

Diversity and Species Composition of Fruit Flies (Diptera: Tephritidae) in Keerom, Papua, Indonesia

Daawia*¹, Supeni Sufaati¹, Bambang Suhartawan², and Irma Rahayu¹

¹ Department of Biology, Faculty of Mathematics and Natural Sciences, Cenderawasih University, Indonesia

² Department of Environmental Engineering, Faculty of Civil Engineering and Planning, University of Science and Technology Jayapura, Indonesia

*Corresponding author; email: daawiasuhartawan@gmail.com

Abstract

Information on fruit flies is essential for integrated fruit fly control programs, whilst such information remains very limited in Papua. This study aims to determine the species diversity and abundance of fruit flies in agroecosystems (Yuwanain) and secondary forest ecosystems (Ubiyau) in Arso District, Keerom Regency. Sampling locations were determined using purposive sampling. Fruit fly samples were collected using plastic bottle traps baited with methyl eugenol. Observations were conducted during May and June 2025. Four species of fruit flies were found in Arso District: *Bactrocera musae*, *B. umbrosa*, *B. fulvicauda*, and *B. dorsalis complex*. All four species were found in the agroecosystem area in Yuwanain, whilst in the secondary forest in Ubiyau, only three species were found: *B. musae*, *B. umbrosa*, and *B. fulvicauda*. All species were pests except *B. fulvicauda*. The Shannon-Wiener species diversity index values for fruit flies in the agroecosystem ($H' = 0.7$) and in the secondary forest ($H' = 0.4$) were both categorized as low. The Simpson Dominance Index in Yuwanain was classified as moderate ($D = 0.636$), whilst in Ubiyau it was categorized as high ($D = 0.800$). In Yuwanain, *B. musae* was highly dominant ($D = 0.617$) with a total individual count of 3,080. The dominance of *B. musae* in Yuwanain was attributed to the abundance of its primary host plant, banana, in the agroecosystem. The evenness index in Yuwanain village was moderate ($E = 0.521$), whereas in Ubiyau it was low ($E = 0.381$), indicating that the distribution of

individual numbers for each species was uneven in the Secondary Forest. Fruit fly abundance was higher in the agroecosystem of Yuwanain (3,921 individuals) than in the secondary forest of Ubiyau (2,272 individuals). This difference is likely due to the greater diversity of host plants in the Yuwanain agroecosystem, including banana, papaya, jackfruit, citrus, wax apple, breadfruit, and chili. In contrast, the secondary forest of Ubiyau contains fewer naturally occurring host plants, such as the native Papua banana and breadfruit. It can be concluded that the species composition and abundance of fruit flies at certain habitat types were determined by the diversity and abundance of host plants.

Keywords: agroecosystem, *Bactrocera*, diversity, methyl eugenol, Papua

Introduction

Keerom Regency is one of the regencies in Papua Province, located on the border with Papua New Guinea (PNG). Keerom Regency is a transmigration area where transmigrants cultivate horticultural crops to meet food needs in Keerom Regency, Jayapura City, and other regencies. There are three districts in Keerom Regency that were transmigrant settlement areas between 1964 and 2000: Arso District with 4,820 households or 20,033 residents, Skanto with 3,309 households or 13,729 residents, and Senggi District with 330 households or 1,218 residents. In Arso and Skanto Districts, food crop and horticultural cultivation have been

conducted intensively utilizing modern cultivation technology. The land area under horticultural crops in 2010 totaled 1,864 hectares.

Fruit flies (Diptera: Tephritidae) are one of the important pests of fruits worldwide, including in Keerom Regency. Fruit flies are destructive insects that attack fruits and other horticultural crops, reducing harvest quality and quantity. Global trade in fresh fruits and vegetables, intensification of human mobility, and climate change facilitate fruit fly (Diptera: Tephritidae) invasions. Life-history traits, environmental stress response, dispersal stress, and novel genetic admixtures contribute to their establishment and spread. Tephritids are among the most frequently intercepted taxa at ports of entry (Papadopoulos et al., 2024).

A survey carried out in Batu City and Malang District examined the species composition of *Bactrocera* fruit flies associated with several horticultural crops, including apples, large chili, red guava, and sweet citrus (Setiawan et al., 2024). The study identified six species fruitflies: *Bactrocera carambolae*, *Bactrocera cucurbitae*, *Bactrocera dorsalis complex*, *Bactrocera verbascifoliae*, *Bactrocera papayae* and *Bactrocera umbrosa* (Setiawan et al., 2024).

Research on the extent of damage and losses caused by fruit flies to fruit and vegetable commodities in Indonesia remains very limited. The level of damage caused by fruit flies on fruits varies considerably. According to Yuliadhi et al. (2022), fruit fly infestations can result in production losses of up to 50%–75%. In Denpasar City, Bali, the percentage of star fruit damage due to fruit fly attacks reached 83.10%, confirming that fruit flies are one of the main causes of fruit damage in agroecosystems (Yuliadhi et al., 2022).

In China, for peach fruits, without control measures, the potential economic losses due to *B. zonata* attacks range from 0.82–3.07 billion dollars, and the potential savings after implementing control measures are estimated at 0.20–1.00 billion dollars (Qin et al., 2021). The main fruit fly pest attacking horticultural crops worldwide, including in Indonesia, is the genus *Bactrocera* (Diptera: Tephritidae). *Bactrocera* attacks more than 100 horticultural crops

(Sahetapy et al., 2019).

