

Research Article

Comparative Ovipositional Preference of the Peach Fruit Fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) for Selected Fruits under Free-Choice Laboratory Setting

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Abstract | *Bactrocera zonata* (Saunders), the peach fruit fly is a severe pest of many important fruits in Pakistan causing massive economic losses. Experiments were executed to reveal the ovipositional preference of *B. zonata* for four selected fruits belonging to different plant families, viz., banana (*Musa acuminata*), persimmon (*Diospyros kaki*), apple (*Malus domestica*) and tomato (*Solanum lycopersicum*). The study was performed under free choice conditions by exposing all the tested fruits in the same arena to *B. zonata* female adults. Results revealed that tested biological parameters were significantly affected by the tested host except sex ratio. However, banana was found the most preferred host with maximum number of pupae recovery (298), maximum emerged flies (185) followed by persimmon, apple whereas tomato was least preferred host with lowest number of pupae (06) and flies emerged (05) respectively. Thus, it is concluded that banana fruit can be used as natural host for rearing of *B. zonata* in the laboratory due to its consistent availability.

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Keywords | Adult emergence, *Bactrocera zonata*, Banana, Host preference, Pupal recovery



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Introduction

Fruit flies (Diptera: Tephritidae) are severe insect pests of horticultural crops in sub-tropical and tropical regions around the globe (Jitendra *et al.*, 2012; Rauf *et al.*, 2013). Being cosmopolitan in nature, fruit flies perpetrate colossal economic losses to a wide range of vegetables and fruits thereby significantly distressing the global trade. In Pakistan, the losses caused by fruit flies' range between 5-100% in

fruits, whereas, 30-100% in vegetables (Syed *et al.*, 1970; Sapkota *et al.*, 2010). Tephritid genus *Bactrocera* is comprised of 50 extremely destructive polyphagous pest species. Among these, *Bactrocera zonata* (Saunders), the peach fruit fly, cause severe losses to over 55 fruit hosts, including mango, peach, apricot, guava, banana, apple and fig (White and Elson-Harris, 1992; Ghanim, 2009; Delrio and Cocco, 2010).

The fruit flies favor laying eggs on hosts that pro-

foundly support the biological activities of the subsequent generation (Joachim-Bravo *et al.*, 2001; Fontellas-Brandalha and Zucoloto, 2004). The female fruit flies select the hosts for egg laying involving a complicated process and comprises a chain of chemical and physical elements that impact the balance and choice between the positive and negative stimuli (Messina, 1990; Kostal, 1993). Of these factors, the nutritional value, foliage characteristics, shape, color, odor and size of fruits have significant impact on the host selection for oviposition by the female *B. zonata* (Balagawi *et al.*, 2005; Jaleel *et al.*, 2018).

Previously, Rasool *et al.* (2017), studied host preference of five fruit flies (*B. zonata*, *B. correcta*, *B. dorsalis*, *B. cucurbitae* and *B. oleae*) and discovered that bitter gourd and guava were the most preferred hosts for the tested species. In citrus fruits, host selection of *B. tryoni* was investigated under no choice and open choice bioassays by Muthuthantri and Clarke (2012). This study revealed that *Bactrocera tryoni* demonstrated an oviposition preference hierarchy among the citrus fruits tested; Murcott and grapefruit were most preferred for oviposition and lemon the least, while preference for Navel and Valencia was intermediate. Similarly, Sarwar *et al.* (2013) studied ovipositional preference and maggot's development of *B. zonata* in mango, peach and apple under free choice in vitro trials. Whereas, Rauf *et al.* (2013) carried out trials in citrus, guava, apple, chikoo, banana and ber, in free choice and no choice trials by indicating that the guava was the most preferred host with mean pupal recovery of 318.00 ± 4.61 pupa/fruit under free choice and 434 ± 2.64 under no choice conditions, followed

by banana (266.00 ± 4.5 p/f) in free choice and ber (177.00 ± 2.08) in no choice experiment. Whereas, apple and citrus were least preferred hosts.

One of our major objectives of the Plant Protection Division at Nuclear Institute for Food and Agriculture (NIFA), Peshawar is to establish and enhance fruit fly colony. Establishment of laboratory rearing of fruit fly and its quality production are very important for conducting different Research & Development activities. Continuous supply of natural host and its acceptability by the fruit flies are among the few pre-requisite factors owing to colony persistency and robustness. Several types of fruits/natural hosts are widely used for culture maintenance at fruit fly laboratories which varies among species and regions. The hunt for such favorable host that encourages subsequent life traits is highly imperative to produce quality individuals of specific fruit fly species.

