Research Journal of Life Science
APRIL-2023 Volume 10 No. 1 (1-12)
journal homepage: www.rjls.ub.ac.id

Population Dynamic and Distribution of *Bactrocera carambolae* and *Bactrocera dorsalis* in Orchard Habitat in Different Geographical Areas

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KEYWORDS

Bactrocera carambolae; *Bactrocera dorsalis* Lombok Island; Majalengka; Population

Abstract Fruitflies, particularly *Bactrocera carambolae* and *Bactrocera dorsalis*, are significant pests that have the potential to diminish the quality and quantity of agricultural products. They may live in diverse habitats, particularly in agroecosystem habitats. Orchard habitats offer a source of food and development for fruit flies like *B. carambolae* and *B. dorsalis* not only in Java, notably Majalengka Regency, but also in Lombok Island and West Nusa Tenggara. Consequently, the purpose of there search is to observe (1) The population dynamic of *B. carambolae* and *B. dorsalis* in the orchard habitat. (2) Distribution of fruit flies *B. carambolae* and *B. dorsalis* trapping results in the orchard habitat. (3) Analyzing the factors affecting the presence of the fruit fly species *B. carambolae* and *B. dorsalis* in the orchard habitat. Fruitflies were sampled using the trap method between December 2021 and March 2022. In the orchard habitat on the mangosteen fruit commodity, the results indicated that *B. carambolae* and *B. dorsalis* had the largest population densities. Additionally, orchard locations on Lombok Island had the highest population density. Furthermore, fruitflies are more prevalent in perennial crops than in annual ones due to higher population density. Perennial crops are the ideal conditions for fruit fly development as compared to seasonal crops.

Introduction

The agricultural sector is one of the nation's mainstay industries for generating foreign exchange through horticultural product exports. According to the Central Bureau of Statistics, the amount of Indonesian fruit exports reached 769,919.2 tons, with an export value of $522.15 million(BPS, 2023). The value of exports has increased significantly from 2021, when it only amounted US$ 393.40 million, despite a decline in export volume. Fruit fly larvae infestations continue to hinder efforts to improve the quality of horticulture export products, such as locally grown fruits that meet international standards.

Fruit flies are one of the most important pests in horticultural crops. Fruit flies could potentially lower the quality and quantity of domestic fruit goods, which could be a barrier to government efforts to expedite exports, which are now being pursued vigorously. Fruit exports to trading partner countries are hampered by destination country policies that require fruit-free export commodities. Japan, China, and Australia are potential export

How to cite this article: Kolopaking, B., Rizali, A., Affandi, A., Hudiwaku, S., and Himawan, T. (2023). Population Dynamic and Distribution of *Bactrocera carambolae* and *Bactrocera dorsalis* in Orchard Habitat in Different Geographical Areas . Research Journal of Life Science, 10(1), 1-12. https://doi.org/10.21776/ub.rjls.2023.010.01.1

countries that put forward strict requirements related to the presence of fruit flies.

Fruit fly infestations reduce yield by 50% to 75%, but under the right environmental circumstances and on susceptible hosts, they can cause 100% of the damage (Dhillon *et al.*, 2005). The distribution and diversity of fruit fly species in an area can be influenced by several factors, such as climatic factors and food availability (Baker *et al.*, 2000). Additionally, places with heavy rainfall will have more fruit fly populations than areas with little rainfall. The intensity of fruit fly infestations increases on fruits and vegetables in cool climates with high humidity and light winds. The factors that have the greatest impact on the intensity of fruit fly attacks include temperature, air humidity, wind speed, and rain fall (Susanto *et al.*, 2017).

Habitat can affect the diversity and composition of fruit fly species. Habitat size, vegetation diversity, and varying altitudes can affect the density of fruit fly populations. Significant impacts can occur on the distribution and species density of each organism due to habitat changes(Raghu *et al.*, 2000).

Endemic fruit fly species in Indonesia belong to the genera Bactrocera and Dacus. Both genera are associated with fruit crops in various habitats. The most important Tephritidae genera are Bactrocera, Ceratitis, Anastrepha, Dacus, and Rhagoletis(Jiang *et al.*, 2018). There are 89 native fruit fly species in western Indonesia, but only eight of them are significant pests. These are *Bactrocera (Bactrocera) Albistrigata* (DeMeijere), *B. (B.) Carambolae* (Drew and Hancock), *B. (B.) Dorsalis* (Hendel), *B. (B.) Papayae* (Drew and Hancock), *B. (B.) Umbrosa* (Fabricius), *B. (Z.) Cucurbitae* (Coquillett), *B. (Z.) Tau* (Walker), *and Dacus (Callantra) Longicornis* (Weidemann).

B. carambolae and *B. dorsalis* are common fruit fly species found in orchard habitats throughout Indonesia, including Majalengka Regency and Lombok Island, West Nusa Tenggara. The objectives of the research conducted were to (1) Observe the population density of *B. carambolae* and *B. dorsalis* fruit flies in orchard habitats in Majalengka Regency and Lombok Island. (2) Observe the distribution of *B. carambolae* and *B. dorsalis* fruit flies trapped in orchard habitats in Majalengka Regency and Lombok Island. (3) Analyze the factors that influence the presence of *B. carambolae* and *B. dorsalis* fruit fly species in orchard habitats in Majalengka Regency and Lombok Island.

