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NON-TARGET ARTHROPOD BY-CATCH ASSOCIATED WITH METHYL EUGENOL TRAPS IN GUAVA (*PSIDIUM GUAJAVA*) ORCHARDS

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ABSTRACT

Methyl eugenol (ME) is widely used as an attractant for monitoring and controlling fruit flies (*Bactrocera* spp.). However, its application may also result in the capture of non-target arthropods (by-catch). This study aimed to identify the taxonomic composition, abundance, and diversity of non-target arthropods captured in ME-based traps and plant-extract traps in a crystal guava (*Psidium guajava* L.) orchard. The study was conducted from June to August 2026 using a 5 × 5 Latin square design involving five treatments: ME, chili extract, banana extract, ME + chili extract, and ME + banana extract, with five traps per treatment. Traps were monitored weekly for ten observation periods. A total of 351 non-target arthropods belonging to seven orders, 16 families, and 22 species were collected. Hymenoptera was the most abundant order (86.3%), with *Dolichoderus thoracicus* accounting for 271 individuals. Banana extract captured the highest number of individuals (232) but exhibited the lowest diversity (H′ = 0.43) and evenness (J′ = 0.19), primarily due to the dominance of *D. thoracicus*. Principal Coordinates Analysis (PCoA) revealed substantial overlap in community composition among treatments, indicating no major differences in non-target arthropod community structure. Overall, non-target captures were numerically dominated by ants, while the addition of plant extracts primarily influenced their abundance rather than substantially altering community composition. These findings highlight the importance of considering nontarget arthropod captures when evaluating the selectivity of fruit fly trapping systems.

Keywords: By catch, Methyl eugenol, Nontarget arthropods, Plant extracts, *Psidium guajava.*

1 INTRODUCTION

Guava is tropical fruit widely consumed by Indonesian communities. Currently, Crystal guava (*Psidium guajava* L.) has become one of the most popular varieties due to its appealing taste and relatively crisp texture (1). Fruit flies,

particularly those belonging to the genus Bactrocera are important insect pests of guava. Under high population densities, these pest can significantly reduce fruit quality and potentially cause crop failure (2). Essentially, damage to crystal guava fruit is caused by fruit fly larvae, which grow and develop inside the fruit (3). Various control measures have been implemented to address this problem, one of which is the application of chemical pesticides. However, excessive or improper pesticide use may pose health risks to consumers through pesticide residues remaining on the fruit (4).

Methyl eugenol (ME) is a phenylpropanoid compound that acts as a powerful attractant for male fruit flies of various species belonging to the genus Bactrocera. Male fruit flies are attracted to ME because it functions as a sex pheromone and mating signal, which is typically associated with compounds produced by female fruit flies (5). This has led to the use of ME as fruit fly control agent through monitoring traps and the Male Annihilation Technique (MAT). MAT is a control method designed to attract and eliminate male fruit flies, thereby reducing mating opportunities and ultimately suppressing fruit fly population (6).

However, in practice no trapping system exhibits perfect selectivity. Fruit fly traps may also capture non-target insects and other arthropods, a phenomenon known as bycatch. This can occur when non target arthropods respond to the attractant compound, are attracted to the trap itself are drawn to fruit flies already captured in the trap, or enter the trap accidentally (7). Therefore, this study aimed to identify and quantify nontarget arthropods captured in ME based fruit fly traps.

2 MATERIAL AND METHODS

2.1 Study site

This research was conducted from June to August 2026. The research observation activities were conducted at Makarios Garden, Jl. Bumi Mas, Alang-Alang Lebar, Palembang City, South Sumatra, located at coordinates 2°55'22"S 104°40'42"E. The preparation for the research, which includes the preparation of Chili and banana extract solutions, was carried out at the Agronomy Laboratory, Faculty of Agriculture, Sriwijaya University and the morphological identification of fruit flies was conducted at the Entomology Laboratory, Department of Plant Protection, Faculty of Agriculture, Sriwijaya University.

