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The diversity of aerial insect in coffee agroforestry, Dampit and Purwodadi district East Java Indonesia

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Abstract. Coffee is one of the export commodities in Indonesia. East Java is one of the largest Coffee supplies with land that is widely spread, such as in Malang and Pasuruan Regencies. The agroforestry system is applied in coffee cultivation, the system has different management from plantations for example the use of shade trees which will affect the structure of aerial insect diversity. Aerial insects play an important role in maintaining the balance of the ecosystem. The research objective was to determine the diversity and dominance of aerial insects in coffee agroforestry in East Java. The research method is exploratory, taking aerial insects using a yellow pan trap. The abiotic factors observed were light intensity, wind speed, temperature and humidity, and data analysis with past 4.03 program. The results of the study found 407 individuals in Dampit coffee agroforestry and 470 individuals in Purwodadi coffee agroforestry. The diversity and dominance index values were found to be the highest in Dampit coffee agroforestry. From the results of the analysis of abiotic factors, it is found that temperature and humidity in Dampit coffee agroforestry have higher values while wind speed and sunlight intensity of Purwodadi coffee agroforestry have higher values. The differences in the number and types of insects as well as the differences in the diversity and dominance index obtained, explained that the two study sites had differences in abiotic factors and shade trees.

1. Introduction

Diversity is a term that describes the richness of various life forms on earth. One of the largest types of diversity that exists is insect diversity. Insects have the ability to respond to environmental changes that cause variations in a population, namely interactions between species [1]. Insect diversity is influenced by the balance of natural ecosystems. Various types of insects have different roles in the food chain, namely as herbivores, carnivores, and also as decomposers of organic waste [2]. Insects have many roles that make insects sensitive and easily affected by ecosystem changes caused by human activities and natural factors. Insects have a role in the process of herbivory, predation, pollination and support the cycle of material transformation in an ecosystem. Thus, soil fertility will be maintained, increasing the productivity of cultivated plants. Therefore, the performance of a healthy community is strongly supported by insect sustainability [3]. Each insect has its own role in an ecosystem, including aerial insects [4].

Aerial insects are flying insects equipped with wings, which generally live on trees as a place to perch, search for food and reproduce [5]. Aerial insects are some insects that can survive on land and have wings that are used to fly. However, not all insects with wings can be said to be aerial insects.

These aerial insects have many roles for plants, namely as herbivores (plant eaters) with the most members, parasitic insects or insects that live as other insects, pollinator insects (pollinators), disease vector insects (transmitters of certain disease seeds), and predatory insects (predators of other insects) [6].

Coffee is one of the export commodities in Indonesia. East Java as one of the largest coffee supplying with land that is widely spread, such as in Malang and Pasuruan Regencies. Based on BPS East Java 2021, Malang Regency is the coffee producing area with the largest harvest in East Java, namely 13,127 tons, not far for it Pasuruan Regency as the coffee producer with the 6th largest harvest, namely 3,755 tons. Cultivating coffee plants requires shade plants which function to reduce sunlight which has an impact on the survival of coffee trees [7].

Apart from that, shade plants also function to maintain soil moisture [8]. In the cultivation of coffee plants planted together with various types of plants, especially trees, is a characteristic of coffee agroforestry [7]. Coffee agroforestry is divided into two forms, namely simple and complex, the difference lies in the number of shade trees.

This research was conducted in the coffee agroforestry of Malang and Pasuruan Regencies, where there are differences in location, height and type of shade to compare the condition of simple coffee agroforestry ecosystems and complex coffee agroforestry, in terms of aerial insects and abiotic factors in the ecosystem, so that the community structure of a Habitat can be understood through insect diversity. This is in accordance that diversity will decrease with increasing disturbance, so insect diversity can be used to monitor habitat changes [9].

2. Methods

2.1. Time and study location

Agroforestry has 2 types of profiles, complex agroforestry, simple agroforestry. Complex agroforestry is the management of planting a combination of forest/woody tree species with field crops to create agroforestry vegetation similar to forests with complex plant layers [10]. Simple agroforestry is a pattern of intercropping with more than one type of plant species, planted as a live fence and random planting in the field [11].

Table 1. Location differences in shade trees for each land

Simple Dampit / 80°19’ 33.00” BT dan 112049’ 7.50” LS	Complex Dampit / 80°19’ 52.51” BT dan 112°049’ 25.18” LS	Simple Purwodadi / 07°46.6'52" N and 112°38.4'59" E	Complex Purwodadi / 07°79.2'40.8" N and 112°64.7'84.9" E
Leucaena sp, *Calliandra* sp, *Litsea* sp, *Musa* sp, *Cocos* sp.	*Calliandra* sp, *Albizia* sp, *Syzigium* sp, *Artocarpus* sp, *Persea* sp, *Moringa* sp, *Erythrina* sp, *Litsea* sp, *Musa* sp.	*Leucaena* sp.	*Paraserianthes falcataria, Musa* sp, *Hibiscus tiliaceus, Durio zibethinus, Persea* sp, *Syzgium* sp.

