



Diversity of Soil Surface Arthropods in Raspberry (*Rubus idaeus* L.) Plantations in Cisarua, West Bandung District, West Java Province

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ABSTRACT

Raspberries are exotic fruits from the Rosaceae family that are in high demand among the public. Information on plant pest organisms and the diversity of arthropods associated with raspberry plants is needed to develop raspberry cultivation in Indonesia. This research aims to study the diversity of arthropods in raspberry plantations in Cisarua District, West Bandung Regency, West Java Province. The research was carried out using a survey method on land measuring 25 x 2.5 meters at an altitude of 1126 meters above sea level (masl). Sampling was carried out using yellow sticky traps, pitfall traps, knockdown methods, flying insect nets, and six direct observations. The observations yielded 1170 arthropods across 9 orders, 40 families, and 55 genera. The diversity index value is categorized as medium and tends to be high ($H' = 2.99$); the evenness index value is categorized as high ($E = 0.75$); and the dominance index value is low ($C' = 0.09$). Based on their ecological function, the arthropods obtained are grouped as decomposers, herbivores, natural enemies (predators and parasitoids), and pollinators. The largest group of decomposer arthropods comes from the Psychodidae family; the most herbivorous come from the Aleyrodidae family; the most natural enemies come from the Chloropidae and Araneidae families; and the most pollinators come from the Tipulidae family. The values obtained indicate the stability of the raspberry planting ecosystem, with no dominant individuals.

Keywords: Aleyrodidae, arthropod diversity, dominance, evenness, Psychodidae

INTRODUCTION

Raspberries are one of the exotic plants of the Rosaceae Family that produce fruit and are increasingly in demand due to their high

nutritional content, including antioxidants, vitamins, and minerals, which contribute to both health benefits and economic value. In Indonesia, raspberries are utilized in various

forms such as herbal beverages, jams, fresh consumption, and cosmetic products (Sundarini, 2016). Raspberries naturally grow in forested and mountainous regions, with at least 25 species reported in Indonesia, 12 of which have been conserved at the Cibodas Botanical Garden (Surya et al., 2015). Currently, Recently, raspberry cultivation has expanded in Indonesia, including at the Bumi Agro Technology Cisarua garden, West Bandung Regency, driven by increasing market demand.

Despite the growing interest in raspberry cultivation, scientific information on arthropod communities associated with raspberry plantations in Indonesia remains limited, particularly in terms of species composition, diversity, and ecological roles within agroecosystems. Arthropods, including insects, mites, and spiders, play crucial roles as herbivores, natural enemies, decomposers, and pollinators, and strongly influence crop productivity and ecosystem stability. However, baseline data on arthropod diversity in raspberry agroecosystems at highland tropical conditions are still lacking.

Therefore, this study provides novel baseline information on the diversity, abundance, and ecological functions of arthropods associated with raspberry plantations in a highland area of West Java, which is essential for understanding agroecosystem stability and supporting sustainable raspberry cultivation in Indonesia.

Arthropods are members of the Phylum Arthropoda and are characterized by a chitinous exoskeleton and segmented bodies (Setiawan & Maulana, 2019). It is known that about 80% of species in the world belong to the Phylum Arthropoda which is divided into 4 main groups, namely Chelicerata (spiders, mites, etc.); Crustaceans (crabs, shrimps, etc.); Myriapods (centipedes, millipedes, etc.); and Insecta (bees, butterflies, etc.).

The role of Arthropods in ecosystems is grouped based on their ecological roles, namely as pollinators, natural enemies (predators and parasitoids), decomposers, and herbivores (Meilin & Nasamsir, 2016). Herbivorous

arthropods that feed on plants are commonly known as pests. Pests that attack in raspberry plants proposed by Gordon et al. (2015) include raspberry beetles (*Byturus tomentosus* F.), spider mites (*Tetranychus urticae* Koch.), and raspberry moths (*Lampronia rubiella*).

Biodiversity describes the interaction between all living things in the ecosystem (Lihawa, 2016). Groups of organisms that inhabit living spaces will interact with other organisms to carry out their biological functions, including arthropods that act as pests, predators, or decomposers (Untung, 2006). Knowing the diversity and role of Arthropods in raspberry planting can be used as biological control that focuses on the interaction of pests and natural enemies (Herlinda & Irsan, 2015). Biological-based pest control can be an alternative way to suppress pests without causing damage to the environment.

