INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 08 Issue 08 August 2025

DOI: 10.47191/ijmra/v8-i08-24, Impact Factor: 8.266

Page No. 4590-4597

The Effect of Yellow Sticky Traps and Methyl Eugenol on the Attractiveness of *Bactrocera* Spp., in Tejakula, Bali, Indonesia

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ABSTRACT: Fruit flies (*Bactrocera* spp.) are pests that attack citrus plants by infesting young fruits, leading to premature fruit drop and significant losses for farmers. This study aimed to identify the species of fruit flies present, determine the most effective trap for controlling fruit fly infestations, and analyze the species diversity and dominance indices of fruit flies attacking mandarin orange (*Citrus reticulata* var. Tejakula) plants. The research was conducted in a farmer's mandarin orange plantation located in Tejakula District, Buleleng Regency. The study took place from June to October 2024 and used a Randomized Block Design (RBD) method, involving morphological identification, observation of trapped fruit flies, and analysis of species diversity and dominance indices. The results showed that three fruit fly species were found: *Bactrocera papayae*, *Bactrocera carambolae*, and *Bactrocera umbrosa* Fabricius. The most effective trap for controlling fruit fly infestations was the methyl eugenol trap. The species diversity index was categorized as low, while the species dominance index was found to be very higt.

KEYWORDS: *Bactrocera* spp, mandarin orange, effective traps

INTRODUCTION

Citrus is one of the the horticultural commodities that were prioritized and developed during the (2015-2019) period due to their potential to boost the national economy (Maulana *et al*., 2019). Orange consumption is closely related to population growth and a healthy lifestyle. Orange trees thrive in both tropical and subtropical regions. One of the most popular local orange varieties in Indonesia is the mandarin orange (*Citrus reticulata* Loura), which is widely cultivated and favored by the public (Maulana *et al.,* 2019). However, in orange cultivation, several problems are faced by farmers, one of which is the infestation of pests and plant diseases. Common pests that attack mandarin oranges include the Asian fruit fly (*Bactrocera* spp.), citrus fruit borer (*Citripestis sagitiferella* Moore), black citrus aphid (*Toxoptera aurantii* B.d.f.), soft scale insect (*Unaspis citri* Comst), citrus mealybug (*Pseudococcus citri* Risso), citrus blackfly (*Aleurocanthus woglumi* Ashby), citrus blossom moth (*Prays citri* Mill), orange peel moth (*Prays endocarpa* Meyr), citrus psyllid (*Diaphorina citri* Kuwa), giant swallowtail butterfly (*Papilio memnon* L.), cotton aphid (*Aphis gossypii* Glov), red spider mite (*Tetranychus cinnabarinus* Boisd), citrus leaf miner (*Phyllocnistis citrella* Staint), whitefly (*Dialeurodes citri* Kuwa), and tropical citrus aphid (*Toxoptera citricidus* Kirk).

The main pest that attacks orange plants is the fruit fly, while the most significant disease that causes a reduction in orange production is Citrus Vein Phloem Degeneration (CVPD). According to Yani (2016), there are 27 species of fruit flies that affect fruit crops in Indonesia, including *Bactrocera tau*, *Bactrocera caudatus*, *Bactrocera cucurbitae*, *Batrocera umbrosa* Fabricus, *Bactrocera papayae*, *Bactrocera lineate*, *Bactrocera furvilineata*, *Bactrocera curvifera*, *Bactrocera longicornis*, *Dacus conopsoides*, *Bactrocera contigua*, *Bactrocera cheesmanae*, *Bactrocera carambolae*, *Bactrocera abdonigella*, *Bactrocera exornata*, *Bactrocera calumniate*, *Bactrocera pseudocucurbitae*, *Bactrocera curreyi*, *Bactrocera recurrens*, *Bactrocera paramusae*, *Bactrocera frauenfeldi*, *Dacus trifaria*, *Bactrocera albistrigata*, *Bactrocera persignata*, *Bactrocera ermittens*, *Dacus leongi*, and *Dacus thistletoni*. The fruit fly (*Bactrocera* spp.) is one of the major pests of horticultural crops worldwide, with over one hundred horticultural plant species suspected to serve as its hosts. At high populations, the intensity of its infestation can reach up to 100%. Fruit flies are considered one of the most important pests of various fruits and vegetables, even becoming a major plant pest (OPT). The fruit fly (*Bactrocera* spp.) can attack oranges at different stages of development, from young fruit to mature fruit. Fruit fly infestations on young fruit cause abnormal growth and eventual fruit drop. In contrast, infestations on mature fruit result in

wet rot due to punctures made by female flies when laying eggs inside the fruit. The larvae that hatch from the eggs then consume the fruit flesh, causing the fruit to drop before it ripens. Fruit fly populations tend to increase significantly when climate conditions are favorable, especially with high humidity and mild wind.

