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Identification and Distribution of Fruit Flies in Chili Cultivation in Kendal Regency

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Abstract

Fruit flies are a common pest in horticultural crops, particularly in chili plants, where they can cause severe damage, it cause significant losses to chili plants of up to 50-100%. This research was conducted to identify the species and distribution patterns of fruit flies present in chili plantations in Kendal Regency. The study was conducted in Gempol, Ngesrepbalong, Limbangan District, Kendal Regency and continued with identification at the Ecology and Biosystematics Laboratory, Faculty of Science and Mathematics, Diponegoro University and the Animal, Fish and Plant Quarantine Center of Central Java. The study was conducted with a monofactor experiment of attractant type treatment and 2 treatment levels, namely Methyl Eugenol (M1) and Clove Oil (M2). Results indicated that traps with methyl eugenol attracted 2,456 fruit flies, while traps with clove oil failed to capture any. There are three species identified, with the following proportions: *Bactrocera dorsalis* (81.6%), *Bactrocera carambolae* (11.4%), and *Bactrocera umbrosa* (7.0%). The highest absolute attack rate occurred at 108 days after planting (DAP) in the clove oil treatment (M2), with 260 plants affected, the lowest attack rate was recorded in the methyl eugenol treatment (M1) at 96 DAP with 95 attacked plants. Relative attack intensity was also highest in the clove oil group at 34.93% (medium category) and lowest in the methyl eugenol group at 19% (low category). The dominant species found in the area was *Bactrocera dorsalis*, although overall fruit fly distribution was not uniform, while the distribution of fruit flies in the area is uneven.

Keywords : distribution, fruit flies, identification

Introduction

Fruit flies are one of the most common insect pests found in horticultural crops. One of their host plants is chili. The species of fruit flies that attack chili plants include *Bactrocera dorsalis*, *Bactrocera carambolae*, *Bactrocera papayae*, and *Bactrocera umbrosa* (Al Rahmat et al., 2021). Fruit flies can cause both qualitative and quantitative damage to crops. Quantitative damage occurs due to a reduction in harvest yield, potentially leading to a complete loss, while qualitative damage relates to the decline in fruit quality due to fruit fly attacks, especially when secondary infections by bacteria cause the fruit to rot (Sahetapy et al., 2019).

Fruit flies can cause significant losses in chili crops, with damage reaching up to 50–100%. The reduction in yield due to fruit fly infestation ranges from 50–75%, and under favorable environmental conditions with susceptible hosts, the damage can reach 100% (Susanto et al., 2018). Fruit fly attacks are commonly found on fruit that is nearing ripeness. Early symptoms include the appearance of small black spots caused by ovipositor punctures. As the pest activity continues inside the fruit, these spots spread, and the larvae consume the fruit flesh, causing it to rot before it ripens. The most destructive stage of the fruit fly is the larval stage (Yusmaizah, 2022).

Fruit fly distribution can be found in various geographical areas depending on the species. However, several biotic and abiotic factors can affect their diversity and population, such as climate, temperature, humidity, weather, light intensity, and the type of surrounding vegetation. The presence of fruit flies is not only influenced by host plants but also by abiotic factors specific to certain regions, which can affect their development (Arum et al., 2020). Spatial distribution information of fruit flies is essential in fruit fly population control programs as a basis for population estimation. Understanding the spatial distribution of insects is important as it helps determine the relationship between fruit flies and their environment, which forms the basis for integrated population control strategies (Anisa, 2019).

One method of controlling and attracting fruit fly populations is the use of certain attractants, such as methyl eugenol and clove oil. The chemical nature of methyl eugenol is similar to the sex pheromone produced by female fruit flies to attract males for mating. By reducing the male fruit fly population, the reproduction rate of the females will decrease, thereby reducing the overall fruit fly population on chili plants (Lukman et al., 2015). Methyl eugenol is volatile and releases a fragrant aroma. It has been successfully used for over 50 years in monitoring and controlling several fruit fly species, such as *B. dorsalis* and *B. cucurbitae* (Royer et al., 2017). Clove oil contains a major component called eugenol, with concentrations ranging from 70% to 96%. This high eugenol content allows clove oil to be used as an attractant to lure fruit flies and aid in population control (Sataral and Lamandasa, 2021).