The diversity of arthropod species in an ecosystem can be known by calculating the value of the diversity index in the ecosystem. The Shannon-Wiener diversity index (H') can determine species diversity based on the number of species found and the evenness between species. The higher the value of the diversity index in an ecosystem or region indicates that the level of stability in the ecosystem has been achieved. This is evidenced by the low value of the dominance index and the high value of the species evenness index. A stable ecosystem will have a big impact, such as controlling pests with the help of natural enemies without human intervention so as to reduce the cost of pest control. In addition, a sufficient abundance of pollinating Arthropod contribute to key ecological processes in agricultural systems, including pollination, which directly enhances plant productivity. However, information on arthropod diversity and ecological roles in raspberry cultivation in Indonesia remains very limited, particularly in highland production areas such as Cisarua, West Bandung Regency. To date, no published data are available on arthropod community structure associated with raspberry plantations in this region, creating a knowledge

gap that limits the development of ecologically based pest management strategies.

Therefore, this study aims to assess the diversity, abundance, and ecological roles of soil-surface and plant-associated arthropods in raspberry plantations in Cisarua, West Bandung Regency. The results of this study are expected to provide baseline ecological data to support sustainable raspberry cultivation and inform integrated pest management (IPM) strategies in Indonesian raspberry agroecosystems.

METHODS

Observations were conducted from February to May 2023 at CV Bumi Agro Technology, Cisarua, Lembang, West Java (6°47'58.6" S; 107°34'04.6" E). Arthropod sampling was carried out using a survey method in a 25 × 2.5 m raspberry plot with plants aged six months after pruning. A systematic sampling design was applied by establishing five sampling points as replicates. At each point, one yellow sticky trap and one pitfall trap were installed, resulting in a total of five traps per method per observation. Active sampling using an insect net and knockdown method was also conducted at each sampling point. Yellow sticky traps were placed at canopy level, while pitfall traps were installed at ground level and left for 24 hours. Collected arthropods were preserved in 70% alcohol and identified in the field and laboratory using standard identification keys (Borror et al., 2004). Specimens that could not be identified to genus level were classified to the lowest identifiable taxonomic level and included in diversity analyses.

Installation of Sticky Yellow Traps

Yellow Sticky Trap or yellow sticky trap Arthropods above ground level (Aryoudi et., 2015). The trap measuring 20 x 12.5 cm is tied with a rope to a bamboo stem with a height of 1 m according to the height of the plant with a distance of 6 plants between the traps (Figure 1). Yellow sticky traps are installed every Thursday and then observed on Saturdays after 2 days of installation. Sampling is carried out six times with sampling intervals once a week.

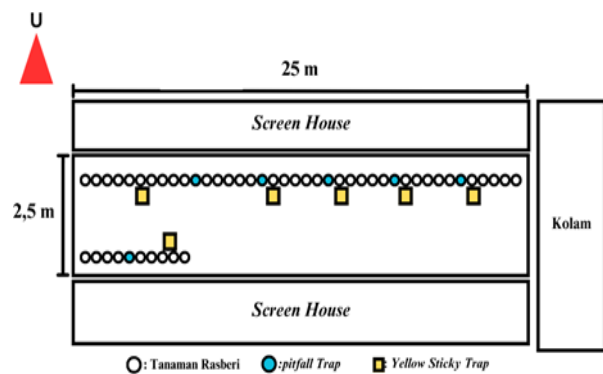


Figure 1. Trap placement plan

Fall Trap Installation

Pitfall traps are used to catch arthropods that are on the ground surface (Aryoudi et al., 2015). The trap is a plastic container with a top diameter of 7 cm, a bottom diameter of 6 cm, and a height of 3.5 cm with 1/3 part filled with soapy water so that trapped arthropods cannot get out of the trap. There are 6 fall traps installed with a distance of 5 plants per trap (Figure 1). Pitfall traps are installed every Thursday and then observed Saturday after 2 days of installation. Sampling was carried out six times with sampling intervals once a week.

Sweeping and Direct Sampling

Sweeping sampling is carried out using insect nets for arthropods that are actively flying. As for passive arthropods, sampling is done by the knockdown method by patting twigs or parts of plants so that insects that perch fall into the container provided. The insects caught are then collected and put into sample bottles.

Identification is carried out on arthropods obtained from sampling. Arthropods are observed morphologically and identified using related identification books. Arthropods that have been identified are grouped based on their classification, while arthropods that have not been identified are grouped based on morphological similarities into morpho-species.

The data obtained were then analyzed, data analysis included the calculation of diversity index according to Shannon-Wiener, type evenness index according to Pielou, and dominance index according to Simpson.