Materials and methods

Study Area and Plot Determination

This study was conducted in orchard habitats in two different geographical locations, in in Majalengka Regency, West Java, and Lombok Island, West Nusa Tenggara. Data were obtained by setting fruit fly traps in four locations in Majalengka Regency, in Panyingkiran, Jatisawit, Sidamukti, and Gunungwangi orchards, as well as in three locations, in Gangga, Lingsar, and Lemor orchards, in Lombok Island, West Nusa Tenggara (Table 1). Each orchard contained six replicated plots of various fruit fly trap installation positions, with 12 trap installation intervals and biweekly trap collecting intervals.

Collection of fruit flies

The research method used was a survey method by collecting fruit fly samples from the installation of traps (Steiner type) baited with Methyl Eugenol (ME) paraferomone. Each research location was determined to have six sample plots where the traps were set. Each sample plot position at the study site was determined by following a transect pattern. The distance between sample plots was set as far as 200 meters according to topographic

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conditions, and the height of the trap was 1.5–2 m above the ground. At each research location, there were six sample plots and six traps. Fruit fly sampling was carried out at two-week intervals for a total of six times (± three months). Fruit fly samples obtained from the installation of traps were counted and the population density of the fruit fly species *B. carambolae* and *B. dorsalis* was observed. The research was conducted from December 2021 to March 2022.

Table 1. The location of orchard habitats used in research in Majalengka and Lombok Island

Location		Geographical Site	Altitude (m asl)	Common name
Majalengka Regency	Panyingkiran, Kec. Panyingkiran	6°48'24.3"S 108°11'42.1"E	60 – 65	Guava (*Psidium guajava*)
	Jatisawit, Kec. Kasokandel	6°48'02.6"S 108°12'24.8"E	70 – 75	Bitter melon *Momordicacharantia*) and Ridge gourd (*Luffa acutangula*)
	Sidamukti, Kec. Majalengka	6°51'35.2"S 108°11'34.0"E	125 – 140	Mango (*Mangifera indica*)
	Gunungwangi, Kec. Argapura	6°53'16.3"S 108°21'03.5"E	1250 – 1265	Red chilli (*Capsicum annum)*
Lombok Island	Gangga, North Lombok	8°19.960'S 116°12.961'E	97 – 197	Cashew (*Anacardium occidentale*)
	Lingsar, West Lombok	8°32.814'S 116°11.828'E	201 – 292	Mangosteen (*Garcinia mangostana*)
	Suela, East Lombok	8°30.805'S 116°33.636'E	470 – 533	Mango (*Mangifera indica*)

Note: * asl: above sea level

Identification of Fruit Flies

Morphological identification was carried out up to species level based on morphological characteristic of fruit flies on the head, thorax, wing venation, abdomen, and legs. The identification reference used the identification key book of tropical fruit flies in Southeast Asia, Indomalaya, and Northwest Australia (Drew & Romig, 2013). Documentation of each morphological character was conducted using a Nikon SMZ 745T trinocular stereo microscope with a Nikon DS-Fi3 camera equipped with NIS-Elements imaging software version 5.20.00.

Data analysis

Population density is the result of counting fruit fly samples obtained from each trap, which was set at each research location. Factors analysis was the relationship or influence that occurred between the population density of *B. carambolae* and *B. dorsalis* to the location of observation, different commodities and types of plant groupings.

Tabulation of observation data in the form of density of fruit flies (*B. carambolae* and *B. dorsalis*) at each location was done on a Google Spreadsheet or Microsoft Excel. Fruit fly density was analyzed using analysis of variance (ANOVA; $P < 0.05$). However, the Shapiro-Wilk Test was used to determine the normality of each variable before analysis. If the data were not normally

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distributed, they were transformed with log(x+1). If there are significantly different analysis results, Duncan's further test is conducted. All analyses were conducted using R statistical software version 4.04 (R Core Team, 2023).

Results and Discussion

Population Dynamic and Distribution of B.carambolae and B. dorsalis in Orchard Habitat in Different Geographical Areas

Bactrocera carambolae was one of the species observed in both research locations, Majalengka and Lombok. Observations of *B. carambolae* fruit flies were carried out by setting up Methyl Eugenol (ME) heavy traps on different commodities. *B. carambolae* fruit fly observations in Majalengka consisted of commodities such as Red Chili (*Capsicum annum*), Guava (*Psidium guajava*), Mango (*Mangifera indica*), Bitter Melon (*Momordica charantia*), and Ridge gourd (*Luffa acutangula*). Each observation of the density of *B. carambolae* fruit flies in the Majalengka area produced a different result and revealed fluctuations (Figure 1). Meanwhile, observations of *B. carambolae* in Lombok were conducted on three different commodities, in cashew (*Anacardium occidentale*), mango (*Mangifera indica*), and mangosteen (*Garcinia mangostana*). The density of *B. carambolae* fruit flies in Lombok also gave different results in each observation and fluctuated (Figure 2).

