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Evaluation of Host Susceptibility, Oviposion and Colour Preference of the Peach Fruit Fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae)

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Abstract: The peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritdae) is a serious polyphagous pest originated in the South and South-East Asia where it attacks more than 50 host plants. The present study was conducted to determine the host susceptibility, oviposion and colour preference of *B. zonata* on different natural hosts under controlled laboratory condition. Ten different fruits *viz.* apple *Malus pumila* Miller., banana *Musa balbisiana,* grape *Vitis vinifera* L., guava *Psidium guajava* L.*,* malta *Citrus aurantium* L.*,* mango *Mangifera indica* L., orange *Citrus sinensis* L., papaya *Carica papaya* L., pear *Pyrus pyrifolia* Burm. and star fruit *Averrhoa carambola* L. were chosen as natural hosts for comparative susceptibility using choice and no-choice tests. The oviposition response of *B. zonata* was evaluated using artificial egging devices smeared with above mentioned hosts paste under choice test. Five different coloured, *viz*., green, red, sky blue, transparent and yellow egging devices smeared with mango paste were used for the colour preference test. Distinct host preference was recorded for *B. zonata* with more or less susceptibility among hosts tested except star fruit where no egg laying was recorded. Based on highest pupal yield (110.3±27.3), mango appeared as the most susceptible host for *B. zonata* in both the choice and no-choice tests. Significantly higher egg collection was recorded on pear (100±4.81) followed by mango (79.25±1.65) paste smeared egging receptacles. Sky blue colour egging device smeared with mango paste found as the most attractive for ovipositon. The present experimental results provide basic information about the oviposition and colour preference of *B. zonata* which can be use to develop phytochemical baits to manage the pest species.

Key words: *Bactrocera zonata* · Host · Oviposition · Colour Preference

INTRODUCTION

Tephritid fruit flies are the most devastating insect pests of fresh fruits and vegetables causing direct and indirect economic losses worldwide. The genus *Bactrocera* is considered a serious threat of horticultural crops because of the wide host range of its species and the invasive power of some species within the genus [1]. The host uses patterns of fruit flies range from highly specific (monophagus, oligophagous) to user of a wide range of hosts from different plant families (polyphgous). The main factors influencing host acceptance behaviour and subsequent host use of dacine fruit flies include pre-alighting factors (e.g., fruit colour, host plant structure, shape and size) and post-alighting factors (e.g., pericarp toughness) [2]. A conjugation of plant physical and chemical factors influences on that choice and the balance between positive and negative stimuli determines the final selection [3-5].

The peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera:Tephritidae) is a serious polyphagous pest that attacks over 50 cultivated and wild plants in many parts of the world [6-9]. It is known as a serious pest of peach *Prunus persica* (L.) Batsch (Rosaceae) and custard apple *Annona squamosa* L. (Annonaceae) in India [10, 11] as well as guava *Psidium guajava* L. (Myrtaceae) and mango

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Mangifera indica L. (Anacardiaceae) in Pakistan [12]. In Bangladesh, the species is known to infest different type of fruits e.g., guava, papaya, different varieties of mango grown at North and North-Western Bangladesh. Although *B. zonata* originates in South and South-East Asia [13] it has spread to other parts of the world, in particular to several countries in the Near East and Egypt [14]. It attacks ripe fruits and inflicts damage to the fruits directly (through oviposition punctures and subsequent larval feeding on pulp) or by causing blemished fruits, which limit marketing possibilities (especially export of fruits) where it is a quarantine pest [9, 15]. For control of different pestiferous fruit flies 'attract-and-kill' methods that combine visual and/or olfactory stimuli have been either fully developed or implemented e.g., for the apple maggot fly, *Rhegoletes pomonella* (Walsh) [16, 17] or experimentally tested e.g., for the med fly *Ceratitis capitata* (Widemann) [18]. Different physiological, nutritional/chemical or behavioural response of various other insects on their host plants has been well documented [19-23]. Several studies have already been conducted on the host susceptibility and oviposition preference of different *Bactrocera* species [24-27] but, very little work [28] was done on the host preference/performance of *B. zonata* in Bangladesh. The present work was therefore conducted to determine the host susceptibility/oviposition preference of *B. zonata* on different natural hosts in choice and to no-choice tests and understand the olfactory and visual stimuli of *B. zonata* using artificial and different coloured egging devices smeared with hosts paste under controlled laboratory condition.