The development of fruit flies is highly influenced by climatic factors and humidity. A humid environment supports the growth of fruit flies, leading to an increase in their population and spread. The intensity of fruit fly infestations varies in proportion to the population density in the field. The higher the fruit fly population, the greater the level of infestation, and conversely, when the population is low, the intensity of the infestation decreases (Pujiastuti, 2007). The size variation of oranges on each tree may also influence the population density of fruit flies.

In Indonesia, one of the major challenges in increasing fruit production and quality is the infestation of fruit flies. It is estimated that approximately 75% of fruit crops are susceptible to attack by this pest. To effectively suppress the fruit fly population, appropriate control techniques are necessary. Control can be implemented early through regular monitoring, allowing preventive actions to be taken as soon as signs of infestation are detected. One commonly used control method is the installation of traps, which come in various forms, from simple to modified designs. Fruit flies are attracted to the green-yellow color spectrum (500–600 nm), which resembles the wavelength of ripe fruit, and therefore yellow traps are commonly used. In addition, other effective methods include the use of attractants containing methyl eugenol to lure male fruit flies, wrapping fruit with plastic to prevent bites, and using essential oil extracts from specific plants as natural repellents.

Fruit fly infestations in Tejakula District remain significantly high, resulting in substantial economic losses for farmers. Information, outreach, and research on fruit fly pests in Tejakula District are lacking. Based on the current conditions in the field, research is necessary to find effective solutions for controlling the fruit fly pest, so that the findings can benefit and provide information to citrus farmers, particularly in Tejakula.

The objectives of this study are (1) to identify the fruit fly species trapped by each trap type, (2) to determine the most effective trap for controlling fruit flies in Tejakula mandarin orange plantations, (3) to analyze the species diversity and dominance indices of fruit flies (*Bactrocera* spp.) in Tejakula mandarin orange plantations.

RESEARCH METHODS

This study was conducted in a farmer-owned mandarin orange plantation located in Tejakula District, Buleleng Regency. Morphological identification of fruit fly species was carried out at the Bali Regional Center for Agricultural Quarantine of Animals, Fish, and Plants, as well as at the Integrated Pest and Disease Management Laboratory, Faculty of Agriculture, Udayana University. The research was conducted from June to October 2024. This study employed a Randomized Group Design (RAK) consisting of three treatments, with each treatment replicated nine times, resulting in a total of 27 experimental units. Observation of fruit flies was conducted through the installation of traps, using yellow sticky traps (mouse glue) and methyl eugenol (petrogenol) attractants. The citrus fruits were observed from 2 months of age until harvest. Each sampled citrus tree used for observation was labeled with identification details, including trap type and number. Observations were carried out weekly, totaling 23 observation sessions from June to October 2024. Fruit flies trapped in each device were counted and identified based on their species. The data obtained from trap effectiveness, species diversity index, and species dominance were tabulated and analyzed using the respective formulas for each parameter. The results were presented in the form of tables and line charts. The implementation of the research includes Morphological Identification of Trapped Fruit Fly Species, Most Effective Trap, Observation of Species Diversity Index and Dominance Index of Fruit Flies (*Bactrocera* spp.). The morphological identification of fruit flies was based on specific characteristics of their body parts. The identification process involved determining morphological features such as the presence and shape of facial spots, color of the mesonotum, number of setae on the scutellum, presence or absence of yellow bands on the lateral and central thorax, the shape and pattern of the abdomen, and the wing vein pattern (costa band) for each *Bactrocera* species. The reference used for identification was the book *"Keys to the Tropical Fruit Flies of South-East Asia"* by Richard A.I. Drew and Meredith C. Romig, published by Griffith University, Australia, in 2013. This variable was observed by comparing the effectiveness of two types of fruit fly traps: yellow sticky traps and methyl eugenol (petrogenol) traps. Effectiveness was determined by counting the number of fruit flies captured by each trap type. The **species diversity index (H')** was calculated based on the number of species found in each treatment using the Shannon-Wiener formula (Rahim, 2023).

$$H' = -\sum_{i=1}^{s} (Pi\ Ln\ Pi)$$

Notes:

H = Shannon-Wiener Diversity Index

S = Number of species

Pi = Proportion of individuals in species *i* (i = 1, 2, 3, ...)

