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ORIGINAL ARTICLE

The variation of abundance and fruit damage of *Bactrocera dorsalis* on two commercial varieties of *Mangifera indica* in main Bio-climatic Zones of Sri Lanka

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Abstract

Bactrocera dorsalis Hendel, (Diptera: Tephritidae) is one of the serious fruit pests in South Asia. In Sri Lanka, there are dearth of past studies on the abundance and infestations of *B. dorsalis* on commercially important fruit varieties. Hence, the present study aimed to investigate the abundance of *B. dorsalis* adults and their infestation levels on Willard (Wld) and Karthakolomban (Kc) mango varieties grown in main bio-climatic zones of Sri Lanka. The study was conducted from September 2020 to February 2021 in eight study sites of four main bio-climatic zones. In every month, flies were collected from field traps. Infested fruits were also collected from study sites and fruit fly infestation levels and adult emergence were studied in the laboratory. The highest percentage of average infestation (Wld: P>0.05; Kc, P<0.05) and the highest mean value for the adult emergence for both mango varieties were recorded in the intermediate zone. The adult emergence for Kc was higher than the Wld in all study sites and it was significantly different between two mango varieties (P<0.05). The highest number of *B. dorsalis* were collected from traps in the intermediate zone (Wld: P<0.05; Kc, P>0.05). The infestation percentages, adult emergence, and the abundance of caught flies increased significantly during the study period for both Wld and Kc (P<0.05). The abundance of trapped flies was significantly varied between mango varieties (P<0.05) and positively correlated with the fruit infestation (Wld: r= 0.69; P<0.05 and Kc: r= 0.61; P<0.05). Trap collections for Kc in the intermediate zone showed a significant positive correlation with the rainfall (r= -0.90; P<0.05). The result of the present study can provide baseline information for the *B. dorsalis* infestation on two commercial mango varieties and the knowledge on their abundance in different bio climatic zones will be helpful to refurbish current pest management strategies.

Keywords: *Abundance, Bactrocera dorsalis, Bio-climatic zones, Fruit damage*

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1. Introduction

Fruit flies (Diptera: Tephritidae) are the most significant among the insect pests in fruits. Many species of fruit flies are polyphagous, and they cause severe damage to various fruit crops in the tropical region (White & Elson 1994; Clarke et al. 2005). Among these species, the most important insect pests of fruits and vegetables is Dacine fruit flies (Diptera: Tephritidae), with the predominant genus, *Bactrocera* Macquart, (Clarke et al. 2005) and which are highly invasive insect pests in many countries (Li 2016; Zulida & Tati 2016; Kartika & Tati 2016). In this group, *Bactrocera dorsalis* Hendel, has been identified as one of the most virulent and serious fruit pests on various commercial fruits such as mango (*Mangifera indica* L.) (Clarke et al. 2005; Wan et al. 2012). The origin of *B. dorsalis* is South Asia (Allwood 1997). As a major pest, *B. dorsalis* causes wide range of damages than the other *Bactrocera* species (Drew & Hancock 1994; Kapoor 2006). Female fruit fly lays eggs usually beneath the skin of the fruit after piercing them with its ovipositor. Their larvae develop by feeding on the flesh of the fruit, causing the fruit unsuitable for consumption (Mohd et al. 2011), and a small number oviposit into unripe fruits (Rattanapun 2009).

According to the Ministry of Science, Technology and Research, Sri Lanka (2016), fruit fly damage was estimated to be more than half of the fruit harvest especially in mangoes and guavas, and their management found to be the biggest challenge to the fruit cultivators in the recent past.

The diversity of mango varieties is greater with respective to various tropical agro-ecological regions representing different bioclimatic zones of Sri Lanka. Although, mango production is seasonal, several varieties of mangoes are available in markets throughout the year in Sri Lanka (Peris 2016).

However, there are no sufficient recent statistics on the pest status of *B. dorsalis* in Sri Lanka due to lack of published past studies on their damage and infestation. Few past studies of *B. dorsalis* in Sri Lanka (Dhanapala 1996; Anonymous 2012; Karunarathna 2012) have been focused on controlling measures, without considering the levels of their fruit damage. No records of recent investigations were found on the variation, abundance, and damages of *B. dorsalis* on commercially important mango varieties grown in different bio-climatic zones of Sri Lanka. Based on the severity of the damages caused by fruit flies including *B. dorsalis* in South Asia (Wan et al. 2012), it is very crucial to determine the abundance and the levels of damage in different fruit varieties in main bio-climatic regions. It is one of the important fundamental aspects in the management of fruit flies.