Diversity index

The species diversity index is calculated using the Shannon-Wiener index (H') using the formula:

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

Information:

- H' is Species diversity
- S is the number of Species
- Pi is the ratio of the number of i-th type individuals of the total sample individuals

The criteria for the diversity index are divided into 3 categories, namely:

- H' < 1 = Low
- 1 < H' < 3 = Moderate
- H' > 3 = Height

Species Evenness Index

The Pielou breed evenness index is calculated by the formula:

$$E = \frac{H'}{\ln(S)} \dots\dots\dots(2)$$

Information:

- H' is Shannon's diversity index
- S is the number of types

As for the range of uniformity indices (Magurran, 1982 in Sirait et al., 2018):

- E approaching 0: the spread of individuals between types is uneven
- E approaching 1: distribution of individuals of inter-type evenness

Dominance Index

The dominance index is calculated by the Simpson dominance index formula:

$$D = \sum \left(\frac{ni}{N}\right)^2 \dots\dots\dots(3)$$

Information:

- D is Simpson's dominance index
- ni is the number of individuals per species
- N is the number of individuals of the entire species

Dominance indicators range from 0 to 1 which is getting closer to number 1 indicating the dominance of certain species (Odum, 1993 in Sirait et al., 2018). Data analysis was performed using Microsoft Excel to calculate the Shannon–Wiener diversity index (H'), Pielou's evenness index (E), and Simpson's dominance index (C').

RESULTS AND DISCUSSION

Land Conditions

CV. Bumi Agrotechnology is located in Cisarua District, West Bandung Regency, at an altitude of 1,126 m above sea level. During the observation period, the average temperature was 25.6 °C with a relative humidity of approximately 85%. The raspberry plantation was characterized by monoculture vegetation, providing a suitable microclimate for various arthropod groups.



Figure 2. Observed field contisions of raspberry crops

Raspberry plants at the observation site were managed without pesticide application. In addition to raspberry plants, the surrounding

area contained other cultivated and non-cultivated vegetation, including horticultural crops and flowering plants, which potentially contributed to habitat complexity and supported arthropod diversity.

Abundance of Arthropods in Raspberry Plants

Repeated trap deployment conducted six times revealed four arthropod classes, namely Insecta, Arachnida, Entognatha, and Diplopoda (Figure 3). Insecta was the dominant class, with 1,128 individuals representing six orders and 35 families. In contrast, Entognatha and Diplopoda were the least abundant classes recorded.

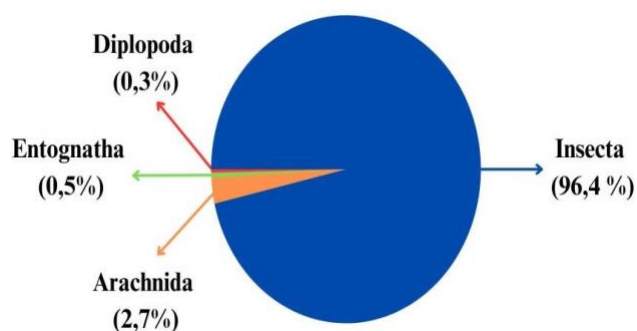


Figure 3. Diagram of the number of Arthropod Classes found

The low abundance of Entognatha and Diplopoda may be related to their preference for moist soil microhabitats. Both groups are known as soil-surface or soil-dwelling arthropods that tend to avoid dry conditions by occupying humid environments such as soil layers or sheltered areas (Christiansen et al., 2009; Stašiov et al., 2014). The use of polybags in raspberry cultivation may limit suitable soil habitats, causing these arthropods to concentrate in more humid microhabitats beneath or behind polybags rather than on exposed soil surfaces.

Insects were the dominant arthropod class at the observation site, with a total of 1,128 individuals recorded. This dominance is commonly observed in agricultural ecosystems, as insects represent the most diverse group within the Phylum Arthropoda (Schowalter, 2006). The most abundant insect orders were Diptera, Hemiptera, and Hymenoptera, whereas Mantodea was the least represented order (Figure 4). Diptera was the dominant order, comprising 680 individuals from 12 families, and

is widely recognized as one of the largest and most ecologically diverse insect orders in agroecosystems (Sanwar, 2020). The most frequently encountered dipteran families associated with raspberry plants were Psychodidae, Sciaridae, and Drosophilidae.

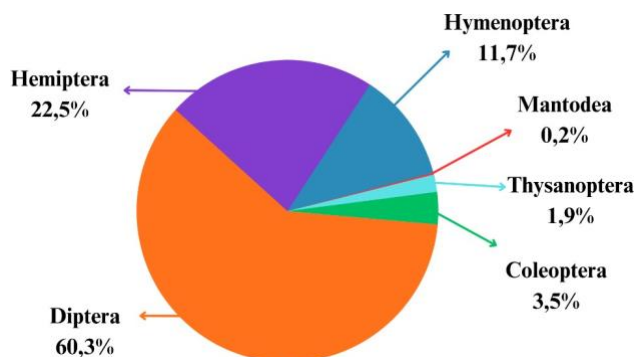


Figure 4. Diagram of the Order of the insecta found

Mantodea was the least abundant insect order recorded in this study. As generalist predatory insects, mantids typically occur at low population densities in agricultural ecosystems due to their position at higher trophic levels (Reitze & Nentwig, 1991). In addition, the low abundance of Mantodea observed in this study may be influenced by the presence of egg parasitoids, such as members of the genus *Pseudogaurax* (Diptera: Chloropidae), which were also recorded at the observation site. *Pseudogaurax* is known as an egg parasitoid of Mantodea and may contribute to population suppression in mantid communities (Gillung & Borkent, 2017).

