

**OVIPOSITION PREFERENCE AND SURVIVAL OF *Zeugodacus cucurbitae*
AND *Zeugodacus tau* UNDER LABORATORY CONDITIONS**

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ABSTRACT

Fruit flies are economically important pests of cucurbit crops. This study investigated the oviposition preference and maggot survival of *Zeugodacus cucurbitae* and *Z. tau* in a choice test using six potential host crops with marketable-sized fruits, namely cucumber (*Cucumis sativus*), squash (*Cucurbita pepo*), bitter melon (*Momordica charantia*), bottle melon (*Lagenaria siceraria*), sponge melon (*Luffa cylindrica*), and pumpkin (*Cucurbita moschata*). The experiment was conducted under laboratory conditions at the Plant Quarantine and Pesticide Management Centre, Lalitpur, April–September 2024. Adult fruit flies were obtained by culturing of fruit fly infested pumpkin fruits in the laboratory. In the choice experiment, the host preference of *Z. tau* was ranked from the highest to lowest as follows: pumpkin > cucumber > sponge melon > squash > bottle melon > bitter melon, whereas *Z. cucurbitae* preference were as; squash > bitter melon > cucumber > sponge melon > pumpkin > bottle melon. The oviposition period of *Z. tau* was 43–74% which was longer than that of *Z. cucurbitae*; however, *Z. cucurbitae* showed a higher daily fecundity (3.80 ± 0.40 eggs/female/day) than *Z. tau* (2.55 ± 0.20 eggs/female/day). The immature survivability was evaluated using a completely randomized design with three replications. Both fruit fly species performed the highest egg hatchability and adult emergence on squash, and the lowest was recorded on bottle melon for *Z. cucurbitae* and on bitter melon for *Z. tau*. Only about 10% of eggs or pupae failed to develop into adults. This finding demonstrates species-specific host preference underlying importance for targeted sustainable fruit fly management.

Keywords: choice test, cucurbits, host, oviposition, survivability

INTRODUCTION

Fruit flies (Diptera: Tephritidae) are the most devastating insect pests of horticultural crops, causing significant yield losses and reducing the market value of many fruits and vegetables. Of the approximately 5,000 known species of Tephritid fruit flies (Momen, Hossain, Seheli, Hossain, & Bari, 2025), two polyphagous species – melon fruit fly (*Zeugodacus cucurbitae*) and pumpkin fruit fly (*Z. tau*), are particularly harmful to cucurbit crops. These species can cause 30–100% yield losses depending on host availability, environmental conditions, and management practices (Dhillon, Singh, Naresh, & Sharma, 2005). *These species* are recorded at least 22 host crops, primarily within the Cucurbitaceae, with *Z. cucurbitae* exhibiting a broader host range reportedly infesting 42 plant

species across 12 families (Jia, Zhang, Wang, & Ji, 2023). Their wide host adaptability makes them formidable pests, especially in tropical and subtropical regions where cucurbit cultivation is extensive.

Gravid female fruit flies utilize their ovipositors to deposit eggs beneath the soft epidermis of host fruits or vegetables. Adult females tend to select oviposition sites based on the suitability of the host for the development and performance of their offspring (Fontellas-Brandalha & Zucoloto, 2004). Moreover, host preference for oviposition and associated offspring performance can exhibit geographic variability, often influenced by local host availability and phenotypic or genetic variation within fruit fly population (Mwatawala, Meyer, Makundi, & Maerere, 2009; Khan, Tahira, & Howlader, 2011). A thorough understanding of these dynamics is essential for predicting fruit fly behaviour and devising targeted pest management strategies tailored to specific agroecosystems.

Upon hatching, the maggot tunnels through the fruit mesocarp, feeding voraciously and causing extensive damage to the fruits. Infestation leads to fruit decomposition and premature fruit drop, render the fruit partially or entirely unmarketable, ultimately reducing yield, and economic losses (Vargas, Piñero, & Leblanc, 2015). The development of effective management strategies for fruit fly control remains challenging, largely due to insufficient understanding the host preferences of the damaging species. This knowledge gap complicates targeted pest management efforts and often leads to excessive reliance on chemical insecticides, which contributes to the development of insecticide resistance and poses environmental and health risks. Therefore, the present study was undertaken to evaluate the host preference for egg-laying performance of two major cucurbit infesting fruit fly species, and their survival rate on various cucurbit hosts aiming to develop a sustainable and host-targeted pest management approaches.