The present study was conducted to determine the percentage of infestations, the emergence of adults from infected fruits and the abundance of adults in field traps of *B. dorsalis* using selected cultivations of two commercially important varieties (Karthakolomban & Willard) of *M. indica* grown in main bio-climatic zones of Sri Lanka. The study further investigated the relationship of infestation percentages and abundance of adult flies with climatic variables.

This paper comprises the part of results of a long–term survey on the climatic and resource variation impacts of *Bactrocera dorsalis* in Sri Lanka.

2. Materials and Methods

Study sites

The study was conducted on monthly basis from September 2020 to February in 2021 during the fruiting season. A main study site from each bioclimatic zone (wet, dry, intermediate, and arid) of Sri Lanka was selected (Fig. 1). Four bio climatic zones of Sri Lanka were divided based on the mean annual rainfall (Peris 2016). Two sub-sampling sites in each main study site were selected based on the availability of mango trees in each variety "Willard" (Wld) & "Karthakolomban" (Kc) (Table 1). Two types of mango varieties such as Wld & Kc were selected for the study, since these are widely grown varieties in Sri Lanka, and both have a high market value (Peiris 2016). Totally, eight sub sampling sites were selected from four main bio-climatic zones, as four sites for Wld mango variety and four sites for Kc variety. For each variety, one site from each bio-climatic zone was selected. Totally six sampling rounds were conducted for each sub sampling site.

Collection of fruit samples

Totally, 960 fruits (both ripe and fallen) were collected from all eight sub sampling sites during the study period as twenty fruits from each sub-sampling site for each variety at once a month. Collected fruits were assessed for infestation damages and for adult fly emergence in the laboratory.

Fruit infestation experiments

Twenty mature mangoes were randomly selected from the ground and from the trees in each variety in each study site in a sampling round. Both over-ripe and ripe fruits were collected to maximize the chances of getting fruit-fly-infested specimens. Each selected fruit was visually examined with the aid of a hand lens to detect fresh oviposition marks that were not visible to the naked eye. Examined fruits with at least one oviposition hole were considered as infected fruits by fruit flies. After incubating such infested fruits under emergence experiments, the infected fruit fly species was confirmed as *B. dorsalis* by identifying emerged adults from each fruit.

Adult fly emergence experiments

The collected mango fruits were brought to the laboratory and the identified fruits for the fruit fly infestation was placed on pre-sterilized sand in plastic containers (18×14×13 cm) and covered with a muslin cloth to keep-off the flies. The mean room temperature during the incubation period was 25 °C and the relative humidity (RH) was in between 75%–86%. Four mango fruits in each variety with approximately same weight were placed on pre-sterilized sand layer in a container for assessing the adult emergence. Elastic rubber bands were used to tighten the muslin cloth cover to prevent flies from entering or escaping the rearing container. Containers were placed in a ventilated room inside the laboratory protecting from ants for a period of four weeks and monitored on weekly intervals. At the end of the fourth week, the rearing containers were carefully examined, and all emerged adult flies were collected.

