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Research Article

The Variation of Oviposition Preference and Host Susceptibility of the Oriental Fruit Fly (*Bactrocera dorsalis* Hendel) (Diptera: Tephritidae) on Commercial Mango Varieties

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The oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), is a serious fruit pest in South Asia; however, studies of their oviposition behavior on different host fruits in Sri Lanka are insufficient. Thus, the present study was conducted to determine the oviposition preference and host susceptibility of *B. dorsalis* on four commercial mango varieties (Karutha kolumban (Kc), Willard (Wld), Vellai kolumban (Vc), and Betti amba (Ba)) under controlled laboratory conditions. The comparative preference and host susceptibility of *B. dorsalis* to four mango varieties were tested by a series of choice and no-choice experiments. The preference for the oviposition was evaluated by observations, and the host susceptibility was investigated by incubating the above-tested fruits separately until the pupation and the emergence of adults. The gravid females of *B. dorsalis* showed a significantly different host preference and susceptibility among the four mango varieties tested. Among four mango varieties, "Kc" showed a significantly high oviposition preference and pupae and adult emergence of *B. dorsalis*. Study findings are useful to design control measures for *B. dorsalis* to prevent their damage to the commercial mango varieties in Sri Lanka.

1. Introduction

Mango (*Mangifera indica* L.) (Anacardiaceae) is known as the most widely cultivated fruit tree, and it is the second most widely distributed fruit crop after the banana in Sri Lanka [1]. Among 18 varieties of mangoes, "Karutha kolumban," "Willard," "Vellei kolumban," and "Betti amba" are widely grown mango varieties and have good market value for many years in Sri Lanka [2]. More than 300 insect pest species have been reported to attack mangoes in different parts of the world [3]. Fruit flies (Diptera: Tephritidae) are considered a group of serious fruit pests [4], and *Bactrocera dorsalis* (Hendel) is reported as a dominant fruit fly species in mango cultivations in South Asia [5].

The origin of *B. dorsalis* is Asia [5], and the species is currently distributed across Asia, Africa, and the Pacific regions [6, 7]. *B. dorsalis* is a serious pest because its females have a wide host range and a high reproductive rate [6], and it prefers to attack mango fruits [5, 8], causing high post-harvest damage.

Female *B. dorsalis* selects host fruits that are suitable for oviposition and for larval performance based on the physiological features of the host. It has been shown that their host selection is influenced by the color, size, shape, and smell of fruit [9–11].

Female fruit flies puncture the peel of the host fruit using their ovipositor, then deposit eggs into the pulp of the fruit, where the larvae hatch and feed on the fruit pulp, causing serious direct damage and making fruits unfavorable for consumption [12]. The fruit damage of *B. dorsalis* is also influenced by the fruit variety and its physiological characteristics [5, 8, 13, 14]. Boinahadji et al. [15] recorded that the oviposition preference and offspring emergence of *B. dorsalis* are high in mangoes, with a shorter development time relative to seven other fruits tested in their study in Senegal.

(a) (b) (c) (d)

Figure 1: The selected four mango varieties: (a) Karutha kolumban; (b) Vellai kolumban; (c) Betti amba; (d) Willard (scale = 30 mm).

Another study revealed that *B. dorsalis* prefers to lay eggs on mangoes that are kept for 15–7 days after harvest [16]. Further, the oviposition preference of *B. dorsalis* varies with the ripening stage of mangoes [13].

In Sri Lanka, several studies have been conducted on the diversity of fruit flies [17–20] and their control measures [21–24]. Nevertheless, these studies did not concentrate on the oviposition preference of fruit flies in Sri Lanka. Recently, Wijekoon et al. [25] reported that the fruit infestation by *B. dorsalis* was higher in the "Karutha kolumban" variety than the "Willard" variety in Sri Lanka. In another study, Wijekoon et al. [26] showed that yellow "Willard" was preferred for oviposition by *B. dorsalis* over other color types.

Hence, studies on the host preferences of *B. dorsalis* in Sri Lanka are scarce. Since there are several commercial mango varieties grown in Sri Lanka, understanding the levels of host preference of *B. dorsalis* in these commercial mango varieties is of the utmost importance for local fruit growers, sellers, and exporters.

