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# Trap-based abundance and assemblage structure of fruit flies (Diptera: Tephritidae) in lemon and papaya orchards

# Kelimpahan berbasis perangkap dan struktur kumpulan lalat buah (Diptera: Tephritidae) di kebun jeruk lemon dan pepaya

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**ABSTRACT**

Fruit flies (Diptera: Tephritidae) are economically important pests that reduce the quality and marketability of tropical fruits. This study compared trap-based abundance and assemblage structure in a lemon orchard and a papaya orchard in Tanjung Baru Village, Ogan Ilir Regency, South Sumatra, Indonesia, from May to July 2025. The same 20 fruiting plants in each orchard were sampled weekly for eight weeks using methyl eugenol traps, yellow sticky traps, and sweep nets. Catches were summarized by species, and Shannon–Wiener diversity (H′), Simpson dominance (D), and Pielou evenness (E) indices were calculated using R. The lemon orchard yielded 4,744 individuals representing four species, whereas the papaya orchard yielded 3,194 individuals representing three species. *Bactrocera dorsalis* dominated both orchards, with 2,782 individuals in lemon and 3,135 in papaya. The lemon orchard had higher diversity (H′ = 0.843) and evenness (E = 0.608), but lower dominance (D = 0.482), than the papaya orchard (H′ = 0.100; E = 0.091; D = 0.964). Methyl eugenol traps yielded the largest cumulative catches. Observed differences should be interpreted descriptively because one orchard represented each crop type. These findings provide baseline information for orchard-level monitoring but represent trap-based patterns rather than complete communities or causal crop effects.

**ABSTRAK**

Lalat buah (Diptera: Tephritidae) merupakan hama ekonomi yang menurunkan kualitas dan nilai jual buah tropis. Penelitian ini membandingkan kelimpahan berbasis perangkap dan struktur kumpulan lalat buah pada kebun jeruk lemon dan pepaya di Desa Tanjung Baru, Kabupaten Ogan Ilir, Sumatera Selatan, Indonesia, dari Mei hingga Juli 2025. Sebanyak 20 tanaman berbuah yang sama pada setiap kebun diamati mingguan selama delapan minggu menggunakan perangkap metil eugenol, perangkap lekat kuning, dan jaring ayun. Hasil tangkapan diringkas menurut spesies, sedangkan indeks keanekaragaman Shannon–Wiener (H′), dominansi Simpson (D), dan kemerataan Pielou (E) dihitung menggunakan R. Kebun jeruk lemon menghasilkan 4,744 individu dari empat spesies, sedangkan kebun pepaya menghasilkan 3,194 individu dari tiga spesies. *Bactrocera dorsalis* mendominasi kedua kebun, dengan 2,782 individu pada jeruk lemon dan 3,135 pada pepaya. Kebun jeruk lemon memiliki keanekaragaman (H′ = 0.843) dan kemerataan (E = 0.608) lebih tinggi, tetapi dominansi (D = 0.482) lebih rendah, dibandingkan kebun pepaya (H′ = 0.100; E = 0.091; D = 0.964). Perangkap metil eugenol menghasilkan tangkapan kumulatif terbesar. Perbedaan yang diamati harus ditafsirkan secara deskriptif karena masing-masing jenis tanaman hanya diwakili oleh satu kebun. Temuan ini menyediakan informasi dasar untuk pemantauan pada tingkat kebun, tetapi merepresentasikan pola berbasis perangkap, bukan komunitas lengkap atau efek kausal jenis tanaman.

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## INTRODUCTION

Fruit flies (Diptera: Tephritidae) are economically important pests of fruit production because larval development within infested fruits can reduce fruit quality, marketability, and commercial yield. In addition to direct production losses, tephritid fruit flies are important phytosanitary pests because the host status of agricultural commodities can affect surveillance requirements, quarantine measures, and access to domestic and international markets (Follett et al., 2021). Several species belonging to the tribe Dacini, particularly those in the genus *Bactrocera*, are of major agricultural concern because of their broad geographical distributions, diverse host ranges, and capacity to persist in cultivated and non-cultivated habitats. Surveys conducted in different horticultural production areas in Indonesia have recorded substantial variation in the diversity, dominance, and distribution of fruit fly species among commodities and locations (Hendrival et al., 2020; Hudiwaku et al., 2022).

The occurrence and relative abundance of fruit flies in an orchard may be influenced by fruit availability, crop phenology, fruit condition, surrounding vegetation, local environmental conditions, and the biological characteristics of individual species. Host use is not necessarily uniform, even among closely related fruit crops. Laboratory experiments showed that the oviposition response of *Bactrocera dorsalis* varied among citrus types and was also affected by fruit ripeness and physical damage, indicating that fruit characteristics can influence host-use patterns (Theron et al., 2023). Field surveys in Indonesian horticultural areas have similarly demonstrated that fruit fly assemblages and dominant species can differ among crops and sampling locations (Hendrival et al., 2020; Pujiastuti et al., 2020). Nevertheless, the capture of adult flies within an orchard does not by itself confirm that the crop is a developmental host. Confirmation of host status normally requires evidence of oviposition, larval development, adult emergence, or infestation obtained directly from sampled fruits (Follett et al., 2021).