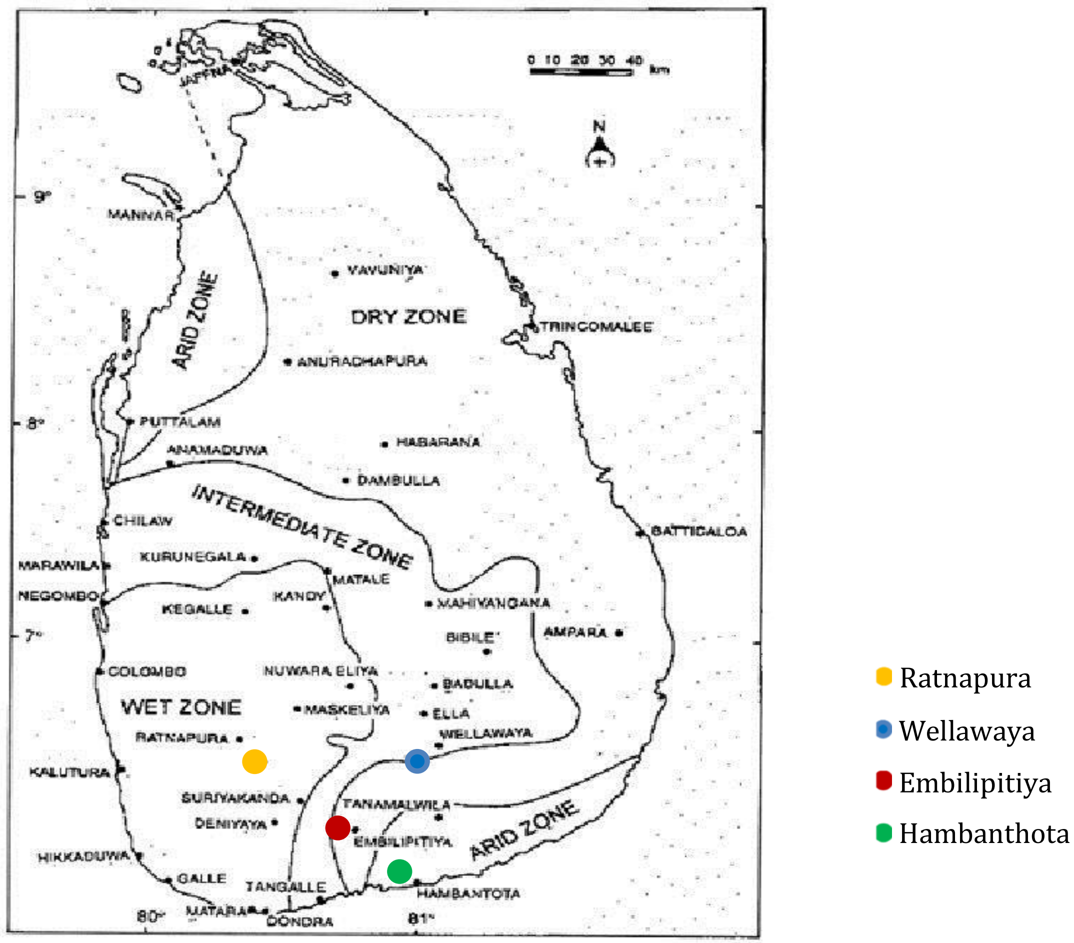

Figure 1: Main-study sites in four different bio-climatic zones of Sri Lanka

Table 1: Description of main study sites and sub-sampling sites in four main bio-climatic zones of Sri Lanka

Bio-climatic zone	**Main study site**	**Coordination of the main study site**	**Coordination of two sub-sampling sites in each main site**
Wet zone	Rathnapura	(6°40'58.01" N, 80°23'57.01" E)	**Balangoda; (Kc)** 6° 39′ 0″ N, 80° 41′ 0″ E, elevation-751m **Kahawaththa;(Wld)** 7°10'0"N, 80°36'0"E, elevation-679m
Intermediate zone	Wellawaya	(6° 44' 15.85" N, 81° 6' 11.005" E)	**Monaragala; (Kc)** 6°45'0"N, 81°14'0"E, elevation-162m **Wellawaya; (Wld)** 6° 44' 15.85" N 81° 6' 11.005" E, elevation-188m
Dry zone	Embilipitiya	(6°20'22.80" N, 80°50'33.59" E)	**Udawalawe; (Kc)** 6° 27' 59.99" N, 80° 52' 59.99" E, elevation-109 m. **Barawakumbuka;(Wld)** 6°10'0"N,80°49'0"E, elevation- 44m
Arid zone	Hambantota	(6° 7' 28.5348'' N, 81° 6' 3.8664'' E)	**Ambalantota**; **(Kc)** 6°7'0"N, 81°1'0"E, elevation- 5m **Debarawewa;(Wld)** 6°17'0"N,81°16'0"E, elevation-28m

Collected adults were preserved using dry preservation method and identified later. The average number of adults that emerged per fruit per study site was calculated.

Collection of adult flies from field traps

The locally made methyl-eugenol (para-pheromone) traps (5 cm diameter and 10 cm height with two circular openings -1 mm radiuses and a methyl-eugenol coated sponge-2×2 cm) were used for collecting adult *B. dorsalis* flies from the field. Eight traps were hanged in eight study sites as one trap per site. Each trap was hung on a tree, which was in the centre of the selected study site at a standard height of 1.5–4 m above the ground level (Ekesi et al. 2009). Field traps were observed once a month. Traps were replaced by new traps in each sampling round. Trapped flies were transferred to vials containing 70% ethanol and brought to the laboratory. Then the number of *B. dorsalis* flies trapped from each sampling round in each sub sampling site was counted.

Morphological identification of adult B. dorsalis

Collected adult flies from field traps and emerged adult flies in adult emergence experiments were identified morphologically using standard identification keys for fruit flies in South Asia and Australia (Plant Health Australia 2018; Daud et al. 2020; Leblanc et al. 2021). Fruit fly specimens were examined using the Light microscope (Nikon-ECLIPSE-E100) (10×4) to confirm the major discriminating morphological and taxonomical features. Samples of identified *B. dorsalis* were deposited at the Department of Zoology, University of Ruhuna, Sri Lanka.