Based on the explanation above, this study aims to identify the species and distribution of fruit flies found in chili plantations in Kendal Regency, so that the appropriate control techniques can be determined for managing fruit flies in chili cultivation in the region.

Research Method

The research was conducted from October 2024 to January 2025 in Gempol, Ngesrepbalong, Limbangan Sub-district, Kendal Regency, and was followed by species identification at the Ecology and Biosystematics Laboratory, Department of Biology, Faculty of Science and Mathematics, Diponegoro University, Semarang, and at the Central Java Animal, Fish, and Plant Quarantine Center.

The materials used in this study included 80% methyl eugenol, clove oil, used motor oil, camphor, and silica gel. The tools used in this study included traps made from 500 ml plastic jars, 2-meter wooden sticks, mattress thread, cotton, scissors, raffia string, infraboard, writing tools, labels, tissue, hot glue gun, camera, stereo microscope, brush, cutter, 250 ml thinwall containers, petri dishes, and a measuring tape.

This research was conducted using a monofactor experiment with attractant type treatment and 2 treatment levels, namely Methyl Eugenol (M1) and Clove Oil (M2). The observed parameters included fruit fly identification, the number of fruit flies captured, absolute attack intensity, and relative attack intensity based on scoring. The identification process was carried out using the fruit fly determination guidebook *The Australian Handbook for the Identification of Fruit Flies* by Plant Health Australia (Plant Health Australia, 2018). Fruit fly collection was done by transferring the trapped flies from the jars into thinwall containers that had been filled with silica gel and camphor. The number of sample plants used was 50% of the total curly chili plant population in the plot.

Absolute attack intensity is calculated using the formula:

$$I = \frac{a}{a + b} \times 100\%$$

Description:
I : Absolute attack intensity
a : Number of plants attacked
b : Number of healthy plants

Relative attack intensity based on scoring is calculated using the formula:

$$I = \frac{(ni \text{ x } vi)}{Z \text{ x } N} \times 100\%$$

Description:
I : Relative attack intensity based on scoring
ni : Number of plants with damage score i
vi : Damage score value
Z : Number of plants observed
N : Highest damage score value

Results and Discussion

Fruit Flies Species Identification

The identification results of fruit flies obtained through trapping using two types of attractants, namely methyl eugenol and clove oil, in chili plantations in Gempol, Ngesrepbalong, Limbangan Sub-district, Kendal Regency, revealed three species: *Bactrocera dorsalis*, *Bactrocera carambolae*, and *Bactrocera umbrosa*.

Figure 1. The results of identification based on two types of attractants, methyl eugenol and clove oil, in chili plantations in Kendal District: (a) *Bactrocera dorsalis*, (b) *Bactrocera carambolae*, (c) *Bactrocera umbrosa*.

Figure 2. Morphology of *Bactrocera dorsalis*, a. entire dorsal, b. abdomen, c. thorax, d. wings, e. legs, and f. face.

The *Bactrocera dorsalis* species has a yellowish brown and oval abdomen, there is a very clear black T pattern that can be seen in Illustration 12. *Bactrocera dorsalis* has a yellowish brown and oval abdomen, there are black lines that cross terga II-III, and run lengthwise on terga III-V in the shape of the letter T (Holis et al. 2023). Terga IV has a triangular anterolateral corner with a dark brown color. *Bactrocera dorsalis* has a black scutum with parallel bands on the lateral side that are yellow (Rahmanda, 2017).

The wings of B. *dorsalis* are transparent with a narrow costal band at R2 + 3 and do not extend to R4 + 5. *Bactrocera dorsalis* has wing venation with a costal line that is right or passes very thinly at R2 + 3 which then extends but does not widen to the tip of the wing (apex) (Lianti et al. 2022). Basal costal cell “b” and costal cell “c” are clear and colorless. B. *dorsalis* has no wing pattern other than the costal and cubital streak patterns (Widihastuty et al. 2022). In the leg section, most of the tibia on the front and back are dark except for the apical part of the middle tibia (Holis et al. 2023). On the caput, a pair of large black oval facial spots (Rahmi, 2022).