Among the fruit fly species occurring in tropical fruit-production systems, *B. dorsalis* is frequently reported as a dominant component of trap catches. In citrus orchards in Malang, East Java, *B. dorsalis* was recorded as the dominant species across different habitat conditions, although the composition and diversity of other *Bactrocera* species varied between sampling locations (Rahmawati et al., 2024). A high relative abundance of *B. dorsalis* has also been reported in orchards in Burundi, where it was more abundant than *Ceratitis cosyra* under the conditions investigated (Ndayizeye et al., 2024). These findings illustrate the ecological adaptability and widespread occurrence of *B. dorsalis*, but they also demonstrate that dominance patterns are context-dependent and may be affected by crop composition, fruit availability, environmental conditions, and the sampling approach employed. Consequently, locally generated surveillance data remain important for characterizing fruit fly occurrence and identifying the species that dominate trap catches in particular production areas.

Trap-based surveillance is widely used to document the occurrence, relative abundance, and temporal fluctuation of fruit flies. Methyl eugenol is a potent male lure for several responsive *Bactrocera* species, particularly *B. dorsalis*, although the strength of the response can vary among individuals, populations, physiological conditions, and trapping procedures (Fan et al., 2022; Sim et al., 2022). Trap characteristics and lure application can also influence capture performance. For example, trap color and methyl eugenol quantity have been reported to affect the number of *Bactrocera* individuals captured under orchard conditions (Bajaj & Singh, 2020; Ivananda, 2024). Yellow sticky traps and sweep nets can provide complementary records through visual interception and active sampling, respectively. However, because these methods differ in attraction mechanism, selectivity, exposure duration, and sampling effort, their combined catches represent a sampled assemblage rather than an unbiased estimate of the complete fruit fly community. Records of species not typically associated with methyl eugenol attraction should therefore be interpreted cautiously.

Previous studies in Indonesia have documented fruit fly diversity, host range, and occurrence across multiple horticultural commodities and geographical areas (Aryuwandari et al., 2020; Hendrival et al., 2020; Pujiastuti et al., 2020). Citrus-focused surveys have further shown that *Bactrocera* assemblages may vary among orchard habitats (Rahmawati et

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al., 2024). However, these studies have generally examined multiple commodities at a broad regional scale, confirmed host associations through fruit collection, or focused on variation within a single crop system. Limited information is therefore available on differences in adult fruit fly assemblage structure, species dominance, evenness, and short-term temporal catch patterns between lemon and papaya orchards monitored concurrently using the same sampling schedule. Information is also limited on the relative contribution of lure-based, visual, and active sampling methods to the assemblages recorded in these two orchard settings.

Therefore, this study compared the trap-based abundance, taxonomic composition, assemblage structure, weekly catch patterns, and method-specific catches of fruit flies recorded concurrently in a lemon orchard and a papaya orchard in Ogan Ilir Regency, South Sumatra, Indonesia. The study was designed as a comparative orchard-level case study intended to provide fine-scale baseline information for monitoring. It did not aim to establish causal effects of crop species, formally compare trap efficiency, or confirm lemon and papaya as developmental hosts based solely on adult captures.

## MATERIALS & METHODS

*Study area and orchard characteristics*

The study was conducted from May to July 2025 in Tanjung Baru Village, Indralaya Subdistrict, Ogan Ilir Regency, South Sumatra, Indonesia (−3.202832, 104.601287). Two fruit orchards located within the same agricultural landscape were selected: one lemon (*Citrus limon*) orchard and one papaya (*Carica papaya*) orchard. The plants were approximately 3–5 years old and were cultivated under polyculture conditions together with other horticultural crops.

The lemon orchard covered approximately 1 ha, whereas the papaya orchard also covered approximately 1 ha. The distance between the two orchards was approximately 20 m. The planting distance was 3 × 4 m for lemon and 2 × 2 m for papaya. The lemon cultivar used in this study was 'Eureka', while the papaya cultivar was 'California'. The surrounding vegetation included key lime (Citrus × aurantiifolia) and jackfruit (*Artocarpus heterophyllus*) trees. Orchard management practices included the application of a herbicide containing atrazine (500 g/L) and mesotrione (50 g/L) (Calaris®), and an insecticide containing profenofos (500 g/L) (Curacron®). Both pesticides were applied at two-week intervals as part of the farmers' routine orchard management during the sampling period.

*Sampling design and fruit fly collection*

Twenty fruiting plants were selected in each orchard and sampled weekly for eight consecutive weeks. The same plants were monitored throughout the study period. In the lemon orchard, where plants were relatively uniformly distributed, the sampling plants were selected along an X-shaped transect. In the papaya orchard, where plants were more irregularly distributed, sampling plants were selected across the cultivated area to provide broad spatial coverage.