Main Identification features of *B. dorsalis* such as, thorax; scutum red-brown & broad parallel sided two vittae, Abdomen; terga III-V with a wraparound T pattern, Legs; legs yellow except the dark hind tibia, Wings; very narrow anal streak & narrow costal band that dips in at end of R_{2+3} (Plant Health Australia 2018; Leblanc et al. 2021) were used to confirm the specimens in the species level.

Collection of weather parameters

Monthly data including rainfall (RF), temperature (TM), and relative humidity (RH) in eight study sites were obtained from the Department of Meteorology, Colombo, Sri Lanka.

Data analysis

Following three indices were calculated.

Abundance of fruit flies in field traps (Modified Prabhat 2011)

$$B.dorsalis \text{ fly catches per trap per month} = \frac{\text{Number of } B.dorsalis \text{ trapped}}{\text{Total number of flies trapped}} \times 100$$

Fruit infestation experiments (Prabhat 2011)

$$\text{Infestation } \% = \frac{\text{Number of fruits showing oviposition marks}}{\text{Total number of fruits examined}} \times 100$$

Emergence of adult flies from infested fruits (Prabhat 2011)

$$B.dorsalis \text{ flies per sub} - \text{site} = \frac{1}{5}\sum \frac{\text{Emerged flies in a container}}{4}$$

Statistical data analysis: Data was coded and entered to a database using the Statistical Package for the Social Sciences (SPSS, version 25) software. Data were checked and cleansed. The data were checked for the normality using Anderson-Darling test. The significance in variations of fruit infestation, adult emergence, and abundance of adult flies from field traps between mango varieties and among bio-climatic zones were compared using one-way ANOVA analysis and using T-tests for two mango types at α=0.05 significance level. Relationships between the abundance of fruit flies from field traps with fruits infestation percentages and weather parameters were examined by Pearson correlation analysis at α=0.05 significance level.

Ethical clearance

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

3. Results

Mean weight (g) (mean ± SE) of the mango used for the study was 112.71±1.78 g for Wld and 290.75±4.23 g for Kc.

Fruit infestation percentages

The average percentage of infestations for Wld was high in the intermediate zone (29%), and moderate for the dry (25%) and arid (25%) zones and low for the wet zone (21%) (Fig. 2). The percentage of infestation for Wld represented non-significant variation (*P*= 0.15) among the selected sites in different bio-climatic zones.

Fig. 2 indicates the percentage of infestation for Wld considerably was high in last three months of the study than that of initial months in all study sites, which was not significant (*P*= 0.29). The pattern of infestation of *B. dorsalis* for the dry zone showed a slight reduction during October to November in 2020.

According to the Fig. 3, the average infestation for Kc revealed a statistically significant (*P*= 0.01) high percentage (35%) for the intermediate zone than the wet zone (17%) (*P*= 0.04). The percentage of infestation for Kc was high in the intermediate zone than that of other three zones over the study period. Fig. 3 revealed a significant increase of infestation percentages of *B. dorsalis* for the Kc in all bio-climatic zones during last four months of the study than previous months (*P*= 0.01). All four zones indicated the highest infestation percentages for Kc fruits during January and February in 2021.

Emergence of adult flies

The average values of total adult emergence for Wld were high in the intermediate zone (5.00±0.85) than that of the dry (3.83±1.2), wet (2.83±0.83) and arid (3.83±1.01) zones. The adult emergence for Wld was not significantly varied (*P*>0.05) among four bio climatic zones. After November 2020, it showed a significant increase in the number of adults emerged for Wld than previous months (*P*< 0.01) (Table 2). Table 03 shows the adult emergence of flies for Kc and it was high (6.50±1.52) for the intermediate zone when compared with the dry (4.67±1.66), the wet (3.00±0.85), and the arid (5.50±1.05) zones.

