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Research Article

Study of Oribatids population on three types of land use at PT Nusantara VIII Plantation, Cisarua Sub-district, Bogor, West Java

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Abstract: Most of the forest area of PT Perkebunan Nusantara VIII have been converted to the plantation (tea, cacao, coffee) and agriculture, such as crops (intercropping of oranges and pineapple) areas. The forest conversion will affect soil biodiversity, which will reduce soil mesofauna population, such as the Oribatids group. Oribatids is one of the soil mesofauna which has a very important role in the soil as a decomposer. Because of its important role and their huge numbers in the soil, Oribatids can be used as a bioindicator of soil fertility. This study aimed to elucidate the abundance and diversity of Oribatids and the relationship between soil properties and population of Oribatids in three types of land use at PT Perkebunan Nusantara VIII. Soil and litter samples were taken in three different types of land use (tea gardens, intercropping, and secondary forests) using a simple random sampling method with a distance of each of the 15 sampling points of 100 m at a soil depth of 0-5 cm. Soil and litter samples were extracted using Berlese Funnel Heat Extractor. Oribatids identification was carried out until the family level, and the Oribatids diversity index were determined according to Shannon's diversity index. The identification results obtained in the three types of land use amounted to 24 families from 172 families found previously. The highest abundance of Oribatids was found in secondary forests both in the soil and litter layer (169.85 and 428.87 individuals/m², respectively), the lowest abundance of Oribatids was found in intercropping both in the soil and litter layer (89.17 and 229.30 individuals/m², respectively). According to Shannon Wiener (H'), the diversity index value ranges from 1.48-1.85 or it was categorized as a low-medium diversity value. The results of this study indicated that there was a positive correlation coefficient value from several families of Oribatids with soil pH, organic C, total N, C/N ratio, water content, and soil temperature.

Keywords: *bioindicator, decomposer, Oribatids, type of land use*

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Introduction

Environmental changes, especially the system of land use or management will quickly change the condition of the soil structure and functions of soil biota whose life depends on the carrying capacity of the soil. The Land is one component that can support the function of an ecosystem, capable of supporting plant growth and productivity, biologically able to maintain environmental quality (Doran and Safley, 1997). Soils have very high biological diversity, and soil organisms are important factors that will be influenced by the soil as their habitat (Havlicek, 2012).

Some of the land in PT Perkebunan Nusantara VIII has undergone land conversion from forests to non-forest areas such as plantations, agriculture, settlements, and tourist attractions. The changes in land use can affect soil environmental conditions, including biological diversity. One of the soil organisms that were affected by the changes was Oribatids. In addition to changes in forest conditions, there are also environmental factors that can reduce the population of Oribatids such as rainfall, soil conditions (soil pH, water content, soil temperature, organic carbon and, soil nitrogen). Changes in soil structure affect the presence and density of Oribatids populations. Oribatids in soil with high organic matter content will keep the nutrient cycle process going on continuously. Oribatids abundance and diversity are lower in disturbed areas than undisturbed areas.

Oribatids is a very small soil mesofauna, having a major role as a decomposer by eating organic matter and fungi, eating moss either dead or living (Maraun et al., 2011). Oribatids is often found on the surface of the soil or in the litter. Gergocs et al. (2011) reported that the Oribatids microhabitat could be found in soil, litter, moss, underwood, leaves, and waters. Environmental differences in soils differences support in the type and amount of organisms living in the soil. Differences in vegetation can make different qualities and the ability to store carbon energy and nutrients. This affects biological activity in the soil. Differences in ecosystems and land use allow for differences in diversity and Oribatids populations. Based on these problems, it is necessary to research to determine Oribatids abundance and diversity in three types of land use, namely tea plantation, intercropping and secondary forest at PT Perkebunan Nusantara VIII, Cisarua District, Bogor, West Java. The research result can become information and become a consideration of soil biological aspect of sustainable land management.