To date, two genera of fruit flies have been found in Papua: *Bactrocera* and *Dacus*. Linda et al. (2018) reported 19 species of fruit flies in Sorong and Raja Ampat Regencies: 11 species attracted to cue lure and 8 species attracted to methyl eugenol. Among the species recorded were several fruit flies endemic to the Pacific region and Papua New Guinea, including *B. frauenfeldi*, *B. curvifera*, *B. repanda*, *B. strigifinis*, *B. mollucensis*, *B. thistletoni*, *B. furvilineata*, *B. retrorsa*, and *Dacus impar*.

Papua is part of the New Guinea biogeographic region, widely recognized as one of the most significant centers of biodiversity in the Indo-Pacific, with exceptionally high endemism. Its complex topography, diverse climatic conditions, and long geological history have promoted intense speciation, resulting in numerous species with highly restricted distributions found nowhere else in the world. Insect taxa, including Diptera, demonstrate particularly remarkable diversification within this region. Nevertheless, rapid forest conversion and agricultural expansion increasingly threaten the long-term sustainability of Papua's biodiversity.

Fruit fly diversity surveys in Papua remain very limited, including in Keerom Regency, where no data on fruit flies exist to date. Fruit fly surveys are very important to conduct in the Arso District, Keerom Regency, considering its role as an agricultural center. Data on fruit fly diversity and distribution are essential for integrated fruit fly population management to reduce fruit fly attacks on various types of fruits. This study aims to determine species diversity and abundance of fruit flies in both agroecosystems and secondary forest ecosystems in Arso District, Keerom Regency.

In this context, the rapid expansion of agroecosystems, including horticultural fields, banana cultivation, and smallholder plantations, has become a major driver of habitat transformation. These land-use changes can influence host plant distribution, modify microclimatic conditions, and alter interspecific interactions, potentially reshaping native tephritid assemblages. Therefore, the purpose

of this research is not only to document the diversity and abundance of fruit flies but also to examine how agroecosystem expansion affects the composition, community structure, and dominance patterns of native Tephritidae compared to adjacent secondary forest habitats.

various types of chillies in plantation fields. Meanwhile, Ubiyau Village consists mostly of primary and secondary forests, so Ubiyau was utilised as a sampling location representing the natural ecosystem, namely secondary forest.

Materials and Methods

Study Area

Keerom Regency is within Papua Province, located at coordinates 2°37'0"–4°0'0" S and 140°15'0"–141°0'0" E. The area of Keerom Regency is approximately 9,365 km². Keerom Regency borders directly with Papua New Guinea (PNG) and has 11 districts: Arso, West Arso, East Arso, Mannem, Skanto, Waris, Yaffi, Senggi, Kaisenar, Web, and Towe.

This research was conducted in Yuwanain Village and Ubiyau Village, which are part of Arso District, Keerom Regency, Papua Province (Figure 1). Yuwanain Village was selected as a sampling location to represent the agroecosystem because most of its area is agricultural land. Yuwanain Village comprises oil palm plantations and mixed smallholder gardens planted with various horticultural fruit crops such as oranges, bananas, watermelons, melons, pumpkins, papayas, and vegetables such as mustard greens, water spinach, spinach, and

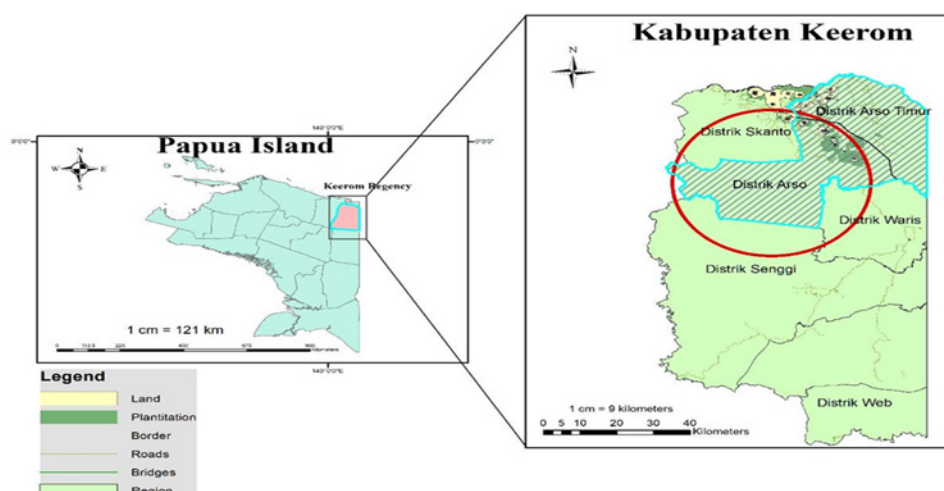
Sampling Method and Timeline

Research locations were selected using purposive sampling, considering the representation of ecosystem types and accessibility for fruit fly sample collection. Fruit fly samples were collected using plastic bottle traps baited with methyl eugenol to capture male fruit flies (Setiawan et al., 2024). Sampling was conducted during May and June 2025. In Keerom Regency (Papua), May–June marks a transitional period toward relatively drier conditions while remaining agriculturally productive. During this time, fruits such as bananas, sweet oranges, papayas, pineapples, wax apples, and guavas are abundant. Therefore, the study was conducted from May to June to coincide with both the seasonal transition and peak fruit availability, ensuring sufficient natural host resources for fruit flies.