The present study was thus carried out to determine the preference for oviposition of female *B. dorsalis* and to identify the most vulnerable variety among four commercial mango varieties (Karutha kolumban (Kc), Willard (Wld), Vellai kolumban (Vc), and Betti amba (Ba)) in Sri Lanka using a series of choice and nonchoice lab experiments.

2. Materials and Methods

2.1. Collection of Mango Fruits for B. dorsalis Colony Preparation. Mangoes (both overripe and ripe) were collected from two main sites (Kc variety, 6°45′0"N, 81°14′0"E, elevation 162 m, Wld variety; 6°44′ 15.85"N, 81°6′ 11.005"E, elevation 188 m, Intermediate zone) in Uva Province, Sri Lanka.

2.2. Establishing of B. dorsalis Colony. The study was conducted from December 2021 to February 2022 under controlled laboratory conditions of temperature and relative humidity (27°C ± 2) and (75%–80% RH) at the Department of Zoology, University of Ruhuna, Sri Lanka.

A total of 672 mango fruits (320 Kc and 352 Wld) were collected from two subplots of each of the aforementioned two main sites. The collected two varieties of mangoes were incubated together in 168 containers to prepare a mixed colony of 200 *B. dorsalis* adults. Here, we hypothesized that there was no effect of the mango variety of origin on female choice for oviposition. As such, the variation in adult emergence based on the variety of origin was ignored during the colony preparation phase because the ultimate objective was to prepare an adult colony of *B. dorsalis*. Fruits were incubated by placing four mangoes in one container (18 cm × 14 cm × 13 cm) with presterilized sand and muslin cloth covered under the laboratory conditions mentioned above. After 10–15 days, emerged adult flies were moved into insect cages (30 cm × 30 cm × 20 cm, 7 cages), which were covered by muslin cloth to prevent adult flies from entering or escaping [27]. The species and sexes of emerging adults were identified before transferring them into the insect cages. The emerged adult flies were identified using taxonomic keys [28–30] at the research laboratory, Department of Zoology, University of Ruhuna, Sri Lanka. Adult flies were fed using a standard artificial diet ((yeast: sugar, 1 : 3 by volume) + water [31]). Emerged males and females of *B. dorsalis* were kept together in cages in a two males: one female ratio for 10–17 days [29]. Mature females were taken from rearing cages and they were used for both choice and no-choice tests.

2.3. Selecting Mango Varieties for Testing. Four commercially important mango varieties ("Kc," "Wld," "Vc," and "Ba") were chosen for the study (Figure 1). These fruits were brought from the field at the unripe stage. Individual fruits were covered with black wrapping paper to prevent infestation by any fruit flies and then stored at the laboratory condition (27°C ± 2 and 75%–80% RH) until fully ripe. Then, all fruits were visually examined to confirm the fully ripe stage and to absence of oviposition sites (using a hand lens) by fruit flies. Fruits with a fully ripe stage and that did not have any oviposition marks were selected for use in choice and nonchoice experiments.

2.4. Preference Tests of Oviposition

2.4.1. Choice Test. In a replicate, four mangoes, one from each variety, were placed randomly on the layer of presterilized sieved sand (6 cm in height) in a standard-size plastic container (18 cm × 14 cm × 13 cm), keeping at the same distance (2 cm) between each fruit. In total, 20 replicates were conducted using 80 fruits and 20 testing containers [32]. Test containers were placed in water baths to protect experimental setups from ants. A mature female fly (*B. dorsalis*) (10–17 days old, [16]) from the culture was released into the center of a testing container. Then, the top of each testing container was tightly covered using a muslin cloth (1 mm mesh size). Elastic rubber bands were used to tighten the muslin cloth to prevent flies from entering or escaping the rearing container. The number of visits (fly on the fruit), number of oviposition attempts, and visit duration in each fruit were observed and recorded over a 3-hr period (10.00–13.00 hr, as described by Kanika et al. [33]). Oviposition attempts were determined based on the observation of efforts to penetrate the fruit skin by female *B. dorsalis*. After 3 hr, the female fly was removed from the container, and the tested fruits were incubated in separate containers until the emergence of pupae and adults. Five control replicates (four mangoes; one mango per variety, but no flies in a replicate) were used to determine whether flies emerged from "nonexposed" test fruits.

