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.v7i1.445

Research Article

OVIPOSITIONAL PREFERENCES OF THE PEACH FRUIT FLY (BACTROCERA ZONATA, SAUNDERS) (DIPTERA: TEPHRITIDAE) AMONG DIFFERENT HOST FRUITS

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Abstract

The females of the highly polyphagous *Bactrocera zonata* damage orchard fruits because they lay their eggs in the fruit. Knowing how to control oviposition can decrease the damage done to fruit. I wanted to know how B. zonata tends to lay its eggs on different host fruits in controlled lab environments. There were experiments with no choice and with choice to observe fruit visits, visit lengths, attempts to lay eggs, eggs laid successfully and how long it took to lay eggs in each fruit. The host fruits in the study were papaya (*Carica papaya* L.), banana (*Musa paradisiaca* L.) and guava (*Psidium guajava* L.). The host fruit made a big difference in how much and for how long *B. zonata* females visited fruit collecting sites in the "no-choice" trials. There were more visits to banana compared to any other fruit and papaya had people staying on the page the longest. No matter the kind of fruit, the number and duration of larvae being deposited were unchanged and no larvae were seen on guava. The time spent on the fruits and the number of attempts at laying eggs changed a lot across the types of host fruits in the choice experiments. Among these fruits, only guava attracted oviposition activities from *B. zonata* females and this did not happen on banana or papaya. They give details about *B. zonata* female behavior which can guide approaches to controlling this pest. Knowing about this information could help lower losses of crops due to this pest.

Keywords: *Bactrocera zonata, host fruits, ovipositional preference, pest behavior, biological control.*

(Received: 05-Jan-2025 Accepted: 10- April-2025) Cite as: Hasnain. M., Ali. Qurban., Nadeem. S., Hussain. D., Hafeez. F., Akram. M., Saleem. M., Ali. I., Akhtar. S, Saleem. M. J., 2025. Ovipositional preferences of the peach fruit fly (*bactrocera zonata*, saunders) (diptera: tephritidae) among different host fruits. Agric. Sci. J. 7(1): 1-8

1. INTRODUCTION

Tephritid fruit flies (Diptera: Tephritidae) are one of the most dangerous pests for global agriculture and have a major influence on productivity (Aluja and Mangan, 2008; Rendón and Enkerlin, 2021). Many of these pests make it difficult to sell horticulture crops and lead to major losses in farming (Sharma *et al*., 2017). Both direct and indirect economic damage is caused to agriculture by the infestation of fruits and vegetables that weakens their quality and looks (Billah *et al*., 2015).

Because these flies lay many eggs and can feed on multiple fruit species, Bactrocera genus in the Tephritidae family is harmful for horticulture (Clarke *et al*., 2005). Bactrocera species are becoming a bigger issue worldwide because they have formed populations outside of Asia. Tephritid fruit flies often result in many economic losses both on Pakistani farms, during the trade of goods, at the retail level and during

exporting. Since their crops can be very sensitive and require a lot, those who farm on a small scale are at greater risk from pests. Without proper management, fruit losses in Pakistan can total 21%, cucurbit losses may increase to 24% and direct losses might be anywhere between 30% and 80% (Gul *et al*., 2024).

B. zonata is the tephritid species found in Pakistan and also is the most destructive one. You can find this in Baluchistan, along the coast and inland farms of Sindh and in large parts of Punjab. Sarwar *et al*. (2013) also found it to be a minor problem in parts of Khyber Pakhtunkhwa by the foothills of Islamabad and Peshawar Valley (Kakar *et al*., 2014). Previously found only in tropical Asia, B. zonata now occurs in many tropical regions (Hussain *et al*., 2022). A lack of prompt action to control fruit flies can seriously affect fruits and vegetables and this can lead to heavy financial losses. These issues point out the need for strong and combined pest management techniques to safeguard horticultural products.

Many studies have looked into herbivorous insect hosts, showing that host performance is crucial for selection and modification of host species and is involved in nearly 25 to 40% of all interactions between insects and animals (Zhou *et al*., 2015). Bactrocera fruit flies are interested in a broad range of hosts. Although some species only live on one type of host, others can attack up to 31 different commercially grown hosts (White and Elson-Harris, 1992).