The research took place for three months at each location, namely in August-October 2022 in complex coffee agroforestry and simple coffee agroforestry in Srimulyo Village, Dampit District, Malang Regency, and in December 2022 - February 2023 in simple and complex coffee agroforestry in Tambaksari Village Purwodadi District, Pasuruan Regency. Insect identification was carried out in the Optical Laboratory and Ecology Laboratory in the Biology Study Program, Faculty of Science and Technology, Maulana Malik Ibrahim State Islamic University, Malang.

2.2. Procedures

Sample collection in the study used yellow pan traps, where the traps would be installed in the morning at around 08.00-09.00 WIB, and placed at each predetermined plot point. The yellow pan trap will be left for a period of 1X24 hours with three repetitions (Figure 1).

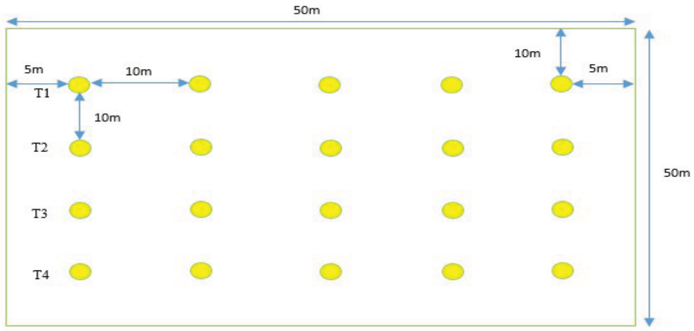

Figure 1. Data collection model insect aerial sampling

Yellow pan traps can easily attract insects, because insects are attracted to bright colors. The yellow pan trap will be filled using a solution of water and 70% alcohol and the solution will be filled to three-quarters of the height of the yellow pan trap. The trapped insects are put into vials filled with 70% alcohol, for further identification in the laboratory.

2.3. Data analysis
Raw data from the research results will be collected into one using Microsoft Excel 2010. Furthermore, the Shannon Wienner diversity index (H'), Simpson's dominance index (C), Sorensen's evenness index (Cs), and Pearson's correlation equation (r) will be analyzed using the past 2020 version 4.05 program.

3. Result and discussion
Based on the research that has been carried out, the results of the aerial insects found in these two areas are:

Ordo	Famili	Genus	Jumlah
Coleoptera	Nitidulidae	*Stelidota*	2
	Cantharidae	*Rhagonycha*	2
	Staphylinidae	*Atheta*	3
	Elateridae	*Athous*	15
	Curculionidae	*Hypothenemus*	217
		Dendroctonus	10
	Chrysomelidae	*Platypria*	2
	Cerambycidae	*Phytoecia*	1
	Cicindelidae	*Neocollyris*	1
	Coccinellidae	*Coccinella*	1
		Henosepilachna	5
	Haliplidae	*Peltodytes*	21
	Laemophoeidae	*Cryptolestes*	11
	Scarabaeidea	*Dichelonyx*	16
		Maladera	12
	Staphylinidae	*Bledius*	1
		Lithocharis	2
		Tachyporus	1
Diptera	Micropezidae	*Taeniaptera*	4
	Sciaridae	*Bradysia*	59
	Lauxaniidae	*Poecilolycia*	11
	Anisopodidae	*Sylvicola*	14
	Chloropidae	*Lasiambia*	34
	Asilidae	*Ommatius*	2
	Calliphoridae	*Calliphora*	1
	Dolichopodidae	*Amblypsilopus*	17
	Ceratopogonidae	*Forcipomyia*	1
	Muscidae	*Musca*	3
	Stratiomyidae	*Hermetia*	1
	Syrphidae	*Melanostoma*	1

Hemiptera	Aphididae	*Sitobion*	12
	Calophyidae	*Calophya*	252
	Cicadellidae	*Bothrogonia*	1
		Penthimia	7
		Osbornellus	7
		Paraphlepsius	4
	Pentatomidea	*Clastoptera*	52
	Tingidae	*Flatormenis*	1
	Clastopteridae	*Andrallus*	5
	Flatidae	*Dulinius*	1
	Aradidae	*Aradus*	1
	Membracidae	*Leptocentrus*	1
Hymenoptera	Chrysididae	*Chrysis*	3
		Passaloecus	1
	Inchnemonidae	*Leptobatopsis*	1
	Formicidae	*Solenopsis*	4
		Lasius	15
		Hypoponera	11
		Prenolepsis	1
		Tetramorium	4
	Dryinidae	*Dryinus*	10
	Diapriidae	*Belyta*	12
	Braconidae	*Cotesia*	2
		Meteorus	4
	Pompilidae	*Auplopus*	3
	Bibionidae	*Plecia*	3
	Crabronidae	*Trypoxylon*	1
	Eucharitidae	*Stilbula*	1
	Scoliidae	*Scolia*	1
Psocoptera	Peripsocidae	*Peripsocus*	1

Table 2. The Family of Aerial Insect Found

So, based on the aerial insect specimens found, the Shannon Wienner diversity index (H'), Simpson dominance index (C) and Sorensen similarity index (Cs) were calculated with the following results (Table 3).