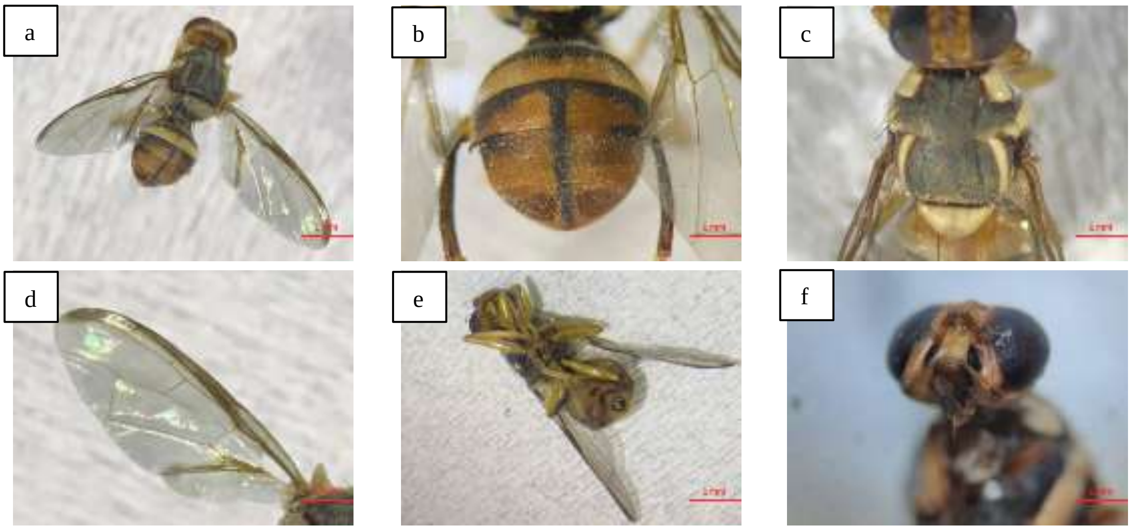

Figure 3. Morphology of *Bactrocera carambolae*, a. entire dorsal, b. abdomen, c. thorax, d. wings, e. legs, and f. face.

The B. *carambolae* species has a brown abdomen on terga III-IV with a very clear "T" pattern, with anterolateral corners on the abdomen terga IV and rectangular in shape, then on terga V the anterolateral corners have a pair of bright brown spots as seen in Illustration 13. *Bactrocera carambolae* has an abdomen with a clear "T" pattern and has a black rectangular pattern on terga IV (Putri and Syamsudin, 2019). This species has a dull black scutum color with a yellow band on the lateral side. B. *carambolae* mostly has a dull black scutum color with a yellow band on the lateral side (Maulani, 2018).

B. *carambolae* has transparent wings with a wide costal band on R2 + 3, and extends on R4 + 5 to the tip of the wing. The wing venation of this species on its costal band exceeds (overlapping) R2+3 to the tip and extends around R4+5 which makes it look like a fishing hook, in the costal cell "b" and costal cell "c" are clean without patterns (Lianti et al. 2022). The underside of the wing has a black band on the anal streak (Siregar and Sutikno, 2015). On the legs, all tibiae are dark, then some species on the front femur have dark preapical spots (Holis et al. 2023). Has a black spot under the antenna with a large size.