Ln = Natural logarithm

Value : Pi : $\frac{ni}{N}$

ni = Number of individuals in species *i*

N = Total number of individuals across all species

Interpretation of H' values:

H' > 3 = High species diversity

1 < H' ≤ 3 = Moderate species diversity

H' < 1 = Low species diversity

The species dominance index was calculated to determine the dominance level of a particular fruit fly species in mandarin orange plantations, using Simpson's Dominance Index as described by Odum (1993), with the following formula:

$$C = \sum_{\frac{ni}{N}} 2$$

Notes:

ni = number of individuals of the *i*-th species

N = total number of individuals of all species

Simpson's Dominance Index criteria are as follows:

D < 0.4 = Low dominance

0.4 ≤ D ≤ 0.6 = Moderate dominance

D > 0.6 = High dominance

RESULTS

Morphological Identification of Trapped Fruit Fly Species

The identification of fruit fly species found in the traps revealed three species, *Bactrocera papayae*, *Bactrocera carambolae*, and *Bactrocera umbrosa* Fabricius. These three species were observed consistently throughout the study period.

Most Effective Trap

Observations showed that both types of traps used in the study were capable of capturing fruit flies in relatively high numbers, with fluctuations occurring at each observation point (Figure 1.). As the harvest period approached, both traps recorded higher catch rates compared to earlier observations. This increase was attributed to the fruit reaching optimal ripeness—characterized by a yellow color, distinct aroma, softer texture, and larger size. These findings align with Muryati and Jan (2005), who stated that fruit fly activity in locating host plants is influenced by fruit color and aroma.

The yellow sticky trap was effective in attracting fruit flies because the yellow folder used in the trap visually resembled ripe citrus fruits, serving as a strong visual cue. Consequently, the flies became trapped on the adhesive surface and died within a few days. This is consistent with the findings of Wijaya *et al*. (2010), who reported that fruit flies are attracted to the yellow-green spectrum (500–600 nm), which corresponds to the typical wavelength range of ripe fruit coloration.

Methyl eugenol traps also proved to be highly effective in capturing fruit flies. According to Susanto et al. (2018), fruit flies are strongly attracted to traps containing methyl eugenol as an active attractant due to its para-pheromonal properties. Budiyani *et al.* (2020) further explained that methyl eugenol functions as a sex pheromone preferred by male fruit flies, as females tend to select mates that have consumed the compound.

Observations also indicated that trapped fruit flies eventually died within a few days, even though the traps did not contain insecticidal toxins. The traps, made from recycled plastic water bottles with holes sized to fit fruit flies, enhanced trapping efficiency. The small hole size effectively prevented the flies from escaping once they entered the trap.

Species Diversity and Dominance Indices of Fruit Flies (*Bactrocera* spp.) Infesting Mandarin Orange Plants

Based on field observations, the abundance of fruit fly populations (*Bactrocera* spp.) was used to calculate the species diversity index and species dominance index for fruit flies infesting mandarin orange (*Citrus reticulata*) plantations.

Table 1. Population of Fruit Flies (*Bactrocera* spp.) Under Each Treatment

No	Species	Treatment		Number of individuals
		Methyl eugenol trap	Yellow trap	
1	*B. carambolae*	4016	2436	6452
2	*B. papayae*	2644	1039	3683
3	*B. umbrosa*	458	412	870
	N	7118	3887	11005
	H'	0.867	0.883	
	C	0.46	0.475	

Notes: N = Number of Individuals, H' = Species Diversity Index, C = Dominance Index

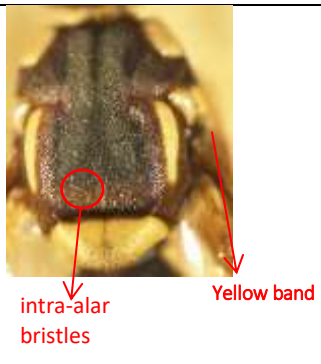
DISCUSSION

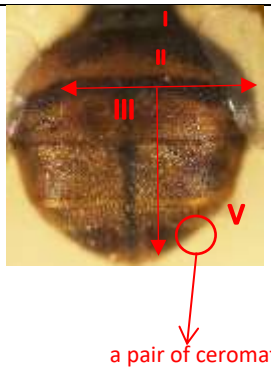
Morphological Identification of Trapped Fruit Fly Species

Key morphological characteristics used to distinguish among *Bactrocera* species include wing patterns, abdominal markings, and thoracic features. The distinguishing characteristics of each species are presented in (Table 1), (Table 2), and (Table 3).