Materials and Methods

The sampling of the soil and litter was carried out in three different types of land use at PT Perkebunan Nusantara VIII, Cisarua District, Bogor, West Java. Mesofauna extraction and identification was carried out in the Soil Biotechnology Laboratory, Department of Soil Science and Land Resources, Faculty of Agriculture, Bogor Agricultural University. Oribatids were collected from soil and litter in three different types of land use (tea gardens, intercropping, secondary forests), using a simple random sampling method with 15 sampling points taken at 100 m so that 90 samples were obtained (soil and litter separated). The sampling of soil at a depth of 0-5 cm, while the collection of soil samples for soil chemical analysis was carried out in composite. Soil and litter samples obtained were then extracted using a Heat Extractor tool, Oribatids which was obtained was then identified using a stereomicroscope to the family level with reference to Krantz and Walter (2009) and Balogh and Balogh (1990). Oribatids abundance and diversity was calculated using a formula of Meyer (1996):

$$N = \frac{IS}{A}$$

where:

IS	:	Mean number of individuals per sample
A	:	Paralon area (cm^2); Paralon area = r2π = (10 cm) 2 x 3.14 = 314 cm^2 = 0.0314 m^2
N	:	Number of individuals /m^2

The diversity index was calculated following Shannon diversity index (Magurran, 2004):

$$H' = -\sum_{i=1}^{s}\left[\left(\frac{(ni)}{(n)}\right)\ln\left(\frac{(ni)}{(n)}\right)\right]$$

where:

H '	:	Shannon's diversity index
This	:	Number of individual families of Oribatids in the sample
N	:	The total of number individuals in the sample

H's value ranges:

<1.5	:	low diversity
1.5-3.5	:	medium diversity
> 3.5	:	high diversity

Abundance analysis and Oribatids diversity were performed using Analysis of Variance (ANOVA), followed by the Duncan test at the level of 5% using SAS 9.1 software to see the differences in Oribatids population in different land types. In addition, correlation analysis for knowing the relationship between soil characteristics (soil pH, water content, C/N, soil temperature, organic C and total-N) with the Oribatids family was made using Pearson correlation.

Results and Discussion

The abundance of Oribatids in three types of land use

Oribatids abundance and diversity found at the study site at PT Perkebunan Nusantara VIII, Cisarua District, Bogor, West Java consisted of 24 families from 172 families previously found (Krantz and Walter, 2009). Environmental factors and the availability of food sources derived from litter decomposition can also affect Oribatids abundance and diversity. The highest abundance was found in the litter layer of 898.09 individuals/m^2 and the lowest abundance was found in the soil layer of 409.77 individuals/m^2 (Table 1). Sulistyorini (2018) also found the highest Oribatids abundance in the litter layer (1242.5 individuals/m^2) and the lowest abundance in the soil layer (450 individuals/m^2).

Table 1. Abundance Oribatids in three different types of land use

Land use type	**Soil**	**Litter**	**Total Family**
	Individual/m^2 ± STD		
Tea Gardens	150.74 ±15.16 b A	239.92 ±23.41 a B	184
Intercropping	89.17 ± 8.40 b B	229.30 ±21.71 a B	150
Secondary Forest	169.85 ±16.05 b A	428.87 ±45.07 a A	282
Total Population/m^2	409.77 b	898.09 a	
Number of families	13	21	

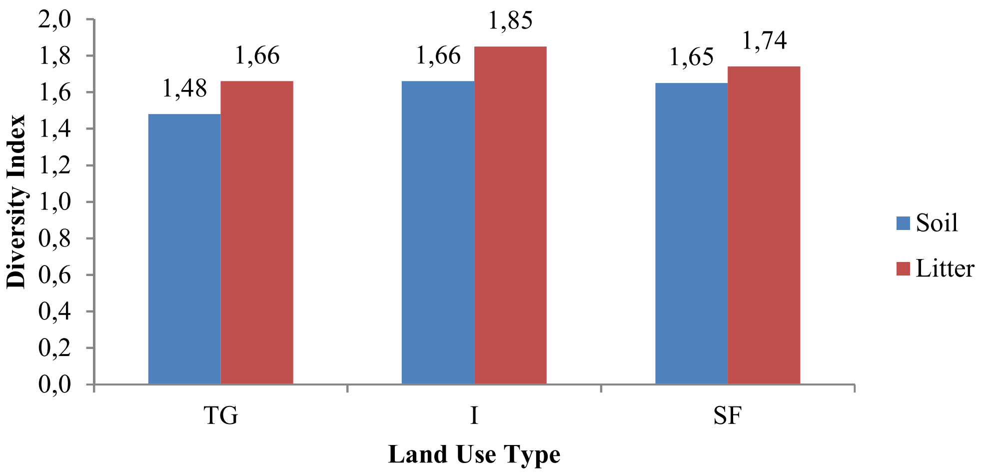
[a] Figures followed by lowercase letters according to the same line show results that are not different based on the DMRT test at the level of 5%; [a]Numbers followed by uppercase letters in the same column show different results based on DMRT test at 5% real level, out of 15 replications; STD = Standard deviation