The number of sampled plants and sampling occasions was kept constant between the two orchards. However, because the study included only one orchard for each crop and the spatial arrangement of the plants differed, the comparisons were interpreted as descriptive differences between the two sampled orchards rather than causal effects of crop species.

Fruit flies were collected using methyl eugenol traps, yellow sticky traps, and sweep nets. A total of 20 methyl eugenol traps and 20 yellow sticky traps were deployed in each orchard during each weekly sampling occasion. One trap of each type was assigned to each sampled plant. Accordingly, the distance between adjacent traps corresponded to the planting distance, which was approximately 3–4 m in the lemon orchard and 2 m in the papaya orchard.

Methyl eugenol traps were constructed from 600-mL plastic bottles with two side openings (2 × 2 cm). Each trap contained 1 mL of Petrogenol® 800 L (800 g/L methyl eugenol; PT Petrokimia Kayaku, Gresik, Indonesia), which was applied to a cotton wick. The trap also contained 350 mL of water and 2 mL of detergent. The traps were suspended approximately 1.5 m above ground level and exposed for 24 h during each weekly sampling occasion. The methyl eugenol and trapping

solution were freshly prepared and replaced at each sampling occasion. Methyl eugenol is a highly effective male attractant for several *Bactrocera* species, particularly *B. dorsalis*, although lure response may vary among species, populations, and physiological conditions (Shelly, 2010). Accordingly, methyl eugenol catches were interpreted primarily as catches of lure-responsive males, whereas records of non-target or atypically captured species were interpreted cautiously.

Yellow sticky traps (20 × 25 cm) were prepared from yellow plastic file folders cut to the required dimensions and coated with adhesive glue. The traps were positioned approximately 1.5 m above ground level and exposed for 24 h during each weekly sampling occasion. Trap color, dimensions, and adhesive coating were standardized throughout the sampling period to ensure consistency in fruit fly captures, as trap characteristics may influence fruit fly attraction and capture efficiency (Kardinan & Maris, 2022).

Sweep-net sampling was conducted around each selected plant using a sweep net with a diameter of 30 cm. A total of 10 sweeps was performed per plant during each sampling occasion. Sampling was conducted between 6:00 and 8:00 a.m. by the same operator throughout the study to minimize variation in sampling effort. All specimens were labelled according to orchard, sampling point, sampling method, and collection date before being transported to the Genetics Laboratory, Department of Agroecotechnology, Universitas Sriwijaya, Indonesia.

*Specimen preservation and identification*

Specimens collected using methyl eugenol traps and sweep nets were preserved in vials containing 70% ethanol. Specimens collected from yellow sticky traps were carefully removed from the adhesive surface using forceps and preserved in 70% ethanol whenever their morphological condition permitted. Each vial was labelled with the orchard code, plant number, sampling method, and collection date.

Fruit flies were examined under a stereo microscope (Olympus Corporation, Tokyo, Japan) and identified to species level based on external morphological characteristics using the identification keys provided in *The Australian Handbook for the Identification of Fruit Flies* (Plant Health Australia, 2018) and *Keys to the Tropical Fruit Flies (Tephritidae: Dacinae) of South-East Asia: Indomalaya to North-West Australasia* (Drew & Romig, 2016).

The external morphological characters examined included facial markings, scutal coloration, wing costal bands, and abdominal tergite patterns. All specimens were identified to species level by the research team using the identification keys described above. The species originally identified as *B. cucurbitae* was reported under its currently accepted taxonomic combination, *Zeugodacus cucurbitae*. Representative specimens were photographed using a smartphone camera equipped with a macro lens and through a stereo microscope for morphological documentation. The specimens were retained in the authors' reference collection.

*Data analysis*

Fruit fly abundance was recorded separately for each orchard, sampling week, sampling method, and species. Total abundance was calculated as the cumulative number of individuals collected over the eight-week sampling period, whereas weekly abundance was expressed as the total number of individuals recorded during each weekly sampling occasion.

For community-level analyses, fruit fly catches obtained using methyl eugenol traps, yellow sticky traps, and sweep nets were pooled within each orchard. Species diversity was calculated using the Shannon–Wiener diversity index (Shannon & Weaver, 1949):

$$H' = -\sum_{i=1}^{S} p_i \ln (p_i) \quad (1)$$

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where $p_i$ is the proportion of individuals belonging to species $i$, and $S$ is the total number of species recorded.

Species dominance was calculated using Simpson's dominance index (Simpson, 1949):

$$D = \sum_{i=1}^{S} p_i^2 \quad (2)$$

where $p_i$ is the proportion of individuals belonging to species $i$. Values approaching 1 indicate stronger dominance by one or a few species.

Species evenness was calculated using Pielou's index (Pielou, 1966):

$$E = \frac{H'}{\ln S} \quad (3)$$

where $H'$ is the Shannon–Wiener diversity index and $S$ is the total number of species recorded. Values approaching 1 indicate a more even distribution of individuals among species.