Table 3. Index diversity in coffee agroforestry

Variable	Dampit Agroforestry		Pasuruan Agroforestry	
	Simple	Complex	Simple	Complex
Total Individu	267	140	291	179
Total Ordo	4	4	6	6
Total Family	17	14	25	22
Total Genus	18	16	30	27
Diversity Index (H')	1,28	**2,52**	1,74	**2,23**
T value for diversity Index	1,137		0,00087925	
Dominance Index	0,48	0, 10	0,38	0,22
T value for dominance index	6,85		0,00014701	
Similarity Index of two fields	0,65		0,67	

Based on the table, the diversity index for coffee agroforestry has a value> 1 where the value indicates a medium category. complex coffee agroforestry diversity index has a higher value than simple agroforestry [12]. High or low the value of the diversity index shows the complexity in an ecosystem.

Based on [13], the Shannon-Wiener diversity index with a value of 1<H'<3 indicates the medium diversity category. The diversity index is used to measure the variety or variety of species in a community in an area or environment, which means that the ecosystem in the two areas is still quite balanced. The higher the diversity index, the higher the balance of the ecosystem. According to [14] a diversity index value in the medium category means that the ecosystem is quite balanced with various moderate ecological pressures.

The differences in diversity index values between Simple and Complex Coffee Agroforestry were further tested using the Diversity t-test which was used to ensure whether there were statistically significant differences or not. Based on [15] diversity index, the p-value can provide information about the significance of species diversity between different environments or regions. If the p-value is small (less than 0.05), then the null hypothesis can be rejected and it can be concluded that there is a significant difference in species diversity between the two environments or regions being compared and vice versa.

As for the dominance index value obtained, it shows the highest value in simple coffee agroforestry. The dominance index measures how much a variable contributes to the total variation in the data. In statistics, the dominance index is generally used to understand the relationship between two variables [16]. The higher the dominance index value, the greater the contribution of a particular species to the total abundance of insects in a particular ecosystem or location.

The dominance index value has an inverse comparison value with the diversity index value, the lower the dominance index value, the higher the diversity index value [17]. This is in accordance with the results obtained, where the number of genera found in Simple Agroforestry is more than in Complex Agroforestry, but the diversity index value is higher in Complex Agroforestry than in Simple Agroforestry, and the dominance index value is also proven to be lower in Complex Agroforestry than in Simple Agroforestry.

The differences in the number and types of insects obtained as well as the differences in the values of the diversity index and dominance index obtained can mean that the two research sites have differences in terms of abiotic environmental factors and the types of shade trees found. This is in accordance with [18] statement that insect life is generally associated with plants, because plants are a source of food, shelter and habitat. Each type of plant has a different attraction to insects. Insects can live in water, soil and plants

There are results of observations of environmental abiotic factors at the two research land locations in (table 4) below:

Table 4. Abiotic factor of coffee agroforestry

Variable	Dampit Agroforestry		Pasuruan Agroforestry	
	Simple	**Complex**	**Simple**	**Complex**
Temperature (°C)	28,52	28,06	27,72	26,02
Wind Speed (m/s)	0,62	0,50	0,69	0,76
Light Intensity (lux)	386,89	372,56	613,93	392,83
Air Humidity (%)	85,6	86,8	75,6	78,1

Based on the environmental abiotic factors that have been observed, each of them has a role in the existence and diversity of aerial insects. According to [16] increasing temperature will cause insects to become abundant, because it increases appetite and growth so that generations grow faster. Stating that insects have different temperature responses where the optimal temperature of aerial insects ranges from 23°C-33° C, where this value can maximize the development of aerial insects, whereas when the air temperature is more than 35° C it can result in reduced diversity of aerial insects and vulnerable air temperatures of more than 45°C will result in death of aerial insects [17].

Apart from that, wind speed also has a significant role in the presence of aerial insects, namely in their mobilization and distribution. Based on [18], wind speed has an influence on the abundance of aerial insects, where changes in wind speed every year show significant changes in the abundance of aerial insects. The percentage value of air humidity in this case also determines the abundance of aerial insects found. [19] Stated that high temperatures and low humidity are detrimental to the survival of flying insects, in such circumstances flying insects such as flies will look for better conditions, namely higher humidity and lower temperatures. This is different from light intensity, where light intensity plays a role in insect metabolism. This is in accordance with the statement by

[20] Stated that insects need light to increase body temperature and speed up metabolism so that larval development becomes faster.

4. Conclusion

In conclusion, based on the research that has been carried out, it was concluded that the diversity index value is in the medium category with a value range between 2.52-1.28, while the highest diversity index value is found in the Dampit complex coffee agroforestry with an H' value of 2.52. The highest number of individuals obtained came from the Purwodadi coffee Agroforestry with a total of 470 individuals consisting of 291 individuals on simple land and 179 individuals on complex land. Differences in the number of individuals and diversity index values are influenced by the abiotic factors of their respective environments, which consist of environmental air temperature, humidity, environmental light intensity, and wind speed.

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