Various fruits such as peach, persimmon, tomato, guava, ber, chiko, mango etc. have been used extensively for mass rearing of fruit flies by many researchers. However, seasonal availability of all these fruits is one of the major limiting factors in adopting these fruits for consistent fruit fly rearing. In this regard we investigated the host preference of *B. zonata* towards four different fruits viz. banana, apple, persimmon and tomato in order to generate information regarding some biological parameters such as pupal formation, adult emergence and sex ratio. Such host assessment data could be supportive in selecting the best host fruit for mass rearing of peach fruit fly in laboratory.

Table 1: List of selected host fruits for host preference trial.

EnglishName	Botanical Name	Family	Colour	Texture
Banana	<i>Musa acuminata</i>	Musaceae	Yellow with brown spots	Soft/ Mature
Persimmon	<i>Diospyros kaki</i>	Ebenaceae	Red orange	Soft/ Mature
Apple	<i>Malus domestica</i>	Rosaceae	Pinkish red	Soft/ Mature
Tomato	<i>Solanum lycopersicum</i>	Solanaceae	Red	Soft/ Mature

Table 2: Mean values for number of pupae, adult flies and sex ration of *Bactrocera zonata* for different host fruits.

Host Fruits	Pupae Recovered	No. flies emerged	Number of male flies	Number of female flies	Sex ratio M:F
Banana	99.33±1.2a	61.66±2.33a	26.33±1.8a	35.33±1.76a	1:1.3±0.05 a
Persimmon	42.00±1.7b	34.66±1.76b	13.00±1.5b	21.33±1.33b	1:1.7±0.19 a
Apple	8.00±0.56c	7.00±0.57c	2.66±0.66c	4.33±0.33c	1:1.8±0.44 a
Tomato	2.00±0.56c	1.66±0.66c	0.33±0.33c	1.33±0.33c	1:1.3±0.33 a
LSD Value	9.97	6.52	3.76	3.68	0.96
F Value	213	192	105	197	0.73
P Value	0.0000	0.0000	0.0000	0.0000	0.5638

Means followed by different letters in columns are statistically different at $P \leq 0.05$.

Materials and Methods

Investigation on natural host preference was conducted in the fruit fly laboratory at Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Khyber Pakhtunkhwa, Pakistan for working out the readily available natural host for *B. zonata*. Four fruit hosts, viz. banana, persimmon, apple and tomato were selected. All the fruits were locally acquired, and the trial was performed under free choice laboratory test at $26 \pm 2^\circ\text{C}$ temperature and $65 \pm 5\%$ R.H.

Insect source

Peach fruit flies used in the experiments were taken from the fruit fly colony maintained in the laboratory in Plant Protection Division, NIFA. The insects taken from this colony were reared in cages ($60 \times 60 \times 60 \text{ cm}^3$) and were fed with protein hydrolysate and sugar in petri dishes as a food source whereas, water put in glass bottles covered by cotton swabs as a water source. Furthermore, the wet swabs of cotton were replaced regularly to avoid any possible contamination by pathogens.

Free choice test

Natural host preference of *B. zonata* was evaluated based on the set parameters as pupal formation, adult emergence, and male/ female sex ratio in free choice experimental trials. For this purpose, four different host fruits (banana, persimmon, apple and tomato) were tested in free choice for oviposition.

A total of three fruits of each host were used and all these fruits (one each) were exposed collectively as free choice in a single cage to the ten days old mated adult female peach fruit flies (50) for a period of 24 hours to lay eggs. Each fruit was then shifted separately to plastic tubs (07 L) containing fine sand (02 cm layer) at the bottom for pupation. Pupae were recovered by sieving the sand through sieve mesh no.16 and the recovered pupae from respective fruit was recorded to get data on pupal recovery. These pupae were transferred separately to plastic jars (03 L) for further observation on the adult emergence and sex ratio. Completely randomized design was used, and the treatments were replicated thrice.

Statistical analysis

Data attained on the tested fruits infested by peach fruit fly for various biological parameters in all the four fruits were compared by using Statistix 8.1 statistical package for analysis of variance (ANOVA).

Least Significant Differences (LSD) Test at $P = 0.05$ probability level was used for comparing the means.