Data in Table 1 show Oribatids abundance and diversity which varied based on land use types such as tea gardens, intercropping and secondary forests. The number of individuals and the number of different soil mesofauna families was, also caused by the type of organic material because the organic matter was an energy source for soil mesofauna. The total of Oribatids abundance in secondary forests was significantly different from the total amount of Oribatids abundance in tea gardens and intercropping. Oribatids abundance in secondary forest ecosystems has a value of 598.72 individuals/m^2. This means more Oribatids dominates in secondary forests than in intercropping and tea garden ecosystems. Each land use has different characteristics. In addition to land use and different characteristics, Oribatids abundance was also influenced by the type of vegetation that grows around it. Differences in vegetation, such as forests, organic farming, gardens, vegetable gardens, and tea gardens can cause differences in the diversity of Collembola (Agus, 2007).

Both of these ecosystems (tea gardens and intercropping) are managed intensively, such as planting, fertilizing, spraying, weeding and harvesting. This is also one of the factors causing Oribatids abundance and diversity to diminish, both in the soil layer and in the litter layer. The cultivation of agricultural land can reduce the population to an average of 25.000 individuals (Coleman et al., 2004). Secondary forest management and maintenance are not carried out intensively. According to Coleman et al. (2004), an abundance of Oribatids in natural ecosystems (forests) was very high, namely 50.000 individuals/m^2. Oribatids abundance in the litter layer was higher than in the soil layer. According to Lisafitri (2015), litter is a food source for soil mesofauna such as Oribatids. The high availability of food sources will certainly cause a high abundance of Oribatids. The thickness of litter also greatly influences its abundance and diversity. According to Fachrul (2012), environmental components affect the evenness of biota so that high evenness can indicate habitat quality. As one of the groups of organic material remodels, Oribatids also likes moist soils and enough organic matter for their survival.

Oribatids Diversity Index

The Shannon Index is a calculation for knowing Oribatids diversity. Figure 1 shows the difference in the Oribatids diversity index value in the soil layer and in the litter layer (tea plantation, intercropping and secondary forest). Among the three types of land use, the highest Oribatids diversity index value was found in intercropping ecosystems in both the soil layer and in the litter layer. Diversity index values obtained from three types of land use (soil layer and litter layer) were included in the low to moderate category because the values obtained are still in the interval of diversity values (<1.5) and (1.5-3.5) according to Magurran (2004). However, the mathematical quantitative value of the highest diversity is found in intercropping ecosystems compared to tea gardens and secondary forests. In intercropping ecosystems planted with three types of plants such as pineapple, oranges, and lemongrass. This was presumably because there was a particular family of Oribatids that was able to suppress other Oribatids families. Oribatids prefers habitats with high humidity. Low diversity index values were found in tea gardens. Wallwork (1976) states that monoculture farming will cause a decrease in the diversity of soil fauna in the soil. From the results of observations and identification in this study 24 families were found, of which 3 families were dominant or had the highest abundance in each soil layer and litter layer (Table 2). This was due to the availability of more organic materials, where organic material can provide a food source as well as an energy source for Oribatids to sustain its life. Mesoplophoridae has the highest abundance of 231 individuals/m^2, followed by Scheloribatidse with 162 individuals/m^2, and Oppiidae 75 individuals/m^2.