MATERIALS AND METHODS

Laboratory culture of fruit flies

The study was conducted at the Plant Quarantine and Pesticide Management Centre (PQPMC), Hariharbhawan, Lalitpur (27°40'50"N and 85°18'47"E), during April-September 2024. The fruit fly infested pumpkin fruits were collected from nearby markets and individually placed in plastic containers (1 L) filled to one-third with moist sawdust (~20% moisture) to facilitate pupation and adult emergence. After emergence, the fruit fly species were identified to species level using morphological keys provided in the Australian handbook (Plant Health Australia [PHA], 2018). Then, *Z. cucurbitae* and *Z. tau* species were kept in separate insect rearing cages under laboratory conditions. Six cucurbit crops were selected for comparative study based on their commercial relevance: cucumber (*Cucumis sativus* L.), squash (*Cucurbita pepo* L.), bitter melon (*Momordica charantia* L.), bottle gourd (*Lagenaria siceraria* Molina), sponge gourd (*Luffa cylindrical* L.) and pumpkin (*Cucurbita moschata* Duchesne). The maggots were reared on cucurbit hosts. The adult fruit flies in rearing cage were supplied with the host fruit (marketable size and healthy) and nutritional supplement [water (3): sugar (1): glucose (1): yeast (1) ratio suggested by Rahaman, Jahan, Islam, and Alam (2015)]. The temperature (26.14 ± 0.41 °C) and relative humidity ($72.60 \pm 4.47\%$) was maintained consistently during the experimentation.

Host preference test

Two separate experiments were conducted for each species in the choice test in which, 10 pairs of each species (6-7 days) were released in wooden cages measuring 60 cm x 60 cm x 60 cm, with three sides covered by mesh and one side fitted with a transparent plastic sheet. Each cage was supplemented with fruit slices (75 g each) of the six cucurbit hosts, placed 5 cm apart, and exposed for 24 hours (Fig. 1). The number of eggs deposited in each fruit slice was counted daily observing under stereo microscopes (DZ.1100, Euromex Microscopes, Holland). Then, each fruit slice was replaced with a fresh slice of the same cucurbit host and continued monitoring until the end of oviposition period.



Fig. 1. Host preference experiment set up (choice test) of fruit fly species in the laboratory.

Survivability tests and adult sex ratio

The survivability of immature stages (eggs, larvae/maggots and pupae) and sex ratio of each fruit fly species continued on the selected six cucurbit hosts. Each host treated as a treatment, i.e. six treatments replicated three times in a completely randomized design (CRD). Five pairs of adult flies of each species were exposed to each host (fruit slice), kept in a plastic container (1L) and covered with muslin cloth for oviposition. For each replicate, 50 freshly laid eggs were transferred into ~25 g fresh fruit slices of each host, placed in petri dishes (9 cm) lined with moist filter paper to maintain humidity. The eggs were monitored daily, and hatching was confirmed by the emergence of first instar larvae (maggots). The number of freshly emerged maggots was recorded to calculate the egg survival rate or egg hatchability. From the newly emerged maggots, 30 neonate maggots were gently

transferred into new slices of the same host (~50 g) for further development. Upon reaching the third instar (full grown maggots), the maggots were transferred to glass jars containing sawdust (~5 cm deep, ~20% moisture) to facilitate pupation. Each jar was covered with muslin cloth secured with a rubber band to prevent escape while allowing aeration. Pupal formation was recorded by counting the number of pupae developed from an initial batch of 30 larvae. Similarly, 30 pupae were used to assess pupal survival. Pupal survival was assessed by counting the number of adults emerged from the 30 pupae. The survival rate at each developmental stage (egg → larva → pupa) was calculated. The number of emerged male and female adults was recorded to calculate their sex ratio.

