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Original article

Refugia Blog to Increase the Diversity of Natural Enemies that Function as Control of Fruit Fly Pests *Bactrocera dorsalis* in Malang Orange Groves

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Abstract

Bactrocera dorsalis is a pest that attacks horticultural fruit crops, especially oranges. Controlling the fruit fly pests can be done by engineering the blog refugia habitat which attracts the arrival of natural enemies. Therefore, it can stabilize the ecosystem and more sustainable for the environment. The aim of this research is to analyzing the application of habitat engineering to the *B. dorsalis* fruit fly population and natural enemy diversity, analyzing fruit fly population fluctuations. This research was conducted on two Orange Groves in Krajan Hamlet, Sumbersekar Village, Dau District, Malang Regency. The method used in this research was a survey method, the natural enemy diversity sampling method was carried out visually (visual encounter survey) with 3 observations with a time span of 08.00-10.00 WIB (morning), 12.00-14.00 (afternoon), and 15.00-17.00 (afternoon). Analysis of fluctuations in the dynamics of the B. dorsalis population was carried out by comparing the population abundance every week for 10 observations with the rainfall factor at the time of observation. The significance of the real difference test for fruit fly fluctuations in orange orchards was tested using the T test, using SPSS software. B. dorsalis fruit flies were collected using petrogenol traps, then identified. The results showed an increase in the diversity of natural enemies in the 2 orange groves planted with refugia. Rainfall, abiotic factors and host plants influenced fluctuations in fruit fly populations. At station 2, rainfall influenced the rise and fall of the fruit fly population, while at station 1 rainfall had no effect, but adjusted to the conditions of abiotic factors in the field.

Keywords: *Bactrocera dorsalis*, fruit flies, blog refugia, population fluctuations, natural enemies

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Introduction

Fruit flies which are considered an important pest in horticultural citrus plantations are from the genus Bactrocera. One species of this genus, namely *Bactocera dorsalis*, is known to be an important pest that attacks several types of fruit and vegetables, namely mango, star fruit, cayenne pepper, red chili, guava, tomato, water apple, and orange (Maisyaroh, et al., 2012). Orange plants are one of the mainstay horticultural commodities in the Sumbersekar area, Dau District, Malang Regency, especially the siam orange type. Siamese oranges (*Citrus nobilis* Lour) are a member of the tangerine originating from Siam (Muangthai). This plant continues to grow and spread to Indonesia (Vargas, et al., 2015). The damage caused by *B. dorsalis* larvae will cause the fruit to fall before it reaches the desired maturity. This is very detrimental to orange farmers because it can hinder increasing production and fruit quality. However, research on fruit fly populations and their control in East Java is still very limited. Therefore, it is important to make efforts to control fruit flies so as not to cause widespread losses (Harahap, et al., 2017).

Fruit fly populations in orange plantations can experience fluctuations because they are influenced by abiotic factors including rainfall, temperature, humidity, light intensity and wind velocity. High rainfall can influence the increase in fruit fly populations. Habitat engineering is the main alternative in biological control efforts. Habitat management is needed to engineer a habitat by managing a combination of physical and abiotic environmental factors, so that optimal conditions are achieved for the development of insect populations. An important role in implementing habitat management is the selection of the most suitable plant types, plant diversity, and spatial scales which influence the distance of predator and parasitoid resources (Baehaki, et al., 2016). According to Leksono, et al (2019), kenikir can function as a refugia plant because it has bright colors and the type of flower that can attract natural enemy insects. The amount of nectar in the flowers also influences the attraction of insects. Sunflower plants are very suitable for use as refugia plants, which can be seen from the shape and size of the wide leaves, long, sturdy and hairy stems and stalks, very suitable as a shelter or temporary residence for natural enemies. The striking color of sunflowers can attract a variety of natural enemies. Meanwhile, marigold plants in the agricultural sector can function as biological agents to attract pest predators, as well as to decorate gardens in the tourism sector (Gu, et all., 2018).

Habitat engineering can optimize the arrival of natural enemies, so that they become predators for pests in an ecosystem. This ability is an advantage for farmers in developing and maintaining their agricultural land, because it is more effective in eradicating pests and is safe for the environment (Leksono, et al., 2019). A biological control strategy by implementing habitat engineering using refugia plants is the right proposal for farmers. If implemented successfully, it can provide effective pest eradication, cost savings, and sustain a sustainable ecosystem. Based on this background, the

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author is interested to analyze the application of the refugia blog to the population of *B. dorsalis* fruit flies and the diversity of natural enemies, analyze population fluctuations of *B. dorsalis* fruit flies.