In addition to the presence of natural enemies, cannibalistic behavior may also contribute to the low abundance of Mantodea observed in this study. Cannibalism in mantids is known to occur during both nymphal stages under limited food conditions and during mating, particularly by female adults (Raut & Gaikwad, 2016). This behavior can reduce reproductive success and suppress population size, as females may prey on males even when food resources are sufficient (Fisher et al., 2020; Prokop & Václav, 2008).

Diversity and Composition of Arthropods in Raspberry Plants

The arthropod diversity index recorded in raspberry plants was classified as moderate, with a Shannon–Wiener diversity value (H') of 2.99 (Table 1). This value indicates a relatively diverse arthropod community within the raspberry plantation.

The moderate arthropod diversity index approaching a high category indicates a relatively balanced raspberry agroecosystem in Cisarua, West Bandung Regency. This condition is supported by a high evenness index ($E = 0.75$), suggesting that arthropod species were evenly distributed and that no single species dominated the community (Table 1). Consistently, the low dominance index value ($C' = 0.09$) further reflects a stable community structure, where ecological roles can be performed without the predominance of particular species (Sanjaya & Dibiyantoro, 2012).

The number of arthropod individuals varied among observation periods, indicating temporal fluctuations in arthropod abundance during the study period (Figure 5).

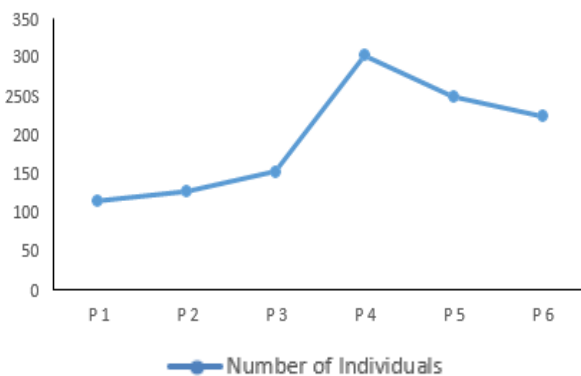


Figure 5. Graph of the Number of individuals found during observations

Arthropod diversity and abundance in raspberry plantations are influenced by both abiotic and biotic factors, which in agroecosystems are closely associated with cultivation practices (Untung, 2006). Temporal fluctuations in arthropod abundance were observed during the study period (Figure 5), with the highest population recorded during the fourth

sampling and a subsequent decline in later samplings. The increased arthropod abundance during the fourth sampling may be associated with the application of manure, which can enhance habitat suitability and food availability for certain arthropod groups. In contrast, the decline observed in the fifth sampling may be related to pesticide application in surrounding strawberry cultivation areas, which could indirectly affect arthropod populations within the raspberry plantation.

Competition occurs when different arthropod groups utilize the same energy resources, either within the same species (intraspecific) or between different species (interspecific). In this study, competitive interactions are indicated among fruit-feeding arthropods, particularly between the families Drosophilidae and Nitidulidae. This is supported by the observed decrease in Nitidulidae abundance concurrent with an increase in Drosophilidae populations at the observation site, suggesting resource competition. In contrast, mutualistic interactions involve reciprocal benefits between organisms at the same trophic level (Krebs, 2014).

Food availability plays an important role in shaping arthropod diversity in raspberry agroecosystems. Raspberry plants at six months of age that have entered the flowering and fruiting stages provide sufficient resources for herbivorous arthropods. Unharvested ripe fruits may serve as food sources for fruit-feeding arthropods such as fruit flies (Diptera: Drosophilidae) and sap beetles (Coleoptera: Nitidulidae). In addition, the uniform age of raspberry plants results in relatively homogeneous resource availability, which likely contributes to the even distribution of arthropod species within the planting area.

