Research Article

Arthropod Insect Communities in Several Different Habitats

Komunitas Serangga Arthropoda Pada Beberapa Habitat Yang Berbeda

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Abstract: Interactions between biotic and abiotic components in ecosystems influence insect mortality, natality, and dispersal, thereby making species composition dynamic. The presence and abundance of arthropods in agricultural systems cannot be precisely predicted, as they are affected by numerous factors such as cropping practices, habitat type, plant age, and interspecific interactions among arthropods. This study aimed to examine the diversity, abundance, and community composition of arthropods across four agricultural habitat types: maize, soybean, weeds, and soil surface. Arthropod samples were collected through direct observation, sweep netting, and pitfall traps. The findings revealed that insects from the order Hemiptera had the highest abundance in comparison to other orders, with 51 individuals recorded on maize and 409 on soybean. In contrast, 244 insects were found on weeds, dominated by the order Diptera. On the soil surface, a total of 482 insects were collected, predominantly from the order Collembola. The Collembola order exhibited the lowest values in terms of relative diversity index (H'), dominance (D), and evenness (E) compared to other habitats. The Bray–Curtis similarity index between soybean and weed habitats was the highest (0.205), indicating a greater similarity in arthropod composition between these two habitats. Conversely, the lowest similarity value (0.043) was observed between soybean and soil surface habitats, suggesting a greater difference in arthropod community composition.

Keywords: diversity, arthropods, agricultural habitats, pitfall trap, Bray–Curtis

Abstrak: Interaksi antara komponen biotik dan abiotik di ekosistem akan mempengaruhi mortalitas, natalitas, penyebaran serangga pada ekosistem, sehingga komposisi spesies selalu dinamis Keberadaan suatu artropoda pada suatu pertanaman budidaya tidak dapat dipastikan berapa jumlahnya karena banyak faktor yang dapat mempengaruhinya salah satunya adalah habitat. Penelitian ini bertujuan untuk mengkaji keanekaragaman dan komposisi komunitas arthropoda pada empat tipe habitat pertanian, yaitu tanaman jagung, kedelai, gulma, dan permukaan tanah. Sampel arthropoda dikumpulkan melalui pengamatan langsung, jaring serangga (sweep net), dan perangkap jebak (pitfall trap). Hasil penelitian menunjukkan serangga pada ordo hemiptera memiliki kelimpahan terbesar dibandingkan dengan ordo lain, yakni pada tanaman jagung terdapat 51 ekor, begitu pula pada tanaman kedelai terdapat 409 ekor serangga. Adapun pada gulma, serangga yang ditemukan berjumlah 244 ekor dengan kelimpahan terbesar berada pada ordo diptera, sedangkan pada permukaan tanah, jumlah serangga yang temukan sebanyak 482 ekor serangga dengan kelimpahan terbesar berada pada kelas Collembola. Collembola memiliki nilai indeks keragaman relatif (H'), dominansi (D) dan indeks kemerataan (E) paling rendah dibandingkan dengan habitat lainnya. Nilai indeks kemiripan tanaman kedelai dengan gulma lebih tinggi dibandingkan dengan habitat lainnya dengan nilai mencapai 0,205, sementara yang paling rendah adalah habitat tanaman kedelai dengan permukaan tanah dengan nilai hanya mencapai 0,043.

Kata kunci: diversitas, arthropoda, habitat serangga, pitfall trap, Bray–Curtis

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INTRODUCTION

The structure of insect communities within ecosystems is constantly changing, as are the components associated with food webs. Interactions between biotic and abiotic components within an ecosystem influence insect mortality, natality, and distribution, thereby rendering species composition inherently dynamic. Human intervention in agricultural systems, if not conducted appropriately, can lead to serious problems. In many cases, the use of pesticides intended to reduce production losses has resulted in undesirable environmental changes (Altieri & Nicholls, 2004). According to Gurr et al. (2017), the diversity of arthropods including herbivores, predators, and parasitoids serves as an ecological indicator of agroecosystem stability. Such widespread application has led to a reduction in aboveground and soil-dwelling arthropod biodiversity, threatening ecosystem services such as pollination and biological control.

In intensive farming systems, particularly those involving short-cycle vegetable crops, community structure is often dominated by a few pest species, with a marked decline in natural enemy populations due to anthropogenic disturbances, especially excessive use of synthetic pesticides. Agricultural ecosystems, or agroecosystems, are inhabited by various interacting community groups, with arthropod communities dominating both in terms of species richness and abundance (Nasution, 2012). According to Altieri & Nicholls (2004), biodiversity in agroecosystems depends on four main characteristics: the diversity of vegetation surrounding the agroecosystem, the diversity of cultivated crops within the agroecosystem, land management intensity, and the degree of isolation of the agroecosystem from natural vegetation.