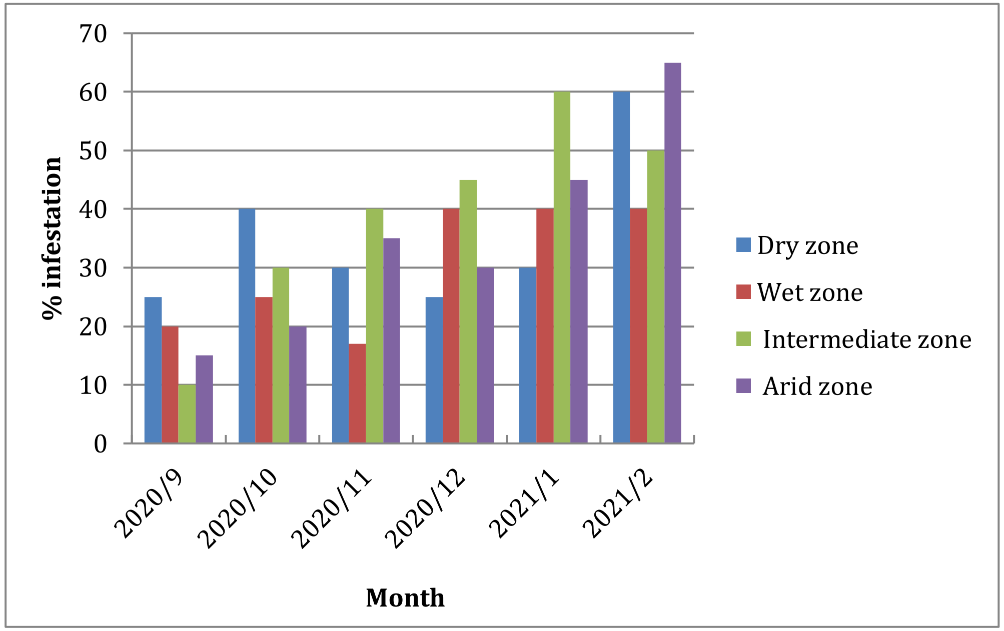

Figure 2: The variation of mean infestation percentages of *B. dorsalis* in Wld variety among four main bio-climatic zones

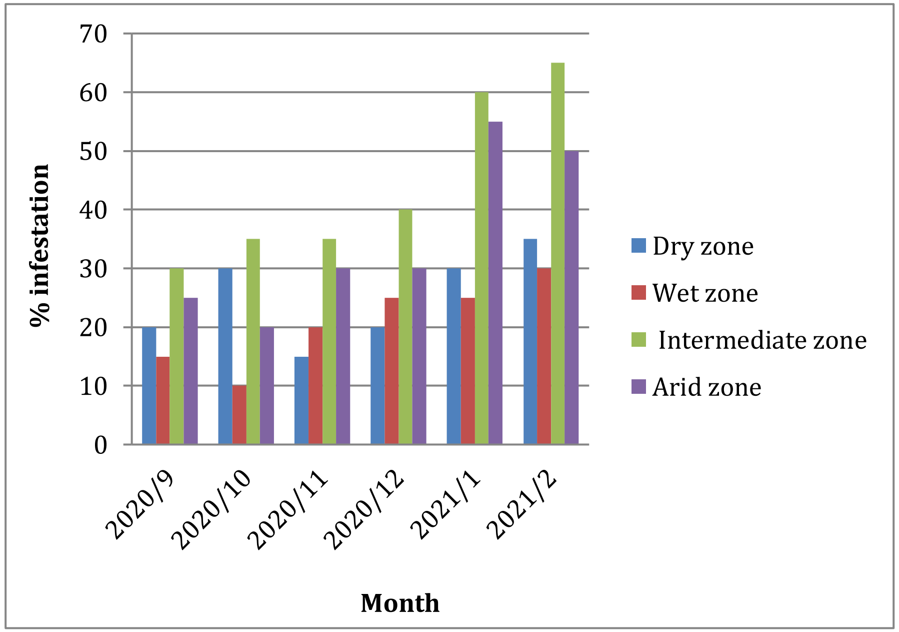

Figure 3: The variation of mean infestation percentages of *B. dorsalis* in Kc variety among four main bio- climatic zones

Table 2. The adult emergence of *B. dorsalis* from Willard variety among bio-climatic zones

Month (2020-2021)	Mean weight(g) of mango variety	The number of *B. dorsalis* adults emerged from incubated Wld/ per fruit per location			
		Dry zone	Wet zone	Intermediate zone	Arid zone
September	(115.17 ± 2.05)	0	0	2	1
October	(110.21 ± 1.91)	2	2	3	3
November	(117.50 ± 1.55)	3	2	5	2
December	(111.02 ± 1.05)	4	4	7	4
January	(109.48 ± 2.21)	5	3	6	5
February	(112.90 ± 1.72)	9	6	7	8

Table 3. The adult emergence of *B. dorsalis* from Karthakolomban variety among bio-climatic zones