Forty bottle traps were installed, divided into 20 traps in the agroecosystem in Yuwanain Village and 20 traps in the secondary forest in Ubiyau Village. All traps were hung from trees using rope at a height of approximately 1 to 1.5

Figure 1

Map Showing Arso District, Keerom Regency, Papua as the Location for Fruit Fly Sampling



m above ground. This height range was selected based on findings by Hooper and Drew (1979), who reported that trap height within the range of 0.1–3.6 m above ground had no significant effect on fruit fly captures in orchard and suburban garden environments. In this study, fruit fly traps were spaced 100 m apart to prevent overlap in lure attraction. This distance ensures that each trap independently represents its surrounding microhabitat, allowing for more accurate assessment of community structure and habitat differences.

Fruit flies were collected weekly, and methyl eugenol attractants were added to the tissue inside the bottle traps; the traps were simultaneously cleaned. Captured fruit flies were wrapped in tissue paper and placed in small, labeled plastic jars containing silica gel to prevent fungal growth. Fruit fly specimens were preserved in 95% ethanol. The use of 95% ethanol is supported by Marquina et al. (2021), who demonstrated that higher ethanol concentrations significantly improve long-term DNA preservation in insects compared to lower concentrations.

In this study, sampling was conducted using only the attractant methyl eugenol due to the limited availability of other attractants, such as *cue lure*, which are difficult to obtain in Papua. Therefore, the Shannon–Wiener index values obtained represent the diversity of specimens captured in response to methyl eugenol, rather than the total fruit fly diversity present in the ecosystem. Consequently, the index reflects sampled diversity influenced by the type of attractant used, and should not be interpreted as an absolute measure of ecosystem health.

Fruit Flies Identification

Fruit fly samples were identified at the Entomology Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Cenderawasih University. Fruit flies were counted and identified using a USB digital microscope and an Olympus Leica LZ 16 stereo microscope. Identification was conducted at the species level based on morphological characteristics of

the head, thorax, abdomen, and wing patterns. Specimens of fruit flies were preserved in vial bottles containing 95% ethanol. Each vial was labeled with the collector's name, sampling date, and location.

Identification used the following references: Economic Fruit Flies of the South Pacific Region by Drew (1989), A global checklist of the 932 fruit fly species in the tribe Dacini (Diptera, Tephritidae) (Doorenweerd et al., 2018) and Adult fruit fly identification of Bactrocera and allied genera using the Lucid multi-entry key platform (Diptera: Tephritidae: Dacinae) using Identification Technology Program (ITP).

Data Analysis

Analysis of fruit fly species diversity and number of individuals per species from each research location was analyzed using the Shannon-Wiener diversity index (H'), Evenness index (E), and Simpson dominance index (D). Species diversity index was calculated utilizing the Shannon-Wiener index formula: $H' = -\sum(\pi_i \ln \pi_i)$, where $\pi_i = n_i/N$; H' = Shannon-Wiener index; n_i = number of individuals per species; N = total number of individuals of all species. According to Magurran (1988): $H' < 1.5$ = low species diversity; $H' = 1.5-3.5$ = moderate species diversity; $H' > 3.5$ = high species diversity.

To determine the evenness or distribution of individuals among species, an analysis was conducted using the Evenness Index (E): $E = H'/\ln S$, where H' = Shannon-Wiener index and S = number of species. According to Wilhm & Dorris (1968), the Evenness index value ranges from 0-1. The evenness index indicates the distribution of individuals amongst species. The larger the E value, the more evenly distributed the number of individuals of each species.

Furthermore, species dominance was calculated using the Simpson Dominance Index to assess the dominance of specific species (Magurran, 1988), with the formula $D = \sum \pi_i^2$, where D = Simpson dominance index; $\pi_i = n_i/N$. According to Odum (2017), a dominance index $D \leq 0.50$ means almost no species dominate (low), a dominance index value (D) $\geq 0.50 - \leq$

0.75 means moderate dominance, whilst a dominance index value ($D \geq 0.75$), approaching 1, means high dominance.

Results and Discussion

Yuwanain Village and Ubiyau Village are part of Arso District, Keerom Regency. The Ubiyau Village area consists mostly of secondary forest, and during this study, 3 species of fruit flies were found: *Bactrocera musae*, *B. umbrosa*, and *B. fulvicauda*. Meanwhile, in the agroecosystem area in Yuwanain Village, 4 species of fruit flies were found: *B. musae*, *B. umbrosa*, *B. fulvicauda*, and *B. dorsalis complex*. Both *B. umbrosa* and *B. fulvicauda* have also been reported in Sorong and Raja Ampat (Linda et al., 2018).

Bactrocera musae has a yellowish face with two black spots in the center. The dorsal part, or scutum, is black, and the wings have specific spots that distinguish it from other fruit fly species. Body length is 6-7 mm, and wingspan is approximately 12-15 mm (Figure 2a).

Bactrocera umbrosa has very unique wing characteristics that are easily recognized and distinguished from other fruit fly species. The wings have 3 prominent transverse bands. On the thorax, particularly on the lateral scutum, there are three broad yellow bands. The abdomen has a black medial line that does not form a T-shape. *B. umbrosa* is medium-sized with a body length ranging from 8.75-9.23 mm and a wingspan of 5.5-8.1 mm (Figure 2b).