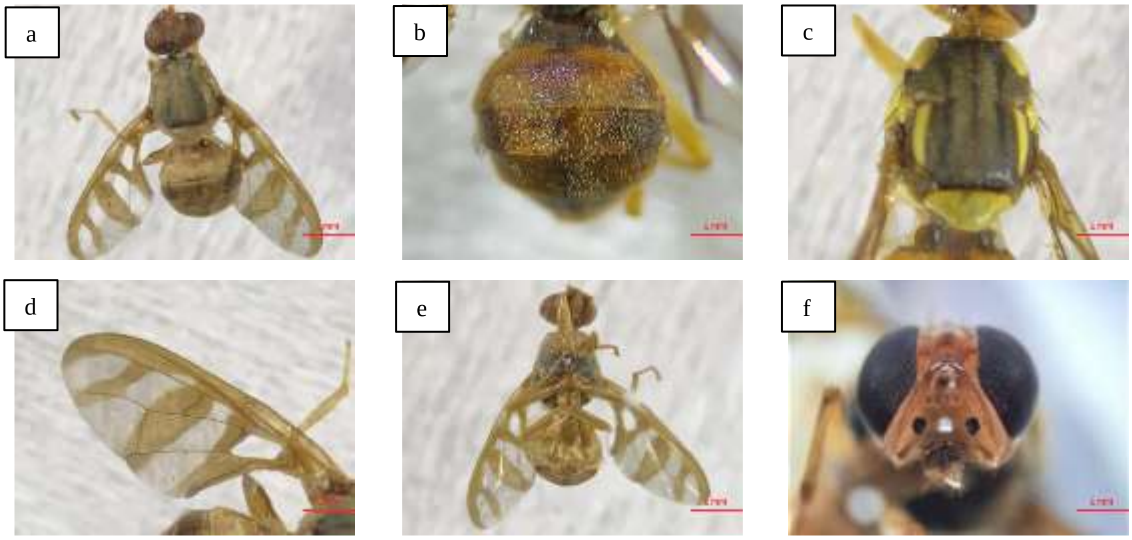

Figure 4. Morphology of *Bactrocera umbrosa*, a. entire dorsal, b. abdomen, c. thorax, d. wings, e. legs, and f. face.

The *Bactrocera umbrosa* species has a yellowish brown abdomen, and there is a black medial line, but there is no T pattern as seen in Illustration 14. The B. *umbrosa* species has a rounded to oval abdomen and tergum III-IV abdomen varies in orange brown widening on the lateral side but there is no T pattern (Lianti et al. 2022). This species has a brownish black scutum and there is a yellow band on the lateral side. The thorax is dominated by black scutum, then for the lateral edge and mesonotal suture it is brown, the lateral postsutural vittae are parallel in shape that extends to reach or passes the intra alar seta (Hidayat and Kusumah, 2015).

B. *umbrosa* has wings with specific variations, with the costal band reaching R4 + 5, then there are three additional transverse lines from the costal band to the lower edge of the wing. On the wings of B. *umbrosa* there are three transverse bands that run from the costal band to the rear edge of the wing (Holis et al. 2023). The three legs are dominated by pale yellow. B. *umbrosa* has yellow femurs and tibia (Chahyadi and Rayvondacande, 2022). On the face, this species tends to be pale yellow with black facial spots and is medium in size.

Fruit Flies Distribution

Table 1. Number of each fruit fly species identified in chili plantations in Kendal Regency

Species	Jumlah	Percentage (%)
Bactrocera dorsalis	2004	81,6%
Bactrocera carambolae	280	11,4%
Bactrocera umbrosa	172	7,0%

The number of each species of fruit fly caught can be seen in Table 2 showing that the most dominant species of the three types of species caught is *Bactrocera dorsalis* with a percentage of 81.6%, this can occur because chili plants are the main host of *Bactrocera dorsalis*. The distribution of fruit flies in chili plantations in Gempol, Ngesrepbalong, Limbangan District, Kendal Regency is uneven because the four types of species caught have different percentages, namely B. *dorsalis* as much as 81.6%, B. *carambolae* as much as 11.4%, and B. *umbrosa* as much as 7.0%.

The distribution and diversity of fruit fly species in an area can be influenced by the availability of food. In chili plantations in Gempol, Ngesrepbalong, Limbangan District, Kendal Regency, there are other plants such as bananas, water apples, and avocados. Holis et al. (2023) explained that *Bactrocera dorsalis* has a main host range, namely, chili, guava, orange, eggplant, cucumber, papaya, and mango. The high abundance of fruit fly species in the fields found can be interpreted that the population of these fruit fly species is more dominantly caught by fruit fly traps given attractant. The most abundant type of fruit fly in traps with methyl eugenol attractant is *Bactrocera dorsalis* (Chahyadi and Rayvondacande, 2022).

Number of Fruit Flies Caught

Table 2. The number of fruit flies caught in chili plantations in Kendal Regency.