Results and Discussion

The data presented in Table 2, depict the mean values of host preference in terms of pupal recovery, adult flies and sex ratio recovered from the host fruits. The data on all parameters revealed significant differences between banana, persimmon, apple and tomato. No significant differences were observed between apple and tomato in terms of pupal recovery ($F=213$, $P=0.0000$), adult flies emerged ($F=192$, $P=0.0000$), number of males ($F=105$, $P=0.0000$) and females ($F=197$, $P=0.0000$). Data regarding sex ratio was not significant ($F=0.73$, $P=0.5638$) among all the fruit hosts. The results showed that banana was highly preferred with mean pupal recovery of 99.33 ± 5.81 pupae/fruit) followed by persimmon (42 ± 1.73 pupae/fruit). It was noticed that the apple was also minimal infested (8 ± 0.58 pupae/fruits) whereas, the least number of fruit fly infestation was recorded on tomato (02 ± 0.58 pupa/fruit).

Maximum mean number of adult fruit flies were emerged from banana (61.66 ± 3.48 / fruit), followed by persimmon (34.66 ± 1.76 / fruit) and the minimum adult fruit flies were emerged from apple (07 ± 0.58 / fruit) and tomato (1.66 ± 0.67 / fruit). The highest male (26.33 ± 1.86) and female (35.33 ± 1.76) fruit flies were noticed in banana followed by persimmon (13 ± 1.15 male and 21.33 ± 1.33 female fruit flies) and the lowest (0.33 ± 0.33 male and 1.33 ± 0.33 female fruit flies) were recorded in tomato.

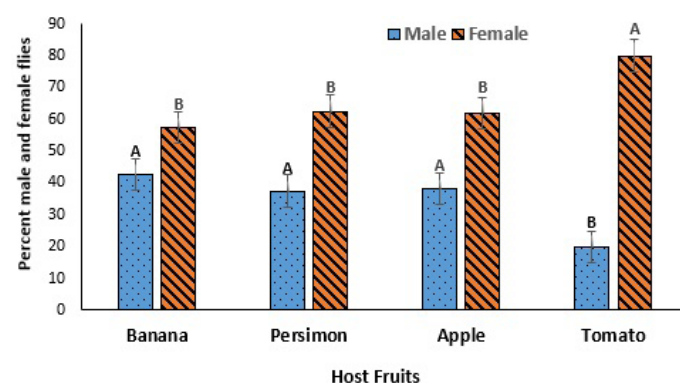


Figure 1: Percent of male and female peach fruit flies calculated from the tested fruits. The means followed by same letters are not significantly different at $P=0.05$. Error bars denote standard error values.

The data presented in Figure 1, illustrate the percentage of male and female adult flies recovered successfully from the pupae. Results showed non significance

among banana, persimmon and apple but significant with tomato in terms of percent male fruit flies emerged. The data revealed maximum percentage of the emerged male fruit flies in banana (43%) followed by persimmon (38%), apple (38%) and minimum in tomato (20%). Similarly, data was also non-significant among banana, persimmon and apple, but significant with tomato in terms of percent female fruit flies emerged. The data determined highest percentage of the emerged female flies in tomato (80%) followed by persimmon (63%), apple (62%) and banana (57%). **Figure 2** shows the total number of puparia recovered (showed by bars) and the subsequent flies' emergence (showed by line) in all the four tested fruits. Maximum number of pupae were recovered from banana fruit (298 followed by persimmon (126), apple (24) and minimum pupae were recorded in tomato (06). Similarly, no. of emerged fruit flies was highest (185) recorded from banana followed by persimmon (104), apple (21) and the lowest no of fruit flies emerged was recorded in tomato (05).

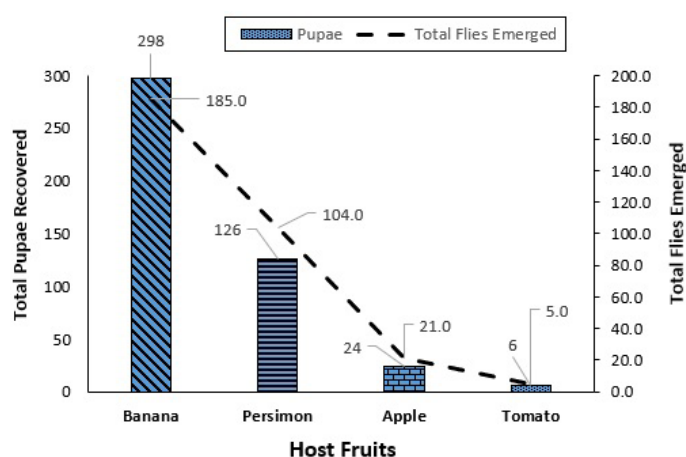


Figure 2: Host preference of *B. zonata* in terms of total pupal recovery and flies' emergence in four different fruits under free choice test.