The indices were calculated using cumulative species counts obtained during the eight-week sampling period for each orchard. Because only one lemon orchard and one papaya orchard were included, differences in abundance and ecological indices were interpreted descriptively and were not considered evidence of a causal crop effect.

Catches obtained using the three collection methods were summarized separately by species and orchard. These catches were used to describe method-specific sampling patterns rather than to compare trap effectiveness because methyl eugenol traps, yellow sticky traps, and sweep nets differed in attraction mechanism, selectivity, exposure duration, and sampling effort.

Data cleaning, initial tabulation, and graphical visualization were performed using Microsoft Excel 2021 (Microsoft Corporation, Redmond, WA, USA). Species diversity, dominance, and evenness indices were calculated using R version 4.5.1 in RStudio Desktop (Posit Software, PBC, Boston, MA, USA). Data processing and graphical visualizations were performed using the R packages ggplot2 (v3.5.2), dplyr (v1.1.4), tidyr (v1.3.1), and vegan (v2.7-1).

## RESULTS & DISCUSSION

*Species composition and assemblage structure*

A total of 7,938 fruit fly individuals were collected during the eight-week sampling period, comprising 4,744 individuals from the lemon orchard and 3,194 individuals from the papaya orchard. Four fruit fly species were recorded in the lemon orchard: *B. dorsalis*, *B. carambolae*, *B. umbrosa*, and *Zeugodacus cucurbitae*. Three species, namely *B. dorsalis*, *B. carambolae*, and *B. umbrosa*, were recorded in the papaya orchard (Table 1; Figure 1).

*B. dorsalis* was the numerically dominant species in both orchards. In the lemon orchard, 2,782 individuals of *B. dorsalis* were collected, representing 58.6% of the total catch. *B. carambolae* was also abundant, accounting for 1,759 individuals or 37.1% of the catch, whereas *B. umbrosa* and *Z. cucurbitae* represented only 2.9% and 1.4%, respectively. In the papaya orchard, *B. dorsalis* accounted for 3,135 individuals or 98.2% of the total catch. By contrast, only 49 individuals of *B. carambolae* and 10 individuals of *B. umbrosa* were recorded.

The predominance of *B. dorsalis* in both orchards is consistent with its frequent occurrence in tropical fruit-production systems. Rahmawati et al. (2024) reported that *B. dorsalis* dominated fruit fly catches in citrus orchards in Malang, East Java, although species composition varied among habitat types. High relative abundance of *B. dorsalis* has also been

reported in orchards outside Indonesia, including its dominance over *Ceratitis cosyra* in Burundi (Ndayizeye et al., 2024). Surveys in several Indonesian horticultural areas have similarly shown that *B. dorsalis* commonly represents a major component of fruit fly catches, although its relative abundance differs among crops and locations (Hendrival et al., 2020; Pujiastuti et al., 2020).

**Table 1.** Species-specific fruit fly catches and assemblage indices in the lemon and papaya orchards

**A. Species-specific catches**

| Orchard | Species | Methyl eugenol trap | Yellow sticky trap | Sweep net | Total | Relative abundance (%) |
|---|---|---|---|---|---|---|
| Lemon | *B. dorsalis* | 1,895 | 875 | 12 | 2,782 | 58.6 |
| | *B. carambolae* | 983 | 768 | 8 | 1,759 | 37.1 |
| | *B. umbrosa* | 87 | 49 | 0 | 136 | 2.9 |
| | *Z. cucurbitae* | 44 | 23 | 0 | 67 | 1.4 |
| | Total | 3,009 | 1,715 | 20 | 4,744 | 100.0 |
| Papaya | *B. dorsalis* | 1,624 | 1,494 | 17 | 3,135 | 98.2 |
| | *B. carambolae* | 20 | 25 | 4 | 49 | 1.5 |
| | *B. umbrosa* | 6 | 4 | 0 | 10 | 0.3 |
| | Total | 1,650 | 1,523 | 21 | 3,194 | 100.0 |

**B. Assemblage indices**

| Orchard | Observed species richness (S) | Shannon–Wiener diversity index (H′) | Simpson dominance index (D) | Pielou evenness index (E) |
|---|---|---|---|---|
| Lemon | 4 | 0.843 | 0.482 | 0.608 |
| Papaya | 3 | 0.100 | 0.964 | 0.091 |

*Notes:* Values represent cumulative catches obtained across eight consecutive weekly sampling occasions. Relative abundance was calculated as the percentage of each species within the total catch recorded in each orchard. Assemblage indices were calculated from pooled catches obtained using methyl eugenol traps, yellow sticky traps, and sweep nets. H′, Shannon–Wiener diversity index; D, Simpson's dominance index; E, Pielou's evenness index.