Methods

Time and place of research

This research have been done conducted in April - November 2023. The method used in this research was a survey method, the natural enemy diversity sampling method was carried out visually (visual encounter survey). Analysis of fluctuations in the dynamics of the *B. dorsalis* population was carried out by comparing the population abundance every week for 10 observations with the rainfall factor at the time of observation. The significance of the real difference test for fruit fly fluctuations in orange orchards was tested using the T test, using SPSS software. *B. dorsalis* fruit flies were collected using petrogenol traps, then identified. Habitat engineering, observation of natural enemies and fruit fly sampling were carried out in two orange groves (Figure 1), one land filled with Siamese oranges and Rimau Gerga Lebong (RGL) oranges as station 1, the other land filled with Siamese oranges only as station 2 in Krajan Hamlet, Sumbersekar Village, Dau District, Malang Regency.

Figure 1. St. 1= Siamese and RGL Orange Orchards (Treatment and control land 1), St. 2 = Siamese Orange Garden (Treatment and control land 2)

Habitat engineering

Habitat engineering was carried out by planting refugia plants (sunflowers, marigolds and cosmos) with the same flowering age, each type of refugia with a total of 25 flowers was planted on the edge of the orange tree. The type of refugia plant chosen is based on the fact that it attracts the presence of natural enemy insects and is easy to obtain by farmers (Goodwill & Amin, 2015). These plants were planted before observing natural enemies or sampling *B. dorsalis*. The treatment and control fields were separated by a footpath. At the edge of the row of orange trees in the treatment area, 3 types of refugia plants were planted with a distance of 1 meter between each plant. There were 3 replications in each treatment and control field with a distance of 7 meters between each replication. The land area is approximately 14 meters long and 10 meters wide (Figure 2). The first orange orchard land or station 1 consists of 2 plots, namely plot 1 (treatment area) and plot 2 (control area). Meanwhile, the second orange orchard land or station 2 is also divided into 2 plots, namely plot 3 (treatment area) and plot 4 (control area). Determination of sampling points with the planting pattern applied, namely the planting pattern at the edge of the plot of land or what is called perimeter refugia. The refugia perimeter pattern is the cause of increasing plant diversity so that predatory insects increase because they are attracted to flowering plants (Djaya, et al., 2022).

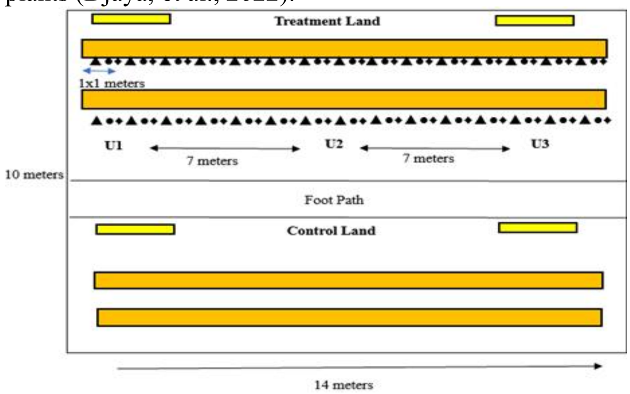

Figure 2. Length= 14 m, Width= 10 m, 1 blog= 1x1, Orange box= Orange tree, Yellow box= Fruit Fly Trap, U1= Repeat 1, U2= Repeat 2, U3= Repeat 3. ▲ = Sunflower, ● = Marigold Flower, ♦= Cosmos Flower.

Observation of natural enemy diversity

Analysis of natural enemy diversity was carried out using the visual encounter survey method which was carried out 3 times, namely in the morning (08.00-10.00 WIB), afternoon (12.00-14.00 WIB), and afternoon (15.00-17.00 WIB). Identification of natural enemy insects using key identification book literature Weirauch et al. (2014), Borror et al. (1992), and Sobari, et al.

(2002), Arida & Joshi, (2013). Visual observations were carried out on each treatment and control land, with 4 plots. The distance between refugia plants is 1 meter and the distance between orange trees and the refugia plants used is also 1 meter. Sampling of natural enemy insect species selected from 3 categories (predator, parasitoid, pollinator) was carried out during the insect's active period. Then, the insects present on each refugia flower (treatment area) and elephant grass plants and chili plants (control area) were then recorded and identified.