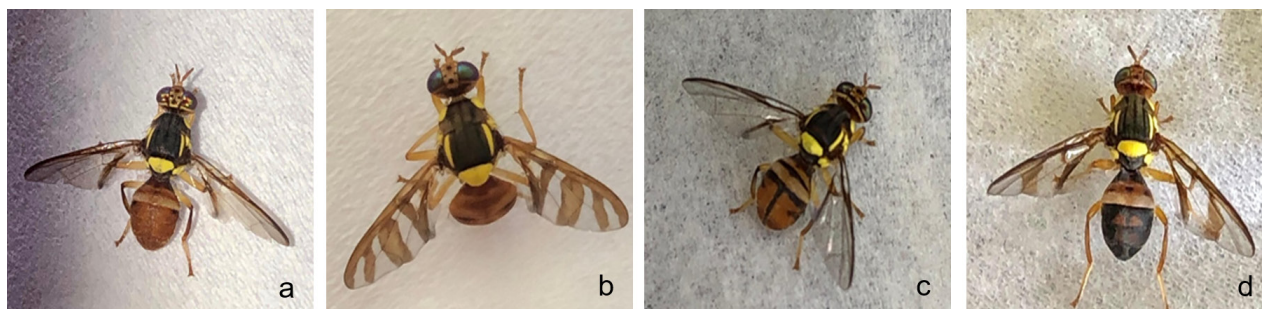
Bactrocera dorsalis belongs to the oriental fruit fly species complex, which includes 52

described species in Asia. Members of this species complex are recognized by their morphological characteristics (Figure 2c). *Bactrocera fulvicauda* is a fruit fly characterized by its orange-brown to black body, orange-yellow postpronotal lobes, and scutum (dorsal thorax) without stripes. This fly has a distinctive abdominal pattern, with tergites 3 and 4 dark on the sides, yellow legs, and wings with a costal band that marks only the tip of vein R4+5. Male flies have pecten (setal combs) on tergite 3 and wings with deep posterior margin indentations (Figure 2d). During the study in Yuwanain Village and Ubiyau Village in Arso District, Keerom Regency, in May and June 2025, 6,193 fruit flies were successfully collected, consisting of *B. musae* 5,105, *B. umbrosa* 545, *B. fulvicauda* 455, and the lowest population was *B. dorsalis complex* with 88 individuals.

Table 1 shows that the *B. musae* population was the highest compared to other fruit fly populations both in the agroecosystem (Yuwanain Village) with 3,080 individuals and in the secondary forest (Ubiyau Village) with 2,025 individuals. The abundance of *B. musae* is presumably related to the abundance of banana plants, which are main host plant of *B. musae*, in both villages. In Yuwanain Village, various banana varieties are widely cultivated, whereas in Ubiyau Village, wild native Papuan bananas grow abundantly in secondary forests. Additionally, chili, papaya, guava, and jackfruit are extensively cultivated in Yuwanain Village, and these plants serve as host plants for *B. musae*.

Figure 2

Bactrocera musae (a), *B. umbrosa* (b), *B. dorsalis complex* (c), and *B. fulvicauda* (d)



Lamba et al. (2024) reported that *B. musae* is the main pest of bananas, particularly infecting ripe bananas up to 37.1% in the Gazelle Peninsula, Papua New Guinea. Holis et al. (2023) reported that *B. musae* attacks chilli plants in Lombok Island. Herrahmawati et al. (2023) also reported that *B. musae* attacked guava, star fruit, durian, papaya, jackfruit, and mango plants in the Depok area, Indonesia. According to Doorenweerd et al. (2018), the distribution of *B. musae* includes the Asia-Pacific region, where it serves as a host for several horticultural plants (oligophagous).

Although the *B. umbrosa* population ranked second, its numbers were not as high as *B. musae*. In Yuwanain Village, 425 individuals were collected, whilst in Ubiyau only 120 individuals. *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), and *Artocarpus integer* (cempedak) are widely cultivated in Yuwanain Village, whereas in Ubiyau Village, breadfruit grows abundantly and naturally in secondary forests. All of these plants serve as host plants for *B. umbrosa*.

Bactrocera umbrosa, is an endemic species originating from Asia and the Pacific. It is known as the breadfruit fruit fly, is known primarily as a pest for *Artocarpus* species, such as breadfruit (*Artocarpus altilis*), jackfruit (*Artocarpus heterophyllus*), and cempedak (*Artocarpus integer*). *B. umbrosa* is a very common species widely distributed in Malaysia, southern Thailand, the Philippines, Indonesia, Papua New Guinea, the Solomon Islands, Vanuatu, and New Caledonia. In PNG, this species is much more common and is frequently

reported attacking breadfruit (Doorenweerd et al., 2018; Herrahmawati et al., 2023).

The *B. fulvicauda* population was 328 individuals in the agroecosystem area of Yuwanain Village, whilst in the secondary forest of Ubiyau Village, it was lower at 127 individuals. *B. fulvicauda* has been reported as a fruit fly species found in the Pacific region, Papua New Guinea, and Papua but is not a major pest of agricultural crops. Linda et al. (2018) reported the distribution of *B. fulvicauda* in Sorong and Raja Ampat Regencies. Doorenweerd et al. (2018) reported that *B. fulvicauda* is distributed in the Asia-Pacific region and is not a crop pest (non-pest).