When deciding on a location to lay their eggs, fully created female fruit flies take into account how good the chosen fruits will be for the survival and proper growth of their offspring (Kienzle *et al*., 2020). It was found by Salman *et al*. (2022) and Kanika *et al*. (2019) that differential preferences in B. zonata are due to adult choice of various fruits for oviposition in both artificial and natural experiments.

Earlier studies examined Bactrocera fruit flies on topics that cover the species in a general manner, not limiting the results to any particular region. We have very little knowledge about which crops and soil types the pests like and which ones they deposit their eggs in throughout Pakistan. Yet, studying the fruit fly's movements improves the way pest monitoring, control strategies and decision making in important crops can be handled. Usually, traditional fruit fly monitoring is done with traps using male lures that might not be effective for some species. Fewer studies look at how females reproduce and what methods can capture more information about pests.

This experiment wants to see how fruit flies decide to eat and lay their eggs when provided with different host fruits. Knowing the host preference of such fruit flies helps explain why or why not certain economically important fruit fly species may be present in a given area. Besides, this technique helps discover those fruit fly species that are not easily attracted by typical male attractants.

Because of the novel method used and the practical concerns explored, this study delivers important findings about fruit flies and new ideas for managing pests sustainably. Especially, the study looks at the habits of oviposition and the choice of host plants of *Bactrocera zonata* among agriculturally significant fruits and vegetables in Pakistan. This research uses experiments and new field approaches for host exposure like placing guava in basket-like structures, joining ecological information and practical pest control.

The approach differs from conventional methods since it does not just use lures for males which allows scientists to find species that lures may not attract. It also displays which crops the pest prefers first, helping show how such choices are made. Studies on regional pest data give important knowledge about guava, banana and cucurbit pest

populations which then guides better ways of managing pests in farming. Because of this approach, scientists can better observe fruit fly behaviors and produce solutions to major agricultural issues in Pakistan.

2. MATERIALS AND METHODS

Adults of *Bactrocera zonata*

The lab raised the beetles in the experiment for five generations, providing them with controlled temperature (28 ± 2°C), humidity (70–80%) and natural light with 12:12 hours of day and night. All new adults (50) were placed in cages 30 cm by 30 cm by 30 cm, each group separated by sex. They mixed a water sponge with yeast cubes and yeast extract in amounts of 3 to 1 to feed the yeast sponge. Only adult females who were 21 days' old took part in the research, as this was when they produced the most eggs (Nor *et al*., 2018).

Host Fruits

Papaya (*Carica papaya* L.), banana (*Musa paradisiaca* L.) and guava (*Psidium guajava* L.) were the three fruits selected to be host fruits. A host to *B. zonata* is provided by these fruits in Peninsular Malaysia and Indo-Pakistan (Allwood *et al*., 1999). The fruits selected for the experiment were taken from the local market, since *B. zonata* finds them suitable for oviposition. All fruits used in the experiments were selected carefully to make sure the results were similar. A close experiment showed that female *B. zonata* preferred to lay eggs in these particular fruits.

Host Fruit Characteristics

Physical Measurements

I measured each type of fruit (guava, banana and papaya) by weighing 10 individual samples with a weighing balance scale. Every fruit's diameter was measured with a Vernier caliper. Average weights and diameters were found and noted down for every fruit type.

Determination of Total Soluble Solids (TSS) and Fruit

The fruits/samples were examined for total soluble solids (TSS, measured in °Brix) as well as firmness:

Total Soluble Solids Determination:

The automatic pocket refractometer (Atago, Japan) was used to obtain the TSS. Some fresh fruit was squeezed to make juice and a couple of drops were applied to the prism of the refractometer. After 15 seconds in the dark so as not to influence the sample, the result was shown as °Brix. The measurement was done three times for each fruit.

Firmness Measurement:

The automatic pocket refractometer (Atago, Japan) was used to obtain the TSS. Some fresh fruit was squeezed to make juice and a couple of drops were applied to the prism of the refractometer. After 15 seconds in the dark so as not to influence the sample, the result was shown as °Brix. The measurement was done three times for each fruit.

Determination of *Bactrocera zonata* Ovipositional Preference

No-Choice Experiment

Each type of fruit (guava, banana and papaya) was put by itself into a clear, round plastic container of size 24 × 10 cm. A container was given a transparent lid and the next step was to put a single gravid female *Bactrocera zonata* inside it. The two-hour observation (09:00–11:00 h) during which the females were observed corresponds to the peak time of the species' oviposition activity (Vargas *et al*., 2015).