Sampling with Petrogenol (*Methyl eugenol*) Trap

Adult fruit flies were collected using petrogenol traps. Petrogenol is an attractant in the form of a clear yellow solution to attract fruit flies. The active ingredient of petrogenol is *methyl eugenol*. *Methyl eugenol* is a pheromone compound for insects to attract members of the opposite sex for mating, colonization and for eating. The fruit fly population was sampled using the petrogenol trap method where incoming fruit flies were trapped in the water in the trap bottle. Four traps were installed in each treatment (2 pairs) and control (2 pairs) fields so that there were 4 replications for the collection of trapped fruit flies. The trap is installed by hanging it at a minimum height of 0.5 m under the canopy of an orange tree that is not too dense or hanging on a tripod (in a vegetable plot). The traps are left for 2 days every week, then the caught fruit flies are collected for the identification process. The materials and tools used during the observation were label paper, petrogenol with the active ingredient *Methyl eugenol*, wire, scissors, tweezers, cotton, 1500 ml mineral water bottle, syringe, plastic clip, magnifying glass (loupe), camera, stationery. Abiotic factors are measured at each sampling, including air temperature and humidity using a thermohygrometer, light intensity using a lux meter, wind speed using an anemometer. Morphological identification of fruit flies using guidance literature based on The Australian Handbook for the Identification of Fruit Flies and CABI-key identification software (White and Hancock, 1997), (Plant Health Australia, 2011). Identification was carried out at the Animal Diversity and Environmental Technology Laboratory, FMIPA UB.

Fluctuation test population of the fruit fly *B. dorsalis*

Fluctuations in the dynamics of the population of *B. dorsalis* were observed every week for 10 observations (10 weeks), then data on weather factors, rainfall for each week of observation was added based on BMKG website (Meteorology, Climatology and Geophysics Agency) data in Dau sub-district area. The influence of differences in rainfall was analyzed on the number of fruit flies trapped each week. The significance of the real difference test for fruit fly fluctuations in orange orchards was tested using the T test so that the dynamic comparison could be seen on the graph, then the calculation application used SPSS software.

Data analysis

Parameters observed in the first stage: abundance, species richness, diversity, importance, and similarity. Diversity in each sample is calculated using the Shannon-Wienner index (H'), evenness using the Evenness index (E), Richness Index (R), and Dominance Index (Simpson's Index) / (D). Abiotic factor parameters were tested using the One Way Anova Test followed by*) Tukey HSD α 0.5. Statistical tests were carried out using the Excel program and SPSS version 15 (SPSS Inc. Chicago, IL, USA). Populations of natural enemy insects and their correlation with environmental factors (temperature, humidity, light intensity and wind velocity) were analyzed using Principal Component Analysis (PCA) using the PAST application. The fruit fly population fluctuation test was analyzed using a difference test (ANOVA).

Results and Discussion

Habitat engineering towards *Bactrocera dorsalis* fruit fly population and natural enemy diversity in Malang orange groves

Habitat engineering using refugia plants can achieve ecosystem balance in citrus fields and increase the diversity of natural enemies. The existence of refugia in orange groves as a microhabitat for the conservation of natural enemies, a source of nectar or food for natural enemies before there is a pest population in a land. The application of a balanced agroecosystem, such as the use of refugia, can reduce pest populations in a land with the presence of natural enemies of plants (Kurniawati & Martono, 2015). The refugia plants chosen are a type of flowering plant that has striking colors and is attractive to insects, namely sunflowers (*Helianthus annuus*), marigold flowers (*Tagetes erecta*), and cosmos flowers (*Cosmos caudatus*). These three types of plants are used as blog refugia in orange groves which have the potential for the presence of pests, so that this blog refugia can become a microhabitat for natural enemies. The characteristics of this refugia plant include fast plant regeneration, easy to obtain seeds, very affordable price for farmers, easy to plant, and can be planted intercropping with other plants (Sakir & Desinta, 2018).

Natural enemies in the form of predatory insects are generally attracted to refugia plants that have bright colors and small flower sizes such as marigolds, parasitoid insects like flowers that have lots of nectar as a food source. Apart from that, pollinator insects also like flowers that have pollen and nectar and bright colors (Rahayu, et al., 2018). Predatory insects are natural enemies that are able to help farmers eradicate pests, so farmers do not need to use pesticides or other chemicals that damage the environment because by implementing blog refugia it becomes an environmentally friendly and sustainable pest control alternative (Keppel, et al., 2012). This interrelated dependence between plants and animals is an association phenomenon which is also called symbiosis, which occurs naturally in nature (Hidayat, et al., 2016).

Both treatment and control fields were visited most frequently by predatory insects. Refugia plants have their own attraction to predatory insects. According to Mustarin et al., (2023) predatory insects have their own preferences regarding color, smell, morphology and other physiology such as size, shape, flowering period and the content of nectar and pollen in marigold, sun and cosmos flowers. The condition of the land after planting refugia plants which have morphology, flower color, or the presence of certain compounds has succeeded in bringing in natural enemies, predator species, so that the abundance of predator species becomes more diverse in the research area. The total types of insects obtained were 34 species divided into 27 families consisting of predatory insects, parasitoids and pests. In the three refugia plants, the highest insect attraction results were found in cosmos flower plants with a total of 23 species, while in sunflowers there were 20 species of insects present and the least in marigold flowers. The total number of insects present was only 15 species. Both treatment and control land area stations found 34 species, 27 families, 8 orders, and a total of 1492 individuals shown in (Table 1).