Month (2020-2021)	Mean weight(g) of mango variety	The number of *B. dorsalis* emerged from the incubated Kc/ per fruit per location			
		Dry zone	Wet zone	Intermediate zone	Arid zone
September	(237.48 ± 3.25)	0	0	3	3
October	(321.17 ± 4.50)	4	2	3	4
November	(273.56 ± 5.05)	1	2	5	3
December	(347.08 ± 3.20)	4	4	6	6
January	(296.21 ± 4.15)	10	4	10	8
February	(269.00 ± 5.23)	9	6	12	9

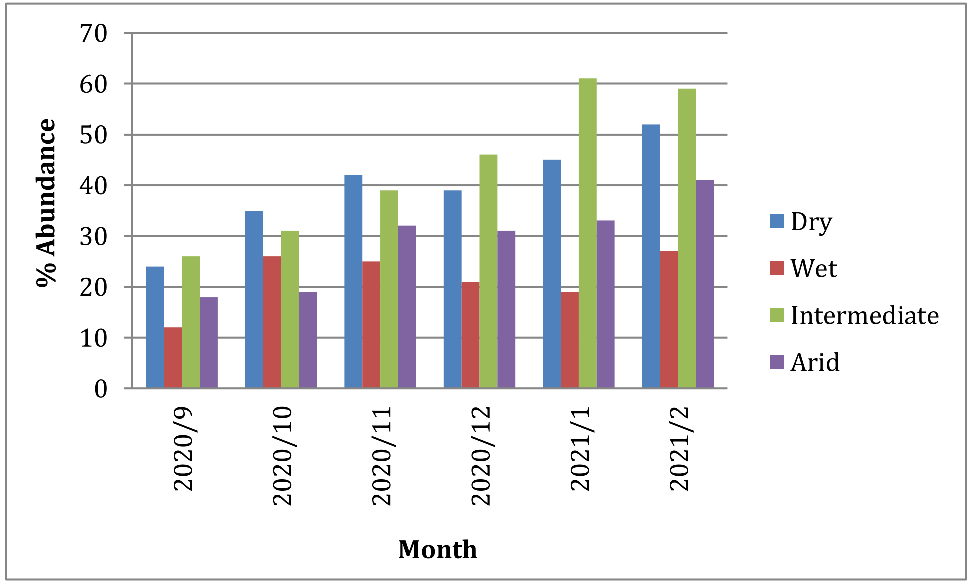

Figure 4. Percentage abundance of *B. dorsalis* collected from Willard cultivated study sites in four main bio-climatic zones

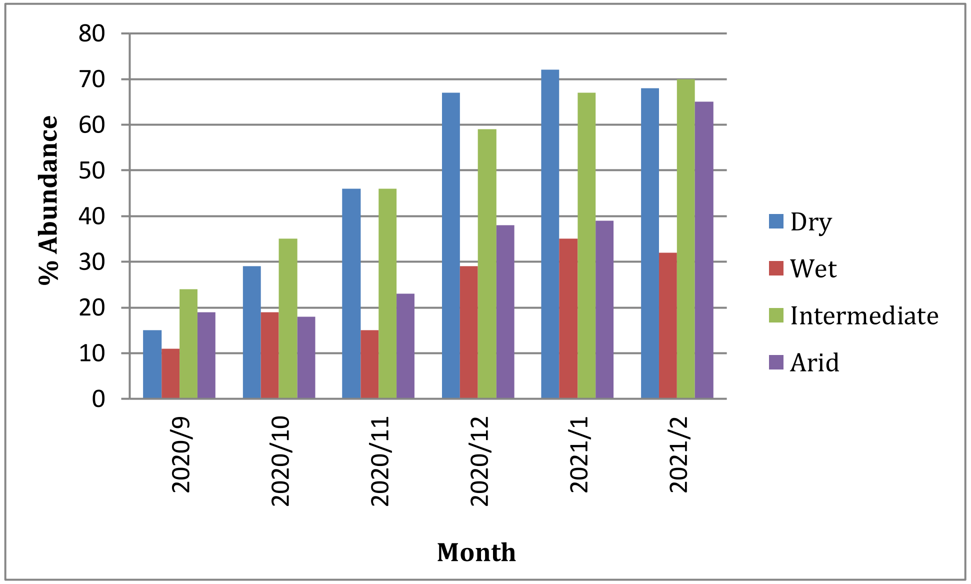

Figure 5. Percentage abundance of *B. dorsalis* caught from Karthakolomban cultivated study sites in four main bio- climatic zones

The average adult emergence for Kc variety was higher than Wld in all zones. The adult emergence of *B. dorsalis* for Kc showed non-significant variation (*P*= 0.31) among bio climatic zones. Interestingly, it had a significant increase of adults' emergence for Kc in all localities after November 2020 (*P*= 0.01). The emergence of adult *B. dorsalis* for Kc was significantly high than that of Wld (*P* < 0.01).