Treatment	Observation Time							Total
	90	93	96	99	102	105	108	
Methyl Eugenol	327	404	269	273	226	537	420	2456
Clove oil	0	0	0	0	0	0	0	0

The results of observations of the number of fruit flies caught, the highest population was found in the methyl eugenol trap (M1) with a total of 2456 individuals as seen in Table 2 which is the total of all species of fruit flies caught that have been explained in Table 1, while in the clove oil trap (M2) no fruit flies were caught. Sodiq et al. (2016) stated that petrogenol is the best attractant to be used as a fruit fly trap compared to vegetable attractants. The chemical properties of methyl eugenol are relatively similar to the sex pheromone produced by female fruit flies to attract male fruit flies for copulation. The lure substance with the active ingredient methyl eugenol is classified as a food lure, meaning that male flies are attracted to come for food, not for sex (Kardinan, 2017).

The aroma of methyl eugenol spreads to a radius of 100 meters which attracts male fruit flies to come into the trap. Septariani et al. (2019) stated that the aroma of methyl eugenol can spread within a radius of 20-100 meters and with the help of wind, the mobility range of fruit flies can reach 3 km. Male fruit flies can fly as far as 6.44-24.14 km depending on the speed and direction of the wind (Robson and Oemry, 2019).

Clove oil is not effective in controlling fruit fly pests when compared to methyl eugenol. Handayani (2021) explained that methyl eugenol is the most effective attractant for controlling fruit fly pests compared to clove oil and other types of fruit essences, methyl eugenol can catch 823 fruit flies/32 days. In the clove oil treatment, it was unable to attract fruit flies because the active compound it contains is the eugenol compound. Rachmawati (2016) explains that clove oil contains eugenol compounds which require an alkylation process to become methyl eugenol compounds. Once they have become methyl eugenol compounds, they can be used to trap fruit flies.

Clove oil has not yet become a methyl eugenol compound so that the evaporation process occurs faster. Sunarno and Ruruk (2018) stated that a dose of essential oil with a high methyl eugenol content can last longer and the aroma released is sharper and causes the evaporation process to occur more slowly, thus affecting the number of imago fruit flies that enter the trap. The more fruit flies that are trapped, the population of male fruit flies in the field will decrease, as a result the number of male fruit flies that can mate with females will decrease. Rachmawati et al. (2022) explained that the use of attractants can interfere with the mating behavior of fruit flies, if the mating rate decreases, the number of female fruit flies that can lay eggs on mangoes will also decrease, so that damage to mangoes due to fruit fly attacks can be suppressed.

The high population of fruit flies at 105 and 108 HST can be caused by the abundant population of chili plants with lots of fruit and has started to enter the harvest time Shahzadi et al. (2019) stated that the fruit fly population is influenced by the number of fruits and plants in the field, and will be more attracted to ripe fruit because the skin is softer and releases compounds that can attract fruit flies. In addition, the number of *Bactrocera* spp. species obtained is influenced by the surrounding vegetation that is close to the river flow with various other plants such as bananas, water apples, and avocados. Juniawan (2020) stated that the presence of plants and continuous water flow throughout the year creates conditions that are suitable for the life cycle of fruit flies.

There is other vegetation in the chili planting land causing a large population of fruit flies to be caught. Higher vegetation diversity will always provide an opportunity to catch the fruit fly population (Hodiyah et al., 2020). The decrease in the fruit fly population at 96-102 HST was due to high rainfall compared to 90 and 93 HST. Fruit fly activity will be better during low rainfall than high rainfall because the development and activity of fruit flies are influenced by the number of rainy days (Selsa and Hesti, 2022).

Chili planting land that has been used to plant chilies continuously provides an opportunity for fruit flies to continue to reproduce and develop, thereby increasing the fruit fly population. The high and low fruit fly population can also be caused by the land used being land that has been continuously planted or land that has just been planted with chilies, as a result there is no break or addition to the life cycle of the main pest, namely fruit flies (Holis et al., 2023). The use of the same active pesticide ingredients for a long time is also a factor causing the high population of fruit flies that are resistant to the active ingredients used in their control. Syahri et al. 2021 that the use of chemical pesticides for a long time and excessively will kill natural enemies (predators and parasitoids) the emergence of pests that are resistant to certain chemicals (resistance), and the explosion of insect pest populations (resurgence).