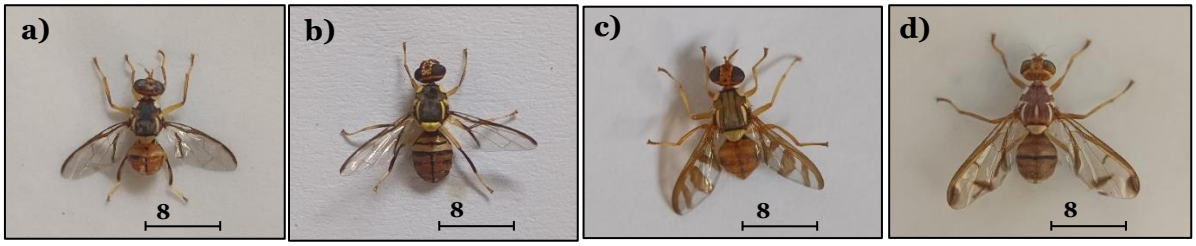


**Figure 1.** Representative adult specimens of (a) *B. dorsalis*, (b) *B. carambolae*, (c) *B. umbrosa*, and (d) *Z. cucurbitae*. Identifications were based on external morphological characters using the keys of Drew and Romig (2016) and Plant Health Australia (2018). Scale bars = 8 mm.

The lemon orchard exhibited higher diversity and evenness than the papaya orchard. The Shannon–Wiener diversity index in the lemon orchard was 0.843, with a Simpson dominance index of 0.482 and a Pielou evenness index of 0.608. In contrast, the papaya orchard showed considerably lower diversity and evenness (H′ = 0.100; E = 0.091) and substantially higher dominance (D = 0.964). The low diversity and evenness recorded in the papaya orchard resulted primarily from the overwhelming numerical dominance of *B. dorsalis*, which represented more than 98% of all individuals collected in the sampled papaya orchard. The greater evenness observed in the lemon orchard reflected the relatively high representation of both *B. dorsalis* and *B. carambolae*, rather than numerical dominance by a single species. Differences in fruit fly assemblages among orchards may be influenced by multiple factors, including fruit availability, plant phenology,

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surrounding vegetation, orchard structure, and local environmental conditions. Previous studies have shown that fruit fly occurrence and host-use patterns may differ among crops and habitats (Hassani et al., 2022; Theron et al., 2023). However, because the present study included only one orchard for each crop type, the observed differences cannot be attributed exclusively to lemon or papaya. Crop identity was confounded with site-specific conditions, orchard management, and surrounding vegetation.

The spatial independence of the trap catches could not be assured because trap spacing followed the crop-specific planting distances, approximately 3–4 m in the lemon orchard and 2 m in the papaya orchard. Moreover, the two orchards were separated by only approximately 20 m. Differences in trap spacing and the possible movement of lure-responsive fruit flies between the nearby orchard areas may therefore have influenced the orchard-level catch totals. The diversity indices were calculated from pooled catches obtained using three sampling methods. Consequently, the indices describe the trap-based assemblages captured by the combined sampling approach and should not be interpreted as complete estimates of the fruit fly communities occurring in the two orchards. In particular, methyl eugenol may have increased the proportional representation of responsive male dacine fruit flies in the pooled dataset.

*Temporal variation in fruit fly catches*

Weekly fruit fly catches varied during the eight-week observation period (Figure 2). In the lemon orchard, *B. dorsalis* remained the most abundant species throughout the study and reached its highest weekly catch during the fifth sampling week. *B. carambolae* showed a similar temporal pattern, with its highest catch also recorded in week five. In contrast, *B. umbrosa* and *Z. cucurbitae* remained consistently low throughout the sampling period. A similar pattern was observed in the papaya orchard, where *B. dorsalis* dominated catches during all sampling weeks and reached its maximum abundance in the fifth week. *B. carambolae* and *B. umbrosa* occurred sporadically and in very low numbers, and both species were absent during some sampling occasions.

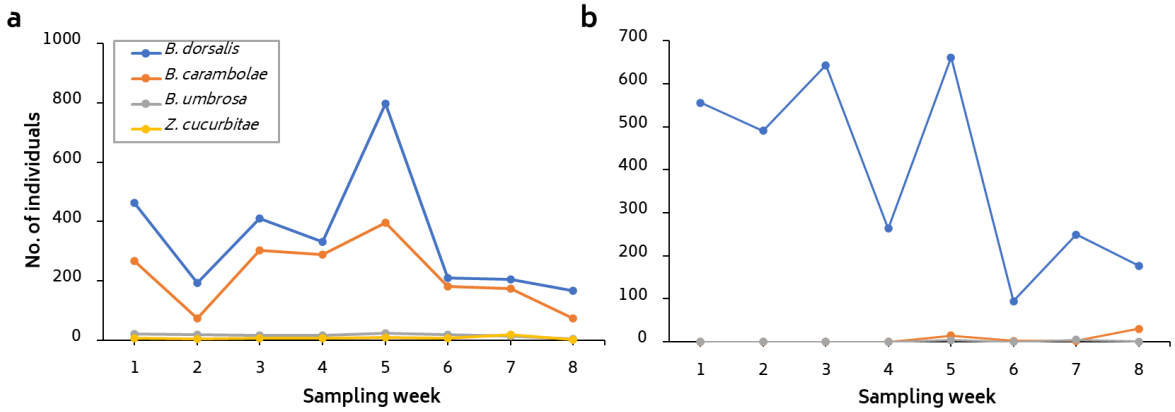


**Figure 2.** Weekly pooled catches of fruit fly species in (a) the lemon orchard and (b) the papaya orchard during eight consecutive sampling weeks. The blue, orange, gray, and yellow lines represent *B. dorsalis*, *B. carambolae*, *B. umbrosa*, and *Z. cucurbitae*, respectively. Values represent pooled counts from 20 sampled plants and the three sampling methods at each weekly sampling occasion.