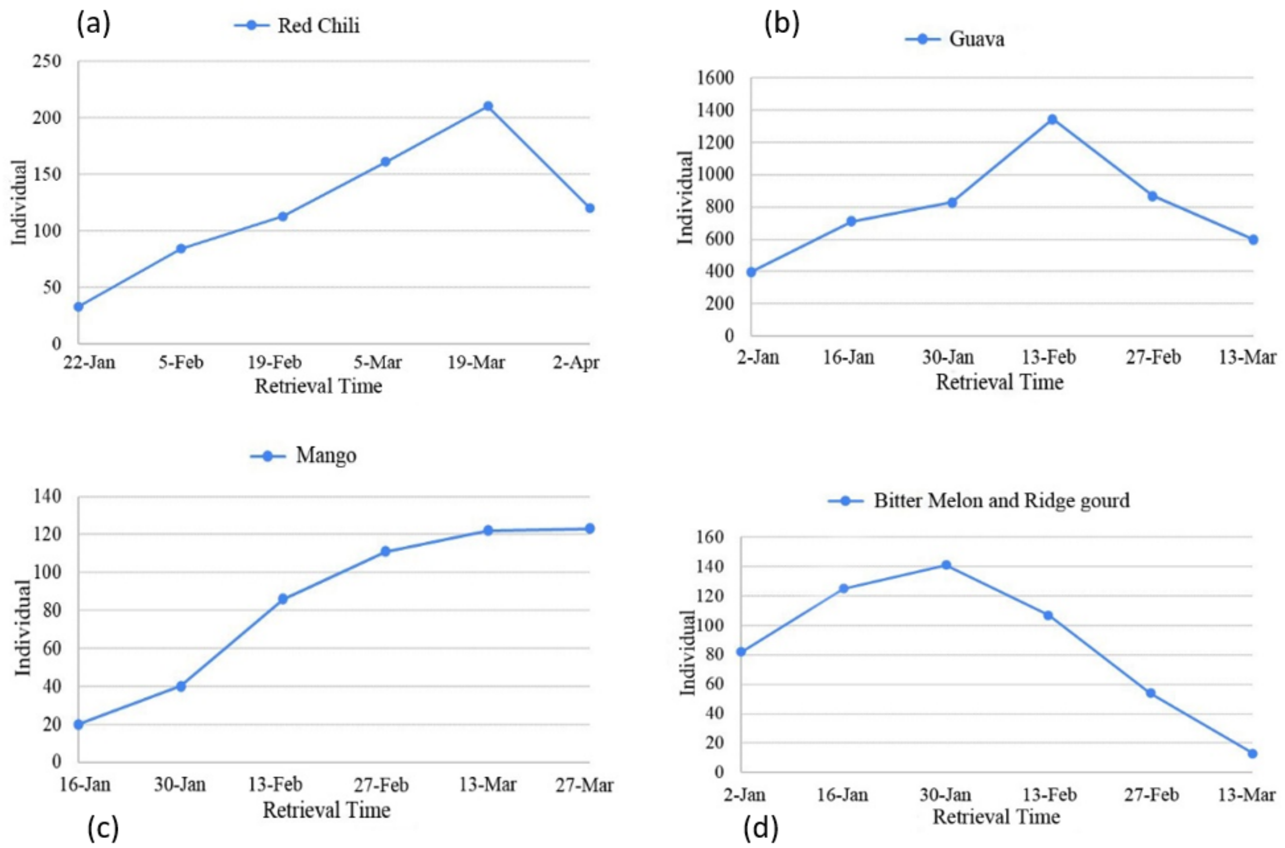

Figure 1. Fluctuation of *B. carambolae* density in Majalengka on red chili (a), guava (b), mango (c), and bitter melon and ridge gourd (d).

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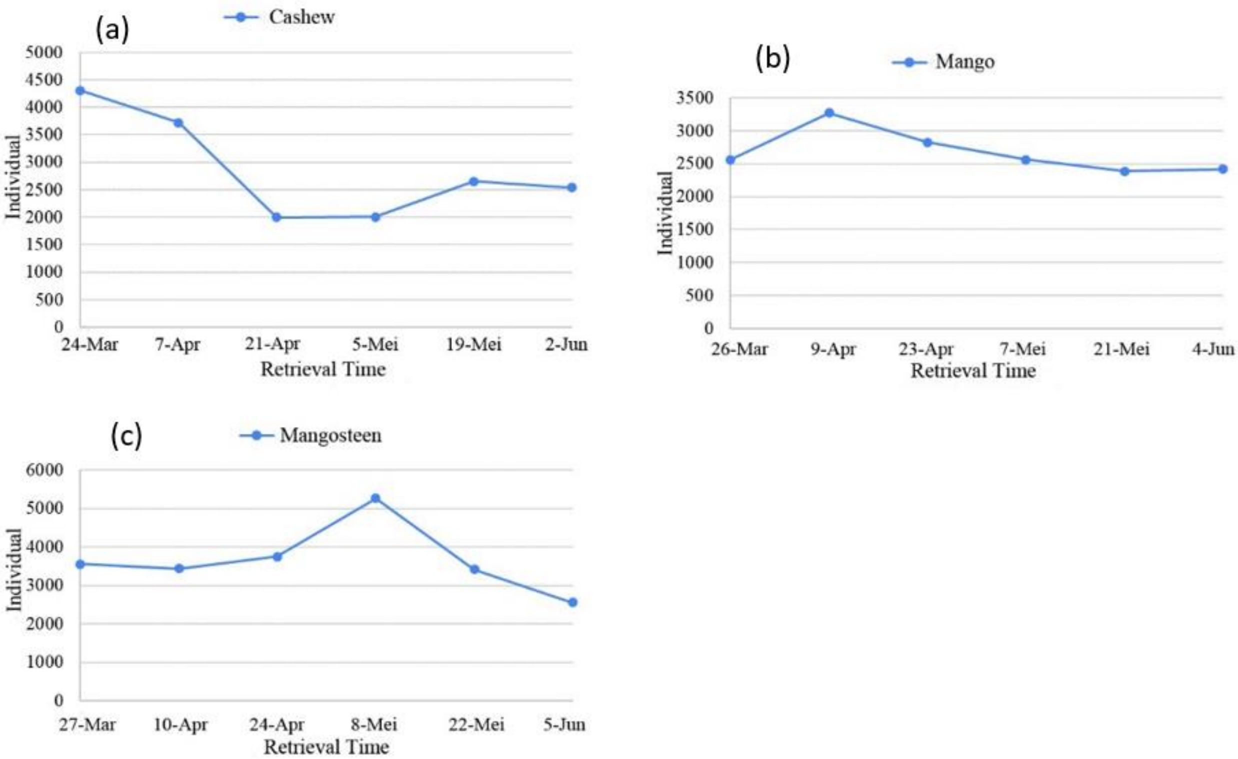