2.2 Experimental Design and Treatment

The experiment used a 5x5 Latin square design (8) with 25 traps, so that each attractant treatment occurred once in every row and every column, controlling two sources of spatial variation within the orchard. Five treatments were compared: 0.25 ml Methyl Eugenol (ME) as a control (P0), 2 ml chili extract (P1), 2 ml banana extract (P2), combination between 1 ml chili extract and 0.25 ME (P3), 1 ml banana extract and 0.25 ME (P4). Local fruits extract made with maceration method, using methanol solvent with ratio 1:10 w/v. After the maceration period, the mixture is subjected to filtration employing filter paper and a glass funnel to isolate the filtrate (attractant extract) from the residual plant material. The extracted filtrate is thereafter collected and preserved in a dark, sealed container to ensure the stability of the volatile chemicals until utilized in trap formulation.

A simple fruit fly trap was constructed using a repurposed plastic mineral water bottle, which will be altered to create an access point for the flies while complicating their exit, thereby efficiently ensnaring individual insects drawn by the attractant bait. Initially, procure a 600 ml plastic bottle and cleanse it of any filth or residue, thereafter, excising around one-third of the upper section to create a "funnel." The severed upper section of the bottle is subsequently inverted and fitted into the lower section, establishing a conduit for the funnel into the bottle. Subsequently, create an absorbent medium by moistening cotton with 1 ml of either a local attractant extract or a standard attractant solution, namely methyl eugenol, and position it at the base of the bottle (9). The trap was positioned in the garden at a height of 1.5 meters above the ground, and separation of 11 meters between traps. The installation of traps occurred for 2 x24 hours once a week and was repeated weekly for a total of ten observation. Randomization of fruit fly traps within guava orchard with 253 trees, planted at 3x4 meters.

2.3 Data Analysis

Nontarget arthropod abundance was summarized as the total number of individuals per trap over the ten weekly observations and displayed as boxplots for each treatment. Community diversity of each treatment, pooled across traps, was described using observed species richness (S), the Shannon–Wiener index (H'), Pielou's evenness (J'), the Gini–Simpson index ($1-D$), the inverse Simpson index ($1/D$), and the Berger–Parker dominance index (d). Sampling completeness was assessed as the ratio of observed richness to the bias-corrected Chao1 richness estimator (S/Chao1). To evaluate the influence of the single dominant species, *Dolichoderus thoracicus*, on community structure, the diversity indices were also recalculated after excluding this species. Differences in community composition among treatments

were visualized using Principal Coordinates Analysis (PCoA) based on Bray–Curtis dissimilarity calculated from trap-level abundance data. Each point in the ordination represents one trap, and 95% confidence ellipses were drawn for each treatment. Traps without captures were excluded from the ordination because Bray–Curtis dissimilarity cannot be calculated for empty samples. All analyses were performed in R using RStudio version 2024.04.2+764.

3 RESULTS AND DISCUSSION

3.1 Taxonomic Composition

A total of 351 non-target arthropods representing seven orders, 16 families and 22 species were collected (Table 1). Hymenoptera was the most abundant order (303 individuals: 86.3 %) and the most species rich (eight species), followed by Coleoptera (five species: 29 individuals; 8.3%). The result revealed an uneven distribution of non-target arthropods across the recorded orders with Hymenoptera showing the highest abundance. At the species level, *Dolichoderus thoracicus* was the most abundant species, accounting for 271 Individuals and representing the largest contribution to the total arthropods collection.

Table 1: Non-target arthropods captured in Methyl Eugenol and plant-attractant traps in a crystal guava orchard. Values are the total number of Individuals collected in all traps during ten weekly observations.

Order	Family	Species	Number of Individuals
Araneae	Salticidae	*Carrhotus viduus*	1
		Chira spinosa	2
	Thomisidae	*Thomisus spectabilis*	2
Blattodea	Blattellidae	*Blattella germanica*	2
Coleoptera	Chrysomelidae	*Asphaera lustrans*	3
	Coccinellidae	*Cheilomenes sexmaculata*	1
	Dermestidae	*Dermestes lardarius*	4
	Staphylinidae	*Paederus fuscipes*	1
	Tenebrionidae	*Tenebrio molitor*	20
Diptera	Stratiomyidae	*Microchrysa polita*	7
Hemiptera	Coreidae	*Leptoglossus* sp.	1
Hymenoptera	Apidae	*Apis dorsata*	2
	Formicidae	*Camponotus* sp.	4
		Dolichoderus thoracicus	271
		Paratrechina longicornis	14
		Pseudomyrmex sp.	1
		Solenopsis sp.	1
	Tenthredinidae	*Caliroa* sp.	3
	Vespidae	*Polistes* sp.	7
Lepidoptera	Erebidae	*Amata huebneri*	1
		Atolmis sp.	1
	Psychidae	*Pagodiella hekmeyeri*	2
Total	16 Family	22 Species	351