Description: TG (Tea Garden); I (Intercropping); SF (Secondary Forest)

Figure 1. Oribatids family diversity index value in three ecosystems in PT Perkebunan Nusantara VIII, Cisarua District, Bogor, West Java

The highest abundance of the mesoplophoridae family was found in secondary forests of 180 individuals/m^2. The high abundance of Mesoplophoridae, Scheloribatidse, and Oppiidae families will help the litter decomposition process because these families were grazing on litter and fungi. Many Oribatids species are found in various habitats, both forests, and grasslands. Forests in tropical or sub-tropical climates have a dense canopy and are a habitat that is beneficial to Oribatids so that it.

Table 2. Oribatids family's highest abundance in three types of land use

Family	Landuse type			Total
	TG	I	SF	
	Individuals/m^{-2}			
Mesoplophoridae	61	49	121	231
Scheloribatidse	34	51	77	162
Oppiidae	51	5	19	75

Description: TG (Tea Garden); I (Intercropping); SF (Secondary Forest)

Forest canopies have various microhabitats for Oribatids (Coleman et al., 2004). Oppiidae is one of the largest families in Oribatids and belongs to a family of many species of more than 1,000 species with 170 genera (Krantz and Walter, 2009). Oppiidae and Scheloribatidse are among the families most commonly found in various habitats Weigmen (2013).

The relationship between the chemical nature of the soil and the Oribatids population

Based on data from soil chemical analysis, soil pH in three types of land use varied with the value of each type of land use amounting to (5.10), (5.46) and (5.54) (Table 3) so that it was included in the acid soil category. Soil pH in secondary forests was lower because in secondary forests there were many decomposed litter which can produce organic acids which can cause lower soil pH. Organic C analysis results showed that the highest values were found in the ecosystem of tea gardens and intercropping, i.e. 5.44 and 5.28, respectively. In general, soil organic matter has an important role in the carbon cycle, nutrients and changes in soil pH (Wang et al., 2013). The results of the total N analysis have criteria of very low values of 0.5%. The highest C/N ratio was found in secondary forest ecosystems; meanwhile the highest value of water content and soil temperature was found in secondary forest ecosystems and tea gardens. The correlation coefficient is a measurement of covariance statistics between two variables. The test results showed a positive correlation between soil characteristics (C/N ratio, organic carbon, total-N, soil pH, soil temperature and water content) with the Oribatids family in the soil layer (Table 4). C/N is one indicator of soil fertility, the higher the C/N ratio, the higher the soil fertility rate (Folser 2002). The positive correlation value indicates a unidirectional relationship between the increase in the number of the Oribatids family and the increase in the C/N value. Nitrogen is a food source for Oribatids.

Table 3 Relationship between soil characteristics in soil layers (0-5 cm) in three types of land use

Land use type	Soil pH	Organic Carbon (%)	Total-N (%)	C/N ratio	Water Content (%)	Soil Temperature (^{0}C)
Tea Gardens	5.54	5.44	0.50	11.04	7.56	20.63
Intercropping	5.46	5.28	0.51	10.54	6.63	19.90
Secondary Forest	5.10	4.96	0.42	11.69	8.29	19.87

The results of the correlation test between soil characteristics (total-N) and the Oribatids family showed varied values. The abundance of Mesoplophoridae, Scheloribatidse, Eupthiracaridae, Protoplophoridae and Haplozetidae families is negatively correlated with total-N. The Protoribatidae family was positively correlated (very strong) with total-N. This means that both variables have a relationship, where, when total-N increases it will also be followed by an abundance and diversity of the Protoribatidae family. Based on the results of the test the correlation between soil characteristics (organic carbon) and the Oribatids family showed a positive correlation (very strong). According to the study of Wulandari et al. (2007), the higher the content of organic matter in the soil, the higher the number of species, the number of species, and the diversity index of soil mesofauna so that the level of soil organic carbon is an important indicator in determining the amount of soil mesofauna. Husamah (2015) also stated that the increase in organic carbon content in soil could significantly affect the increase in soil mesofauna population. The content of organic matter (organic carbon) in the soil can reflect the quality of the soil, so that the content of organic matter can be said to be very low if <2%, and low if >2%, organic matter content that ranges from 2-10% has a very important role.