Data analysis

Descriptive statistics (mean and standard error) were used to summarize results of egg count and oviposition preferences across cucurbit hosts. For the survivability test, data on egg survival/hatchability, larval survival, pupal survival, and sex ratio were subjected to analysis of variance (ANOVA) considering two factors (fruit fly species and host crops) using GenStat version 18. Fisher's protected least significant difference (LSD) test was performed as a post-hoc procedure to separate treatment means at a 5% level of significance. Additionally, two-sample, two tailed t-tests were used to compare key reproductive parameters (oviposition duration, oviposition rate, and fecundity) between fruit flies, *Z. cucurbitae* and *Z. tau*.

RESULTS

Ovipositional preference of two fruit fly species

There were significant differences between *Z. cucurbitae* and *Z. tau* in terms of oviposition rate and oviposition duration irrespective of cucurbit hosts (Fig. 2). Although the maximum egg-laying rate of *Z. cucurbitae* was considerably higher (~6 eggs/female/day) compared to *Z. tau* (~4/female/day), the overall fecundity of mated gravid females of both fruit fly species was nearly similar (Table 1). This was due to differing oviposition patterns: *Z. cucurbitae* had a shorter oviposition period with a higher daily egg-laying rate, while *Z. tau* exhibited a longer oviposition period but with a lower daily egg-laying rate. The oviposition period of *Z. tau* was 43-74% longer than *Z. cucurbitae*; however, the egg-laying rate was higher in *Z. cucurbitae*.

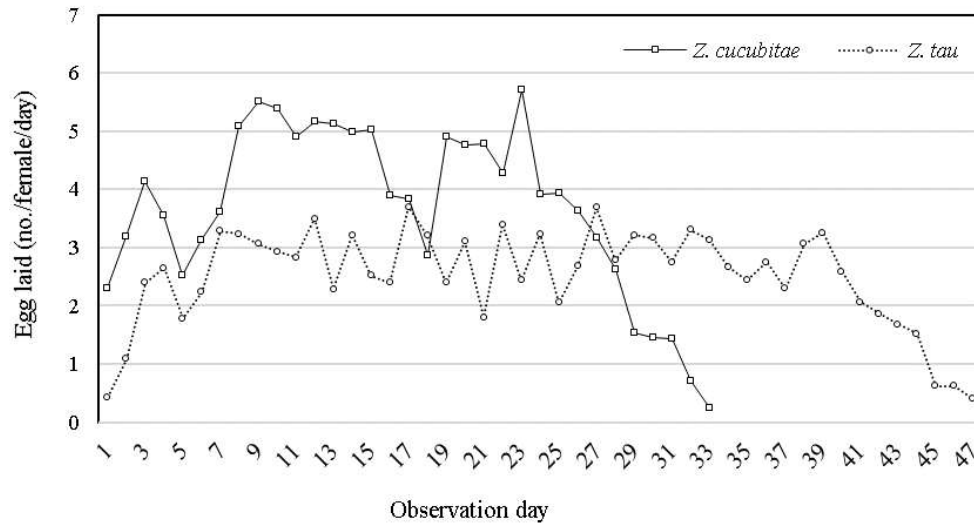


Fig. 2. Number of eggs laid in choice test irrespective to crops over the oviposition period (up to 47 days) by *Z. cucurbitae* and *Z. tau* in the laboratory.

Host preference of fruit fly species

Host preference for total number of eggs laying varied significantly between the two fruit fly species. *Z. cucurbitae* preferred squash the most, followed by bitter gourd, cucumber, sponge gourd, pumpkin, and the least preferred host was bottle gourd. In contrast, *Z. tau* exhibited a strong preference to pumpkin, followed by cucumber, sponge gourd, squash, bottle gourd, and the least to bitter gourd (Table 1). Although there was no significant difference in the total number of eggs laid per female between the two species, results suggested species-specific host selection behaviors likely influenced by differences in host suitability.