The *B. dorsalis complex* population was the lowest compared to other fruit fly species populations, found only in the agroecosystem of Yuwanain Village, with 88 individuals, and not found in the secondary forest of Ubiyau Village (Table 1). *B. complex dorsalis* is rarely detected in forest habitats because its ecology is closely linked to human-modified environments. This species is better adapted to agricultural areas, orchards, and home gardens where cultivated fruits are abundant. Its preferred host plants, such as mango, guava, citrus, and papaya, are commonly grown on farms at Yuwanain Village but are limited or absent in natural forests in Ubiyau. Forest ecosystems mainly contain wild fruit species that are more scattered, seasonal, and sometimes chemically less suitable for this fly. In addition, forest microclimatic conditions, such as dense canopy cover, lower light intensity, and cooler understory temperatures, are generally less favorable than the warmer, more

Table 1

Data on Species and Population of Fruit Flies in Yuwanain and Ubiyau Villages

| Species | Population | | Total population |
|------------------------------------|------------|--------|------------------|
| | Yuwanain | Ubiyau | |
| <i>Bactrocera musae</i> | 3,080 | 2,025 | 5,105 |
| <i>Bactrocera umbrosa</i> | 425 | 120 | 545 |
| <i>Bactrocera fulvicauda</i> | 328 | 127 | 455 |
| <i>Bactrocera dorsalis complex</i> | 88 | 0 | 88 |
| Total population | 3,921 | 2,272 | 6,193 |

open environments found in agroecosystems. Competition may also play a role, as forests often harbor native fruit fly species that are better adapted to shaded habitats and wild host plants. Consequently, although individuals may occasionally disperse into forest areas, stable populations of *B. dorsalis complex* are unlikely to establish themselves in forest habitats.

B. dorsalis complex is an oriental fruit fly with a wide host plant range (polyphagous), including mango (*Mangifera indica*), papaya (*Carica papaya*), and guava (*Psidium guajava*). *Bactrocera dorsalis* is a dominant pest attacking agricultural crops globally, particularly in Asia and Africa. According to Doorenweerd et al. (2018), *B. dorsalis* is distributed in the Asia-Pacific region. The term *Bactrocera dorsalis complex* was used because the species within this complex are morphologically very similar and difficult to distinguish using standard morphological identification methods. Without molecular analysis or advanced diagnostic tools, it is not possible to reliably separate the individual species within the complex. Therefore, specimens were grouped and reported as the *B. dorsalis complex* to avoid misidentification and to reflect the taxonomic uncertainty inherent in the methods used.

The increasing volume of transcontinental trade has contributed to an escalating rate of *Bactrocera* pest introductions to new regions (Zhao et al., 2024). *Bactrocera dorsalis* attacks many types of horticultural crops (polyphagous), which is one of the pest species in the Tephritidae family and is highly invasive in many regions of Africa and the Pacific islands. *Bactrocera dorsalis* was reported to attack 20 to 40 hostplants species. Mango and guava were the major commercial host plants for *B. dorsalis* (Hassani et al., 2022; Nanga et al., 2022).

Figure 3 shows that the fruit fly population abundance in the agroecosystem area of Yuwanain Village was higher compared to the secondary forest of Ubiyau Village. This is due to the greater diversity of fruit fly host plants in the agroecosystem compared to the secondary forest. In Yuwanain Village, a total of 3,921 fruit fly individuals were found, consisting of *B. musae*

3,080 individuals (79%), *B. umbrosa* 425 (11%), *B. fulvicauda* 328 (8%), and the lowest population was *B. dorsalis complex* with 88 individuals (2%). Figure 4 shows the population abundance of fruit fly species in Yuwanain Village.

In the secondary forest of Ubiyau Village, the fruit fly population was lower at 2,272 individuals. Figure 5 shows fruit fly abundance in Ubiyau Village with the highest *B. musae* population of 2,025 individuals (89%), followed by *B. fulvicauda* 127 individuals (6%), and *B. umbrosa* 120 individuals (5%). Figure 5 shows the population abundance of fruit fly species in Ubiyau Village.

Shannon-Wiener diversity index (H'), Evenness Index (E), and Simpson dominance index (D) for fruit flies were calculated for each research location. H' , E , and D values for Yuwanain Village are shown in Table 2. The fruit fly species diversity index value in the agroecosystem in Yuwanain Village ($H' = 0.7$) was higher compared to the fruit fly diversity index in the secondary forest of Ubiyau Village ($H' = 0.4$) as shown in Tables 2 and 3. Although the fruit fly diversity index in Yuwanain Village was higher than in Ubiyau Village, both locations had low diversity indices according to the categories established by Magurran (1988): $H' < 1.5$ = low species diversity; $H' = 1.5-3.5$ = moderate species diversity; $H' > 3.5$ = high species diversity. The possibly low fruit fly diversity index at both research locations was due to the use of only one type of attractant in fruit fly traps. Many male fruit fly species are attracted to cue lure attractants such as *B. cucurbitae*, *B. frauenfeldi*, *B. mollucensis*, *B. recurrens*, *B. paramusae*, *B. thistletoni*, *B. repanda*, *B. trifasciata*, *B. curreyi*, *B. strigifinis*, and *B. furvilineata* (Linda et al., 2018). The Shannon–Wiener index reported in this study represents sampled diversity, not the ecosystem's total or absolute diversity.