Table 4. Analysis of the correlation between the abundance of the Oribatids family with several soil characteristics

No	Family	Soil Characteristics					
		C/N Ratio (%)	Organic Carbon (%)	Total- N (%)	Soil pH	Soil Temperature (^{o}C)	Water Content (%)
1	Mesoplophoridae	0.80	-0.99	-0.95	-1.00	-0.68	0.70
2	Scheloribatidse	0.86	-0.97	-0.98	-0.99	-0.60	0.77
3	Oppiidae	0.08	0.64	0.25	0.50	0.98	0.22
4	Protoribatidse	-0.77	0.99	0.94	0.99	0.71	-0.67
5	Tetracondylidae	0.25	0.50	0.08	0.35	0.93	0.39
6	Eupthiracaridae	0.99	-0.78	-0.97	-0.87	-0.22	0.96
7	Protoplophoridae	0.96	-0.50	-0.81	-0.63	0.15	0.99
8	Haplozetidae	0.84	-0.97	-0.97	-0.99	-0.62	0.76
9	Mycobatidae	-0.82	0.18	0.58	0.34	-0.47	-0.89
10	Eremobelbidae	0.07	-0.75	-0.41	-0.64	-0.99	-0.06
11	Lohmanidae	-0.82	0.18	0.58	0.34	-0.47	-0.89
12	Malaconothridae	0.07	-0.75	-0.41	-0.64	-0.99	0.06
13	Caloppiidae	-0.07	0.75	0.41	0.64	0.99	0.06

Description: 0 = no correlation between two variables; > 0-0.25 = moderate correlation; > 0.25-0.5 = strong correlation; > 0.75-0.99 = very strong correlation; 1 = perfect correlation (Sarwono, 2006)

Soil pH significantly affects the diversity and abundance of soil mesofauna (Adeduntan, 2009). Based on the results of the correlation test between the Oribatids family and soil pH, there was a significant correlation between the pH of the soil with the Oribatids family. The abundance of Mesoplophoridae, Scheloribatidse, Eupthiracaridae and Haplozetidae families has a negative correlation with soil pH, This means that every time the soil pH value increases, it was not always followed by the abundance of the Oribatids families. In this study, there was a range of soil pH that was in accordance with Oribatids living conditions, which was in the range of 5.10 to 5.44. According to Wallwork (1970), soil that has an acidic soil pH, it is estimated that the most prominent soil fauna population is the Acari and Collembola groups. Oribatids is one of the acidophilus soil mesofauna which means that this organism likes to live in habitats with an acidic environment where an Oribatids abundance in acid soils is higher than Oribatids abundance in natural forests of 200.000 individuals/m^2 and 20.000 individuals/m^2 (Maraun and Scheu, 2000).

Soil temperature is one of the soil physics factors that significantly determines the presence and density of soil organisms so that the soil temperature will determine the level of decomposition of soil organic matter (Suin, 1997). Based on the results of the correlation test between the Oribatids family and soil properties three families were positively correlated with soil temperature, namely with values, Oppiidae, Tetracondylidae, and Caloppiidae of 0.98, 0.93 and 0.99, respectively.

Soil moisture content determines the level of soil moisture and is one of the important factors because it affects the activity of the organism and limits its spread (Michael, 1995). The abundance of the Eupthiracaridae family, Protoplophoridae has a positive correlation with water content, with correlation values of 0.96 and 0.99. The results of the analysis showed that the families Eupthiracaridae and Protoplophoridae increased with increasing water content in the soil. This positive correlation can also be possible because of its role in the process of decomposition of organic matter, and Oribatids has an indirect role in the process.

Conclusion

The number of Oribatids families found in the three types of land use were 24 families, with the dominant families being Mesopolophoridae, Scheloribatidse, and Oppiidae. The highest Oribatids abundance value was found in secondary forest ecosystems both in the soil layer and in the litter layer. This is because in secondary forests, the availability of more litter is also present and there is also diverse vegetation so that it can provide a source of food for Oribatids to survive. The highest Oribatids family diversity index value is found in intercropping ecosystems, it is thought that in the intercropping ecosystem there are several dominant Oribatids families capable of suppressing other families. The abundance of Mesoplophoridae, Scheloribatidse, Eupthtiracaridae, Protoplophoridae, Haplozetidae, Oppiidae, Protoribatidse, Tetracondylidae, Caloppiidae correlated positively with soil pH, organic C, total N, C/N ratio, water content, and soil temperature.

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