Table 1. Egg counts of *Z. cucurbitae* and *Z. tau* (mean $\pm$ se) in selected cucurbit hosts in choice test

Host crop	Eggs (female/day)		Eggs (female/oviposition period)	
	<i>Z. cucurbitae</i>	<i>Z. tau</i>	<i>Z. cucurbitae</i>	<i>Z. tau</i>
Bitter gourd	4.50 $\pm$ 0.48	1.98 $\pm$ 0.17	150	84
Bottle gourd	2.61 $\pm$ 0.27	1.90 $\pm$ 0.11	81	88
Cucumber	4.41 $\pm$ 0.43	2.96 $\pm$ 0.25	140	139
Pumpkin	3.11 $\pm$ 0.36	3.54 $\pm$ 0.36	92	167
Sponge gourd	3.10 $\pm$ 0.42	2.51 $\pm$ 0.17	103	119
Squash	5.10 $\pm$ 0.45	2.38 $\pm$ 0.16	164	112
Grand Total	3.80 $\pm$ 0.40	2.55 $\pm$ 0.20	122 $\pm$ 13.91	118 $\pm$ 12.86

Survival rate and sex ratio

The survival rate of eggs, maggots, pupae and sex ratio of both *Z. cucurbitae* and *Z. tau* are presented in Table 2. There was significant influence of host on egg hatchability and adult emergence percentage of both fruit fly species. The survival rate across developmental stages of both *species* was generally higher, with nearly all larvae turning into pupae. However, approximately 10% of eggs or pupae failed to enter the next development stage. Some natural mortality of maggots was observed during larval development across cucurbit hosts. Pupation performance was consistent across all hosts except bitter gourd and bottle gourd which showed 2-3% larvae mortality.

Table 2. Survival rate across developmental stages and sex ratio of *Z. cucurbitae* and *Z. tau* in selected cucurbit hosts in the laboratory

Treatments	Survival rate (mean $\pm$ se %)			Adult sex-ratio (Female/male)
	Eggs (n=50)	Maggots (n=30)	Pupae (n=30)	
Species				
<i>Z. cucurbitae</i>	91.00 $\pm$ 1.31	99.40 $\pm$ 0.31	90.11 $\pm$ 1.40	1.13 $\pm$ 0.11
<i>Z. tau</i>	91.33 $\pm$ 1.42	99.12 $\pm$ 0.50	89.41 $\pm$ 2.21	1.40 $\pm$ 0.12
LSD (F-test)	ns	ns	ns	**
Hosts				
Bitter gourd	88.67 ^c $\pm$ 2.90	97.22 ^b $\pm$ 1.30	85.62 ^{cd} $\pm$ 5.00	1.50 $\pm$ 0.13
Bottle gourd	84.00 ^d $\pm$ 1.31	98.89 ^{ab} $\pm$ 0.71	82.61 ^d $\pm$ 1.50	1.23 $\pm$ 0.06
Cucumber	93.33 ^b $\pm$ 1.00	100.00 ^a $\pm$ 0.00	92.78 ^{ab} $\pm$ 1.61	1.16 $\pm$ 0.17
Pumpkin	93.33 ^b $\pm$ 1.91	100.00 ^a $\pm$ 0.00	91.67 ^{ab} $\pm$ 3.32	1.39 $\pm$ 0.11
Sponge gourd	90.67 ^{bc} $\pm$ 1.50	100.00 ^a $\pm$ 0.00	90.00 ^{bc} $\pm$ 1.21	1.20 $\pm$ 0.13
Squash	97.00 ^a $\pm$ 0.40	99.44 ^a $\pm$ 0.61	96.11 ^a $\pm$ 1.00	1.10 $\pm$ 0.04
Grand Total	91.00 $\pm$ 2.31	99.41 $\pm$ 0.71	89.80 $\pm$ 3.11	1.26 $\pm$ 0.05
Host LSD (F-test)	3.15**	1.87*	4.72**	ns
Species*host (F-test)	4.46**	ns	6.68**	ns

Means followed by the same letter(s) within the column do not differ significantly by Fisher's protected LSD at 5% significance level. **, * and ns represent the P value <0.01, <0.05 and non-significant, respectively.