2.4.2. No-Choice Test. Fruit from each variety was placed individually in a testing container, and a mature female (10–17 days old) was introduced to each container. Twenty replicates were conducted for each mango variety (i.e., 80 total replicates). After observing their number of visits (fly on the fruit), number of oviposition attempts, and visit duration for 3 hr, the female fly was removed, and the tested fruits were incubated individually [16]. Except for the simultaneous offering of four varieties of mangoes, the procedures and conditions were identical to those described in the choice test. Five control replicates were used per variety.

2.5. Measurements of Fruit Physical Characters. Three parameters, fruit weight, circumference, and peel thickness, were measured for mango varieties. Fruit weight (g) was measured by a digital balance (Mettler PE3600, Switzerland). Fruit circumference (mm) was measured using a standard measuring tape. For the fruit circumference, measurements were taken from three places, and the average values were recorded. Fruit peel thickness (mm) was measured with a Vernier Caliper (Drapper, Model Number 18066, UK). The fruit peel was removed randomly from five places, and the average peel thickness was recorded.

All measurements of mangoes (a total of 160 mangoes) were taken after testing the oviposition preference of *B. dorsalis* females and before incubating the tested mangoes for pupae and adult emergence.

2.6. Emerging Pupae and Adults. All fruits tested in choice and no-choice experiments were examined carefully for possible oviposition marks. Then, they were labeled and incubated separately in plastic containers (18 cm × 14 cm × 13 cm) with presterilized sand and muslin cloth covered under controlled laboratory conditions (27°C ± 2 and 5%–80% RH) [16]. At the end of the fourth week, the containers were carefully examined, and all pupae and emerging adult flies (males and females) were counted.

Fruits used for control tests in both choice and nonchoice conditions were incubated in separate containers to confirm whether there were any pupae or adults recovered.

2.7. Statistical Analysis. The data were coded and entered into a database created using the Statistical Package for the Social Sciences (IBM SPSS, 20.0 version) software. The normality of the data was tested using the Anderson–Darling test. Since the data followed a normal distribution, parametric tests were performed. The significance of the variation in the number of visits, visit duration, the number of oviposition attempts by female flies, and the number of pupae and adults that emerged per variety of mango, and fruit weight, circumference, and peel thickness per variety in both choice and non-choice conditions were compared using the ANOVA with multiple comparison test (Tukey's test HSD) at the 0.05 significance level.

3. Results

Fruits of both "Kc" (209.49 ± 3.4 g) and "Vc" (182.68 ± 2.40 g) are larger than those of the "Ba" (132.67 ± 1.01 g) and "Wld" (123.41 ± 1.17 g) varieties.

3.1. Oviposition Preference

3.1.1. Choice Test. The mean number of host fruit visits ($F_{(3,80)} = 54.012$, $P < 0.05$), oviposition attempts ($F = 30.651$, $P < 0.05$), and mean fruit visit duration ($F_{(3,80)} = 76.133$, $P < 0.05$) of *B. dorsalis* varied significantly among four mango varieties. A significantly higher number of visits were recorded for the "Kc" variety (3.7 ± 0.03) ($P < 0.05$), followed by "Ba" (2.55 ± 0.05) and "Vc" (1.3 ± 0.03). A significantly lower number of visits was recorded for "Wld" (0.95 ± 0.02) ($P < 0.05$) compared to other varieties (Figure 2(a)). The highest number of oviposition attempts was recorded for the "Kc" variety (1.95 ± 0.03) ($P < 0.05$), whereas the lowest was recorded for the "Vc" variety (0.4 ± 0.02) (Figure 2(b)).

Female flies spent a longer period on the "Kc" mango variety (30.05 ± 0.38 min) ($P < 0.05$), the moderate duration for the "Ba" (13.9 ± 0.36 min) variety, and a shorter period was observed for both "Vc" (5.0 ± 0.21) and "Wld" (4.2 ± 0.23 min) ($P < 0.05$) (Figure 2(c)).

3.2. No-Choice Test. Females of *B. dorsalis* showed significantly different fruit visits ($F_{(3,80)} = 9.811$, $P < 0.05$), oviposition attempts ($F_{(3,80)} = 4.815$, $P < 0.05$), and fruit visit duration ($F_{(3,80)} = 12.333$, $P < 0.05$) among four mango varieties. The highest number of fruit visits was recorded for the "Kc" variety (3.4 ± 0.07) ($P < 0.05$), and the lowest visits for the "Wld" variety (1.6 ± 0.03). Moderate visits were recorded for "Ba" (2.9 ± 0.06) (Figure 3(a)). The highest oviposition attempts were recorded for the "Kc" mango variety, which was significantly different (1.6 ± 0.04) ($P < 0.05$) from the "Wld" variety. The lowest oviposition attempts were recorded for the "Wld" variety (0.55 ± 0.03) (Figure 3(b)). The visit duration for the "Kc" variety (13.05 ± 0.29 min) was significantly high ($P < 0.05$) compared to the "Vc." The shortest visit duration was recorded for the "Vc" mango variety (5.3 ± 0.16 min) (Figure 3(c)).