Absolute Intensity of Fruit Flies Attack

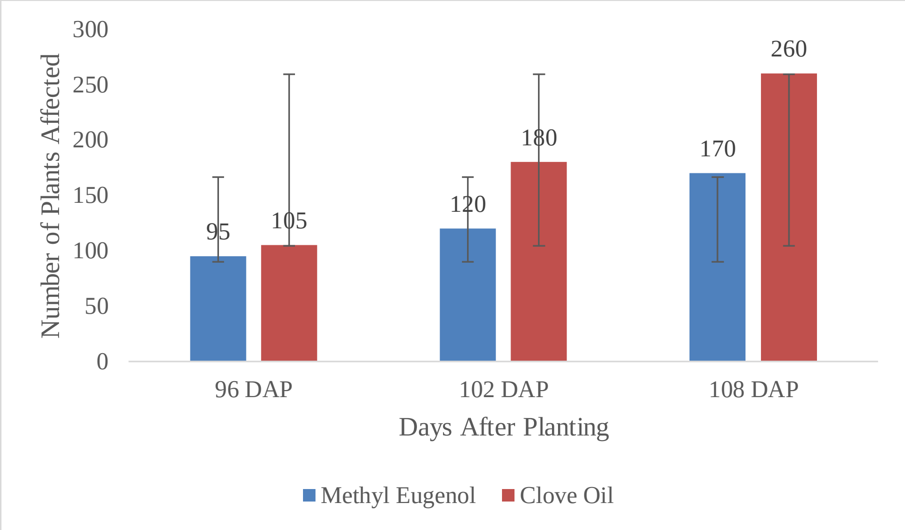

Figure 5. Absolute Intensity of Fruit Fly Attack

The results of observations of the absolute attack intensity of fruit flies, obtained the highest absolute attack intensity in the clove oil treatment (M2) at 108 HST with 260 attacked plants, while the lowest absolute attack intensity was in the methyl eugenol treatment (M1) at 96 HST with 95 attacked plants can be seen in Illustration 15. The high absolute attack intensity in plants treated with clove oil is due to the absence of fruit flies being attracted and trapped in the treatment. Rachmawati (2016) explained that clove oil contains eugenol compounds that require an alkylation process to become methyl eugenol compounds, when they have become methyl eugenol compounds, they can be used to trap fruit flies. The low absolute attack intensity in plants treated with methyl eugenol is because methyl eugenol is effective in controlling fruit flies. Sodiq et al. (2016) stated that petrogenol is the best attractant to be used as a fruit fly trap compared to plant attractants, because methyl eugenol is an insect attractant compound, especially for male fruit flies.

The number of pests caught in the trap will also affect the intensity of damage caused by fruit flies, because the more fruit flies trapped, the lower the intensity of damage caused. Budiyani and Sukasana (2020) stated that the smaller the number of fruit fly catches, the higher or increasing the intensity of fruit fly attacks, while the larger the number of fruit fly catches, the lower the intensity of fruit fly attacks. The factors causing the high and low absolute intensity of fruit fly attacks are related to the number of fruits and the level of fruit ripeness. Holis et al. (2023) stated that in ripe fruit, the level of damage will generally be higher than in unripe fruit, because the texture of the skin is still hard. The characteristic of fruit flies is that they can only lay eggs in the fruit, the larvae (maggots) that hatch from the eggs will damage the fruit flesh, so that the fruit rots and falls. The intensity of fruit fly attacks will increase in suitable climatic conditions, namely when low temperatures around 26oC and high humidity of 90% will be good for fruit fly activity. Sakti et al. (2023) explained that damage to chilies due to fruit fly attacks in the dry season only reached 10-20%, while in the rainy season damage to chilies due to fruit fly attacks could reach 90%.