Temporal fluctuations in fruit fly catches have also been reported in other tropical orchard systems. Khan et al. (2021) found that the abundance of *Bactrocera* species varied seasonally in guava and mango orchards and was associated with changes in environmental conditions. Long-term observations in papaya orchards have likewise shown that fruit fly abundance and spatial aggregation can vary through time and among orchard areas (Araujo et al., 2021, 2022). The concurrent peaks recorded during the fifth sampling week may have coincided with changes in fruit availability, fruit maturity, weather, or other orchard conditions. However, fruit phenology, temperature, humidity, and rainfall were not

quantitatively assessed. Routine biweekly insecticide applications may also have influenced weekly trap catches, but the exact timing of pesticide applications relative to each sampling occasion was not systematically recorded. Consequently, the causes of the observed weekly fluctuations cannot be determined from the current dataset. The temporal patterns should therefore be interpreted descriptively rather than as evidence that fruit condition, microclimate, or insecticide application caused the observed abundance peaks.

*Catch patterns among sampling methods and study implications*

Methyl eugenol traps yielded the largest cumulative catches in both orchards (Figure 3). In the lemon orchard, methyl eugenol traps captured 3,009 individuals, representing 63.4% of the total catch, whereas yellow sticky traps captured 1,715 individuals and sweep nets captured 20 individuals. In the papaya orchard, methyl eugenol traps captured 1,650 individuals, yellow sticky traps captured 1,523 individuals, and sweep nets captured 21 individuals.

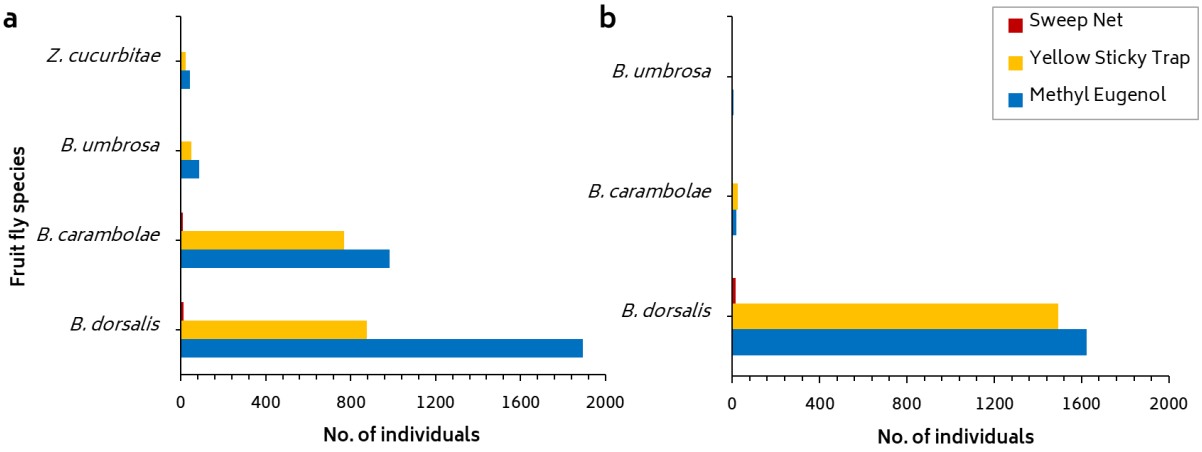


**Figure 3**. Cumulative fruit fly catches obtained using three sampling methods in (a) the lemon orchard and (b) the papaya orchard. The red, yellow, and blue bars represent sweep-net, yellow sticky-trap, and methyl eugenol-trap catches, respectively. Values represent cumulative catches obtained over eight weekly sampling occasions.

For *B. dorsalis*, methyl eugenol traps captured 1,895 individuals in the lemon orchard and 1,624 individuals in the papaya orchard. Yellow sticky traps also captured substantial numbers of this species, particularly in the papaya orchard, where 1,494 individuals were recorded. Sweep-net sampling produced considerably fewer specimens of all species than the two passive trapping methods.

The large catches obtained using methyl eugenol are consistent with the strong attraction of male *B. dorsalis* and several other responsive *Bactrocera* species to this parapheromone. Lure responsiveness may vary according to species, population, physiological condition, and trapping procedure (Fan et al., 2022; Sim et al., 2022). The high representation of *B. dorsalis* in the pooled dataset may therefore reflect a combination of its local occurrence and its strong response to methyl eugenol. Notably, 44 individuals of *Z. cucurbitae* were recovered from methyl eugenol traps. Because males of this species are generally associated with cue-lure attraction, these records should be interpreted as atypical or incidental captures and should not be regarded as evidence of methyl eugenol responsiveness (Shelly, 2010).