The greatest abundance of insects was found at station 1 plot 1, followed sequentially by station 2 plot 3, station 1 plot 2, and station 2 plot 4. The abundance of insects at station 1 in plot 1 was due to the area of treatment land that had been planted with refugia plants. the flowering conditions are fertile, there are host plants that often bear heavy fruit, namely Siamese orange trees and RGL. Apart from that, environmental conditions on station 1 land also support the presence of many insects due to good temperature, moderate wind speed and sufficient light intensity. Meanwhile, the second largest was followed by station 2 on plot 3 with a total of 256 individuals. The factor that most influences the lower presence of insects at station 2 compared to station 1 is because the location of the land is at a higher altitude than station 1, so that the incoming wind blows stronger which prevents insects from flying and landing properly on the plants. Apart from that, the refugia plants planted also have lower fertility levels than those in station 1 land.

Table 1. Abundance of Natural Enemy Insects in Treatment and Control Lands. Note: Plot 1= Treatment area (Station 1), Plot 2= Control area (Station 1), Plot 3= Treatment area (Station 2), Plot 4= Control area (Station 2).

Ordo	Family	Species	PLOT			
			1	2	3	4
Hemiptera	Delphacidae	Laodelphax striatellus	158	0	29	0
	Lygaeidae	Nysius ericae	9	1	0	0
	Aphididae	Cinara piceae	19	0	11	0
	Cicadellinae	Cicadella viridis	111	0	78	0
	Cicadellinae	Idiocerus herrichii	5	0	1	0
	Flatidae	Lawana candida	5	0	0	0
Diptera	Drosophilidae	Drosophila melanogaster	28	0	28	65
	Muscidae	Musca domestica	35	75	29	73
	Chironomidae	Chironomus sp	3	0	2	0
	Opomyzidae	Geomyza balachowskyi	35	0	7	0
	Chlorophidae	Aphanotrigonum trilineatum	29	0	21	0
	Bombyliidae	Exoprosopa rhea	7	0	8	0
	Syrphidae	Copestylum vesicularium	47	0	31	0
	Chironomidae	Procladius lugens	3	0	0	0
Coleoptera	Chrysomelidae	Aspidimorpha miliaris	4	0	0	0
	Coccinelidae	Coccinella transversalis	18	0	14	0
	Coccinelidae	Coccinella septempunctata	22	0	5	0
	Cucurlionidae	Myllocerus undecimpustulatus	34	0	21	0
	Chrysomelidae	Aulacophora femoralis	14	0	5	0
Lepidoptera	Erebidae	Amata huebneri	36	13	3	28
	Lycaenidae	Leptotes cassius	6	1	0	0
	Pieridae	Pieris brassicae	0	6	0	31
	Pyralidae	Selagia argyrella	8	1	2	0
	Hesperiidae	Telicota bambusae	9	0	0	0
	Hesperiidae	Pelopidas mathias	0	2	0	0
	Pieridae	Eurema hecabe	0	5	1	15
Odonata	Libellulidae	Orthetrum sabina	0	20	0	41
	Cetoniidae	Oxythyrea funesta	13	0	0	0
	Platycnemididae	Platycnemis latipes	0	20	0	0
	Libellulidae	Pantala flavescens	0	10	0	47
Hymenoptera	Apidae	Apis cerana	17	7	16	52
	Formicidae	Dolichoderus thoracicus	69	95	64	241
Mantodea	Hymenopodidae	Creobroter gemmatus	30	0	20	0
Neuroptera	Chrysopidae	Chrysoperla carnea	6	0	5	0
	Total Individual		780	256	238	218
	Total Population			**1492**		

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A comparison of the insects present on each refugia plant is shown in (Figure 3), the most species present were on kenikir flowers with a total of 23 species. This is because the kenikir flower inflorescences in stations 1 and 2 are always consistently flowering and even continue to grow in branches, so they are very attractive to the diversity of visiting insect species. Meanwhile, the smallest number of species was found in marigold flowers, because they grow in areas that experience a lot of drought and wilt, and the flowers are not as big as cosmos flowers. According to Sihombing, et al., (2013) the flower blooming period and the long flower life of refugia plants can influence the number of pistils on the flowers. As the age of the cosmos flower increases, the number of pistils on the flower also increases. The number of pistils on the cosmos flower can influence the amount of honey and pollen produced by the flower, thereby influencing the presence of insects, especially pollinator types.