Figure 2. Fluctuation of *B. carambolae* density in Lombok on cashew (a), mango (b), and mangosteen (c) commodities

Fluctuations in *B. carambolae* density can be observed through graphs on different commodities located in Majalengka. The red chili commodity produced the highest density on the fifth observation on March 19, with 210 individuals. Furthermore, the guava commodity from the first observation on January 2 continued to increase until the highest density on February 13, then decreased until the last observation. Commodities in the form of mango plants also experienced an increase from the first observation on January 16 to the highest on the last observation on March 27 at 123 individuals. Lastly, bitter melon and ridge gourd had the highest density on the third observation on January 30 and continued to decline until the last observation on March 13.

The density of *B. carambolae* fruit flies were also observed in different locations, in Lombok, with three types of commodities such as cashew, mango, and mangosteen. Cashew commodities had the highest density of *B. carambolae* on the first observation on March 24 at 4311 individuals, then continued to decline until the last observation. Furthermore, in the mango plant, the highest density was found on the second observation on April 9 at 3268 individuals and continued to decline until the last observation on June 4. The mangosteen commodity produced the highest density on the fourth observation on May 8 at 5263 individuals.

Fluctuations in the density of *B. carambolae* in each commodity at each location are influenced by the phase of plant growth when traps are set and retrieved. The fruit fly *B. carambolae* is also an important pest that is often found attacking fruiting plants. The density of this fly will be higher if the plant is in the fruiting stage as it attacks and damages the plant's fruit, as opposed to when it is unproductive or fruitless. Host plant phenology will affect the presence and density of *B. carambolae*.

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The density of the fruit fly species *Bactrocera dorsalis* differed between Majalengka and Lombok sites. Trapping in the form of Methyl Eugenol (ME) attractant was conducted in two different locations, in Majalengka and Lombok, with different commodities. *B. dorsalis* fruit fly research in Majalengka consisted of commodities such as Red Chili (*Capsicum annum*), Guava (*Psidium guajava*), Mango (*Mangifera indica*), Bitter Melon (*Momordica charantia*), and Ridge gourd (*Luffa acutangula*). The density of *B. dorsalis* fruit flies in the Majalengka location of *B. dorsalis* in each observation obtained different results and showed fluctuations (Figure 3). Meanwhile, observations of *B. dorsalis* in Lombok were conducted on three different commodities, in Cashew (*Anacardium occidentale*), Mango (*Mangifera indica*), and Mangosteen (*Garcinia mangostana*). The density of *B. dorsalis* fruit flies in Lombok locations also gave different results for each commodity (Figure 4).

The graph of *B. dorsalis* density fluctuations in each commodity shows different results. Each commodity was installed and retrieved from traps at the same time, thus affecting the condition and phenology of plants at the time of observation. The density of *B. dorsalis* in red chili commodities continued to increase from the first observation on January 22 until the highest density was found on the fifth observation on March 19, then decreased on the last observation on April 2. The guava commodity experienced an increase in density from the first observation on January 2 to the highest density on the fourth observation on February 13, then decreased until the last observation. The density of *B. dorsalis* in the mango commodity continued to increase from the first observation on January 16 to the last observation, which showed the highest density. Finally, in bitter melon and ridge gourd commodities, the highest density was found in the second observation on January 16 and continued to decline until the last observation.