Although methyl eugenol traps produced the highest numerical catches, these results should not be interpreted as a formal comparison of trap effectiveness. Methyl eugenol traps, yellow sticky traps, and sweep nets differ in attraction mechanism, sex selectivity, sampling duration, and sampling effort. Methyl eugenol traps predominantly target lure-responsive males, yellow sticky traps rely largely on visual interception and attraction, and sweep nets represent short-duration active sampling. A statistically valid comparison of efficiency would require standardized sampling effort and an experimental design specifically developed to compare trap performance.

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The study provides initial information on the species composition and temporal catch patterns of fruit flies in the two sampled orchards. Orchard-level surveillance is important for identifying numerically dominant species and selecting appropriate monitoring approaches, particularly in areas where several economically important fruit fly species may occur (Kean et al., 2024). However, adult captures within an orchard do not by themselves demonstrate that the crop is a developmental host. Confirmation of host status requires evidence such as larval infestation, pupal development, or adult emergence from collected fruits (Follett et al., 2021). Future studies should include several independent lemon and papaya orchards, standardize catches as individuals per trap-day or trap-week, and record fruit phenology, surrounding vegetation, orchard management, pesticide applications, and microclimatic variables. Fruit collection and rearing would also be required to confirm which fruit fly species successfully complete their development in lemon and papaya fruits.

## CONCLUSIONS

The sampled lemon and papaya orchards differed markedly in their trap-based fruit fly assemblage structure. The lemon orchard had higher species richness, diversity, and evenness, whereas catches in the papaya orchard were overwhelmingly dominated by *B. dorsalis*. Four fruit fly species were recorded in the lemon orchard: *B. dorsalis*, *B. carambolae*, *B. umbrosa*, and *Zeugodacus cucurbitae*, whereas three species were recorded in the papaya orchard. Methyl eugenol traps yielded the largest cumulative catches in both orchards, followed by yellow sticky traps, while sweep-net sampling yielded relatively few individuals. However, these patterns should not be interpreted as a formal comparison of sampling-method efficiency because the three methods differed in attraction mechanism, selectivity, exposure duration, and sampling effort. The findings provide fine-scale baseline information for orchard-level fruit fly monitoring but are limited to one orchard per crop and do not establish causal effects of crop type or confirm developmental host associations.

## ETHICS STATEMENT

Ethical approval was not required because this study involved field sampling of non-protected invertebrate pest species and did not involve humans or vertebrate animals. Permission to conduct sampling was obtained from the orchard owners.

## DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

## REFERENCES

Araujo, M. R. D., Martins, D. D. S., Fornazier, M. J., Uramoto, K., Ferreira, P. S., Zucchi, R. A., & Godoy, W. A. (2021). Long-term fruit fly monitoring and impact of the systems approach on richness and abundance. *The Canadian Entomologist*, *153*(6), 682–701. https://doi.org/10.4039/tce.2021.32

Araujo, M. R. D., Martins, D. D. S., Fornazier, M. J., Uramoto, K., Ferreira, P. S. F., Zucchi, R. A., & Godoy, W. A. C. (2022). Aggregation and spatio-temporal dynamics of fruit flies (Diptera, Tephritidae) in papaya orchards associated with different area delimitations in Brazil. *Acta Scientiarum. Agronomy*, *44*, e53466. https://doi.org/10.4025/actasciagron.v44i1.53466

Aryuwandari, V. E. F., Trisyono, Y. A., Suputa, S., De Faveri, S., & Vijaysegaran, S. (2020). Survey of fruit flies (Diptera: Tephritidae) from 23 species of fruits collected in Sleman, Yogyakarta. *Jurnal Perlindungan Tanaman Indonesia*, *24*(2), 122. https://doi.org/10.22146/jpti.57634

Bajaj, K., & Singh, S. (2020). Preference of *Bactrocera* spp. to methyl eugenol based different coloured traps. *Indian Journal of Agricultural Sciences*, *90*(1), 233–235. https://doi.org/10.56093/ijas.v90i1.98692

Drew, R. A. I., & Romig, M. C. (2016). Keys to the tropical fruit flies (Tephritidae: Dacinae) of south-east Asia: Indomalaya to north-west Australasia. Wallingford, UK: CABI.