A. *Bactrocera papayae*

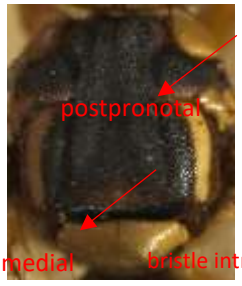
Table 2. Morphological characteristics of *Bactrocera papayae*

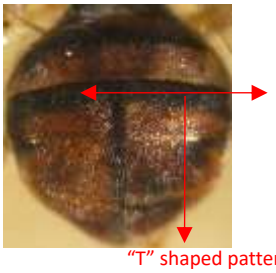
• Right wing		- The wing has a black band on the costa confluent with vein R2+3, while the apex pattern does not show any broadening.
• Left wing		- A distinct black band is visible along the costa and anal veins, with a clearly defined basal costal cell (bc cell).
Thorax		- The scutum is predominantly black, equipped with supra-alar bristles on the anterior side and a yellow band on the lateral side (lateral postural vittae). - The lateral yellow band is broad and runs parallel, ending just behind the intra-alar bristles.

Abdomen		- Terga III to V are orange-brown with a characteristic T-shaped pattern. - A pair of bright yellow oval ceromata (spots) is present on tergum V.
Imago of *Bactrocera papayae*		- The species exhibits variable body sizes.

B. *Bactrocera carambolae*

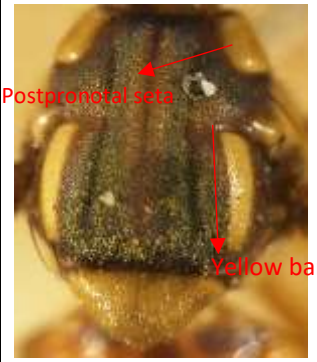
Table 3. Morphological Characteristics of the Fruit Fly Species *Bactrocera carambolae*

Wings • Right wing		- The wing displays a black band located along the anal vein (anal streak).
• Left wing		- The apex of the wing has a hook-like pattern that expands beyond vein R2+3.
Thorax		- The scutum is generally dull black, with a medium-sized yellow band on the lateral side (lateral poststural vittae), running parallel and extending beyond the intra-alar bristles (ia). - The postpronotal area is yellow or orange. - No yellow band is present on the medial part of the thorax.

Abdomen		- Terga III–V are orange-brown in color with a characteristic T-shaped pattern. - The anterolateral corners of tergum IV are rectangular in shape. - The anterolateral corners of tergum V bear a pair of light brown ceromata (spots).
Imago Of *Bactrocera Carambolae*		- The specimens exhibit variable body sizes

C. *Bactrocera umbrosa* Fabricius

Table 4. Morphological Characteristics of the Fruit Fly Species *Bactrocera umbrosa* Fabricius

Wings • Right wing		- The wing exhibits distinctive variations.
• Left wing		- Three transverse bands are present on the wing.
Thorax		- The scutum is black in color. - A yellow band is present on the lateral side. - Two postpronotal setae are present on the scutellum.

Abdomen	 without a T-shaped pattern	- The abdomen shows variation and is sometimes blackened and expanded on the lateral sides. - No T-shaped pattern is present.
Imago of *Bactrocera umbrosa* Fabricius		- The specimens exhibit variable body sizes