3.3. Host Susceptibility

3.4. In Choice Condition

3.4.1. Physical Parameters of Host Fruits. The mean of fruit weight, fruit circumference, and peel thickness were significantly different among four mango varieties ($P < 0.05$) (Table 1). A significantly high fruit weight was recorded for the "Kc" ($P < 0.05$) compared to the other three varieties. The fruit

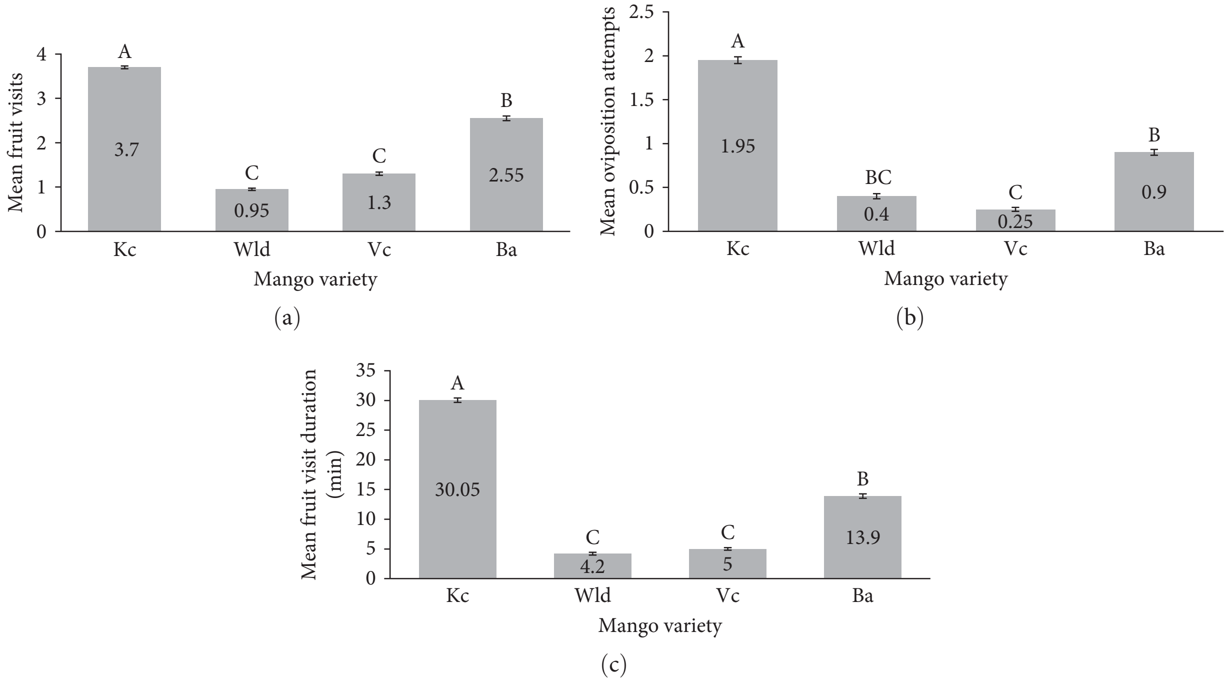

Figure 2: Mean (±SE), (a) no. of visits, (b) no. of oviposition attempts, and (c) visit duration/min by female of *B. dorsalis* on four mango varieties in the choice experiment (3 hr), means with different letters differ significantly ($P < 0.05$, Tukey's test).