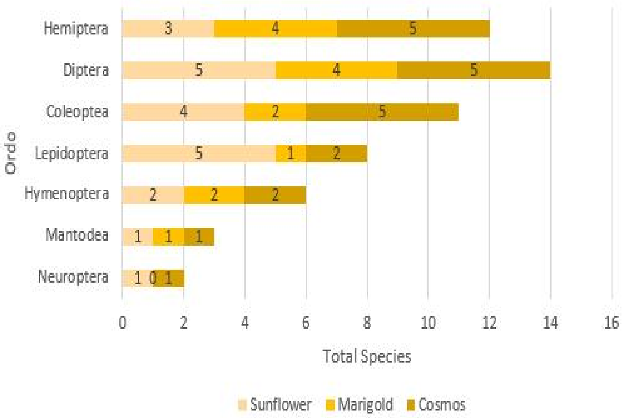

Figure 3. Comparison of Natural Enemy of Insects on Refugia Plants. 1, 2, 3, 4, 5 = Total Species Present on Refugia Plants (Sunflower, Marigold, Cosmos)

The presence of refugia plants in the research area certainly adds to the diversity of insects present. Diversity Index (H') of insects on three types of refugia plants obtained at different observation times, namely at 3 times (morning, afternoon, evening) at 08.00-10.00 am, 12.00-14.00 and 15.00-17.00 afternoon. The flowering phase of each plant at the same time. Station 1 consists of 2 plots, namely plot 1 (treatment area) and plot 2 (control area). Station 2 is also divided into 2 plots, namely plot 3 (treatment area) and plot 4 (control area). At station 1 the highest diversity results were obtained for plot 1 with a value of (2.83) while at station 2 plot 3 with a value of (2.21) both were classified as medium diversity. The diversity value obtained in plot 2 (0.96), then in plot 4 (0.97) both are in the low diversity category. The low diversity in plot 2 is because the plants on the land are only grass, without any refugia plants which attract insects, while in plot 4 the value is slightly higher than in plot 2 because of the additional host plants in the land area, namely chili plants which are more attractive. Many insects come as pollinators or predators. The high diversity at station 1 is due to the fertility level of 3 types of refugia plants being greater than at station 2. According to research (Nugroho, et al., 2013) the high or low diversity index depends on the number of species and the number of individuals of each species. If the number of species is large and the number of each species is evenly distributed, the diversity index will be higher. Apart from that, differences in the fertility of refugia plants influence the high and low diversity index values, which are also influenced by morphological and physiological factors such as size, shape, color, smell, flowering time and nectar and pollen content in refugia plants (Risaldi, et al., 2021).

The evenness (E) index results show the same pattern with the highest value obtained by station 1 (0.80) indicating the medium category, and station 2 is lower with a value of (0.21). Plot 4 has a higher evenness value of (0.31) than plot 2 with a value of (0.27). The wealth index results in plot 1 also obtained the highest value (4.24) which is classified as high wealth category, while plot 3 has a value (3.82) which is classified as medium category. The lowest wealth value was obtained by plot 2 (0.27) while on the other hand, plot 4 had a higher wealth value (0.31) (Figure 4). Medium to high evenness values will be in line with low dominance values so that certain species do not dominate very much and the community structure is in a stable state (Putra & Utami, 2020). This situation is also influenced by refugia plants which can support a diversity of predators and parasitoids, thereby making the environment more stable (Djaya, et al., 2022). The wealth index shows the high category in plot 1, while plots 2, 3 and 4 show the medium category. Differences in richness index are also influenced by the environment and food availability which supports the development of pest insect populations and also provides alternative sources of prey and hosts for natural enemies. The smaller the value of species evenness, the distribution of a population is uneven or in an ecosystem it is dominated by certain species (Kartikasari, et al., 2015).

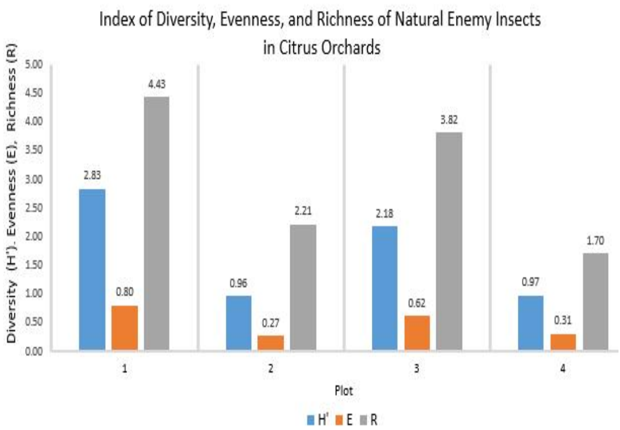

Figure 4. Index of Diversity = (H') Evenness =(E), and Richness = (R) of Natural Enemy Insects in Citrus Orchards. Note: Plot 1= Treatment area (Station 1), Plot 2= Control area (Station 1), Plot 3= Treatment area (Station 2), Plot 4= Control area (Station 2).