Shannon–Wiener index values were calculated only from individuals captured with a specific attractant. Therefore, the index reflects the diversity of species responsive to the lure used (*methyl eugenol*), rather than the complete fruit fly community present in the habitat. Consequently, the recorded value should not be interpreted as

Figure 3

Diagram of Species and Composition of fruit Flies in Yuwanain and Ubiyau Village

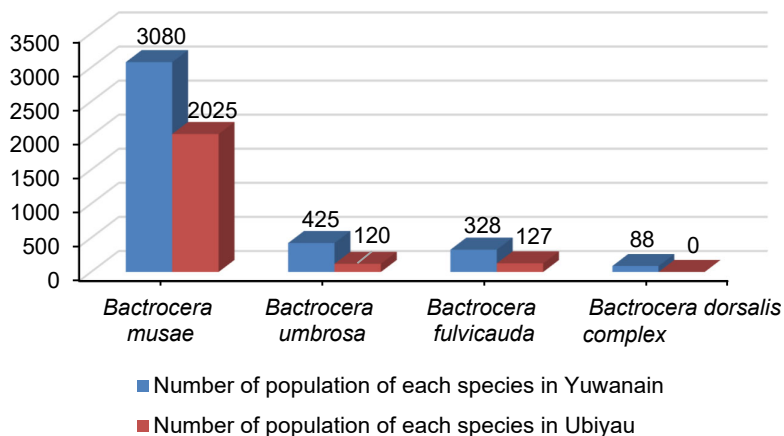


Figure 4

Diagram of Population Abundance of Fruit Fly Species in Yuwanain Village

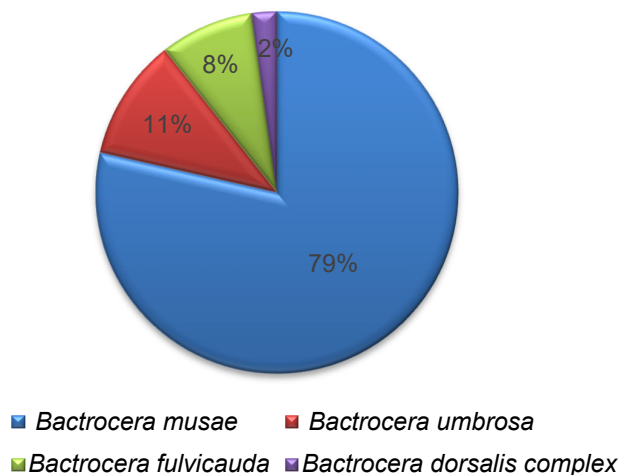
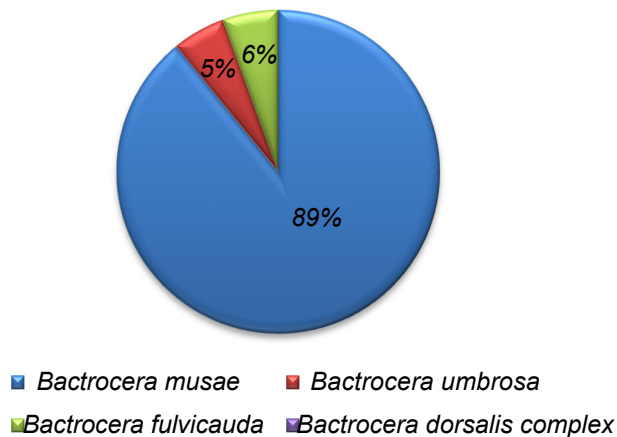


Figure 5

Diagram of Population Abundance of Fruit Fly Species in Ubiyau Village



a direct measure of overall ecosystem health, but rather as an indicator of diversity within the attractant-biased sample. Species diversity is influenced by various factors, including season, spatial distribution, environmental stability, host diversity, competition, and other complex factors (Hudiwaku et al., 2022). According to (Supriatna, 2018), the biodiversity index value will be high if all individuals come from different species and will be low if individuals come from only one species. Table 2 shows a value ($D = 0.636$) in Yuwanain Village, meaning the Simpson dominance index value is moderate. Ubiyau Village has a dominance index ($D = 0.800$), indicating high dominance (Table 3). According to Odum (2017), a dominance index $D \leq 0.50$ means almost no species dominates (low), a dominance index value ($D \geq 0.50 - \leq 0.75$) means moderate dominance, whilst a dominance index value ($D \geq 0.75$, approaching 1, means high dominance. In Yuwanain Village, *B. musae* was highly dominant with $D = 0.617$ and a total individual count of 3,080. Species dominance is caused by various factors, including host range, host abundance and distribution, parasitism, and other competition (Linda et al., 2018). The dominance of *B. musae* in Yuwanain Village is due to its host plants being very diverse and abundant in the agroecosystem area, particularly banana plantations which are very commonly found and are the main host plant of *B. musae*.

The fruit fly species evenness index in the secondary forest of Ubiyau Village was low ($E = 0.381$), indicating an uneven distribution of individuals among species, as the value is close to 0. According to Wilhm and Dorris (1968), lower evenness values reflect dominance by one or a few species. In contrast, the evenness index in the agroecosystem of Yuwanain Village was moderate ($E = 0.521$), suggesting a more balanced distribution of individuals across species. The larger the E value, the more evenly distributed the number of individuals of each species; conversely, the smaller the E value, the more uneven the distribution of individual numbers in each species.

It is strongly recommended that farmers in Keerom Regency implement the Male Annihilation Technique (MAT) to control fruit flies of the genus *Bactrocera*. This method works by installing traps containing male-specific attractants, such as *methyl eugenol* or cue lures, to reduce the male population and disrupt mating. Farmers are advised to place traps regularly throughout orchards at adequate spacing, conduct routine monitoring of fruit fly populations, and combine MAT with proper field sanitation practices, such as collecting and destroying infested fruit. By integrating these practices into an Integrated Pest Management (IPM) approach, farmers in Keerom can achieve more effective, environmentally friendly, and sustainable fruit fly control while protecting crop productivity.