Relative Attack Intensity Based on Scoring

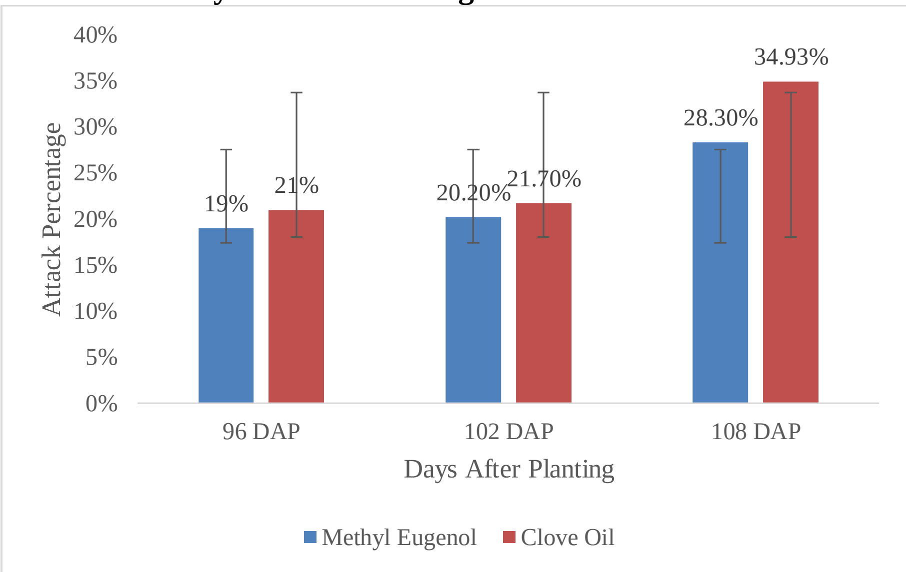

Figure 6. Relative Attack Intensity Based on Scoring

The results of observations of relative attack intensity based on scoring, the highest attack was in the clove oil treatment (M2) at 108 HST of 34.93%, while the lowest relative attack intensity based on scoring was in the methyl eugenol treatment (M1) at 96 HST of 19% can be seen in Illustration 16. The relative attack intensity based on scoring in the clove oil treatment (M2) at 108 HST of 34.93% is included in the moderate category, while in the methyl eugenol treatment (M1) at 96 HST of 19% is included in the mild category. Warduna et al. (2015) stated that categorizing the intensity of attacks (I) of insect pests in general as follows: 'Light' = I ≤ 25%, 'Moderate' = 25% □ I ≤ 50%, 'Heavy' = 50% □ I ≤ 90%, and 'Very Heavy' = I □ 90%.

The high intensity of relative attacks based on scoring on plants treated with clove oil is due to the absence of fruit flies that are attracted and trapped in the treatment. Rachmawati (2016) explained that clove oil contains eugenol compounds that require an alkylation process to become methyl eugenol compounds, when they have become methyl eugenol compounds, they can be used to trap fruit flies. The low intensity of attacks based on scoring on plants treated with methyl eugenol is because methyl eugenol is effective in controlling fruit flies. Sodiq et al. (2016) stated that petrogenol is the best attractant to be used as a fruit fly trap compared to plant attractants, because methyl eugenol is an insect attractant compound, especially for male fruit flies. The number of pests caught in the trap will also affect the intensity of damage caused by fruit flies, because the more fruit flies trapped, the lower the intensity of damage caused. Budiyani and Sukasana (2020) stated that the smaller the number of fruit fly catches, the higher or increasing the intensity of fruit fly pest attacks, while the larger the number of fruit fly catches, the lower the intensity of fruit fly pest attacks.

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Conclusion

The conclusion of this study is a total of 2,456 fruit flies were captured using the methyl eugenol trap, while none were caught in the clove oil trap. Identification of the captured fruit flies revealed three species with different distributions: *Bactrocera dorsalis* at 81.6%, *Bactrocera carambolae* at 11.4%, and *Bactrocera umbrosa* at 7.0%, with *Bactrocera dorsalis* being the most dominant species. The clove oil treatment was found to be less effective as a fruit fly trap, with an absolute attack intensity of 52%, indicated by 260 infested plants and 240 uninfested plants.

The recommendation that can be given is to use attractants other than methyl eugenol, such as cuelure, zingerone, and trimedlure, in order to capture a greater variety of species, making them applicable to a wider range of host plants.

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