The following parameters were recorded:

1. How many fruit plantations were included in the visits.
2. Length of time fruit is visited in the cage.
3. The number of oviposition attempts.
4. Numbers of successful ovipositions.
5. Time taken for an egg to be deposited from insertion of the ovipositor to its removal.

A counter was used to record the number of flies that came and the stopwatch was used to measure each behavior's duration.

Choice Experiment

Fruits were put together in a rearing cage (as I mentioned above) with an interval of 10 cm between every fruit for the selection study. The food group's cage received a gravid female B. zonata and her ovipositing was watched in the same conditions (09:00–11:00 h) as before. The same information was written down for the no-choice test. In the lab, the choice and no-choice trials were carried out five times each under conditions of 28 ± 2°C, 60–70% (R.H) humidity and 12:12 hours of light and dark.

Data Analysis

The study used a Completely Randomized Design with five replications per treatment, analyzing fruit characteristics like physical measurements, TSS, firmness, and *B. zonata* ovipositional behavior. Data was analyzed using one-way ANOVA, with mean comparisons performed using Tukey's Honestly Significant Difference test at a 5% significance level. All statistical analyses were conducted using MINITAB® 17 software.

3. RESULTS AND DISCUSSION

Fruits Characteristics

There was a substantial difference between the guava, banana, and papaya fruit properties at ($P < 0.05$) found in the fruit weights, with papaya being the heaviest (0.98 kg), followed by banana (0.33 kg) and guava (0.12 kg). Regarding fruit diameter, guava was significantly smaller than banana and papaya both, measuring 2.47 cm, 3.20 cm, and 7.87 cm, respectively.

The study found that guava had the lowest Total Soluble Solids content (8.53°Brix) compared to banana and papaya, indicating less sweetness. However, significant differences were observed in firmness among the three fruits. Banana was the softest, followed by papaya, while guava had the highest firmness (67.30 N), indicating it was much firmer than both.

Oviposition Behavior Preference of *B. zonata* on various Host Fruits: A No-Choice Experiment

The frequency of oviposition attempts, length of fruit visits, and number of fruit visits all differed significantly ($P<0.05$), according to the data (Table 2). Nevertheless, neither the quantity of ovipositions nor the length of time spent in oviposition were found to vary significantly ($P>0.05$). According to Table 2, female *B. zonata* visited bananas 30.70 times more often than guavas (13.00 times) and papayas (2.33 times). It's interesting to note that the flies stayed on papaya for the longest (55.20 minutes) as opposed to guava (15.90 minutes) and banana (2.81 minutes) (Table 2). This may be explained by the mature banana fruits' softer flesh and increased sugar content (Table 1), which may draw flies for oviposition. *B. zonata* preference for oviposition behavior on Various Host Fruits: A No-Choice Experiment.

The host fruit's volatiles affect the preference of *B. zonata* females. In order to find food, mates, and places to lay their eggs, insects often employ a variety of volatile molecules as signals. For gravid females to find appropriate oviposition locations from a distance, volatile chemical signals from the host plant are essential (Kamala Jayanthi *et al*., 2014).

The frequency of oviposition attempts by *B. zonata* females was found to be significantly higher on bananas (Table 2), indicating that these attempts are often used as an initial probing action for egg insertion (Sarwar, 2020). In natural environments *B. zonata* females are often attracted to wounds, cracks as well as bruises proceeding the fruit (Rattanpal *et al*., 2017), farming practices, insect eating and feeding, harvesting and pruning, plant diseases, and fruit over ripeness are some of the issues that can affect agricultural production (Rattanapun *et al*., 2009). The study found no significant difference in oviposition number or duration

Table 1: Properties of Host Fruit Characteristics

Fruits	Weight (kg)	Diameter (cm)	TSS (°Brix)	Firmness (N)
Guava	0.12±1.01a	2.47±1.09a	8.53±1.32a	67.31±1.43a
Banana	0.33±1.02b	3.20±1.20b	11.30±1.35b	6.24±1.33b
Papaya	0.98±1.11c	7.87±1.35b	10.13±1.15ab	12.43±1.65c

Means having same letter within each column are not significantly different at the 0.05 level

Table 2: Oviposition Behavior Parameters of *Bactrocera zonata* under No-Choice Experiment

Fruit Host	No. of Fruit Visit	Duration of Visit (min)	No. of Attempts to Oviposit	No. of Ovipositions	Duration of Oviposition Completed (min)
Guava	13.00±4.04a	15.90±14.80a	1.07±0.67a	0.00±0.00a	0.00±0.00a
Banana	30.70±17.50b	2.81±1.67b	8.67±1.86b	1.33±0.58a	3.34±2.42a
Papaya	2.33±0.88c	55.20±2.60c	2.00±1.15a	1.00±0.67a	1.24±0.63a

Means having same letter within each column are not significantly different at the 0.05 level by Tukey's HSD test.