Abundance of adult B. dorsalis in field traps

Among the total fly catches for Wld, 803 of flies were identified as *B. dorsalis*. Fig. 04 shows the variation of adult fly abundance for Wld among bioclimatic zones during the study period. The abundance of *B. dorsalis* was higher in the intermediate zone (43.67±5.87) and their abundance for Wld were significantly varied among bio climatic zones (*P*< 0.01). The number of collected flies has significantly increased at the later months of the study (January and February) (*P*= 0.01). For all bio-climatic zones, the highest trap catch for Wld was recorded in January and February 2021.

The total 941 of adult *B. dorsalis* were collected from field traps located in Kc cultivated sampling sites. Comparatively the percentage abundance of flies for the Kc was higher than that of the Wld sites in all bio-climatic zones. The highest trap catches of *B. dorsalis* for Kc was recorded in the intermediate zone (50.17±7.50). The abundance of *B. dorsalis* for Kc has varied among the sampling sites in bio-climatic zones (*P*= 0.05).

Fig. 5 reveals that the abundance of adult *B. dorsalis* has increased significantly in all study sites of Kc after first two months of the study (*P*< 0.01). The abundance of adult flies collected from traps was significantly different between the Kc and Wld (*P*= 0.01). There was a significant positive and moderate correlation between the abundance of flies (from traps) and the percentages of fruit infestation for both Wld (r= 0.68; *P*= 0.001) and Kc (r= 0.61; *P*= 0.001).

Correlation of the abundance of B. dorsalis with weather parameters

The abundance of flies collected from traps varies for two mango varieties and for the different bioclimatic zones. The correlation between the abundance of flies with rainfall (RF), temperature (TM) and relative humidity (RH) with mango varieties and with study sites in bioclimatic zones was analysed. Among the four bio climatic zones, intermediate zone revealed a good relationship with weather parameters, while other three zones did not show a correlation with RF, TM, and RH. There was a significant and strong positive correlation for Kc (r= 0.90; *P*= 0.01) between RF and the abundance of *B. dorsalis* in the intermediate zone. Whereas a weak positive correlation of the abundance of fruit flies with RF was recorded for Wld (r= 0.08; *P*= 0.87) in the intermediate zone. The temperature (TM) was positively correlated with the abundance of *B. dorsalis* in dry and wet zones for both mango varieties (Dry zone: Wld (r= -0.63; *P*> 0.05) and Kc (r= -0.34; *P*> 0.05) and Wet zone; Wld (r= -0.77; *P*> 0.05) and Kc (r= -0.30; *P*> 0.05). During the study period, TM was negatively correlated with the abundance of *B. dorsalis* for

Wld (r= -0.69; *P*>0.05) and Kc (r= -0.70; *P*> 0.05) in the intermediate zone. The relative humidity (RH) showed a moderate and positive correlation for both Wld (r= 0.50; *P*> 0.05) and Kc (r= 0.50; *P*> 0.05) in the intermediate zone.

4. Discussion

Bactrocera dorsalis (Oriental fruit fly) is known to be one of the main fruit pests of *M. indica* (Clarke et al. 2005). The present study reveals that *B. dorsalis* has found over all bioclimatic zones in Sri Lanka, and this study was focused only on *B. dorsalis* despite some other species were observed in the samples. However, within this study period, several other *Bactrocera* species were recorded in very few numbers. The highest adult abundance of *B. dorsalis* indicated that this species is probably the predominant fruit fly on mango fruits in Sri Lanka. The predominance of *B. dorsalis* over other *Bactrocera* species was also recorded in mango cultivations in several other countries such as China (Li 2016) and Indonesia (Zulida & Tati 2016; Kartika & Tati 2016). The wide distribution of *B. dorsalis* could be due to the cultivation of common mango varieties over the different climatic regions in Sri Lanka (Anonymous 2011).

The selected Willard and Karthakolomban mango varieties for the present study are the most popular and widely consuming fruit types by Sri Lankans (Peiris 2016). Both varieties are dominantly grown under dry climatic conditions and comparatively, low extent, and the production has been recorded in wet zone areas (Henegadera et al. 2002). However, both varieties are available in markets throughout the year due to cultivation in extensive and intensive scales in different agro-ecological zones of Sri Lanka (Peris 2016). Fruit fly damage depends on the fly population and the fruiting season in the area (Kumar et al. 2011). The present study was conducted during the main mango harvesting season, thus in dry climatic conditions mangoes are harvested mostly during October to January. However, in wet zone, their harvesting season is during April to July (Peris 2016).