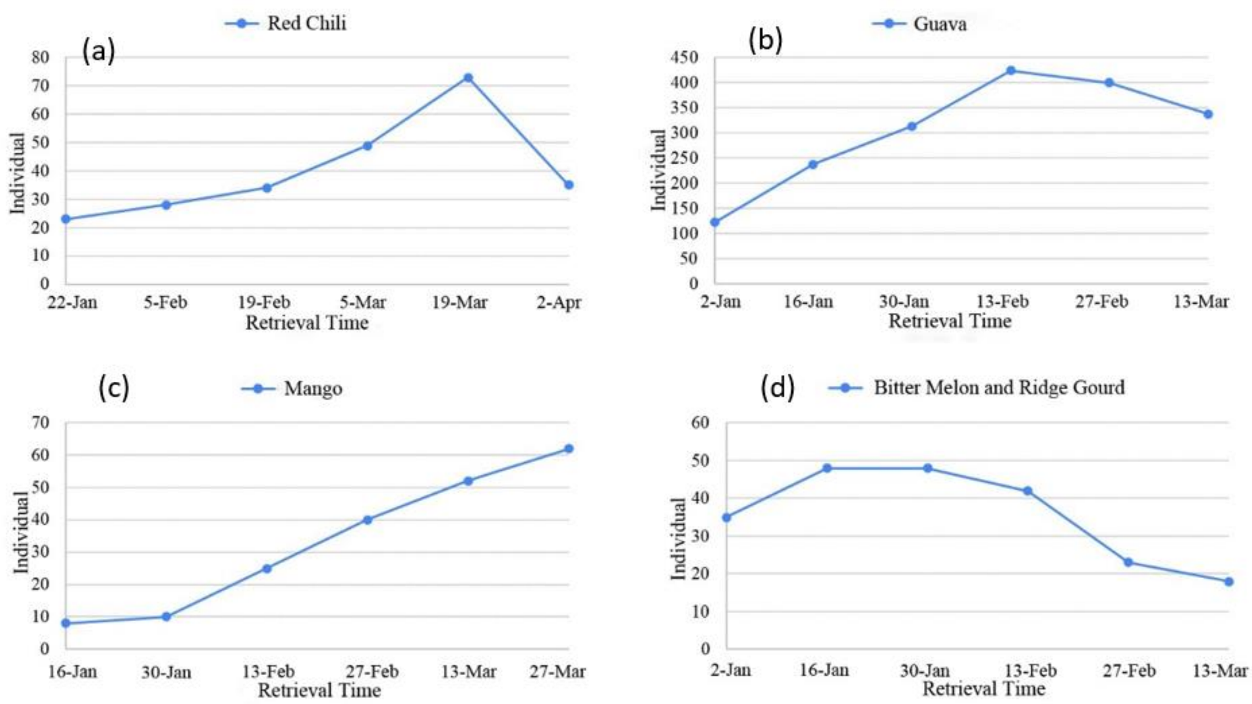

Figure 3. Fluctuation of *B. dorsalis* density in Majalengka on Red Chili (a), Guava (b), Mango (c), and Bitter melon and Ridge gourd (d) Commodities

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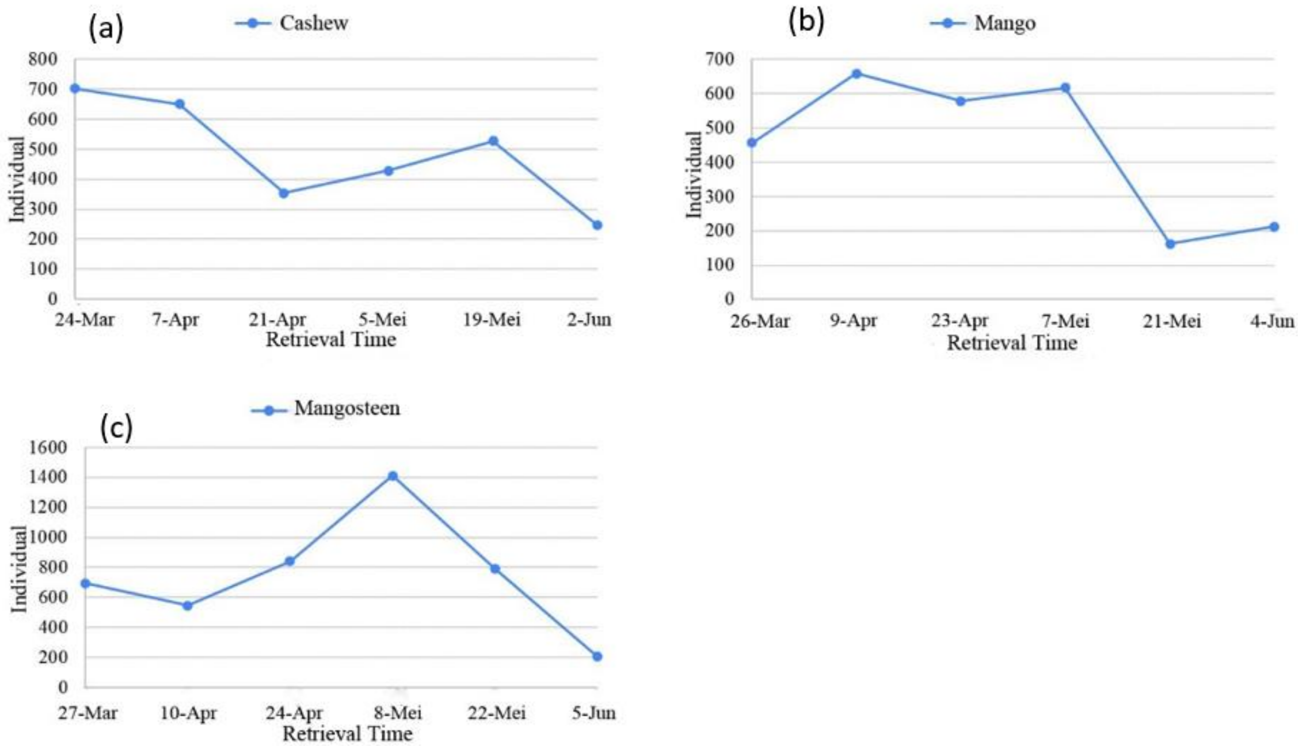

Figure 4. Fluctuation of B. dorsalis density in Lombok on cashew (a), mango (b) and mangosteen (c) commodities

The density of *B. dorsalis* fruit fly in Lombok in the three commodities of cashew, mango, and mangosteen showed different results. The first observation in cashew produced the highest density on March 24, and then decreased and slightly increased until the last observation on June 2. The density of *B. dorsalis* in mango plants was highest on the second observation on April 2 at 659 individuals, then decreased until the last observation on June 4. Finally, the mangosteen commodity showed the highest density on the fourth observation on May 8, then decreased until the last observation.