Table 3: Oviposition Behavior Parameters of *Bactrocera zonata* under Choice Experiment

Host Fruit	No. of Fruit Visit	Duration of Visit (min)	No. of Attempts to Oviposit	No. of Ovipositions	Duration of Oviposition Completed (min)
Guava	2.33±1.33a	45.50±34.60a	2.67±1.76a	0.67±0.67a	1.16±1.16a
Banana	1.00±1.00a	0.17±0.17b	0.00±0.00b	0.00±0.00a	0.00±0.00a
Papaya	0.67±0.67a	1.41±1.41b	0.00±0.00b	0.00±0.00a	0.00±0.00a

Means with the same letters within column are not significantly different (P>0.05) by Tukey's HSD test.

among fruits, but bananas had slightly higher parameters at 1.33 times and 3.34 minutes (Table 2). This could be attributed to the softer pulp of banana fruits, which likely facilitates easier ovipositor insertion and helps *B. zonata* larvae move more easily while feeding (Ansari *et al*., 2019).

Different scientists reported that fruits with lower hardness and firmness tend to have higher infestation rates and greater oviposition preference (Sau *et al*., 2023; El-Gendy *et al*., 2020). Guava, with its highest firmness value, did not show any oviposition activity, indicating it's not a suitable fruit for

B. zonata females to lay eggs shown in table 1, as firmness is a crucial factor influencing adult oviposition preference (Seo *et al*., 2023).

Choice Experiment

Interestingly, *B. zonata* females only showed oviposition activity on guavas; no oviposition behavior was seen on bananas or papayas (Table 3). In contrast, no oviposition activity was seen on guava in the no-choice trial (Table 2). Overall, there was a notable variation in the number of attempted ovipositions and the length of fruit visits. Nevertheless, there was no discernible variation in the quantity of fruit visits, ovipositions, or length of oviposition (Table 3). Despite being the toughest fruit, guava showed considerably higher values for oviposition behavior across all measured parameters (Table 1). The number of fruit visits among the host fruits, however, did not differ significantly (Table 3). Other elements that could affect the preference of female flies for oviposition include fruit volatiles, fruit lesions or cracks, and oviposition holes made by conspecifics.

A female *Bactrocera zonata* inspects the skin of possible host fruit by using both her antennae and mouth, then checks if it's suitable for laying eggs by probing it with her ovipositor (Theron *et al*., 2023). Spiders depend on how a plant appears, including its look and smell, in addition to how it smells, to choose where to build (Shelly, 2018). A round shape is highly favored among these characteristics, because a sphere catches the eye from multiple directions. This is one reason guava fruits which usually have this feature, are liked so much (Scales, 2021).

But the way *B. zonata* lays eggs is affected by more than the thickness and hardness of fruits which means something else must influence host acceptance and susceptibility (Isabirye *et al*., 2016). All the female flies studied here were lab-reared and never participated in egg-laying activities. It is believed that because they have had little or no prior experience, newly formed females are not good at choosing their host. B. zonata eggs are generally deposited on fruits that have good quality and factors including size, colour, skin penetration and maturity level play major roles (Aluja and Mangan, 2008; Gogi *et al*., 2017).

CONCLUSION:

Where and how *Bactrocera zonata* deposits its eggs is affected by features of the host fruit. Guava's hardness led to few female parasitoids trying to lay eggs on it, but banana which had low hardness and high TSS, had the most activity. During the experiment, fruit choice varied which emphasizes that preference can be affected by the circumstances.

This research has found that size, color, penetrability and ripeness are not the only things that affect *B. zonata*'s choice of host. Researchers should observe oviposition in real field settings to learn more about it. Having this knowledge helps create better ways to control and check pests.

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