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The soil macrofauna diversity in 'Negeri Lama' Oil palm plantation area, Indonesia

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ABSTRACT

The PT. Socfindo oil palm plantation in the 'Negeri Lama", North Sumatera, Indonesia area has been operating since 1927. Currently, it has Generation III plants (± 90 years) with peat soils, and mineral peat soil, Generation IV plants (± 90 years) with peat soil and mineral peat soils, and with years of planting between different generations. The peculiarity in plantation timing management in each generation also determines the existence, both density and relative density, and the frequency of soil macrofauna in the area. Soil macrofauna plays a role in maintaining the balance of the soil ecosystem. This research was conducted to determine the presence of soil macrofauna in the oil palm plantation in "Negeri Lama" area, involving survey method. This research was performed from February 2017 to April 2018. The determination of sampling points was carried out by Purposive Random sampling method, and sampling of soil macrofauna was using the Quadratic and Hand Sorting methods. It was found that 22 soil macrofauna species were grouped into several categories, namely 3 phyla, 6 classes, 10 orders, 16 families, and 19 genes. The highest population density was found in Generation IV (Mineral Peat) plantation area with 122.22 species/m^2 and the lowest density value was found in Generation III (Peat) planting area with 95.24 species/m^2. In conclusion, the presence of soil macrofauna in all generations consists of 5 species, namely *Pontoscolex corethrurus, Geophilus flavus, Blattella germanica, Odontoponera denticulata and Gilvus macrotermes*.

Key words : *Planting generation, Soil macrofauna, Population density, Physical and chemical factors*

Introduction

North Sumatra is one of the provinces in Indonesia that relies on the plantation and industrial sectors to be the largest foreign exchange earners. One of them is the Oil Palm Plantation which covers an area of 1,392,532 hectares, consisted of those which are managed by the State with an area of ± 324,111 hectares, Private area of ± 657,077 Ha, and the People with an area of ± 411,344 Ha. In the other words, the total area of oil palm plantations spread across Indonesia reaches 12.71%. Moreover, the area of oil palm plantations keeps developing overtime. This results an increasing development of oil palm export commodities, which can be seen from the average rate of growth of oil palm area during the period of 2004-2014 with 7.67%, whereas Palm oil production increased by an average of 11.09% per year. (Ditjenbun, 2014) This condition will certainly appear to develop further.

The opening and construction of oil palm plantations in the "Kebun Lama" plantation area, Labuhan Batu Regency, North Sumatra, Indonesia was initially started in 1927. To date, there are plantation areas that have entered the III (third) and IV (fourth) generation. The plantation area was converted from peat forest to oil palm plantations, started in Generation III, years 1927-1958 (± 31 years), 1958-1996 (± 69 years), and in 1996-present (± 90 years). While generation IV started in 1927-1957 (± 30 years), 1957-1989 (± 62 years), 1989-2012 (± 85 years), and in 2012-present (± 90 year). Over time, in each of these oil palm plantation areas, especially those near the Bilah River, they often experience flooding, erosion and sedimentation of mineral soils carried from the upper reaches of the River, so that mineral fields are formed on the surface.

Oil palm plantations owned by PT. Socfindo, in "Negeri Lama" area, has developed its oil palm plantation overtime. Frequently, the land is used continuously without regarding to maintain and provide the chance for the soil to naturally renew its physical-chemical-biological condition, or to restore its fertility. This situation causes a decrease in the level of soil fertility physically, chemically, and biologically. In general, oil palm plants are rarely touched by the treatment of tillage, both on disks and in wicket. In addition, the treatment of fertilization and application of unsustainable herbicides and harvesting of plates or harvesters' footrests, even the application of very insoluble fertilizers, such as Rock Phosphate and Doloinite will cause the soil to become denser and compact. This condition causes the porosity of the soil becomes more narrow, so that the drainage and rooting respiration, as well as soil biota will be disrupted, resulting in difficult root systems and soil biota to develop and operate well on the land.

The Policy Synthesis Team (2008) stated that excessive use of chemical fertilizers can damage the physical, chemical, and biological properties of the soil, and reduce the population and biodiversity of the land. Furthermore, Dewi (2001) explained that the decline in soil fauna diversity was caused by intensive tillage, fertilization and monoculture planting on conventional farming or plantation systems.