Each plant has a different life phase or phenology, which causes differences in density in each commodity and different observation times. The fruit fly *B. dorsalis* is a type of insect that is an important pest of horticultural crops such as chilies, tomatoes, gambas, etc. This fruit fly has piercing-sucking mouthparts that damage plants in the fruiting phase. *B. dorsalis* damages the fruit by inserting eggs into the fruit of the plant. This condition causes the presence of fruit on plants in each commodity to affect the density of fruit flies in the observation field. The greater density of *B. dorsalis* fruit flies in the observation field at a certain time of collection, the more likely it is that there are numerous fruits serving as hosts for fruit flies o rthat the plants are in the fruiting stage. Plants that are in the fruitless phase will show a lower density of *B. dorsalis* compared to plants that are in the fruiting phase.

The overall population density of *B. carambolae* fruit flies in orchard habitats in Majalengka (6,494) was lower than in orchard habitats in Lombok Island (55,221). Similarly, the population density of *B. dorsalis* in orchard habitats in Majalengka (2,490) was lower than in orchard habitats in Lombok Island (10,084). The overall population density in the two

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geographically different Regencies of Majalengka and Lombok Island can be seen in Table 2. The orchard habitat in Lombok Island is considered to be able to provide a place for fruit fly species, both *B. carambolae* and *B. dorsalis*, to grow from their population numbers, which are influenced by their geographical conditions compared to the orchard habitat in Majalengka.

Effect of Different Hosts and Geographical Regions on Fruit Flies

Fruit flies of the species *B. dorsalis* have been observed in a variety of settings with various commodities and plant groupings. The density of *B. carambolae* fruit fly was analyzed based on 7 different commodities in 2 locations, in Lombok and Majalengka. Then, it was also analyzed based on the type of grouping of annual and perennial plants. Based on the results of the analysis of variance, it was found that of the 7 commodities observed, the density of fruit flies of *B. carambolae* species was significantly highest in mangosteen commodities in Lombok (F = 410.1; P = <2e-16) (Figure 5a). The analysis based on the location of the study found that the density of *B. carambolae* was highest in Lombok (F = 4552.3; P = <2e-16) (Figure 5b). Finally, the analysis based on the type of plant grouping found that the highest density was found in annual plants (F = 5154.3; P = <2e-16) (Figure 5c).

B. carambolae species have different population numbers based on different commodities in each location. Based on the results of the analysis through the boxplot graph, it was found that the density of *B. carambolae* in the Lombok mangosteen commodity was significantly different from other commodities, with as many as 16,022 individuals. This high density was followed by Lombok cashew and Lombok mango commodities. The highest density of *B. carambolae* in Majalengka is in the guava commodity, with 4,749 individuals. Then, the lowest density was in Majalengka location in mango and bitter melon commodities. From the analysis of the two locations, it was found that Lombok had a significantly higher density of *B. carambolae* compared to Majalengka. The type of plant grouping in the form of annual and perennial plants was also observed; it was found that the highest *B. carambolae* was located in the type of perennial plants compared to annual plants.

The population density of *B. dorsalis* showed that in the 7 commodities observed, the highest density was significantly found in the mangosteen commodity in Lombok (F = 105.1; P = <2e-16) (Figure 6a). Analysis based on the location of the study showed that the density of *B. dorsalis* was highest in Lombok (F = 534.0; P = <2e-16) (Figure 6b). Finally, the analysis based on the type of plant grouping found that the highest density was found in annual plants (F = 889.3; P = <2e-16) (Figure 6c).

Table 2. Population density of *B. carambolae* and *B. dorsalis* in Orchard Habitats in Majalengka Regency and Lombok Island.

Species	Population density		Attractants
	Majalengka Regency	Lombok Island	
B. carambolae	6.494 (11%)	55.221 (89%)	ME
B. dorsalis	2.490 (20%)	10.084 (80%)	ME
Number of Individuals (N)	8.984 (12%)	65.305 (88%)	