A higher proportion of female was recorded on both fruit-fly species. The female: male ratio was significantly higher in *Z. tau* than *Z. cucurbitae* (Table 2). Higher female proportion in *Z. tau* may facilitate their multiplication faster than *Z. cucurbitae*. Different types of cucurbit hosts did not significantly influence the sex ratio for emerging adults of both fruit fly species.

The interaction between fruit fly species and host plants was significant for both egg hatchability and adult emergence (Fig. 3). The egg, larva and pupa survivability did not differ significantly between the fruit-fly species. Squash and bottle gourd remained consistent for both species as the most preferred and the least preferred hosts, respectively, which was also reflected in their offspring performance. A significant but inverse relationship between species was observed in different hosts.

The bitter gourd was the second most preferred host of *Z. cucurbitae*, and the least preferred host of *Z. tau* in terms of both oviposition preference and survivability (Fig. 3). A similar trend of ovipositional preference and survivability was to pumpkin.

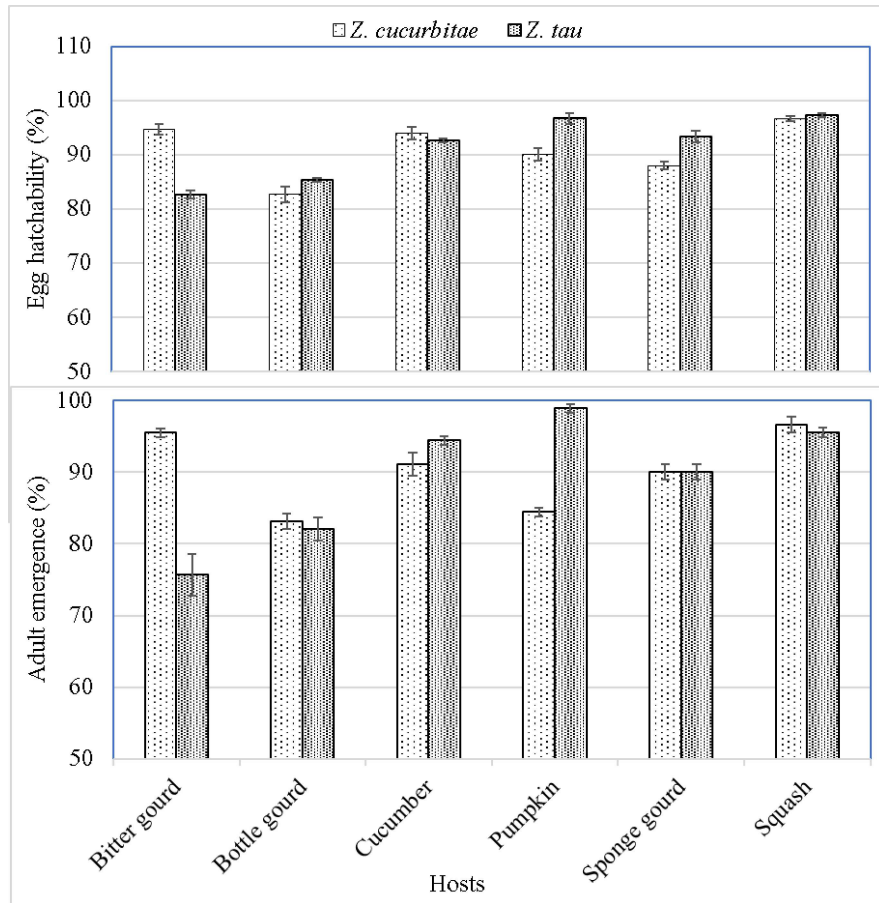


Fig. 3. Interaction effect of species (*Z. cucurbitae* and *Z. tau*) and cucurbit hosts on adult emergence (mean $\pm$ se) and egg hatchability (mean $\pm$ se) in the laboratory.