MATERIALS AND METHODS

Stock Rearing of Insect: Rearing of *B. zonata* was maintained in the laboratory of Insect Biotechnology Division (IBD), Institute of Food and Radiation Biology (IFRB), Atomic Energy Research Establishment (AERE), Savar, Dhaka for more than 10 generations. *B. zonata* infested mangoes were collected in 2015 from Chapainawabganj, Bangladesh. Approximately 2, 000 adult flies were maintained in mesh cages (60 x 60 x 60 cm) (Megaview 'bugdorm', Taiwan). The flies were supplied with protein based diets in the liquid form, i.e., baking yeast: sugar: water at 1:3:4 ratio and dry form, i.e., casein: yeast extract: sugar at 1:1:2 ratio. Water was supplied in a conical flask socked with a cotton ball. The temperature and the relative humidity of the rearing room maintained at 27±1°C and 75±5% and 14h light and 10h dark cycle.

Natural Hosts: Ten different natural hosts used for the experimental purposes were: apple *Malus pumila* Miller., banana *Musa balbisiana,* grape *Vitis vinifera* L., guava *Psidium guajava* L.*,* malta, *Citrus aurantium* L.*,* mango *Mangifera indica* L., orange *Citrus sinensis* L., papaya *Carica papaya* L., pear *Pyrus pyrifolia* Burm. and star fruit *Averrhoa carambola* L.

Host Susceptibility of *B. zonata* in Terms of Pupal Production

Choice Test: Fifty pairs of 16-21 day-old *B. zonata* were placed inside the mesh cage (60 x 60 x 60 cm). Each of the ten different fruits was weighed (50 g) and offered simultaneously for egg lying for 3 h (9 a.m.-12. p.m.). Fruits were then collected and each of them was kept in Petri-dish separately and kept on a layer of saw dust (Pupation media) inside a plastic bowl. Plastic bowls were covered with thin clothes for pupation and after 2 to 3 days plastics bowls were checked regularly for drop out the rotting host-juice from the Petri-dish to avoid the unnatural death of larvae. Pupae were collected on 7-10 days by sieving the sawdust. Total number of pupae produced from each host was counted and recorded separately.

Non-Choice Test: The above mentioned ten different fruits (each weighted 50 g) were kept separately in ten different small cages (31x21x31cm) containing 15 pairs of adult *B. zonata* for 3 h for oviposition. Then same procedure was followed for pupal collection as described for the choice test.

Oviposition Preference Test on Artificial Egging Device: Ten different natural hosts (apple*,* banana, grape, guava*,* malta*,* mango, orange, papaya, pear and star fruit) paste were used in the oviposition preference under choice test. Transparent plastic bottles (1.5 cm in diam.) having 30-40 holes (0.5 mm) smeared with each host paste was used as egging receptacle. These were finally put inside the cage (31x 21x 31cm) containing 50 pairs *B. zonata* by placing them on a large Petri dish (14.5 x 2.5 cm) in an alternate fashion for 3 hours. Then eggs from each egging receptacle were collected in water and counted under a stereomicroscope and recorded.

Colour Preference Test: Five different colour *viz.,* green, red, sky blue, transparent and yellow egging devices (4 cm in diam.) were used for egg collection. The devices (diagram 1) were then saturated with mango paste and kept inside the cage containing 150 pairs 18-21day-old