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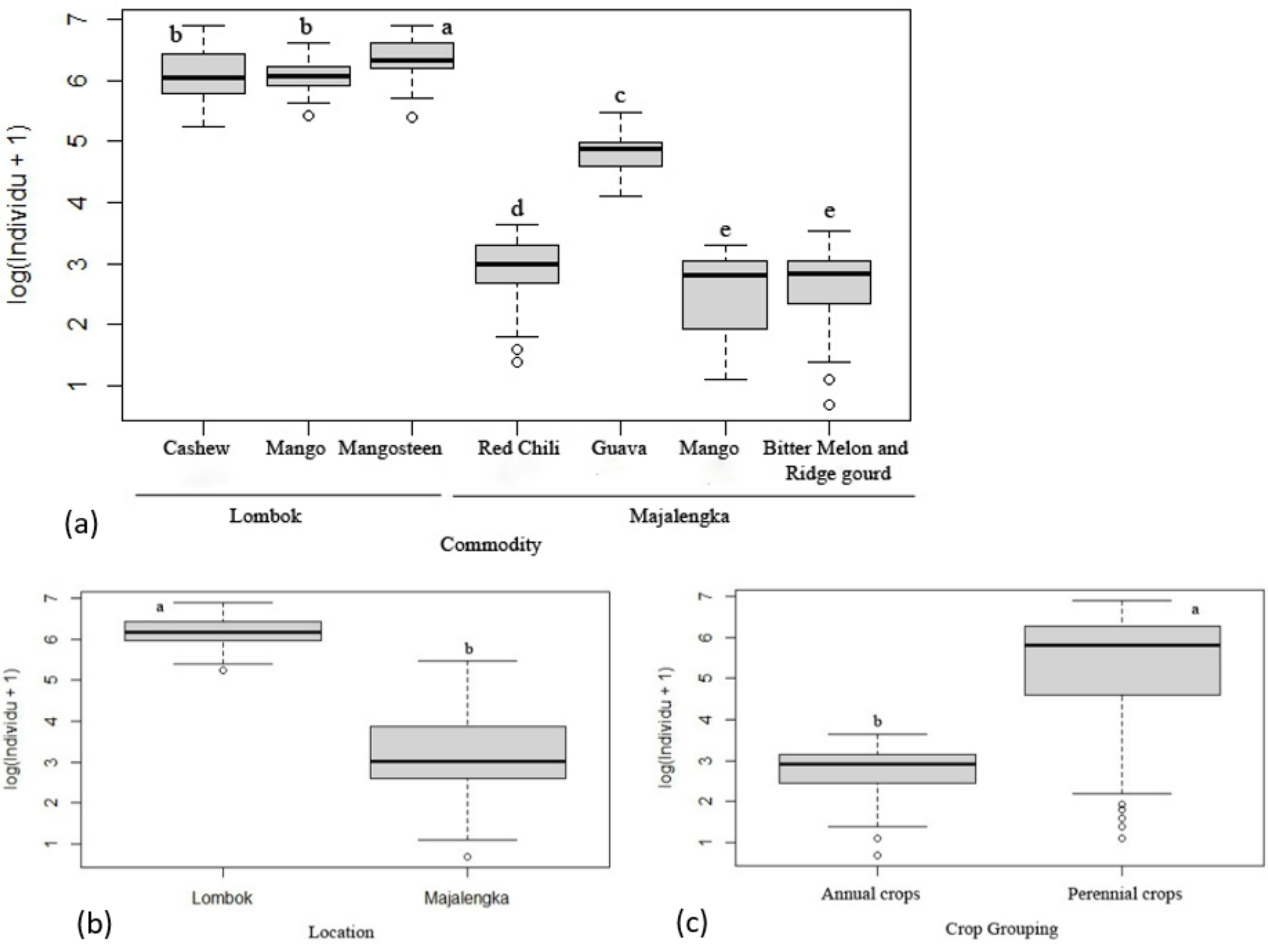

Figure 5. Effect of commodity (a), location (b), and type of crop grouping (c) on the density of *B. carambolae* fruit flies.

B. dorsalis is the most common species in the mangosteen commodity, accounting for 2687 individuals. Based on the results of the analysis through the boxplot graph above, it was found that the density of *B. dorsalis* in the Lombok mangosteen commodity was significantly different from other commodities. This high density was followed by the cashew commodity Lombok, Mango Lombok, and guava Majalengka. The largest density in Majalengka, as seen from different locations, was in guava commodities, with as many as 1837 individuals. Then, the density in Majalengka of red chili, mango, bitter melon, and ridge gourd commodities is not significantly different from one another. In general, in both locations, the density of *B. dorsalis* in Lombok was significantly higher than that in Majalengka. The type of grouping of perennial and annual crops found that perennial crops have a significantly higher density of *B. dorsalis* compared to annual crops.

B. carambolae and *B. dorsalis* are known to be polyphagous fruit flies. *B. dorsalis* has been reported to utilize more than 300 plant species (CABI, 2019), and *B. carambolae* utilizes up to 75 plant species (Allwood *et al.*, 1999;CABI, 2020). It is common for *B. carambolae* and *B. dorsalis* to share the same host during their life cycles (Harris *et al.*, 2003; Danjuma *et al.*, 2013; Aryuwandari *et al.*, 2020).According to Ginting

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(2009) in Supratiwi *et al.*, 2020, vegetation structure and the presence of hosts can also cause a limited number of individuals and a limited distribution, as well as the extent of the distribution area.

According to Rahmanda (2017) in Supratiwi *et al.*, 2020, chili is a real host plant of the species *B. dorsalis* (Hendel) and *B. carambolae* (Drew &Hancok). Meanwhile, according to Larasati *et al.*, 2016, the hosts of *B. carambolae* (Drew & Hancock) are members of the Solanaceae family, such as eggplant, chili, tomato, and rutaceae.