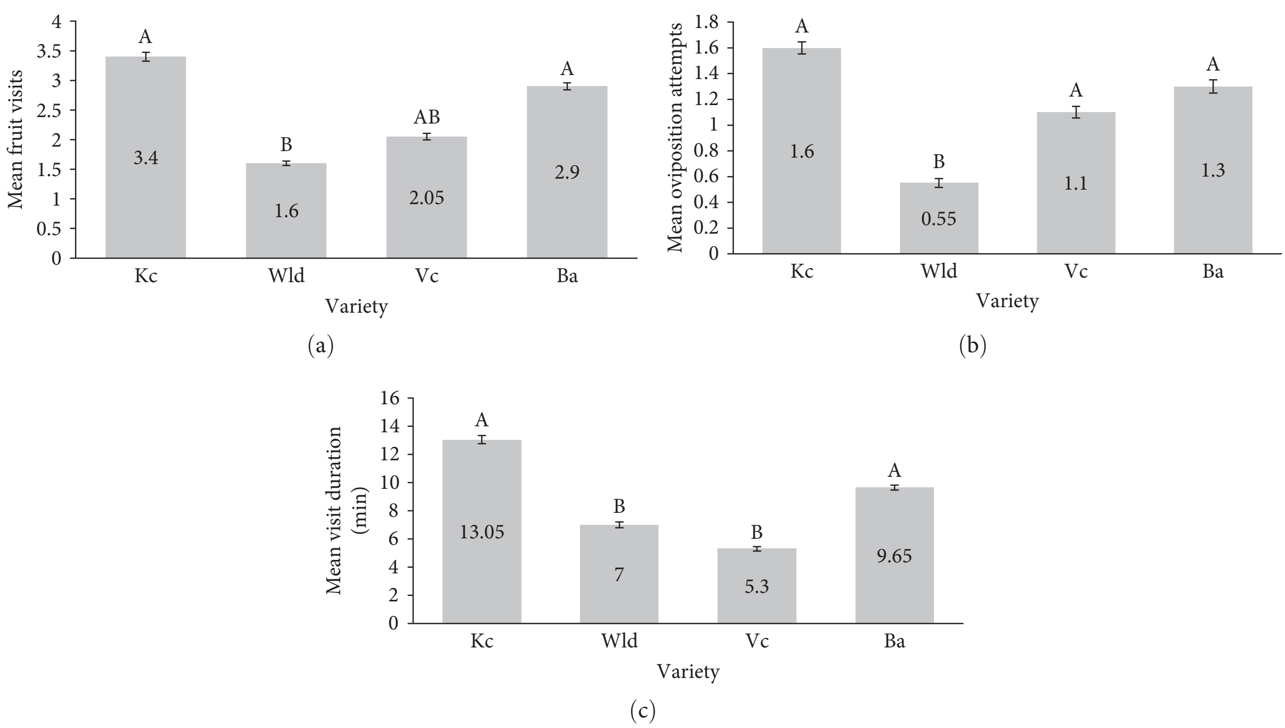

Figure 3: Mean (±SE), (a) no. of visits, (b) no. of oviposition attempts, and (c) visit duration/min by female of *B. dorsalis* on four mango varieties in the no-choice experiment (3 hr), means with different letters differ significantly ($P < 0.05$, Tukey's test).

circumference of each mango variety was statistically significant ($P < 0.05$) (Table 1).

3.4.2. Emergence of Pupae and Adults. The number of pupae and emerged adults was significantly different among the four mango varieties ($P < 0.05$) (Table 2). A significantly higher number of pupae (17.25 ± 0.57, $P < 0.05$) and adults (10.65 ± 0.37, $P < 0.05$) were recorded for the "Kc" mango variety than the other three varieties. The lowest number of pupae (2.53 ± 0.20) and adults (1.50 ± 0.13) were recorded

Table 1: Fruit weight, fruit circumference, and peel thickness of four commercial mango varieties in choice test.

Mango variety	Mean (± SE) weight of fruit (g)	Mean (± SE) fruit circumference (mm)	Mean (± SE) peel thickness of fruit (mm)
Kc	209.49 ± 3.4^{a}	268.15 ± 0.28^{a}	1.41 ± 0.006^{a}
Wld	123.41 ± 1.17^{c}	196.85 ± 0.27^{c}	1.48 ± 0.003^{a}
Vc	182.68 ± 2.40^{b}	173.20 ± 0.41^{d}	1.42 ± 0.007^{a}
Ba	132.67 ± 1.01^{c}	232.40 ± 0.34^{b}	1.33 ± 0.004^{a}
F value	94.11	796.4	5.74
P value	0.001	0.000	0.001

Means within columns with different letters differ significantly ($P < 0.05$, using Tukey's test).