Table 1. The Value of The Arthropod Diversity Index in Raspberry Plants

Ordo	Family	Genus	Amount	Diversity Index (H')	Category (H')	
Araneae	Araneidae	Ms 1	8	0,0341	Low	
		Ms 2	18	0,0642	Low	
		Ms 3	2	0,0109	Low	
	Oxyopidae	Ms 1	1	0,0060	Low	
		Salticidae	Ms 1	2	0,0109	Low
		Thomisidae	Ms 1	1	0,0060	Low
Coleoptera	Byrrhidae	Ms 1	6	0,0270	Low	
	Byturidae	Byturus	2	0,0109	Low	
	Chrysomelidae	Ms 1	2	0,0109	Low	
	Coccinellidae	Ms 1	2	0,0109	Low	
	Nitidulidae	Carphophilus	14	0,0530	Low	
	Scarabaeidae	Gnorimus	2	0,0109	Low	
	Staphylinidae	Ilyobates	11	0,0439	Low	
	Diptera	Ceratopogonidae	Ms 1	4	0,0194	Low
		Chironomidae	Ms 1	2	0,0109	Low
		Chloropidae	Pseudogaura	35	0,1050	Low
		x				
Dolichopodidae		Medetera	6	0,0270	Low	
Drosophilidae		Ms 1	68	0,1654	Low	
		Ms 2	33	0,1006	Low	
Fannidae		Fannia	55	0,1437	Low	
Muscidae		Musca	85	0,1905	Low	
Psychodidae		Ms 1	234	0,3219	Low	
Scathophagidae		Ms 1	11	0,0439	Low	
Scatopsidae		Ms 1	2	0,0109	Low	
Sciaridae		Sciara	139	0,2531	Low	
Tipulidae		Nephrotoma	6	0,0270	Low	
Entomobryomorpha	Entomobryidae	Ms 1	6	0,0270	Low	
Hemiptera	Aleyrodidae	Ms 1	136	0,2502	Low	
	Alydidae	Ms 1	4	0,0194	Low	
	Aphididae	Ms 1	51	0,1366	Low	
	Cicadellidae	Ms 1	30	0,0939	Low	
		Ms 2	13	0,0500	Low	
		Ms 3	2	0,0109	Low	
	Flatidae	Cryptobarsac	7	0,0306	Low	
	Membracidae	Ms 1	1	0,0060	Low	
	-	Ms 1	10	0,0407	Low	
	Hymenoptera	Aphelinidae	Ms 1	18	0,0642	Low
Braconidae		Ms 1	20	0,0696	Low	
Diapriidae		Ms 1	10	0,0407	Low	
figitidae		Ms 1	10	0,0407	Low	
Formicidae		Myrmicaria	19	0,0669	Low	
		Solenopsis	3	0,0153	Low	
Ichneumonidae		Ms 1	3	0,0153	Low	
	Ms 2	15	0,0559	Low		

Ordo	Family	Genus	Amount	Diversity Index (H')	Category (H')
		Ms 3	4	0,0194	Low
	Mymaridae	Ms 1	16	0,0587	Low
		Ms 2	2	0,0109	Low
	Pteromalidae	Ms 1	12	0,0470	Low
Mantodea	Mantidae	Ms 1	2	0,0109	Low
Polydesmida	Polydesmidae	Ms 1	4	0,0194	Low
Thysanopte	Thripidae	Ms 1	21	0,0722	Low
Total			1170	2,9913	Moderate

Information:	-	= unidentified
	Ms 1	= Morpho-species 1
	Ms 2	= Morpho-species 2
	Ms 3	= Morpho-species 3
Category:	H' < 1	= Low Diversity
	1 < H' > 3	= Moderate Diversity
	H' > 3	= High Diversity

Table 2. Index of Diversity, Evenness, and Dominance of Arthropods in Raspberry Crops

Degree Index	Value Analysis	Category	Scale
Diversity Index (H')	2,9913	Moderate	1 < H' > 3
Evenness Index (E)	0,75	High	E > 0,5
Dominance Index (C)	0,09	Low	C < 0,5

Category:	H' < 1	= Low Diversity
	1 < H' > 3	= Moderate Diversity
	H' > 3	= High Diversity
	E < 0,5	= Species are unevenly distributed
	E > 0,5	= Species evenly distributed
	C < 0,5	= No dominant species
	C > 0,5	= There are species that dominate

Vegetation surrounding raspberry plants also functions as refugia for arthropods. Several plant species found at the observation site, including flowering plants such as marigolds, broadleaf plants such as mint, and various wild plants, have the potential to serve as refugia (Horgan et al., 2016). Refugia plants act as microhabitats that provide shelter and support ecological interactions within agroecosystems (Keppel et al., 2011). In addition, these plants supply alternative food resources such as nectar and offer suitable sites for shelter and reproduction of predatory arthropods, parasitoids, and pollinators.

The application of manure and the absence of pesticide treatment on raspberry plants also contribute to arthropod diversity. Manure enhances soil organic matter and nutrient availability, providing food resources for decomposer arthropods (Rowen et al., 2019). An increase in decomposer populations may indirectly support higher trophic levels by supplying alternative prey for predatory arthropods present in the agroecosystem (Eyre et al., 2009).

