) were transferred to a plastic tray (10 X 5 X 5 cm) which contained mixture of sandy and loamy soil (1:2).

The newly emerged adults were differentiated as male and female. Thirty males (n = 30) and 30 females (n = 30) were transferred with one fruit fly per container (15 X 10 cm) which contained cotton-soaked honey water solution (10 ml) and a piece of fresh fruit in each container. There were total 60 containers, 30 containers for male and 30 for female. Finally, total longevity of each sex was recorded.

For morphometric study of fruit fly, five eggs in each Petri dish (see above) along with fresh chopped piece of cucumber were maintained and various life stages were observed as described above. Total fifty samples (n = 50) of each stage was recorded. Morphometric observations such as length and breadth were observed under the microscope with the help of stage and ocular micrometres.

## **RESULTS AND DISCUSSION**

### **Egg**

*Zeugodacus tau* eggs are elliptical, smooth, transparent, tapering at the one end and rounded at the other end and turns brownish black during hatching (Singh *et al.*, 2010). Fertilized matured *Z. tau* have sharp and pointed ovipositor and with the help of this apparatus female lays the eggs beneath the cucumber fruit skin in a group and sometimes in a single (Singh *et al.*, 2010; Sumrandee *et al.*, 2011). Morphometric observations showed that the length (mm) of eggs varied from 1.18 - 1.41 mm with a mean of  $1.31 \pm 0.010$  and the breath varied from 0.24 – 0.35 with a mean of  $0.24 \pm 0.004$  mm (Table 1). Similar results were proposed by Changqing *et al.* (1994), Gupta and Verma (1993) and Singh *et al.* (2010).

### **Maggots (I, II and III instars)**

Maggots did not have legs on their body (apodous) (Singh *et al.*, 2010). They pass three stages (instars). After hatching, maggots burrow into the fruit tissue and feed inside. The first instars were almost translucent with few markings on their body (Gupta and Verma, 1993). The length and breath of first instar maggots were measured  $1.39 \pm 0.010$  mm X  $0.25 \pm 0.005$  mm. Similarly, the second instars measured  $4.46 \pm 0.009$  mm X  $1.16 \pm 0.005$  mm and third instars measured  $8.38 \pm 0.012$  mm X  $1.38 \pm 0.016$  mm (Singh *et al.*, 2010) (Table 1). The second and third instars maggots were creamy white (Singh *et al.*, 2010). Third instars maggots had tapered head with prominent black mandibles (Changqing *et al.*, 1994).

### **Pupa**

Pupae were brown and cylindrical in shape (Singh *et al.*, 2010). The average length and breadth of pupa was  $5.11 \pm 0.017$  mm and  $1.54 \pm 0.009$  mm, respectively (Table 1).

### **Newly emerged adults (Male and Female)**

Adults have orange-brown scutum marked with black stripes and contains lateral two and median one yellow stripes. Females have pointed abdomen (Sumrandee *et al.*, 2011) and males have round abdomen. The length of male adult *Z. tau* measures  $7.32 \pm 0.138$  mm. The breadth of *Z. tau* male with expanded wings was  $14.4 \pm 0.225$  mm. Length of female adult *Z. tau* measures  $9.37 \pm 0.186$  mm and breadth with expanded wings was  $16.30 \pm 0.223$  mm (Table 1), thus male was smaller than female (Khalid, 1999).

**Table 1.** Morphometrics of various life stages of *Zeugodacus tau* in cucumber

Life stages	Length (mm)		Breadth (mm)	
	Mean ± SE	Range	Mean ± SE	Range
Egg	1.31 ± 0.010	1.18 - 1.41	0.24 ± 0.004	0.24 – 0.35
I instar maggot	1.39 ± 0.010	1.18 – 1.53	0.25 ± 0.005	0.24 – 0.36
II instar maggot	4.46 ± 0.009	4.35 – 4.59	1.16 ± 0.005	1.06 – 1.18
III instar maggot	8.38 ± 0.012	8.23 – 8.47	1.38 ± 0.016	1.06 – 1.53
Pupa (includes prepupal stage)	5.11 ± 0.017	4.82 – 5.29	1.54 ± 0.009	1.41 – 1.65
Male (with expanded wings)	7.32 ± 0.138	6.50 – 8.00	14.4 ± 0.225	13.00 – 15.50
Female (with expanded wings)	9.37 ± 0.186	8.00 – 10.00	16.30 ± 0.223	15.00 – 18.00

Measurements from egg to pupal stages are the means of 50 observations. Male and female measurements are the means of 15 observations.