Table 2: The emergence of *B. dorsalis* pupae and adults from four mango varieties under choice conditions.

Variety	Mean (±SE) no. of pupae	Mean (±SE) no. of adults emerged	Pupae to adult emergence (%)	Sex ratio M : F
Kc	17.25 ± 0.57^{a}	10.65 ± 0.37^{a}	61.8	0.7 : 1.0
Wld	2.53 ± 0.20^{b}	1.50 ± 0.13^{b}	59.3	0.4 : 1.0
Vc	2.75 ± 0.29^{b}	1.95 ± 0.22^{b}	70.9	0.6 : 1.0
Ba	8.00 ± 0.30^{b}	5.0 ± 0.22^{b}	62.5	0.6 : 1.0
F value	17.792	13.910	—	—
P value	0.0001	0.0001	—	—

Means within columns with different letters differ significantly ($P < 0.05$, using Tukey's test).

Table 3: Mean comparison of fruit weight, fruit circumference, and peel thickness among four commercial mango varieties tested under nonchoice conditions.

Mango variety	Mean (±SE) weight of fruit (g)	Mean (±SE) fruit circumference (mm)	Mean (±SE) peel thickness of fruit (mm)
Kc	212.33 ± 3.94^{a}	269.40 ± 0.33^{a}	1.35 ± 0.003^{a}
Wld	116.63 ± 1.68^{c}	196.85 ± 0.27^{c}	1.45 ± 0.005^{a}
Vc	190.24 ± 1.76^{b}	176.70 ± 0.32^{d}	1.36 ± 0.006^{a}
Ba	125.15 ± 1.26^{c}	231.65 ± 0.31^{b}	1.32 ± 0.004^{a}
F value	75.89	873.58	4.54
P value	0.0001	0.001	0.006

Means within columns with different letters differ significantly ($P < 0.05$, using Tukey's test).

Table 4: The emergence of *B. dorsalis* pupae and adults from four mango varieties under no-choice conditions.

Variety	Mean no, (±SE) of pupae emerged	Mean no. (±SE) of adults emerged	Pupae to adult emergence (%)	Sex ratio M : F
Kc	22.90 ± 0.68^{a}	14.70 ± 0.44^{a}	64.2	0.8 : 1.0
Wld	4.05 ± 0.25^{b}	2.45 ± 0.16^{b}	60.5	0.7 : 1.0
Vc	11.65 ± 0.48^{b}	8.15 ± 0.36^{b}	70.0	0.8 : 1.0
Ba	7.90 ± 0.27^{b}	5.95 ± 0.22^{b}	75.3	0.7 : 1.0
F value	15.836	13.488	—	—
P value	0.0001	0.001	—	—

Means within columns with different letters differ significantly ($P < 0.05$, using Tukey's test).

for the "Wld" mango variety. The highest percentage of adults emerging from their pupae was observed in the "Vc" variety (70.9%). The sex ratio of emerged adults showed that the female emergence was higher than the male emergence of *B. dorsalis* for all tested mango varieties (Table 2).

3.5. In No-Choice Condition

3.5.1. Physical Parameters of Host Fruits. The fruit weight, circumference, and peel thickness were significantly different ($P < 0.05$) among four mango varieties (Table 3). The highest fruit weight ($P < 0.05$) and circumference ($P < 0.05$) were recorded for the "Kc" mango variety with moderate peel thickness ($P > 0.05$). The fruit circumference is distinct in each variety of mango ($P < 0.05$) (Table 3).

3.5.2. Emergence of Pupae and Adults. The emergence of pupae and adults of *B. dorsalis* was significantly different among four mango varieties ($P < 0.05$) (Table 4). A significantly highest number of pupae (22.90 ± 0.68, $P < 0.05$) and adults (14.70 ± 0.44, $P < 0.05$) were recorded for the "Kc" variety, whereas the lowest number of pupae (4.05 ± 0.25) and adults (2.45 ± 0.16) were recorded for the "Wld" variety. The highest percentage of adults emerged in "Ba" (75.3%), whereas the lowest was in "Wld" (60.5%). When considering the male–female ratio, the emerging female adults were higher than males in all tested mango varieties (Table 4).

In the no-choice test, the numbers of fruit visits, their spending time on the fruit, and ovipositon attempts by *B. dorsalis* were comparatively higher for all mango varieties than in the choice test.