The non-target arthropods captured in methyl eugenol (ME) and plant extract traps in this crystal guava orchard were dominated numerically by ants (Table 1). A catch in which ants are the main non-target group has also been reported for food-baited fruit fly traps in tropical orchards (10), so this pattern may be a general feature of traps hung in fruit tree canopies and not specific effect of ME. In absolute terms the catch was small 351 individuals in 10 weeks. This

comparable with the low capture rates reported for male lure traps in California, where nontarget captures were below four insects per day at most (11) .

The remaining taxa were mostly incidental. Scavengers such as *Tenebrio molitor* (20 individuals), *Microchrysa polita* (7), *Dermestes lardarius* (4) and *Blattella germanica* (2) were probably attracted to dead flies and trap contents rather than to the lures themselves. In Hawaii, saprophagous insects, mostly Diptera, were abundant in ME traps only when enough dead flies had accumulated, and many species earlier listed as attracted to male lures are scavengers that were probably drawn to decaying flies (7).

3.2 Diversity Indices and Sampling Completeness

Diversity indices differed markedly among treatments (Table 2). Banana extract (P2) captured the largest number of individuals (232) but had the lowest diversity and evenness ($H' = 0.43$; $J' = 0.19$; $1/D = 1.17$), reflecting overwhelming dominance by D. thoracicus (Berger–Parker $d = 0.92$). Chili extract (P1) showed a similar but weaker pattern (54 individuals; $H' = 1.06$; $J' = 0.46$; $d = 0.76$), again driven mainly by D. thoracicus. In contrast, methyl eugenol alone (P0) and the two combination treatments (P3 and P4) supported more even assemblages ($H' = 1.81–2.04$; $J' = 0.81–0.98$; $1/D = 4.59–7.36$; $d = 0.22–0.40$), although with far fewer individuals (9–41). Observed species richness was similar among treatments (S = 8–10), indicating that the differences in diversity were caused mainly by differences in evenness rather than by the number of species. The bias-corrected Chao1 estimator indicated that the sampling recovered 82.5% of the estimated total richness (22 of 26.67 species). Sampling completeness was high in P3 (90.9%) and P2 (89.3%), moderate in P4 (70.6%) and P1 (66.7%), and lowest in P0 (43.2%), where the small sample size (N = 9) means that its diversity values should be interpreted with caution.

Table 2: Diversity indices of non-target arthropods captured in methyl eugenol traps in crystal guava orchards, pooled across replicate plots for each treatment and for all treatments combined

Treatment	*N*	*S*	Chao1	*S*/Chao1 (%)	*H′*	*J′*	1–*D*	1/*D*	*d*
P0	9	8	18.50	43.2	2.04	0.98	0.86	7.36	0.22
P1	54	10	15.00	66.7	1.06	0.46	0.42	1.71	0.76
P2	232	10	11.20	89.3	0.43	0.19	0.15	1.17	0.92
P3	41	10	11.00	90.9	1.86	0.81	0.78	4.61	0.39
P4	15	8	11.33	70.6	1.81	0.87	0.78	4.59	0.40
Total	351	22	26.67	82.5	1.11	0.36	0.40	1.66	0.77

Note: N = number of individuals; *S* = observed species richness; Chao1 = bias-corrected Chao1 estimated richness; *S*/Chao1 = sampling completeness; *H′* = Shannon–Wiener index; *J′* = Pielou's evenness; 1–*D* = Gini–Simpson index; 1/*D* = inverse Simpson index; *d* = Berger–Parker dominance index. Treatments: P0 = Methyl Eugenol (ME), P1 = Chili Extract, P2 = Banana Extract, P3 = ME + Chili extract, P4 = ME + Banana Extract.