Each fruit fly species has a specific host range. Some species have a wide host range, such as *B. carambolae*, *B. dorsalis*, and *B. albistrigata*. *B. carambolae* is known to be an important pest on various fruit crops in Indonesia(Hudiwaku *et al.*, 2021). *B. dorsalis* is polyphagous, has a host range of more than 300 hosts, and is able to lay eggs in fruits that have a hard pulp texture (Plant Health Australia, 2018). The density of fruit fly species in orchard habitats is higher than in natural forest habitats because certain species become more dominant than others. The availability of hosts such as fruits will result in the number of individuals of certain associated species becoming dominant, such as *B. carambolae* and *B. dorsalis* (Hudiwaku *et al.*, 2021).

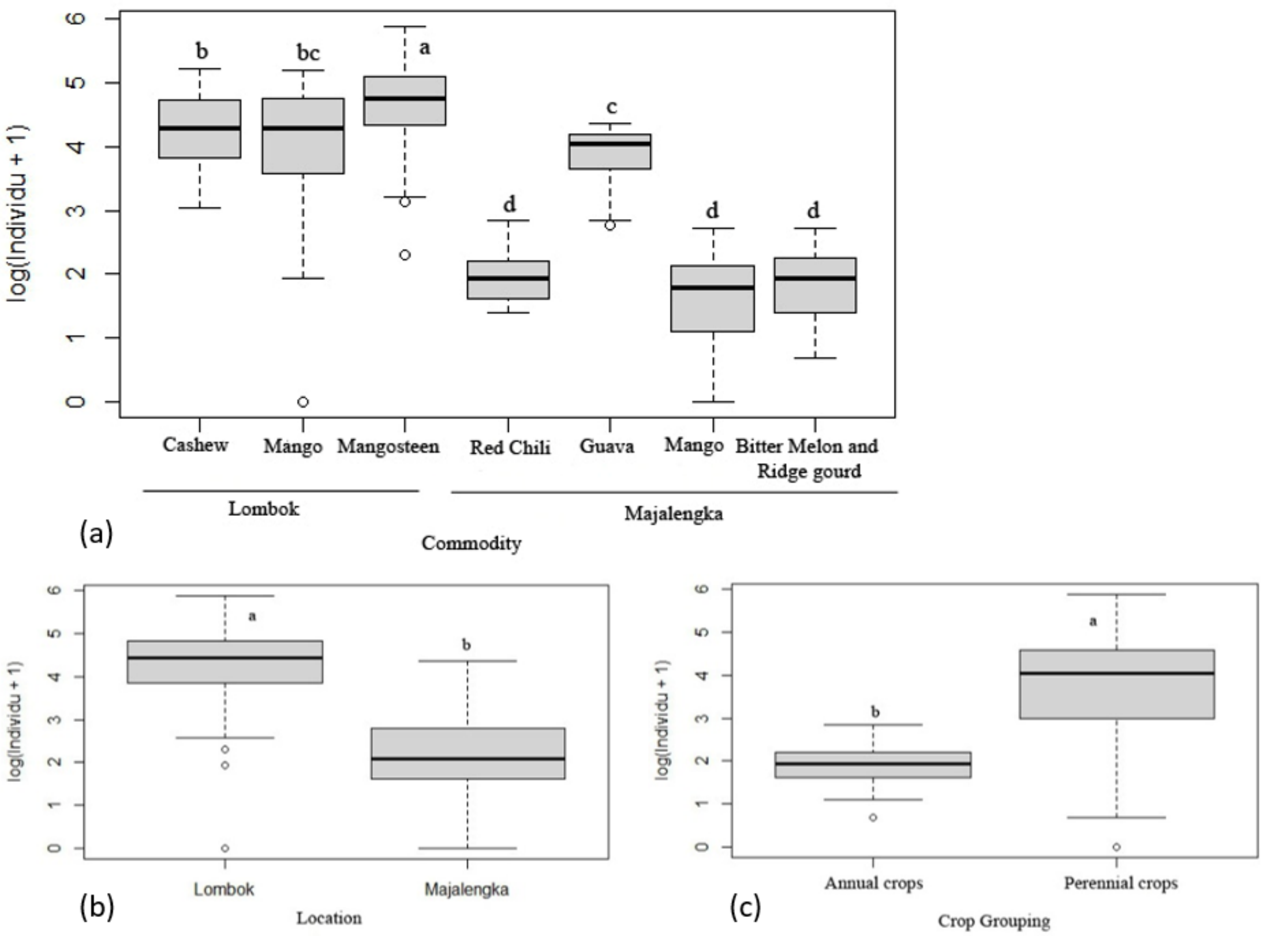

Figure 6. Effect of commodity (a), location (b), and type of crop grouping (c) on the density of *B. dorsalis* fruit flies

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Conclusions and Suggestion

Fruit fly population density is influenced by host plant phenology, the availability of alternative hosts, and favorable environmental conditions. Perennial plantation habitats are ideal locations for fruit fly development compared to annual plantation habitats. Further research and monitoring with various habitat types as well as more varied commodities and methods are recommended to obtain accurate data on the population density and distribution of fruit flies and determine control programs.

Acknowledgements

The authors would like to thank the Department of Plant Pests and Diseases, Faculty of Agriculture, University of Brawijaya, the Agricultural Extension and Human Resources Development Agency, the Ministry of Agriculture of the Republic of Indonesia for the scholarship provided in the 2019 study assignment program, and the Soekarno Hatta Agricultural Quarantine Agency for facilitating the laboratory.

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E-ISSN 2355-9926