4. Discussion

The present study revealed the variation in the oviposition preferences of *B. dorsalis* on four selected commercial mango varieties in Sri Lanka. In this study, laboratory experiments were conducted, and the laboratory approach allowed equalization of the abundance and availability of different fruits and a sharper focus on host preferences [13].

It is well documented that the oviposition preferences of fruit flies depend mainly on the type of host fruits that promote the survival and growth of their offspring [34–36]. Boinahadji et al. [16] further showed that *B. dorsalis* is able to infect freshly harvested immature fruits, whereas all ripe mangoes were used in the present study. As evident by the present study, the number of fruit visits, visit durations, attempts to oviposit, and number of emerged larvae and adult flies varied significantly among the selected four commercial mango varieties. This result coincides with the findings of [13, 37] that the damage caused by fruit flies varies across different mango varieties.

Our study revealed that *B. dorsalis* preferred to visit and oviposit in "Kc" mangoes compared to the other three varieties tested. Hence, their pupae and adult emergence were also higher in "Kc" mangoes than those of the other three varieties. These results are in accordance with the findings of Diaz-Fleischer and Aluja [38] that the most suitable host fruit environment provides the best survival for fruit flies. According to Boinahadji et al. [16], the variety and physiological conditions of the host mango significantly influence the oviposition preference of *B. dorsalis*. Further, Boinahadji et al. [16] reported that mango is the most favorable fruit for the development of *B. dorsalis* with a shorter development time. As revealed by the present study, "Kc" mangoes have high fruit circumference, fruit weight, and moderate peel thickness compared to the other three varieties. These factors could be linked to having a high host preference and a higher pupae and adult emergence of *B. dorsalis* on the "Kc" variety because "Kc" provides a larger fleshy area. According to Sohail et al. [39], fruit flies prefer to select large host fruits over small ones. Further, "Kc" fruits have excellent fruit quality, a sweet taste with a relatively high pH of the flesh part (5.4), and the highest edible portion (78.9%) [2] relative to the other three mango varieties.

In both choice and no-choice conditions, female flies visited and oviposited in the "Ba" variety after "Kc." The fruit circumference of "Ba" is high after "Kc," and it is one of the most popular mango varieties among Sri Lankans due to its sweet taste [1]. Further, the pupal and adult emergence of *B. dorsalis* in the choice condition is also moderate for "Ba." Therefore, it is evident that, in comparison to the other three mango types, *B. dorsalis* has a moderate host preference and offspring performance due to its medium fruit size.

The "Wld" mango variety showed the lowest numbers of host visits, visit duration, oviposition attempts, pupae, and adult emergence of *B. dorsalis*, as well as the highest peel thickness and the lowest fruit weight among the four mango varieties. Their lowest host preference and susceptibility could be explained by their thick fruit peel, which might discourage the fruit fly oviposition behavior, and Ismail et al. [40] reported that the peel thickness, fruit weight, and diameter have a considerable role in the ovipositional behavior of *B. dorsalis*.

In the no-choice experiment, the number of fruit visits, fruit visit duration, attempts to oviposit, and number of pupae and adult flies that emerged from *B. dorsalis* were obviously high compared to the choice condition. This outcome is most likely reflected because females had no choice to select their preferred host mango in the no-choice condition [13].

5. Conclusions

The mango variety and the physical fruit characteristics have a significant impact on the variation of oviposition preference, pupae, and adult emergence of *B. dorsalis*. "Kc" is the more vulnerable mango variety for the oviposition and offspring emergence of *B. dorsalis*. The "Wld" is the less preferred mango variety by female *B. dorsalis* for their oviposition. The study findings will be critical in planning and implementing future management strategies to prevent *B. dorsalis* damage to commercial mango varieties.

Data Availability

Data are available upon request from the corresponding author.

Ethical Approval

The ethical approval for this study was obtained by the Ethical Review Committee (UOK/ERC/FS/21/023), Faculty of Science, University of Kelaniya, Sri Lanka.

Conflicts of Interest

The authors would like to declare that there are no conflicts of interest in undertaking this research.

Authors' Contributions

Chandana Dammika Wijekoon conducted field surveys, data collection, data entering, data analysis, and writing the manuscript; Mangala Ganehiarachchi, Hemantha Wegiriya, and Shamen Vidanage supervised the research and reviewed the manuscript.

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