**Life duration**

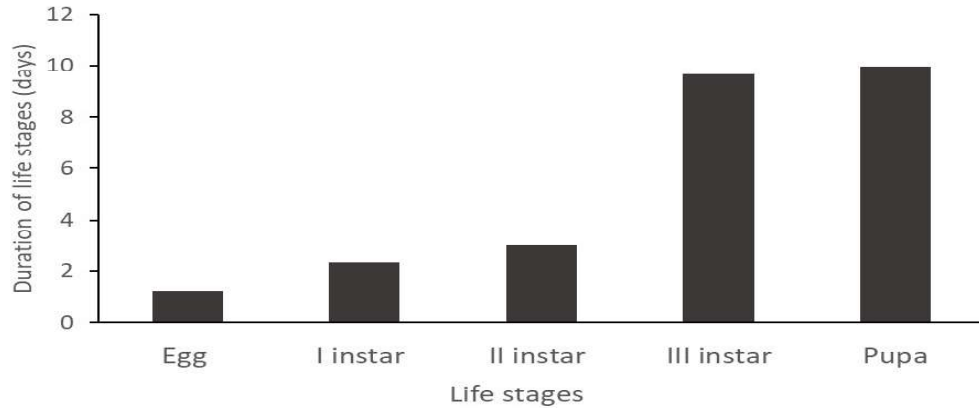
Egg incubation period was 24 to 48 h with a mean of  $1.23 \pm 0.058$  days. Majority eggs were hatched in one day and few of them took two days for hatching. Sixty-nine percent (in a sample of  $n = 182$ ) of egg hatchability in 26.5 OC and 73% RH were recorded. This result was similar with the finding of Wasem *et al.* (2012) and Kabir *et al.* (1997). All maggots were survived for 14 days. The development period of first, second and third instars maggots were  $2.33 (\pm 0.0875)$  days,  $3.00 (\pm 0.000)$  days and  $9.67 (\pm 0.443)$  days, respectively (Fig. 1) (Changqing *et al.*, 1994; Frias *et al.*, 2006; Liu and Lin, 2000; Singh *et al.*, 2010) (Table 2). Pupal duration was varied from 8 to 12 days with a mean of  $9.67 \pm 0.260$  days (Kabir *et al.*, 1997). Total development period from egg to newly emerged adult was varied from 21 to 34 days with a mean of  $26.00 (\pm 0.815)$  days (Fig. 1) (Liu and Lin, 2000).

**Table 2.** Duration of various life stages of *Zeugodacus tau* in cucumber

Life stages	Duration (Days)	
	Mean ± SE	Range
Egg	$1.23 \pm 0.058$	1 - 2
I instar maggot	$2.33 \pm 0.0875$	2 - 3
II instar maggot	$3.00 \pm 0.000$	3 – 3
III instar maggot	$9.67 \pm 0.443$	7 - 14
Pupa (includes prepupal stage)	$9.67 \pm 0.260$	8 - 12
Duration from egg to adult	$26.00 \pm 0.815$	21 - 34
Male Longevity	$110.93 \pm 1.419$	100 - 132
Female longevity	$119.46 \pm 2.730$	100 - 145

Measurements from egg to pupal stages are the means of 30 observations. Duration of male and female longevity means date from the adult emergence to death in honey water (1:5) solution.

When male and female was supplied with honey water (1:5) solution, male *Z. tau* can survive for 110.93 days ( $\pm 1.419$ ) and female *Z. tau* can survive for 119.46 days ( $\pm 2.730$ ) (Kabir *et al.*, 1997; Waseem *et al.*, 2012) (Table 2). The average room temperature during life cycle study was 26.79°C and RH was 78.04%.



**Fig. 1:** Life duration of various stages of *Zeugodacus tau* in cucumber.

## CONCLUSION

Pumpkin fruit fly, *Z. tau* is a destructive pest of cucurbitaceous crops in South Asia. All cucurbitaceous crops including tomato are the most damaging crops. It has complete life cycle i.e. egg, maggots, pupa and adult. Females oviposit eggs in a group or single inside the fruit pericarp. Maggots are damaging stage. Egg to pupal duration is 26-30 days. Male *Z. tau* has short life cycle than female. The life cycle study conducted here can help to design an appropriate IPM protocol for the sustainable management of fruit fly.

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