The dominance index (D) shows whether there are species that dominate or not in a land. The results of the dominance index show that the highest value was obtained by plot 4 (1.79), indicating that there is a very dominant species, namely the *Dolichoderus thoracicus* species, followed by *Apis cerana* included in the taxa of the order Hymenoptera (Figure 5). This is because at station 2 the control area is an area of chili plants which stimulates the presence of many pollinators such as *Apis cerana* and the predator *Dolichoderus thoracicus*. According to (Purwatiningsih, et al., 2012). states that more than 80% of the role of pollination by insects (pollinators) can be carried out by honey bees. The order Hymenoptera such as bees (family Apidae) includes insects that act as pollinators. Bees, which are part of the Hymenoptera order, have the ability to help pollinate plants, because the bee's body is covered with fine hairs which are useful for capturing pollen from flowers. The absence of refugia plants has an effect on reducing the presence of various insects and actually increasing the population of certain insects which results in a high dominance of one insect species in a land.

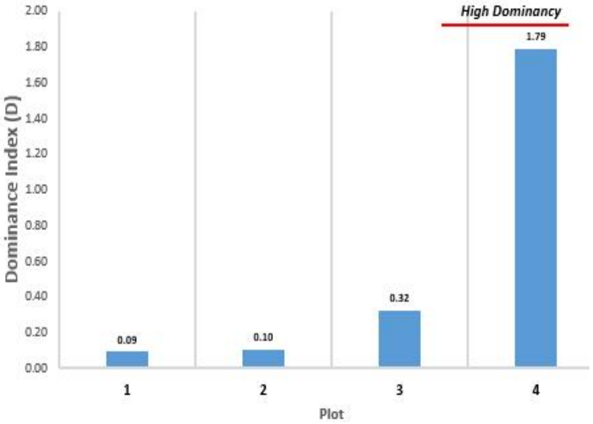

Figure 5. Dominance Index = (D). Note: Plot 1= Treatment area (Station 1), Plot 2= Control area (Station 1), Plot 3= Treatment area (Station 2), Plot 4= Control area (Station 2).

For all abiotic factors in the 4 observation plots, significantly different test results were shown in (Figure 6). The high and low diversity of insects at each station is influenced by environmental conditions. Abiotic factors include air temperature and wind speed, which have the highest values in plot 3 so they are the most significantly different. This is because the land area factor in plot 3 is higher than other land. The temperature in plot 3 has a value of 30ºC (Figure 6A), which is suitable for insect development because a certain temperature range for best survival for insects is a minimum temperature of 15°C, an optimum temperature of 25°C and a maximum temperature of 45°C (Allifah, et al., 2020). In the humidity factor, plot 2 shows a real difference compared to the other plots (Figure 6B), this is because plot 2 has quite humid environmental conditions with a value of 51% due to the presence of trees other than oranges on the edge of the land such as banana trees, and tall elephant grass. The most significantly different wind speed factor is shown in plot 3 (Figure 6C) with a value of 2 m/s. This is because the geographical conditions of the land are at an altitude of around 800 meters above sea level, higher than plots 1 and 2, so the wind can travel faster without any obstacles. In terms of light intensity, plots 1 and 2 are significantly different, while plots 3 and 4 are not significantly different (Figure 6D). The significant difference in the average light intensity in plots 1 and 2 is because plot 2 is a control area which has many lush trees besides orange trees so that the light entering is also less than plot 1. The insect population will be greater in the morning and afternoon than in the afternoon days because they get suitable environmental conditions for activities and looking for food. According to Nuriyanti et al., (2017) light can increase body heat in insects so that metabolism becomes faster and the insect's body temperature increases because insects are cold-blooded.

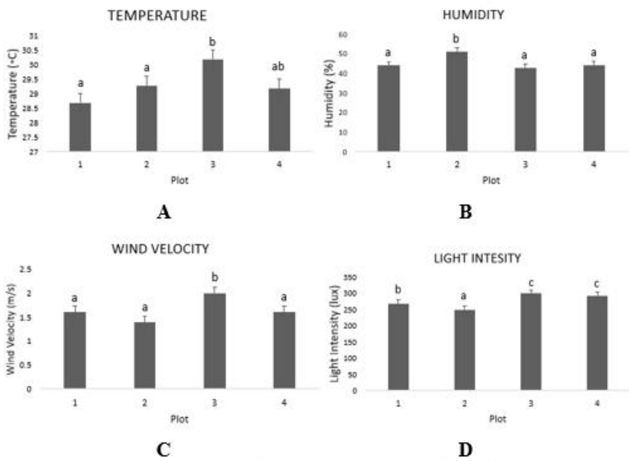

Figure 6. A= Temperature in all plot, B= Humidity in all plot, C= Wind velocity in all plot, D= Linght intensity in all plot. Shows Real Difference Test (t) Abiotic Factor Parameters Based on One Way Anova Test followed by*) Tukey HSD α 0.5