Hamid (2012) stated that plant diversity influences local herbivore diversity, which in turn shapes the diversity of parasitoids and predators at higher trophic levels. The presence and abundance of arthropods in cultivated crops are uncertain and influenced by various factors, including cultivation practices, plant age, and interactions among arthropods (Nasution, 2012).

MATERIALS AND METHODS

The tools used included: pitfall traps, plastic bags, shovels, plastic cups, labels, paintbrushes, forceps, pencils, sieving mesh, and stereo microscopes. The materials used consisted of soapy water solution and 70% alcohol. Insect sampling was conducted through direct observation of arthropods on the plant canopy, weed vegetation, and soil surface. Observations were carried out on four sampling plots, each consisting of a one-meter row of crop plants.

Observation of canopy-dwelling insects involved recording all arthropods present on the canopy parts of maize and soybean plants within each sampling unit. Observation of insects on weed vegetation was conducted using a sweep net, which was swung five times across the weedy area. Captured insects were collected and stored in plastic sample bags.

Observation of ground-surface insects was carried out by installing pitfall traps using plastic cups filled with a soapy water solution. Holes were made near maize and soybean plants to place the traps, which were left in place for 24 hours. On the following day, insects trapped in the pitfall traps were collected, stored in sample bags.

Data Analysis

The identified arthropods were tabulated into a database using a pivot table in Microsoft Excel 2013. The diversity of arthropods in each observation plot was analyzed using α-diversity indices such as the Shannon-Wiener diversity index (H'), Evenness index to assess species distribution (Magurran, 2004), Simpson's dominance index, and the Bray-Curtis similarity index to evaluate the resemblance between two observation plots. Additionally, species richness estimates across different habitats were calculated using the Chao1 estimator. Each of these indices was calculated using the following formulas:

Species Diversity Index

The species diversity index value was determined using the Shannon-Wiener formula, as follows:

$$H' = - \sum Pi \ln Pi$$
$$Pi = ni/N$$

Explanation:
E = Evenness value of a specie
H′ = Shannon-Wiener diversity index
S = Total number of species

The value of the Shannon-Wiener index typically ranges between 1.5 and 3.5 (Magurran, 2004). A higher H′ value indicates greater species diversity and higher ecosystem stability in a given location.

Evenness Index (E)

The Evenness Index (E) is used to determine how evenly individuals are distributed among species within a community.

$$E = H' / \ln S$$

E = Species evenness value
H′ = Shannon-Wiener diversity index
S = Total number of species

The Evenness Index reflects the degree to which species are evenly distributed within a habitat. Higher E values indicate a more even distribution of species across the community. The index ranges from 0 to 1 (Magurran, 2004).

Simpson Diversity Index (1/D)

$$D = \sum Pi^2$$

Pi = Proportion of individuals in species i
S = Total number of species
Dmax = Maximum number of species
The Simpson Index is expressed as either 1/D or (1 - D).
Equitability = (1-D) / Dmax

The Simpson Diversity Index is used to assess the complexity of a community and the species diversity within a population (Magurran, 2004). The value of this index ranges from 0 to 1, where values approaching 1 indicate a more complex community structure and higher species diversity.

Bray-Curtis Similarity Index

The similarity in insect species composition between two locations was calculated using the Bray-Curtis similarity index

C = Bray-Curtis similarity index
W = The sum of the lesser values for shared species in both habitats
A = Total number of individuals (or species) in habitat A
B = Total number of individuals (or species) in habitat B

The Bray-Curtis index ranges from 0 to 1. A value of 1 indicates that both habitats have identical species composition and abundance.

RESULTS AND DISCUSSION

Arthropod Abundance in Various Habitat Types

Based on the observational results, several insect orders were identified. In maize, a total of 51 insects were recorded, with the highest abundance belonging to the order Hemiptera. Similarly, in soybean, 409 insects were recorded, with Hemiptera being the most dominant order. In contrast, 244 insects were found in weed vegetation, with Diptera representing the most abundant order. Meanwhile, on the soil surface, a total of 482 insects were recorded, with Collembola constituting the dominant group. It should be noted that Collembola were identified only at the class level and were not further classified into orders (Table 1).

Table 1. Composition and Abundance of Arthropods on Maize, Weeds, Soybean, and Soil Surface

Ordo	Habitat			
	Corn	Soybean	Weed	Soil Surface
Coleoptera	4	13	5	6
Collembola*	3	0	6	426
Diptera	15	92	197	5
Hemiptera	19	177	3	6
Hymenoptera	6	89	24	33
Isoptera	0	0	0	1
Lepidoptera	3	2	1	0
Orthoptera	1	3	5	5
Thysanoptera	0	33	3	0
Total	51	409	244	482

*Specimens of Collembola were identified only at the class level, without further resolution to the order level.