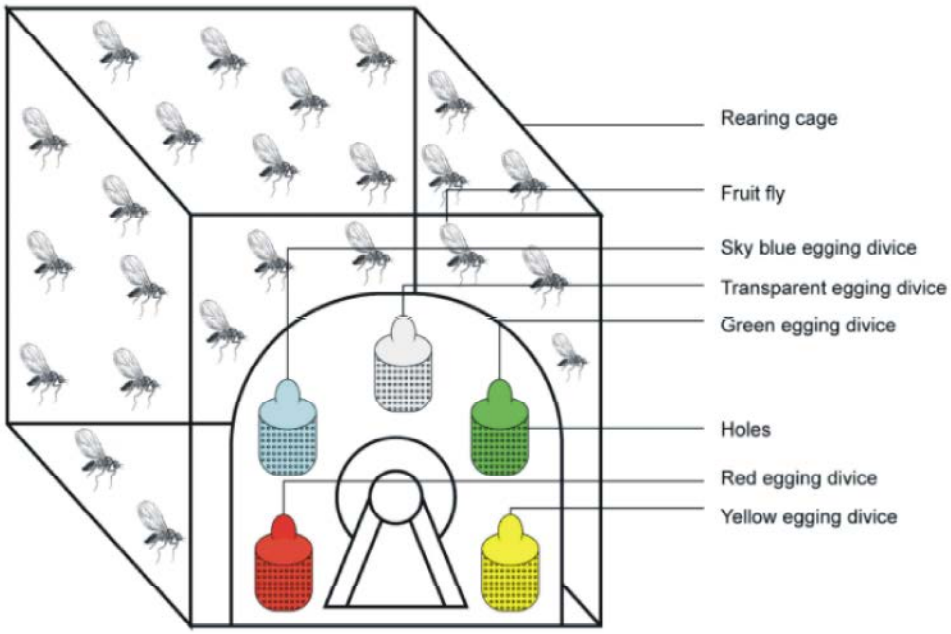

Diagram 1: Colour preference test of *B. zonata*

B. zonata in an alternate fashion for 3 h. Eggs from different colour egging receptacles were then collected in water and the total number was counted under stereomicroscope and recorded. All the experiments mentioned above were repeated for four times.

Statistical Analysis: Analysis of Variance (ANOVA) was conducted for data collected from all experiments. Tukey's pair wise comparison test was done by statistical software Minitab (version- 17).

RESULTS AND DISCUSSION

Host Preference of *B. zonata* in Terms of Pupal Production: Comparative host susceptibility of *B. zonata* in terms of pupal production from different natural hosts shown in Table (1). In choice test, pupal yield of *B. zonata* was significantly higher (df=9, 30, F=11.12, P<0.001) on mango and apple under control laboratory condition. Mean (±se) pupal yield of *B. zonata* was higher on mango (110.3±27.3), followed by apple (105.2±17.7), malta (45.50±5.85), guava (45±7.75), papaya (38±7.17), pear (34±5.37) and grape (31.50±8.17), respectively. It was lower in case of banana (6±2.58) and orange (6±0.913). *B. zonata* laid no egg on star fruit.

In no-choice test mango also ranked highest position in terms of total pupal production (85.75±9.30) by *B. zonata*. In the present test papaya (68.50±7.50) appeared as second highest susceptible host for *B. zonata* followed by apple (62.3±17.0), pear (56.75±7.98), guava (45.50±9.26), orange (33.0±4.02), malta (33.5±0.6), banana (26.75±5.94) and grape (19.00±0.81), respectively in terms of pupal yield (df=9, 30, F=10.39, P<0.001) (Table 1). *B. zonata* was observed to lay no egg on star fruit as mentioned above in choice test.

Oviposition Preference Test on Artificial Egging Device: The oviposition response of *B. zonata* to artificial egging devices smeared with ten different hosts paste under choice test shown in Fig. (1). Significantly (df=9, 30, F=286.97, P<0.001) higher egg production of *B. zonata* was recorded on egging device smeared with pear (100.8±58.5) followed by mango (79.3±30.6) and apple (76.8±33.9). The lowest number of egg (8.25±3.20) was deposited by *B. zonata* on malta smeared egging device. Rest of the hosts paste showed more or less attraction for oviposition. No egg was observed to lay by *B. zonata* on star fruit paste smeared egging device as noticed in host susceptibility tests.

Influence of Different Colours on the Oviposition Preference of *B. zonata*: The influence of different colour egging devices on the oviposition preference of *B. zoznata* shown in Fig. (2). Significantly (df=4, 40, F=150.88, P<0.001) highest number of egg was recorded in sky blue colour egging device (520.7±30.0) smeared with mango paste. The order of attraction of *B. zonata* to different colour egging devices was i.