Analysis of the relationship between abiotic factors and insect populations is shown in (Figure 7), showing that the axis (PC 1) has a diversity value of 50% and the diversity on the axis (PC 2) is 31%. In plot 1, it is correlated with the total individuals of the total natural enemy population species. Plot 2 correlates with the abiotic factor humidity. Plot 3 correlates with dominance, evenness, diversity, and species richness, while the abiotic factors correlate with temperature, wind speed, and light intensity. Plot 4 correlates with abiotic factors temperature and species dominance. Overall, plot 3 includes the most correlations with abiotic factors and natural enemy populations. Meanwhile, the other plots have their respective correlations with natural enemy populations and abiotic factors. Thus, the results of measuring the value of abiotic factors are related to the number of natural enemy populations present. This is in line with the statement of Mustakim, et al., (2014) which states that abiotic factors in the environment greatly influence survival rates, population development and population distribution.

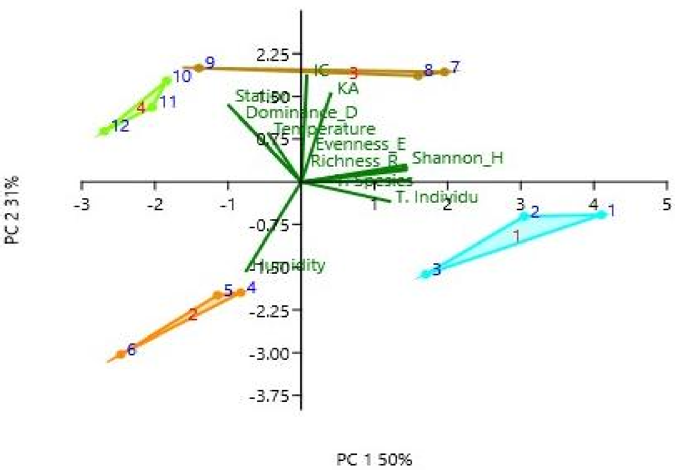

Figure 7. Correlation of abiotic factors with natural enemy populations in the Orange Orchard using Biplot analysis. Note: Sequentially 1,2, 3, 4= PLOT, PC 1 & 2 = variation of computational data.

Population fluctuations of *Bactrocera dorsalis* in Malang Orange Groves

The data in (Figure 8) shows that the number of *B.dorsalis* fruit fly populations varies with changes in rainfall every week. The results of observations of fruit fly populations in the first 4 weeks in orange grove 1 (station 1) showed a decrease in population compared to the last 4 weeks, this was because the harvest period on the host plants had not yet begun or was still in the post-harvest stage before the flowering period, as well as the rainfall factor. increases so that it can interfere with the mobility of trapped fruit flies. At station 1, in the 1st week there was a total population of 64 trapped fruit flies, followed by 73 heads in the 2nd week. The large number of trapped populations could be because the previous orange plantings had not been controlled so that there were still many fruit fly populations in the land. Then, in the 3rd and 4th weeks there was a decrease respectively, namely 54 and 32 individuals, with a slight increase in the population in the 5th week, namely 43 individuals. This decrease was due to increased rainfall, especially in the 4th week with a rainfall level of 30 mm. Meanwhile, the highest population number was obtained in the 8th week, amounting to 141 individuals, this was influenced by the host plant starting to harvest so that it attracted the presence of fruit flies, but the rainfall actually decreased, namely 25 mm, influencing fruit fly activity to be more optimal so that the population increased. In the 6th week there was an increase in population from the previous week of 96 individuals and not much different in the 7th week of 97 individuals. In the 9th and 10th weeks the population decreased respectively, namely 62 and 37 individuals. It is stated in other references that high rainfall can inhibit the mobility of fruit flies in searching for food so that the number of fruit flies caught is small, but appropriate abiotic factors in the land have a big influence on the increase in the fruit fly population. When there is a difference in rainfall levels and the number of fruit fly populations on land, it can be influenced by land abiotic factors that support an increase or decrease in fruit fly populations (Susanto, et al., 2017).

The effect of rainfall on fruit fly population fluctuations in orange orchard 1 is inversely proportional to orange grove 2 (station 2) where the increase in population each week is directly proportional to the increase in rainfall. In the 1st week, the total population of trapped fruit flies was 129 individuals. The increase in population was due to the additional host factor of chili plants at station 2 which influenced the increase in fruit flies in the traps. Apart from that, the presence of fruit flies at station 2 has become the main pest that always attacks citrus plants at that location. Therefore, the population has the potential to be larger than station 1. In the 2nd and 3rd weeks there was a decrease with a total of 110 and 96 individuals, this could be influenced by the fact that in the 3rd week the rainfall decreased by 26 mm. Increasing fruit fly population occurred again in the 4th week with a total of 114 individuals in line with an increase in rainfall of 37 mm, followed by a decrease in the population in the 5th week with a total of 93 individuals in line with a decrease in rainfall of 27 mm. Then the population increase sequentially occurred in the 6th and 7th weeks with a total of 189 and 194 individuals. The highest increase in population at station 2 occurred in the 7th week in line with the highest increase in rainfall, namely 51 mm. The increase in the fruit fly population followed by increased rainfall can have a close correlation with the fertilization of the host plant (orange trees/chili plants) and the fertilization period occurs when it often rains. Apart from that, they are also attracted to the aroma of methyl eugenol in the trap (Kaurow, 2011). In the 8th week, the population decreased again with a total of 141 individuals, according to Melani (2008). The decreasing number of fruit flies trapped using petrogenol traps every day can be assumed to be that the fruit flies trapped are only male. In the 9th week, the population experienced an increase of 171 because the orange trees were harvesting, and in the last week of the 10th, the population decreased by 112, followed by a decrease in rainfall of 20 mm.