According to a study by Afifah et al. (2015), insect species associated with soybean plants were recorded at 539 morphospecies, including 192 herbivores, 83 decomposers, 69 predators, 162 parasitoids, 1 pollinator, and 32 insects whose roles remain unidentified. Differences in arthropod composition across plant types are influenced by several factors, one of which is the routine application of pesticides in crop cultivation practices. The use of insecticides that are incompatible with parasitoid insects may lead to increased pest populations and the emergence of secondary pests in agroecosystems worldwide (Hendrival & Khalid, 2017).

Collembola are organisms commonly known to inhabit the soil and are classified as mesofauna due to their body size, which ranges from 0.25 mm to 8 mm. Globally, approximately 6,000 species from 500 genera have been described, whereas in Indonesia, around 250 species from 124 genera and 17 families have been identified (Warino et al., 2017).

Collembola showed the highest abundance among all orders of insect, reaching a total of 426 individuals (Figure 1). This high abundance is attributed to the favorable conditions of the sampling habitat, which support Collembola growth. This finding is consistent with the study by Warino et al. (2017), which reported a high number of genera found on soil disks in February 2014. The presence of slightly moist grass vegetation likely created a suitable ecosystem for nine genera from two families, namely Entomobryidae and Isotomidae. Warino et al. (2017) also observed variations in species diversity and individual abundance across different habitats, such as soil surface, litter, and soil layers.

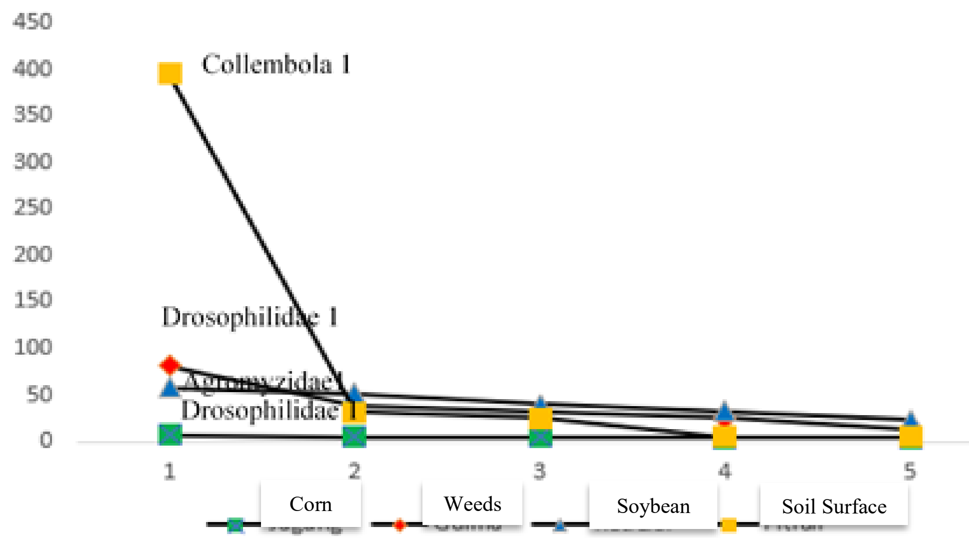

Figure 1. Rank Abundance of Arthropods Across Different Habitats

Moreover, Collembola abundance is influenced by the humidity level of the sampling habitat. Warino et al. (2017) stated that moisture plays a critical role in determining the distribution pattern of Collembola. Similarly, Suhardjono et al. (2012) emphasized that soil moisture is a key factor affecting the spatial distribution of Collembola populations.

Natural enemies also play a critical role in suppressing pest insect populations in crop fields. These beneficial organisms can reduce the abundance of target pests. The presence of natural enemies can influence the population dynamics of herbivorous insects in soybean agroecosystems and help prevent their population growth from reaching economically damaging levels (Purwanta & Rauf, 2000; Hendrival & Khalid, 2017).

Effect of Habitat Type on Arthropod Diversity and Abundance

The diversity index (H′) in soybean plants was higher than in other habitats, reaching 3.113708, while the highest evenness index (E) was observed in maize at 0.9433365. The dominance index (D) was also higher in soybean compared to maize, weeds, and the soil surface, with a value of 0.9317735 (Table 2).

Collembola had the lowest values of relative diversity index (H′), dominance index (D), and evenness index (E) among all habitats. The diversity indices in maize, soybean, and weed habitats were still classified as high, with values ranging from 1 to 3. In contrast, the soil surface habitat was considered low because its value was below 1. Similarly, the evenness index in maize, soybean, and weed habitats was categorized as relatively even (E > 0.6), whereas the soil surface showed low evenness (E < 0.6) (Table 2).