Sampling completeness differed among treatments. The Chao1 estimator indicated that the overall catch recovered 82.5% of the estimated richness (22 of 26.67 species). Completeness was high in P3 (90.9%) and P2 (89.3%) but only 43.2% in P0, where just nine individuals were collected. Richness and diversity values from such small samples, including P4 (*N* = 15), are unreliable for comparison, because diversity should be compared at equal completeness and not at equal sample size (12). Other limitations should be acknowledged. The study was done in one orchard over ten weekly checks with five traps per treatment, so the results cannot be extrapolated to other orchards or seasons. The design had no unbaited trap, so true attraction to ME or to the extracts could not be separated from accidental entry or from attraction to dead flies.

3.3 Abundance Distribution of Non-Target Arthropods Across Treatments

The distribution of total non-target arthropod abundance per trap across all attractant treatments (P0-P4) exhibited a generally low and consistent pattern across most replicates, with median values remaining below 10 individuals per plot. Nevertheless, an extreme outlier was observed in one replicate of treatment P2 (banana extract), where abundance spiked above 210 individuals per plot, accompanied by moderate outliers in treatments P1 (approximately 40 Individuals) and P3 (approximately 25 individuals). These localized surges were driven by the mass capture of the dominant ants at specific locations, whereas treatments P0 and P4 showed the most compact abundance distributions without pronounced outliers (Figure 1)

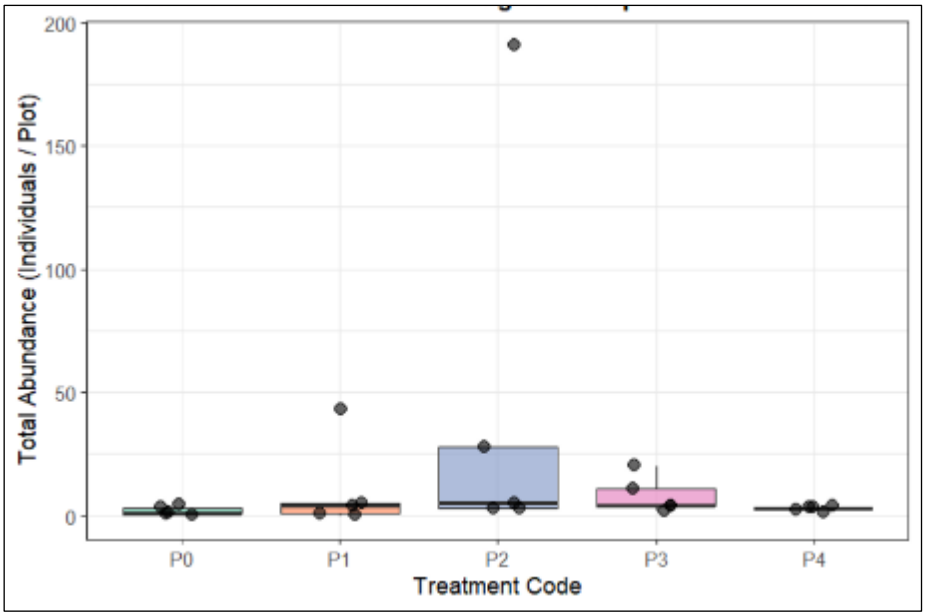


Figure 1: Abundance of non-target arthropods per trap in each attractant treatment (P0, methyl eugenol (ME); P1, chili extract; P2, banana extract; P3, ME + chili extract; P4, ME + banana extract). Boxes show the interquartile range with the median as the horizontal line, whiskers extend to 1.5 × the interquartile range, and points are individual traps (*n* = 5 traps per treatment).

3.4 Principal Coordinates Analysis (PCoA) of Arthropods Community Structure Across Treatments

Principal Coordinates Analysis (PCoA) revealed that the first two ordination axes accounted for 36.23% of the total variation in non-target arthropod community structure, comprising 21.07% on PCoA 1 and 15.16% on PCoA 2. The ordination points and confidence ellipses across all five attractant treatments (P0, P1, P2, P3, P4) exhibited substantial overlap near the center of the ordination space without forming distinct, segregated clusters. This overlapping pattern indicates that the composition and structure of captured non-fruit fly arthropods communities remained relatively uniform across treatments, suggesting that the addition of plant extracts (chili and banana) to methyl eugenol (ME) did not induce a major shift in surrounding non-target arthropods community (Figure 2).