Present investigations on the host preference of peach fruit flies towards four different hosts (banana, persimmon, apple and tomato) revealed that banana was the most preferred host in terms of showing significantly enhanced fruit fly development compared to the other tested hosts. The examined order of preference for *B. zonata* was banana > persimmon > apple > and tomato. On the other hand, sex ratio was found to be non-significantly different among all the fruits. These results imply that banana with regard to the performance of *B. zonata* could be termed as the most favorite host. Banana has a particular aroma and a very delicate skin which make it more attractive food for *B. zonata* (Ren *et al.*, 2008). Sohail *et al.* (2015), in a host preference experiment, also reported higher

degree of preference of *B. dorsalis* for banana. Apple and tomato were least preferred by the peach fruit fly which might be due to their hard outer skin compared to banana (Sauers-Mulle, 2005; Behera *et al.*, 2010).

It is worth mentioning that the developmental parameters of fruit fly are highly dependent on the type and quality of the hosts (Sarwar *et al.*, 2013). Tested fruits exhibit high degree of variations in the proportion of different nutrients, pattern of digestion, absorption capacity *etc.* These attributes are used by fruit flies for its preference of one fruit over the other for its oviposition and larval food (Häggström and Larsson, 1995; Shah *et al.*, 2007; Rasool *et al.*, 2017). Various studies also revealed that certain visual and olfactory cues are exploited by female fruit flies to locate and select its host for oviposition (Brévault and Quilici, 2007; Mahfuza *et al.*, 2011). Sauers-Muller (2005) reported that fruit size and shape greatly influences fruit fly infestation and those phenotypic characters show more susceptibility as might be the case in present experiment. It indicates that the physio-chemical properties such as appearance, firmness or hardness, odor, color *etc.* of host have great influence on being traced and selected by the fruit flies for oviposition (Brévault and Quilici, 2007; Ren *et al.*, 2008). This complex sensory system work behind in an organized way to perceive the nutrition and quality of a host and finally analyze its suitability as larval diet (Wisotsky *et al.*, 2011; Sarwar *et al.*, 2013).

The selection of banana and persimmon as the fit-test fruit for offspring's development and survival by *B. zonata* shows strongly linked relationship between host selection and offspring performance (Fontellas-Brandalha and Zucoloto, 2004; Akol *et al.*, 2013; Sarwar *et al.*, 2013). It is also important to mention that fruit flies usually show certain degree of preference for fruits which have previously been frequently infested (Prokopy and Papaj, 1988). However, this may not be the case in present study as for larval rearing different types of infestation free hosts were provided instead of a specific one. Apparently, as discussed above, banana appeared to be the sweetest host (Sauers-Muller, 2005) as compared to other tested hosts that led to higher infestation by the peach fruit flies. It is also manifested that, for larval rearing of peach fruit flies, banana could be used as an ideal natural diet to get a robust culture for higher pupal recovery and adult emergence. However, for more concrete and conclusive results, banana may be tested with other

fruits for host preference in the laboratory along with their biochemical analysis.

Conclusions and Recommendations

The results indicated that banana fruit was efficiently infested by *B. zonata* and hence can be used in the laboratory for round the year rearing of *B. zonata* as a possible alternative to artificial diet. The *B. zonata* is an economic pest of banana and persimmon which may reduce income of the growers, and affect sale of these fruits. *Bactrocera zonata* can inflict losses in other fruits like apple and tomato as well.

Novelty Statement

The present research provides baseline data that banana could be used as efficient natural host for the quality production of fruit flies under controlled conditions for different Research & Development activities. It also gives experimental support that *B. zonata* has great preference for banana and persimmon by inflicting heavy losses and is likely to impact domestic market and exports.

Authors Contributions

Muhammad Salman: Conceived the basic idea, conducted the experiments and prepared the article.

Muhammad Hamayoon Khan: Collaborated in drafting the article.

Muhammad Zahid: Helped in improving the basic idea.

Gul Zamin Khan: Contributed in modifying and improving the methodology.

Fazli Rahim: Assisted in fruit fly rearing and data recording.

Usman Khaliq: Performed the statistical analysis.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this article.

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