Most Effective Trap

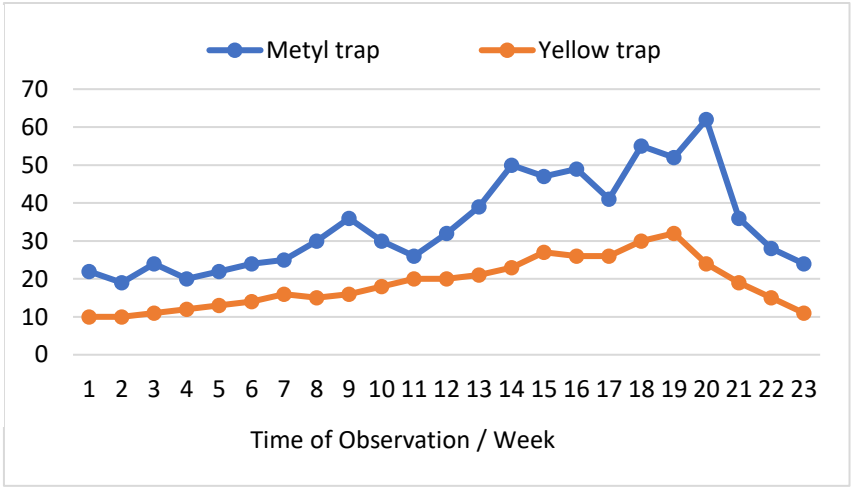


Figure 1. Capture Results from Yellow Sticky Traps and Methyl Eugenol

Both types of traps used in the study exhibited observable differences in the number of fruit flies captured. The methyl eugenol trap captured significantly more fruit flies than the yellow sticky trap. As shown in Figure 4.1 (blue line representing methyl eugenol), the methyl eugenol trap consistently yielded higher captures from the first to the fourteenth observation, although the difference was not always substantial. At the twentieth observation, the trap showed a consistently higher capture rate.

This increase is likely due to the fruit fly oviposition activity that began during the sixteenth to seventeenth observations, as the citrus fruits had started to ripen, making them suitable for egg-laying. The ovipositor of the female fruit fly was able to penetrate the fruit surface. The period from egg to larva takes approximately 10 days, after which the infested fruit falls, and the larvae inside pupate in the soil over 8–12 days, averaging around 10 days (Sodiq, 1993). By the nineteenth observation, the pupae had developed into adult flies (imago stage), which led to the peak capture observed at the twentieth observation.

Capture rates declined from the twenty-first to the twenty-third observation. This was due to the onset of fruit harvesting during the twenty-first observation, which reduced the availability of fruit in the field and, consequently, the number of fruit flies attracted to the area.

Species Diversity and Dominance Indices of Fruit Flies (*Bactrocera* spp.) Infesting Mandarin Orange Plants

Based on Table 1. the yellow sticky trap recorded the highest species diversity index at 0.883, followed by the methyl eugenol trap with a value of 0.867. Both types of traps indicated relatively low species diversity. This low diversity index is attributed to the limited number of fruit fly species observed during the study. According to McPheron & Steck (1996), the low

fruit fly diversity is likely due to the ecosystem being physically regulated through agricultural practices such as the application of insecticides, pesticides, attractants, and adhesive traps. In general, species diversity tends to be higher in ecosystems managed naturally or left undisturbed, and lower in those that are intensively managed or controlled by human interventions such as farming activities.

Regarding the dominance index data, the yellow sticky trap exhibited a higher dominance index (0.475) compared to the methyl eugenol trap (0.46). *Bactrocera carambolae* significantly dominated the fruit fly community, with 2,436 individuals captured using the yellow trap and 4,016 individuals with the methyl eugenol trap. Although *B. carambolae* was dominant in both traps, the higher dominance index in the yellow trap indicates a stronger dominance effect than in the methyl eugenol trap. These results align with the findings of Susanto et al. (2021), who reported that *Bactrocera carambolae* dominates fruit fly communities in both yellow sticky traps and methyl eugenol traps, albeit with varying dominance index values. In this study, *Bactrocera carambolae* showed a notable dominance in the yellow sticky trap, with a species dominance index value of 0.475, placing it within the moderate dominance category.

CONCLUSION

There are three species of fruit flies that infest mandarin orange (*Citrus reticulata*) plants, namely *Bactrocera carambolae*, *Bactrocera papayae*, and *Bactrocera umbrosa* Fabricius, the methyl eugenol trap is more effective than the yellow sticky trap in controlling fruit fly populations, as indicated by the higher number of fruit flies captured, the species diversity index was categorized as low, while the dominance index was classified as moderate.

ACKNOWLEDGMENTS

The author would like to express his gratitude to the Bali Provincial Research and Innovation Agency for funding this research through a research collaboration with the Research and Community Service Institute of Udayana University, as well as to the lecturers who have guided and mentored me so that I was able to complete this research well.

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