Table 1: Mean (± SE) number of pupae of *B. zonata* from ten different natural hosts in both choice and non-choice tests.

	Mean (± SE) number of pupae in	
Name of Natural hosts	Choice test	No-Choice test
Apple	105.20±17.7a	62.30±17.0abc
Banana	6.00±2.58c	26.75±5.9cde
Grape	31.50±8.1b	19.00±0.81de
Guava	45.00±7.7b	45.50±9.2bcd
Malta	45.50±5.8b	33.50±0.64bcde
Mango	110.30±27.3a	85.75±9.3a
Orange	6.00±0.9c	33.00±4.0bcde
Papaya	38.00±7.1b	68.50±7.5ab
Pear	34.00±7.3b	56.75±7.9abcd
Star fruit	0	0

Means within column with different letters differ significantly (P<0.05).

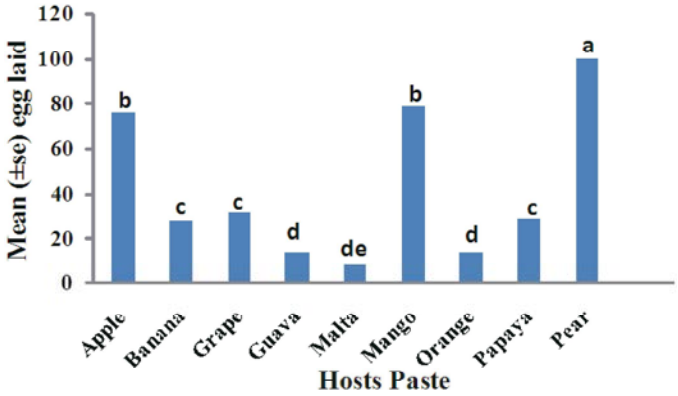

Fig. 1: Mean (±SE) number of eggs laid by *B. zonata* in egging devices smeared with paste of ten different natural hosts in choice test

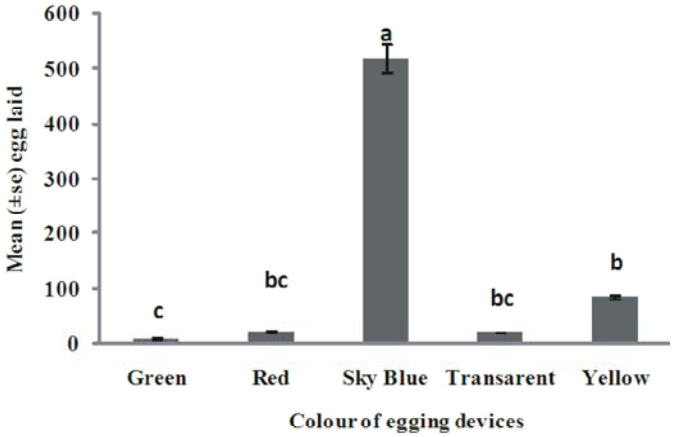

Fig. 2: Mean (±SE) number of eggs laid by *B. zonata* into different colour egging devices smeared with mango paste.

Sky blue (78.92%), ii. Yellow (12.98%), iii. Red (3.38%) and iv. Transparent (3.23%), respectively. Green colour found as least preferred egging device where only 1.46 % eggs were laid by *B. zonata*.

How adult females recognize the appropriate hosts for oviposition is a matter of controversy. The secondary substances and or flavour as well as nutritional value may play relevant role and determinant for oviposition. A set of factors acting together may be involved in host recognition by the adult female [29]. The female age is an important factor in the hierarchic change [30]. Learning is possible and there are cases in which females were able to learn the characteristics of different biotypes of the same host [31]. In the lack of a preferable host, the females may