In contrast, the decline in arthropod abundance observed during the fifth sampling is likely associated with pesticide application in adjacent crops. Pesticide exposure can disrupt ecological interactions such as predation and competition, leading to instability in arthropod communities (Sanchez-Bayo, 2021). Residual pesticide effects and pest displacement from nearby treated plants may also contribute to changes in community composition, as indicated by the increased abundance of Aleyrodidae (Hemiptera) in the sixth sampling. This family is known to have a broad host range, including tomato and strawberry plants cultivated around the observation site (Sani et al., 2020).

Arthropod Community Structure in Raspberry Plants

Arthropods found in raspberry plants during observations are grouped according to their functional roles, namely decomposers, herbivores, parasitoids, predators, and pollinators. The number of Arthropods by their role is presented in Figure 6. Decomposer

arthropods constituted the largest functional group (46.5%; 531 individuals), indicating that the detrital pathway plays a central role in this raspberry agroecosystem. Their dominance is likely driven by the continuous input of organic matter from manure application, plant residues, and fallen fruits, which enhance microbial activity and provide abundant resources for detritivores (Rowen et al., 2019). High environmental humidity (85%) may have further promoted decomposer survival and activity (Tantipantip et al., 2016). Moreover, the absence of pesticide application likely minimized disturbance to soil-surface arthropods (Sanchez-Bayo, 2021), allowing decomposer populations to remain stable.

The Shannon–Wiener index ($H' = 2.99$) reflects moderate to high diversity and is comparable to diversity levels reported in other horticultural systems such as strawberry and vegetable fields (Basir et al., 2017; Widiarta et al., 2006). This suggests that, despite being a relatively small-scale planting system, the raspberry field supports a structurally balanced arthropod community. The low abundance of pollinators may be associated with limited floral resource availability during the sampling period.

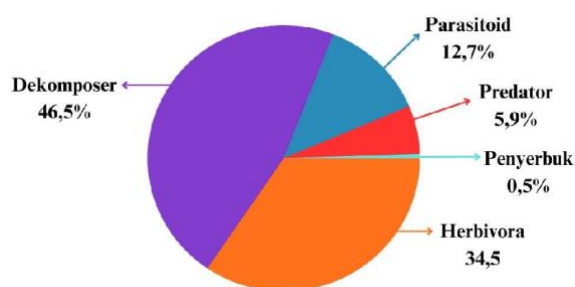


Figure 6. The role of arthropods found in raspberry plants.

The most commonly found decomposer arthropods belong to the family Psychodidae of the order Diptera with 234 individuals (Figure 7). Psychodidae flies or moth flies are characterized by tapered wings, very hairy and are found in moist and shady places (Borror et al., 2004). This is in accordance with the conditions of the observation land where there are many puddles and drainage channels. Adults lay their eggs in

a humid environment. The fly larvae then live by eating organic matter as well as decaying plants into pupae. After 5 days, the pupa of the fly will become an adult fly. Imago moth flies do not have good flight skills so many are found around their egg-laying sites (Akhoundi et al., 2022).



Figure 7. Moth fly, body length + 2 mm (Family Psychodidae).

Other decomposer arthropods found belong to the classes Diplopoda and Entognatha. The arthropods of the class Diplopoda found were identified as belonging to the Order Polydesmida, Family Polydesmidae (Figure 8). Polydesmida is an order of millipedes with a lateral flat body shape (Borror et al., 2004). Polydesmidae bodies consist of 18-20 segments, measuring more than 11 mm, and dorsal yellow, brown, or black (Arndt et al., 2008).



Figure 8. Millipede, body length + 13 cm (Order Polydesmidae).

Decomposer insects identified as the order Collembola belong to the Family Entomobryidae (Figure 9). Order Collembola or spring tail is a wingless insect that has a characteristic branched structure or funicle on the fourth abdominal segment used for jumping (Borror et al., 2004). The family Entomobryidae is composed of 64 genera and 1829 species so

that it becomes one of the families of the Order Collembola with many species groups.



Figure 9. Spring tail, body length + 3 mm (Family Entomobryidae).

Other arthropods found at the site are herbivorous arthropods. Some herbivorous arthropods found recorded as pests that commonly attack raspberry plants include fruit flies (Diptera: Drosophilidae), fruit beetles (Coleoptera: Byturidae), gum beetles (Coleoptera: Nitidulidae), thrips (Thysanoptera: Thripidae), aphids (Hemiptera: Aphididae) and whitefly (Hemiptera: Aleyrodidae). Whitefly (Hemiptera: Aleyrodidae) is the most abundant herbivorous arthropod found during observations with a total of 136 individuals (Figure 10). At the observation site no spider mites were found attacking raspberry plants. The absence of spider mites in raspberry plants is thought to be due to environmental factors that do not support the growth of mites. Spider mite populations increase in environments with high temperatures, low humidity, and dust (Pramudianto & Sari, 2016). This is due to faster mite reproduction times and the slow development of pathogenic fungi in dry and hot weather (Meena et al., 2013). Aleyrodidae included in the suborder Sternorrhyncha has the main characteristic of the front and rear wings having the same size and covered with white powder (Borror et al., 2004).