Significantly, the abundance of *B. dorsalis* from field traps was positively correlated with the fruit infestation percentages. It implies *B. dorsalis* uses mango fruits as their main host to multiply rapidly during the fruiting season. In the non-fruiting season, *B. dorsalis* uses multiple hosts for their survival (Peris 2016). Among the four bio-climatic zones selected, intermediate zone had the highest number of trap catches, the percentage of fruit infestation and the adult fly emergence for both mango varieties. This could be linked to the favourable growth conditions and the available more breeding habitats in the intermediate zone for *B. dorsalis* than the other three zones during the study period. Undoubtedly, the variations of fruit infestation percentages and adults' emergence from infested fruits are directly related to the abundance of flies at the study sites (Kumar et al. 2011). Further, the intermediate zone showed moderate correlation coefficient values for RF, TM and RH when compared with the dry and wet zones. Interestingly, RF showed a significant positive correlation with fruit fly catches for Kc and non-significant positive correlation for Wld in intermediate zone. Similarly, RH showed a positive correlation and TM showed a negative correlation with the abundance of fruit flies for both mango varieties in the intermediate zone. This could be due to the increase of fly abundance with the growing mango production under favourable climatic conditions because the seasonal mango production in Sri Lanka is mainly attributed with the rainfall patterns rather than the temperature (Peris 2016). In 2019, Musasa et al. further evident that the prevailing weather conditions with the fruiting season of mango fruits could be linked to higher field trapping density of *B. dorsalis*. The decreasing temperature and humidity cause for the low fruit fly density (Neilsen 2005; Rwomushana 2009), and it agreed with the present study results of RH in intermediate zone, whereas controversy with TM.

Comparatively, wet zone indicated the lowest fruit infestation, adult emergence, and the abundance of flies from field traps than other three bio-climatic zones. These results are linked with the mango fruiting season because the main harvesting period of mango trees in the wet zone is April to July (Peris 2016). This might be a reason to have notable deduction of the fruit damage coupled with the low abundance of adult flies for both mango verities in the wet zone. A remarkable increase of fly abundance, fruit infestation and adult emergence for both Wld and Kc were observed at the last two months of the study. The period of the present study coincided with the long supply season of most of mango varieties which come to the market during October to January (Peris 2016). The increasing of the number of over ripped and fallen fruits at the later part of the fruiting season provide ideal breeding and feeding grounds for fruit flies (Peris 2016).

The Study reveals a significantly high adult fly abundance from field traps in Kc cultivated study sites than the Wld. The fruit infestation and adult emergence by *B. dorsalis* were remarkably higher for Kc than the Wld. Further, results evident that the Kc fruits showed a high mean weight than Wld. The fruit size of Kc is bigger than Wld and which provide more surface area for infestations, a large feeding space and food materials for fruit fly maggots. The overall fruit quality of both Wld and KC is “excellent” with sweet taste whereas the pH of the flesh part of Kc (5.4) higher than the Wld (4.94) (Krishnapillai & Wijeratnam 2016). Hence, the favourable pH levels of Kc variety provide better habitat for the survival of larvae of *B. dorsalis.* Further, in 2011, Kumar et al. reported that the damage to fruits by fruit flies vary on different varieties of mangoes.

The correlation coefficient of number of flies from field traps with TM showed contradictory results in our study comparing with previous findings in other tropical countries. Several studies have been revealed that the temperature and humidity have a positive correlation with the abundance of fruit flies (Neilsen 2005; Rwomushana 2009; Musasa et al. 2019). Hence long-term studies are needed to determine the effects of climatic conditions on the population dynamics of *B. dorsalis* in different bioclimatic zones of Sri Lanka.

5. Conclusions

Bactrocera dorsalis is a common fruit fly in all study sites during the present survey and found to be commonly distributed over all bioclimatic zones of Sri Lanka. The intermediate zone showed a significantly high abundance, fruit infestation and adult fly emergence of *B. dorsalis.* Karthakolomban variety was more susceptible for *B. dorsalis* than the Willard. The Presence of high mango production during the fruiting season positively affected the increase of fruit damage of *B. dorsalis*. The abundance of *B. dorsalis* in mango cultivations showed certain correlation with the fruit infestation and adult emergence. Further studies are needed to identify the relationship of *B. dorsalis* population with climatic variables.

6. Acknowledgement

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Conflicts of interest: Authors would like to declare that there are no conflicts of interest.

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