lay eggs on hosts of lower hierarchy [32]. Based on pupal yield the present experimental results (Table 1) revealed that all the tested fruits except Star fruit are more or less susceptible to *B. zonata* under laboratory condition. In both the choice and no-choice tests mango appeared as the most susceptible host. Rauf *et al.* [33] showed that guava as the most preferred host for *B. zonata* with mean pupal recovery of 318.00 ± 4.61 pupa/fruit (p/f) under free choice and 434 ± 2.64 p/f under no choice conditions, followed by banana (266.00 ± 4.5 p/f) in free choice and ber (177.00 ± 2.08 p/f) in no choice experiment. They found apple and citrus as least preferred hosts. Shehata *et al*. [34] observed that the most favourite host to *B. zonata* was pear fruits followed by guava, peach, apple and finally apricot. Vinay and Babita [35] noted banana as the most suitable host for the Oriental fruit fly, *Bactrocera dorsalis* (Hendel). Banana also reported as the most favourite food in terms of average adult recovery under free choice, while guava was most preferred host for egg laying with average pupal recovery in free choice of fruits by *B. dorsalis* [36]. On the other hand, Khan *et al*. [25] found mango as the best natural host for *B. dorsalis* in terms of larval rearing, pupal weight, but banana paste appeared as the best oviposition stimulant while used in artificial egging receptacle. Distinct host preference of the melon fly, *Zeugodacus* (*Bactrocera*) *cucurbitae* (Coq.) was recorded by Khan *et al.* [27] using nine hosts where bitter gourd and cucumber observed as more susceptible hosts based on highest pupal yield. It was revealed that host itself and host paste exert differential influence on tephritid fruit flies and vary in terms of susceptibility and egging stimulant due to their nutritional and chemical composition. However, the host susceptibility and attraction for oviposition by *Zeugodacus*/*Bactrocera* spp. reported by different authors were inconsistent due to different natural hosts were used by different authors at different time and space [27].

The oviposition preference in fruit flies may affected by the odour, colour and shape of host fruits [37]. Female age and experience also noted to influence the oviposition preference hierarchy [38]. Aleryan *et al.* [39] investigated certain natural oviposition stimulants on egg deposition of *B. zonata* under laboratory conditions and found that the mandarin juice serve as a more convenient stimulant. Saha *et al*. [24] reported tomato juice as oviposition stimulant for *Z. cucurbitae*. Whereas, Khan *et al.* [27] found cucumber juice as strong oviposition stimulant to *Z. cucurbitae* and the pumpkin fruit fly, *Zeugodacus tau* (Walker). In the present experiment *B. zonata* showed significantly higher oviposition preference to mango paste which partially support the findings of Sarwar *et al.* [40] who noted mango as the most preferred host for *B. zonata* due to the maximum number of pupae formed, pupae weight and obtained emergence of adult flies followed by peach and apple.

Experiments conducted by several authours indicated that *Bactrocera* species are able to discriminate coloures and some visual characteristics of host coloures play an important role on oviposition site selection [41-43]. In the present experiment *B. zonata* observed to significantly attract to sky blue colour egging device for oviposition and hardly eggs were laid into green colour egging device. Whereas the work of Ismail [44] on the comparison between yellow and white colours card Jackson traps revealed that *B. zonata* preferred white colour trap than the yellow one. *B. zonata* was reported to attract to red colour traps (3.75 fruit flies/trap/week) in mango ecosystem [45]. According to Wen-Yen *et al.* [46] the green paper with broader and higher reflectance showed the highest attraction to the *B. dorsalis* than other colour papers tested. Green colored egging device also reported as the most attractive for oviposition of *Z. cucurbitae* and *Z. tau* while smeared with cucumber paste [27]. The above discussion indicated that different *Zeugodacus*/*Bactrocera* spp. response to different egging devices/materials with different coloures and visual cues. The possible reasons for these variations may be due to the differences of geographical origin of the fruit fly species [27] and also the variation of colour hue and brightness of artificial oviposition substrates [41] used in different studies.

In conclusion, the present study revealed mango as the most susceptible host for *B. zonata* in terms of pupual production and oviposition preference tests. Egg production recorded neither on star fruit nor star fruit paste smeared egging device under laboratory condition. *B. zonata* was highly attracted to sky blue colour egging device and least to green one while smeared with mango paste. Future chemical analysis of most preferred host (Mango) may lead to development of synthetic oviposition stimulant for artificial egg collection. It might also be useful in developing phytochemical bait to use in 'attract and kill' technique to combat against this pestiferous fruit fly.

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