Table 2

Shannon-Wiener Diversity Index, Evenness Index, and Simpson Dominance Index of Fruit Flies in Yuwanain Village

| Species | Population | D | pi | ln pi | H' | E |
|------------------------------------|------------|-------|-------|--------|-------|-------|
| <i>Bactrocera musae</i> | 3,080 | 0.617 | 0.786 | -0.241 | 0.190 | 0.137 |
| <i>Bactrocera umbrosa</i> | 425 | 0.012 | 0.108 | -2.222 | 0.241 | 0.174 |
| <i>Bactrocera fulvicauda</i> | 328 | 0.007 | 0.084 | -2.481 | 0.208 | 0.150 |
| <i>Bactrocera dorsalis complex</i> | 88 | 0.001 | 0.022 | -3.797 | 0.085 | 0.061 |
| Total | 3,921 | 0.636 | 1.000 | | 0.723 | 0.521 |

Notes: Species diversity index was calculated utilizing the Shannon-Wiener index formula: $H' = -\sum(pi \ln pi)$, where $pi = ni/N$; H' = Shannon-Wiener index, ni = number of individuals per species, N = total number of individuals of all species.

Table 3

Shannon-Wiener Diversity Index, Evenness Index, and Simpson Dominance Index of Fruit Flies in Ubiyau Village

| Species | Population | D | pi | ln pi | H' | E |
|------------------------------|------------|-------|-------|--------|-------|-------|
| <i>Bactrocera musae</i> | 2,025 | 0.794 | 0.891 | -0.115 | 0.103 | 0.093 |
| <i>Bactrocera umbrosa</i> | 120 | 0.003 | 0.053 | -2.939 | 0.155 | 0.141 |
| <i>Bactrocera fulvicauda</i> | 127 | 0.003 | 0.056 | -2.883 | 0.161 | 0.147 |
| Total | 2,272 | 0.800 | 1.000 | | 0.419 | 0.381 |

Notes: Species diversity index was calculated utilizing the Shannon-Wiener index formula: $H' = -\sum(pi \ln pi)$, where $pi = ni/N$; H' = Shannon-Wiener index, ni = number of individuals per species, N = total number of individuals of all species.

Conclusions

From this study, four species of fruit flies were found in Arso District, Keerom Regency, Papua: *Bactrocera musae*, *B. umbrosa*, *B. fulvicauda*, and *B. dorsalis complex*. The first three species were pests that attack various horticultural crops, while *B. fulvicauda* is a non-pest. All four species were found in the agroecosystem area in Yuwanain Village, whilst in the secondary forest in Ubiyau Village, only three species were found: *Bactrocera musae*, *B. umbrosa*, and *B. fulvicauda*. The Shannon-Wiener species diversity index values for fruit flies in the agroecosystem in Yuwanain Village and in the secondary forest in Ubiyau Village were both categorized as low. The Simpson Dominance Index in Yuwanain Village was classified as moderate ($D = 0.636$), whilst in Ubiyau Village it was categorized as high ($D = 0.800$). In Yuwanain Village, *B. musae* was highly dominant ($D = 0.617$) with a total individual count of 3,080. The dominance of *B. musae* in Yuwanain Village was due to its primary host plants being very abundant in the agroecosystem banana plantation area. The evenness index value in Yuwanain Village ($E = 0.521$) was moderate, and in Ubiyau Village ($E = 0.381$) was low or approaching zero, indicating that the distribution of individual numbers for each species was uneven. It can be concluded that the diversity index was the same for both agroecosystems and secondary forests, categorized as low; what differed was abundance, with the number of individuals per species higher in agroecosystems than in

secondary forests. The population of pest fruit fly species was influenced by the high population of host plants cultivated in Agroecosystems. Furthermore, the polyphagous, oligophagous, and monophagous nature of fruit fly species also influences their dominance. This study reflects a two-month sampling period; therefore, longer-term surveys covering both seasons are recommended to better understand annual population fluctuations.

Acknowledgement

We extend our gratitude to the Village Heads of Ubiyau and Yuwanain Villages who granted permission to the research team to conduct fruit fly research in both villages. We also thank the Research and Community Service Institute of Cenderawasih University for funding this research.

References

Dooreneerd, C., Leblanc, L., Norrbom, A. L., San Jose, M., & Rubinoff, D. (2018). A global checklist of the 932 fruit fly species in the tribe Dacini (Diptera, Tephritidae). *ZooKeys*, 730, 19–56. <https://doi.org/10.3897/zookeys.730.21786>

Drew, R. A. I., Alulapictus, D., Aquilus, D., Badius, D., Concolor, D., Discors, D., Dissimilis, D., Impar, D., Maprikensis, D., Melanohumeralis, D., Memnonius, D., Nigriculus, D., & Palmerensis, D. (1989). *The tropical fruit flies (Diptera:*