DISCUSSION

Zeugodacus tau exhibited a more consistent and prolonged egg-laying ability but lower in rate (egg/female/day) compared to *Z. cucurbitae*. Mir, Dar, Mir, and Ahmad (2014) reported that the oviposition period of *Z. cucurbitae* varied from 12 to 28 days and fecundity ranged from 58-92 eggs. In contrast, Singh, Kumar, and Ramamurthy (2010) documented a longer oviposition period of approximately 50 days for *Z. tau*, with an average daily laying rate of 9.9 ± 8.5 eggs and a total fecundity of 464.6 ± 67.98 eggs per female. Recently, Li et.al. (2026) reported that *Z. cucurbitae* exhibited a significantly higher oviposition rate and a shorter oviposition period than *Z. tau*.

Host preference among cucurbits by the fruit fly species varied in this study. Such variation has also been widely documented. Ullah, Das, and Islam (2008) identified squash as the most preferred host among selected cucurbits, whereas Shahzadi et al. (2019) reported bitter gourd as the most preferred host for *Z. cucurbitae*. Nazir et al. (2024), using ANN-based Multi-Layer Perceptron model and decision tree-based Random Forest (RF) models, demonstrated that *Z. cucurbitae* preferred bitter gourd > pumpkin > cucumber, while *Z. tau* preferred pumpkin > cucumber > bitter gourd for oviposition. Similarly, Pradhan, Gupta, Kumar, and Longkumer (2020) observed higher fecundity of *Z. cucurbitae* on bitter gourd (78 eggs) and lower fecundity on bottle gourd (48 eggs). Khan et al. (2011) also reported bitter gourd and cucumber as highly susceptible hosts. Host preference in fruit flies is influenced by multiple factors, including fruit odor, color, size, and shape (Li-Li, Li-Yan, Qiao-Gen, Shu-Dong, & Hua-Guo, 2008).

Variation in sex ratio among different hosts was observed; however, these differences were not statistically significant. Chaudhary, Patel, and Kumar (2025) reported a female-biased sex ratio (1.27:1) of *Z. cucurbitae* on cucumber. In contrast, Desai, Jakhar, Patel, and Dalvaniya (2018) observed a relatively higher male proportion (1:0.93) in *B. cucurbitae* reared on sponge gourd and bitter gourd. Similarly, Gaddanakeri and Rolania (2020) also documented host-related variations in sex ratio. Mir et al. (2014) also reported that seasonal fluctuation and the type of available food material play a decisive role in determining fruit fly sex ratios. Collectively, these findings suggest that sex ratio in fruit flies is influenced by host cultivar, seasonal variation, and prevailing environmental conditions rather than a single determining factor.

The survival performance was influenced by the host in both *Z. tau* and *Z. cucurbitae*. Laskar (2013) reported high egg hatchability of *Z. cucurbitae* on pumpkin (89.6%) and bitter gourd (86.4%), further indicating that preferred hosts enhance reproductive success. In *Bactrocera dorsalis*, females tend to lay more eggs on preferred hosts, resulting in improved offspring survival (Kalia & Srivastava, 1992) and thus the survival is assessed for offspring performance (Rauf, Ahmad, Rashdi, Ismail, & Khan, 2013). This aligns with the evolutionary hypothesis that female fruit flies select hosts that maximize progeny fitness (Akol, Masembe, Isabirye, Kukiriza, & Rwomushana, 2013).

CONCLUSIONS

Squash (*Cucurbita pepo*) was the most preferred host for oviposition by *Z. cucurbitae*, whereas pumpkin (*Cucurbita moschata*) was the most preferred host for oviposition by *Z. tau*. *Z. cucurbitae* exhibited a higher oviposition rate, while *Z. tau* had a longer oviposition period; however, no significant difference was observed in the total fecundity of the two species. Survival rates at different developmental stages varied among host plants and between fruit fly species, thereby influencing their overall population dynamics. The preferred hosts supported higher survivorship of the immature developmental stages in both fruit fly species. These findings enhance our understanding of host suitability and may contribute to the development of more sustainable and effective management strategies for fruit flies infesting cucurbit crops.

ACKNOWLEDGEMENTS

We appreciate the Plant Quarantine and Pesticide Management Centre (PQPMC), Hariharbhawan, Lalitpur for providing the laboratory facilities to execute this study.

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