Table 2. Values of Relative Diversity Index (H′), Dominance Index (D), and Evenness Index (E) in Maize, Weed, Soybean, and Soil Surface Habitats

Habitat	H′	E	D
Corn	2,672673	0,9433365	0,922722
Weeds	2,304723	0,6776209	0,8306907
Soybean	3,113708	0,7919242	0,9317735
Soil Surface	0,806951	0,2979823	0,3177373

This pattern is influenced by several factors, including the use of insecticides. Indriyati & Wibowo (2008) found that the application of chlorpyrifos insecticide reduced species diversity, species richness, and individual evenness within Collembola families. A similar effect was observed in spiders, especially those from the Linyphiidae family, although their diversity remained relatively unchanged. The reduction in Collembola diversity due to pesticide application aligns with a meta-analysis that reported significant impacts on their mortality and ecological function (Gunstone *et al.*, 2021). Mahendra *et al.* (2023), which reported that the diversity index (H′) in Integrated Pest Management (IPM) fields was higher than in conventional systems. Although the diversity and evenness index values fell within the moderate-to-high range, both were generally better in IPM fields.

Index values are also affected by pollution within a habitat. According to Kafrianto et al. (2018), ecological responses to pollution or other disturbances usually include reductions in taxonomic richness and abundance, as well as shifts in taxonomic composition from sensitive to tolerant taxa. Kafrianto et al. (2018), stated that the diversity index (H′) is significantly influenced by the number of families and population sizes. A large number of species concentrated within a single family results in lower diversity compared to fewer species spread across multiple families. The importance of habitat diversification, such as intercropping or maintaining vegetative field margins, plays a critical role in supporting arthropod communities and enhancing diversity indices (Campera *et al.*, 2024; Tsuruda *et al.*, 2025).

A higher evenness index (E) indicates a healthier ecosystem, while a lower E value reflects a more disturbed or unbalanced condition. The same applies to the diversity index (H′)—a higher H′ suggests a more diverse arthropod community and implies greater habitat stability. Species dominance (D) also determines the diversity of arthropods within a habitat. According to Ojijia (2016), the dominance index (D) reflects the abundance of individuals in a specific habitat. Thus, greater diversity is often associated with higher dominance values, indicating the ecological significance of those individuals within the habitat. Oka (1995) noted that in plant communities with high diversity, no single species becomes dominant; conversely, in communities with low diversity, one or two species may dominate the entire system.

Composition of Similarity, Estimation, and Dominance of Arthropods Across Different Habitats

The similarity index between the soybean and weed habitats was higher than that of other habitat combinations, reaching a value of 0.205. This was followed by the maize and weed habitats, which had a similarity index of 0.183. The lowest similarity index was observed between the soybean and soil surface habitats, with a value of only 0.043 (Table 3).

Table 3. Bray-Curtis Similarity Index of Arthropods Across Different Habitats

Habitat	Corn	Weeds	Soybean	Soil Suface
Corn	1			
Weeds	0.183	1		
Soybean	0.139	0.205	1	
Soil Surface	0.068	0.050	0.043	1

These results indicate that habitat similarity influences the degree of species overlap among arthropods encountered in each habitat. The higher the similarity index value (approaching 1), the more similar the habitats are in terms of arthropod species composition. Conversely, a lower index value indicates substantial differences between habitats, resulting in a distinct arthropod assemblage in each environment.

Arthropod Species Estimation Across Habitats

Species estimation was conducted to predict the potential number of arthropod species within each habitat (Table 4). Based on the calculations, the estimated species richness in the soil surface habitat was higher than in the other habitats, reaching 82% based on the Chao1 index and 87% based on the Chao2 index. In contrast, the weed habitat showed a considerable discrepancy between the two estimators, with 73% in Chao1 and only 47% in Chao 2. These results suggest that the total number of species alone does not necessarily determine the quality of a habitat. A more important factor is the evenness of species distribution. Although the species estimation values in the soybean habitat were relatively lower, the evenness index was higher than that of the soil surface habitat, indicating a more balanced and potentially more stable community structure.

Table 4. Percentage of Estimated Arthropod Species in Different Habitats

Habitat	Chao1	Chao2
Corn	78	81
Weed	73	47
Soybean	71	70
Soil Surface	82	87

CONCLUSIONS

A total of 51 insect individuals were recorded in maize, with the highest abundance observed in the order Hemiptera. Similarly, in soybean, 409 insect individuals were recorded, also dominated by Hemiptera. In the weed habitat, 244 insects were found, with Diptera representing the most abundant order. Meanwhile, on the soil surface, 482 insects were recorded, with Collembola as the dominant group. Among the habitats studied, Collembola exhibited the lowest values for the relative diversity index (H′), dominance index (D), and evenness index (E). The Bray–Curtis similarity index revealed a higher similarity between the soybean and weed habitats (0.205) compared to other habitat pairs. In contrast, the lowest similarity was observed between the soybean and soil surface habitats, with a value of only 0.043.

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