- Tephritidae: Dacinae) of the Australasian and Oceanian Regions. *Memoirs of the Queensland Museum, Nature*, 26. <https://doi.org/10.3316/informit.T2025082200005591546575831>
- Hassani, I. M., Delatte, H., Ravaomanarivo, L. H. R., Nouhou, S., & Duyck, P. (2022). Niche partitioning via host plants and altitude among fruit flies following the invasion of *Bactrocera dorsalis*. *Agricultural and Forest Entomology*, 24(4), 575–585. <https://doi.org/https://doi.org/10.1111/afe.12522>
- Herrahmawati, Q., Yulianti, R., & Yasman, Y. (2023). Short Communication: Dacini tribe's fruit fly species in Depok (Indonesia) with special reference to the abundance of orchard fly, *Bactrocera dorsalis*, for fruit pest controlling. *Biodiversitas Journal of Biological Diversity*, 24(4). <https://doi.org/10.13057/biodiv/d240460>
- Holis, A. I., Haryanto, H., & Isnaini, M. (2023). Populasi dan intensitas serangan lalat buah (*Bactrocera* spp.) pada pertanaman cabai keriting (*Capsicum annum* L.) di Desa Darmasari Kabupaten Lombok Timur. *Jurnal Ilmiah Mahasiswa Agrokomplek*, 2(1), 161–170. <https://doi.org/10.29303/jima.v2i1.2332>
- Hooper, G. H. S., & Drew, R. A. I. (1979). Effect of height of trap on capture of tephritid fruit flies with cuelure and methyl eugenol in different environments 12. *Environmental Entomology*, 8(5), 786–788. <https://doi.org/10.1093/ee/8.5.786>
- 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. <https://doi.org/10.5994/jei.19.2.111>
- Lamba, K., Abraham, L., Kawi, A. P., Guaf, T., Nugi, A., & Tenakanai, D. (2024). Infestation level of banana fruit fly (*Bactrocera musae*, Tryon) on Kalapua banana (*Musa* sp.) in Gazelle Peninsula, Papua New Guinea. *Journal of Entomological and Acarological Research*, 56(1). <https://doi.org/https://doi.org/10.4081/jear.2024.12572>
- Linda, L., Witjaksono, W., & Suputa, S. (2018). Species composition of fruit flies (Diptera: Tephritidae) in Sorong and Raja Ampat, West Papua. *Jurnal Perlindungan Tanaman Indonesia*, 22(2), 193. <https://doi.org/10.22146/jpti.25280>
- Magurran, A. E. (1988). *Ecological diversity and its Measurement*. Springer Netherlands. <https://doi.org/10.1007/978-94-015-7358-0>
- Marquina, D., Buczek, M., Ronquist, F., & Łukasik, P. (2021). The effect of ethanol concentration on the morphological and molecular preservation of insects for biodiversity studies. *PeerJ*, 9, e10799. <https://doi.org/10.7717/peerj.10799>
- Nanga Nanga, S., Hanna, R., Fotso Kuate, A., Fiaboe, K. K. M., Nchoutnji, I., Ndjab, M., Gnanvossou, D., Mohamed, S. A., Ekesi, S., & Djieto-Lordon, C. (2022). Tephritid fruit fly species composition, seasonality, and fruit infestations in two Central African agro-ecological zones. *Insects*, 13(11), 1045. <https://doi.org/10.3390/insects13111045>
- Odum, E. P. (2017). Fundamentals of ecology (1953). In *The future of nature* (pp. 233–244). Yale University Press. <https://doi.org/10.12987/9780300188479-022>
- Papadopoulos, N. T., De Meyer, M., Terblanche, J. S., & Kriticos, D. J. (2024). Fruit flies: Challenges and opportunities to stem the tide of global invasions. *Annual Review of Entomology*, 69(1), 355–373. <https://doi.org/10.1146/annurev-ento-022723-103200>
- Qin, Y., Ullah, F., Fang, Y., Singh, S., Zhao, Z., Zhao, Z., & Li, Z. (2021). Prediction of potential economic impact of *Bactrocera zonata* (Diptera: Tephritidae) in China: Peaches as the example hosts. *Journal of Asia-Pacific Entomology*, 24(4), 1101–1106. <https://doi.org/https://doi.org/10.1016/j.aspen.2021.10.004>
- Sahetapy, B., Uluputty, M. R., & Naibu, L. (2019). Identifikasi lalat buah (*Bactrocera* spp), pada tanaman cabai (*Capsicum annum* L.) dan belimbing (*Averrhoa carambola* L.) di

- Kecamatan Salahutu Kabupaten Maluku Tengah. *Agrikultura*, 30(2), 63. <https://doi.org/10.24198/agrikultura.v30i2.23659>
- Setiawan, Y., Hauroinsiyah, F., Hamdoen, F. M., Devi, M. P., & Tarno, H. (2024). Diversity of Fruit flies (Diptera: Tephritidae) attracted by methyl eugenol in carambola and papaya orchards in Malang Regency, East Java, Indonesia. *PLANTROPICA: Journal of Agricultural Science*, 09(1), 55–60. <https://doi.org/10.21776/ub.jpt.2024.009.1.6>
- Supriatna, J. (2018). Biodiversity indexes: value and evaluation purposes. *E3S Web of Conferences*, 48, 01001. <https://doi.org/10.1051/e3sconf/20184801001>
- Wilhm, J. L., & Dorris, T. C. (1968). Biological parameters for water quality criteria. *BioScience*, 18(6), 477–481. <https://doi.org/10.2307/1294272>
- Yuliadhi, K. A., Susila, I. W., Supartha, I. W., Sultan, A., Yudha, I. K. W., Utama, I. W. E. K., & Wiradana, P. A. (2022). Interaction of parasitoids associated with fruit flies attacking star fruit (*Averrhoa carambolae*) in Denpasar City, Bali Province, Indonesia. *IOP Conference Series: Earth and Environmental Science*, 980(1), 012051. <https://doi.org/10.1088/1755-1315/980/1/012051>
- Zhao, Z., Carey, J. R., & Li, Z. (2024). The global epidemic of *Bactrocera* Pests: Mixed-species invasions and risk assessment. *Annual Review of Entomology*, 69(1), 219–237. <https://doi.org/https://doi.org/10.1146/annurev-ento-012723-102658>