Aleyrodidae is a family of pests of concern because the species in it are important pests that cause high damage to plants. The host spectrum of Aleyrodidae is very broad, this pest can attack plants from various families such as cassava, tomatoes, cabbage, raspberries, and others (Sani et al., 2020). Whitefly damages plants by absorbing nutrients from the leaves. As a result,

the leaves will turn yellow and shrivel so that photosynthesis activity is inhibited. This pest also secretes excretions of honey liquid which is a medium for the growth of soot dew fungi (Soumia et al., 2020).



Figure 10. Whitefly, body length + 3 mm (Family Aleyrodidae).

The family Drosophilidae (Diptera) is the second most abundant herbivorous arthropod found during observations after the whitefly. Flies of Drosophilidae, also called small fruit flies, have a yellowish color and are easily found around decaying plants and fruits (Figure 11). In the observed raspberry plants found 2 morpho-species of the Family Drosophilidae. In morpho-species 1 there are spots on the wings (Figure 11A), while in morpho-species 2 the wings are not patterned (Figure 11B).

The Drosophilidae family is reported to be the main pest on raspberry plants, one of which is the species *Drosophila suzukii*. *D. suzukii* is also called Spotted Wings Drosophila because of its characteristic black spot wings on male flies. This fly is thought to originate from Asia but become an invasive pest in Europe and America. *D. suzukii* attacks on raspberry plants can cause losses of 2 to 100% (DiGiacomo et al., 2019).

The number of Drosophilidae flies found in raspberry plants is due to fruiting raspberry plants where flies lay their eggs. Drosophilidae flies will lay their eggs by piercing their ovipositor into the fruit then the larvae of the fly will grow inside the fruit until the fruit is damaged and rotted (Kirschbaum et al., 2020). Unharvested raspberries are also thought to cause

drosophilidae fly populations at the observation site to be high. *D. suzukii* flies not only lay their eggs on healthy fruit, but can also lay their eggs on damaged fruit or fruit that has fallen to the ground (Kienzle et al., 2020).

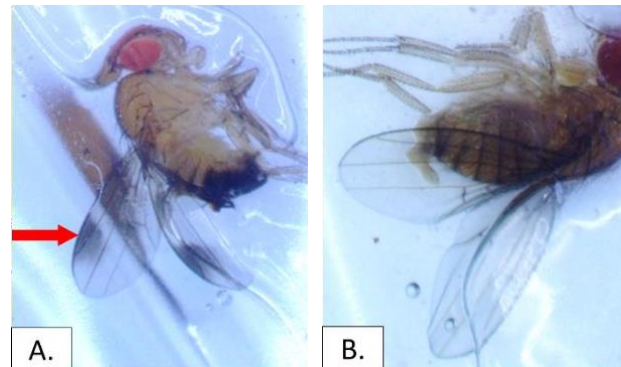


Figure 11. Family Drosophilidae. (A) morpho-species 1 (body length + 3 mm); (B) morpho-species 2 (body length + 3 mm)

Carnivorous arthropods found at the observation site consisted of 145 parasitoid individuals and 94 predatory individuals. Parasitoid arthropods are arthropods that grow and feed on the host to complete their life cycle (Gillung & Borkent, 2017). The parasitoid arthropods found consist of the Family Chloropidae belonging to the order Diptera, parasitoid wasps belonging to the Order Hymenoptera Family Braconidae, Ichneumonidae, and Mymaridae. Family Chloropidae, Genus *Pseudogaurax* is the most common genus and family of parasitoid arthropods.

Chloropidae or grass flies are a family of the Order Diptera which has striking yellow and black characteristics. Some species of Chloropidae are pests, especially in cereal crops. However, some species have been found to act as parasitoids (Barnes et al., 1992). One example of Chloropidae acting as parasitoids is the genus *Pseudogaurax* (Figure 12).

The genus *Pseudogaurax* is a genus in the family Chloropidae that acts as a parasitoid against insects and spiders. Gillung & Borkent (2017) explained that the genus *Pseudogaurax* is known to be parasitoid against various types of insects such as butterflies (Lepidoptera),

praying mantises (Mantodea), and ants (Hymenoptera: Formicidae), while spiders known to be hosts of *Pseudogaurax* include those from the families Araneidae, Nephilidae, Tetragnathidae, and Theridiidae. Praying mantis (Mantodea) and spiders of the Family Araneidae were also found on raspberry plants during observations.