According to Herrahmawati, et al (2023), the availability of a large number of hosts on land influences the large population of fruit flies present on a land. The correlation between climatic factors and fluctuations in fruit flies on fruit and vegetable crops will increase in a climate that is cool, has high humidity and winds that are not too strong. The influence of rainfall is important, where areas that have high rainfall will be followed by a high population. The dynamics of changes in fruit fly population numbers are closely related to the conditions of the biotic and abiotic environmental factors in which the fruit flies live.

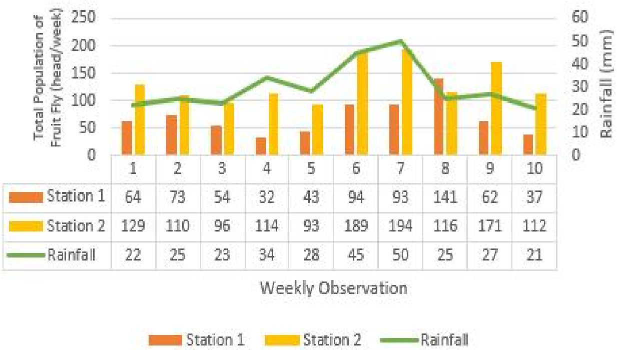

Figure 8. Population Fluctuation Test of *B. Dorsalis* (Station 1) : Plot 1= Treatment area, Plot 2= Control area, (Station 2) : Plot 3= Treatment area, Plot 4= Control area

The results of the fruit fly population fluctuation test (Figure 9), showed no significant differences in the 2 orange groves every week until the 10th week. This shows that the average population size does not differ much each week. The increase in fruit fly populations in orange orchards is also directly proportional to the increase in rainfall. In orange grove 1 in weeks 1, 2, 6, 7, 8, and 9 it was significantly different from weeks 3, 4, 5, and 10. This was because there was a much higher population number found in the 8th week. with a total of 141 fruit flies trapped, while the lowest population was obtained in week 4 with a population of 32 fruit flies. The significant difference in population numbers influenced the results of the fluctuation test in orange grove 1. The rise and fall of the population in orange grove 1 was influenced by abiotic factors in the field, as well as the harvest period of the host plant. Temperature and humidity factors can influence fruit fly population fluctuations in the field, because they can affect the development and reproduction of fruit flies. Meanwhile, rainfall and a high number of rainy days can cause fruit fly populations to increase (Herrahmawati, et al., 2023).

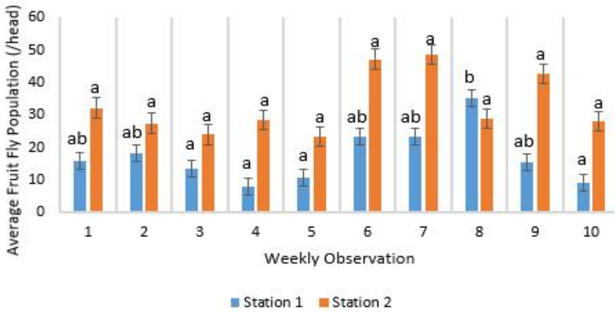

Figure 9. *B. dorsalis* Fluctuation Test in Citrus Orchads. Station 1= Plots 1 and 2, Station 2= Plots 3 and 4.

Conclusion

Habitat engineering with refugia plants on the B. dorsalis fruit fly population and the diversity of natural enemies in Orange Garden showed an increase in the population of insects that came to the treatment area (refugia plants) compared to the control area (without refugia plants), as shown in the diversity results plots 1 and 3, which are treatment areas, show medium category diversity results. The control areas, namely plots 2 and 4, are classified as low diversity. Fluctuations in the population of B. dorsalis fruit flies at station 2 were influenced by rainfall, which was characterized by high fruit fly populations in line with increasing rainfall. Fluctuations in the B. dorsalis population at station 1 were inversely proportional to increasing rainfall, but were more influenced by abiotic factors in the land.

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