Fan, Y., Zhang, C., Qin, Y., Yin, X., Dong, X., Desneux, N., & Zhou, H. (2022). Monitoring the methyl eugenol response and non-responsiveness mechanisms in oriental fruit fly *Bactrocera dorsalis* in China. *Insects*, *13*(11), 1004.

https://doi.org/10.3390/insects13111004

Follett, P. A., Haynes, F. E. M., & Dominiak, B. C. (2021). Host suitability index for polyphagous tephritid fruit flies. *Journal of Economic Entomology, 114*(3), 1021–1034. https://doi.org/10.1093/jee/toab035

Hassani, F., Quilici, S., & Duyck, P.-F. (2022). Niche partitioning via host plants and altitude among fruit flies following the invasion of *Bactrocera dorsalis*. *Agricultural and Forest Entomology*, *24*, 300–310. https://doi.org/10.1111/afe.12522

Hendrival, H., Aryani, D. S., & Saputri, N. (2020). Diversity and host range of fruit flies (Diptera: Tephritidae) in horticultural commodities in lembah seulawah district, Aceh Besar regency, Aceh Province, Indonesia. *Journal of Tropical Horticulture*, *3*(1), 6. https://doi.org/10.33089/jthort.v3i1.38

Hudiwaku, S., Himawan, T., & Rizali, A. (2022). Keanekaragaman, komposisi spesies, dan kunci identifikasi lalat buah (Diptera: Tephritidae: Dacinae) di Pulau Lombok. *Jurnal Entomologi Indonesia*, *19*(2), 111–126. https://doi.org/10.5994/jei.19.2.111

Ivananda, D. (2024). Pengaruh Volume metil eugenol terhadap lalat buah (*Bactrocera* spp.) pada tanaman jeruk manis (*Citrus sinensis* L. Osbeck) di desa Plampangrejo kabupaten Banyuwangi. *Berkala Ilmiah Pertanian : UPT Penerbitan Universitas Jember*, *7*(4). https://doi.org/10.19184/bip.v7i4.53688

Kardinan, A., & Maris, P. (2022). The effect of methyl eugenol from Ocimum minimum on the sticky trap to the direction and daily activity of fruit flies (*Bactrocera* spp.). *Journal of Tropical Plant Pests and Diseases*, 22(1), 16–22. https://doi.org/10.23960/jhptt.12216-22

Kean, J. M., Manoukis, N. C., & Dominiak, B. C. (2024). Review of surveillance systems for tephritid fruit fly threats in Australia, New Zealand, and the United States. *Journal of Economic Entomology*, *117*(1), 8–23. https://doi.org/10.1093/jee/toad228

Khan, M. H., Khuhro, N. H., Awais, M., & Asif, M. U. (2021). Seasonal abundance of fruit fly, *Bactrocera species* (Diptera: Tephritidae) with respect to environmental factors in guava and mango orchards. *Pakistan Journal of Agricultural Research*, *34*(2), 266–272. http://dx.doi.org/10.17582/journal.pjar/2021/34.2.266.272

Ndayizeye, L., Odette, M., Nduwarugira, D., Sibomana, C., & Dieudonné, N. (2024). Dominance of *Bactrocera dorsalis* hendel on ceratitis cosyra walker (Diptera: Tephritidae) in orchards in Bujumbura, Burundi. *Archives of Agriculture and Environmental Science*, *9*(2), 345–349. https://doi.org/10.26832/24566632.2024.0902020

Plant Health Australia. (2018). The Australian handbook for the identification of fruit flies. Version 3.1. Plant Health Australia. Canberra, ACT, Australia: Plant Health Australia.

Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology,* 13, 131–144. https://doi.org/10.1016/0022-5193(66)90013-0

Pujiastuti, Y., Irsan, C., Herlinda, S., Kartini, L., & Yulistin, E. (2020). Keanekaragaman dan pola keberadaan lalat buah (Diptera: Tephritidae) di Provinsi Sumatera Selatan. *Jurnal Entomologi Indonesia*, *17*(3), 125. https://doi.org/10.5994/jei.17.3.125

Rahmawati, Y. F., Leksono, A. S., Gama, Z. P., & Rizali, A. (2024). Diversity of *Bactrocera* spp. in different habitat types in citrus orchards at Malang regency. *Al-Hayat: Journal of Biology and Applied Biology*, *7*(2), 107–118. https://doi.org/10.21580/ah.v7i2.20834

Shelly, T. E. (2010). Effects of methyl eugenol and raspberry ketone/cue lure on the sexual behavior of Bactrocera species (Diptera: Tephritidae). *Applied Entomology and Zoology,* 45(3), 349–361. https://doi.org/10.1303/aez.2010.349

Shannon, C. E., & Weaver, W. (1949). The mathematical theory of communication. Urbana, IL: University of Illinois Press.

Sim, S. B., Curbelo, K. M., Manoukis, N. C., & Cha, D. H. (2022). Evaluating *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) response to methyl eugenol: Comparison of three common bioassay methods. *Journal of Economic Entomology*, *115*(2), 556–564. https://doi.org/10.1093/jee/toac018

Simpson, E. H. (1949). Measurement of diversity. Nature, 163(4148), 688. https://doi.org/10.1038/163688a0

Theron, C. D., Kotzé, Z., Manrakhan, A., & Weldon, C. W. (2023). Oviposition by the oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), on five citrus types in a laboratory. *Austral Entomology*, *62*(4), 503–516. https://doi.org/10.1111/aen.12667

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