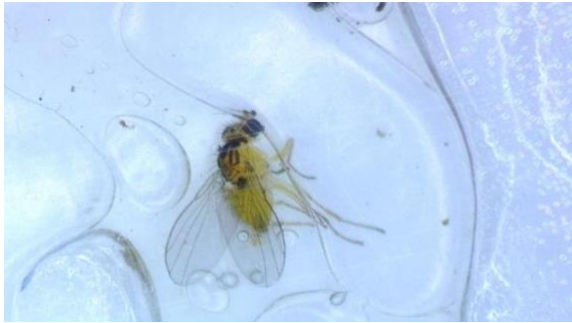


Figure 12. Family Chloropidae Genus *Pseudogaurax* (body length + 3 mm).

The order Araneae became the order of predatory arthropods most commonly found during observations. Spiders (Araneae) in agroecosystems have an important role as natural enemies of insect pests. Spiders have a wide prey target so many are dubbed as generalist predators (Dewi et al., 2019). Spiders are the most common predators allegedly because of the growing conditions of raspberries planted close together according to the spider's need to make nests and hide from high temperatures. Spider populations are generally abundant in environments with dense vegetation because it makes it easier for spiders to make nests and available food sources (Syafriansyah et al., 2016).

Spiders found in raspberry plants were identified as belonging to the families Araneidae, Oxyopidae, Salticidae, and Thomisidae. The family Araneidae is a type of web-making insects (web spiders), while Oxyopidae, Salticidae and Thomisidae are types of hunter spiders. The family Araneidae is the most common family with a total of 28 individuals. Araneidae or orb-web spiders are web-making spiders that are circular in shape. This family is a large family group and is spread almost all over the world (Borror et al., 2004). The family Araneidae has eight trapezoid-like eyes with lateral eyes that are spaced from

the median eye (Rajendra & Garima, 2021). This family is nocturnal and generally nests in places with minimal light exposure.

Individuals identified as Araneidae are regrouped into 3 morpho-species based on their morphology (Figure 13). Morpho-species 1 of Araneidae were found to have tubercles on opisthosoma with a greenish-yellow color (Figure 13A). Morpho-species 2 of the family araneidae has a more slender body with rounded opisthosoma with tubercles and greenish in color (Figure 13B). Morpho-species 3 of the family araneidae cephalothorax is red with greenish opisthosoma with rounded tubercles and pedipalps (Figure 13C).



Figure 13. Opisthosoma pattern of Family Araneidae. (A) morpho-species 1 (body length + 5 cm); (B) morpho-species 2 (body length + 2 cm); (C) morpho-species 3 (body length + 2 cm).

The group of pollinating arthropods became the least group with members only belonging to the Family Tipulidae. Tipulidae is the largest family in the Order Diptera with a total of 15,000 species worldwide and 1054 species in the Southeast Asian Region including Indonesia (Yule & Yong, 2004). The body of this family is elongated in shape and accompanied by long limbs. Individuals from Tipulidae obtained are from the genus *Nephrotoma* (Figure 14).



Figure 14. Family Tipulidae (body length + 1 cm).

The life cycle of Tipulidae consists of the egg, larva, pupa, and imago phases. Larvae of Tipulidae generally live in puddles or moist environments, but some larvae are found also living underground or decaying organic matter (Freeman, 1968). Imago of Tipulidae live only a few days to mate and lay eggs (Pritchard, 1983). However, some imago are known to feed on nectar and can act as pollinators (Singer, 2001; Tarigan et al., 2022). During observations, individuals from the Family Tipulidae are found occasionally and erratically. This is thought to occur due to the condition of raspberry plants that are not always in flowering conditions when the observation takes place.

CONCLUSIONS

The arthropod community in the raspberry plantation in Cisarua District, West Bandung Regency, was dominated by decomposers (Psychodidae), followed by herbivores (Aleyrodidae), parasitoids (Pseudogaurax; Chloropidae), predators (Araneidae), and pollinators (Tipulidae). The Shannon–Wiener index ($H' = 2.99$) indicated moderate to high diversity, accompanied by high evenness ($E = 0.75$) and low dominance ($C = 0.09$), demonstrating a balanced community structure without species overdominance.

Ecologically, these findings indicate that the raspberry agroecosystem in Cisarua maintains functional trophic interactions that support natural biological regulation. The coexistence of herbivores and their natural enemies suggest potential for intrinsic pest suppression, thereby

reducing reliance on chemical inputs. Overall, the diversity pattern reflects a relatively resilient system capable of sustaining ecological processes essential for long-term cultivation stability.

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