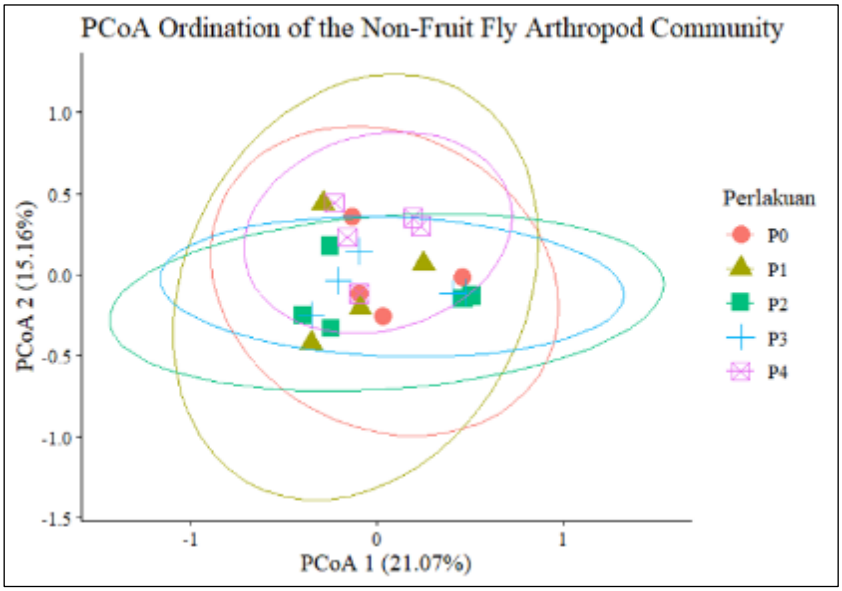


Figure 2: Principal Coordinates Analysis (PCoA) ordination of non-target arthropod communities based on Bray–Curtis dissimilarity. Each symbol is one trap (*n* = 23; two traps without captures were excluded) and ellipses show the 95% confidence ellipse of each treatment (P0, methyl eugenol (ME); P1, chili extract; P2, banana extract; P3, ME + chili extract; P4, ME + banana extract). Percentages on the axes are the proportion of the total variation explained by each axis.

The diversity indices (Table 2) show that the contrast among treatments came from dominance and not from species richness. Observed richness was similar (S = 8–10), but P2 and P1 had the lowest evenness and diversity (H' = 0.43 and 1.06; J' = 0.19 and 0.46) because *D. thoracicus* made up 92% and 76% of their catches (Berger–Parker d = 0.92 and 0.76). When *D. thoracicus* was excluded, the five treatments converged (N = 9–25; H' = 1.81–2.10; J' = 0.87–0.98). This indicates that the plant extracts changed mainly the number of ants entering the traps and not the structure of the rest of the arthropod community, a conclusion supported by the strong overlap among treatments in the PCoA ordination (Figure 2). ME alone captured the fewest non-target arthropods (9 individuals; 2.6% of the total), consistent with Hawaiian studies in which ME attracted only a few non-target species. In contrast, the extract-only treatments, particularly banana extract (P2), were less selective. An unexpected result is that P4 (ME + banana extract) captured only 15 individuals whereas P2 (banana extract alone) captured 232. Our design cannot tell whether ME reduced the attractiveness of the banana extract to ants or whether the difference reflects the smaller extract volume in the combined treatments (1 ml versus 2 ml), because the presence of ME and the extract volume is confounded. A factorial design that varies both factors independently is needed to resolve this (13).

4 CONCLUSION

A total of 351 non-target arthropods representing seven orders, 16 families and 22 species were captured in ME—based and plant extract traps in the crystal guava orchard. Hymenoptera was the most abundant order, with Dolichoderus thoracicus being the dominant species. Banana extract (P2) resulted in the highest nontarget arthropod abundance but the lowest diversity and evenness whereas ME alone (P0) and the combination treatments (P3 and P4) exhibited relatively more even arthropod assemblages. Therefore, nontarget arthropod captures, particularly ant dominance, should be considered when evaluating the selectivity of attractant-based fruit fly trapping system. Further studies involving unbaited controls, independent variation of attractant concentrations and multiple orchard locations are needed to better distinguish attractant effects from incidental captures and assess the broader ecological implications of these trapping systems.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no financial or non-financial conflicts of interest that could have influenced the work reported in this manuscript.

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