According to Anwar *et al.* (2006) and Hanafiah *et al.* (2003), biodiversity, including the presence of soil fauna is one component in the soil ecosystem that plays an important role in improving soil structure, pore space, aeration, drainage, water storage capacity, decomposition of organic waste, mixing of soil particles and microbial dispersion.

Soil fauna activities are largely determined by environmental factors, such as physical, chemical and biological conditions, availability of food, and tillage method which generally affect the soil fauna population. The effect can be both the presence, distribution, abundance and diversity of species (Wallwork, 1970). Furthermore, Suin (1997) stated that the group of soil fauna is very diverse, ranging from Protozoa, Rotifers, Nematodes, Annelids, Mollusks, Arthropods, to small vertebrates. The most important groups of soil fauna include protozoa, nematodes, annelids and arthropods.

Soil fauna is an important part of an ecosystem, especially in agriculture or plantation ecosystems. It is considered as soil fauna is involved in various soil processes, including degradation of organic matter, nutrient mineralization, population control of pathogenic organisms, improving soil structure, and mixing organic matter with soil. Handayanto and Hairiah (2009) and (Hanafiah *et al.,* 2003) (Buckman and Brady, 1982) Anderson (1994)

The activity of soil macro fauna in an ecosystem can be influenced by various factors, such as: Climate (rainfall, light intensity, etc.), physical and chemical properties of soil (temperature, humidity, soil moisture content, pH and soil organic matter), Nutrients and biota (basic vegetation and other soil fauna) and land use and management (Buckman & Brady, 1982). Furthermore Wallwork (1970) explained that the presence and density of soil macro fauna is largely determined by abiotic and biotic factors, such as physical, chemical, biotic and food availability conditions, as well as methods of tillage in plantation and agricultural areas also affect soil macro fauna populations, both presence, distribution, density and diversity of species.

Population dynamics of various types of soil macrofauna depend on environmental factors that support it, like in the form of food sources, competitors, predators and physical-chemical environmental conditions (Irwan, 1992). Moreover, Notohadiprawiro (1998) stated that the structure and composition of soil macrofauna is highly considered on the environmental conditions, since soil macro fauna prefers weak and neutral to humid environments.

Materials and Methods

This research was conducted in February 2017 until April 2018 in the oil palm plantation area owned by PT. Socfindo which is located in the "Negeri Lama", Labuhan batu Regency, North Sumatra, Indonesia with the coordinate of 02°18′36.85"–02°21′14.36" NL and 100°02′00.06"–100°05′17.84" EL and altitudes ranging from 3-16 m above the sea level. Furthermore, identification and analysis of data from soil macrofauna samples were obtained carried out from the Ecology Laboratory of the Department of Biology, University of Sumatera Utara, Indonesia.

Materials

Monolith (Squared plot) from Stainless steel sizes 30 x 30 x 30 cm, hoes, dodos, tarps, plastic bags, gunny sacks, tweezers, painting brushes, sample bottles, permanent markers, notebooks, pencil, metric tools and graphical paper laminated, Global Position System (GPS), digital camera, soil tester, soil thermometer, hygrometer, magnifying glass, and Stereo Binocular Microscope were used for this research. Formalin 4% and Alcohol 70% were also used.

Research Method

This research was conducted using the Survey Method. The determination of the location of the sample plots was carried out by the Purposive Random Sampling method, namely by selecting locations randomly on oil palm plantations each generation, and soil types (Table 1). Furthermore, soil macrofauna sampling was carried out using the Square and Hand Sorting Method.

Collecting Sample of Soil Macrofauna

At each location of oil palm plantations between the predetermined generations, a plot with 30 x 30 cm size was made with a Monolith tool from Stainless Steel. The sampling was conducted with the distance between each square closest to 10 m. The soil from each squared was taken at a depth of 20 cm and the soil was putted into burlap (plastic sacks). Sampling was carried out at 06.00-09.00 am. Then, the land was immediately sorted to obtain the land macrofauna. The soil macrofauna obtained was collected and cleaned with water, and grouped based on the similarity of the morphological form. Also, the number of each group or type was calculated. After that, it was putted into a plastic bag and preserved with 4% formalin, then transferred to a sample bottle containing alcohol 70 %. Finally, the sample was taken to the laboratory for identification and analysis. Zischi (1962); Nelson (1962) Axellsen *et al.* (1971); Adianto (1977, 1983); Suin (1982, 1988, 1994), and Arlen (1998).

Identifying the Soil Macrofauna Species

The preserved macrofauna samples taken from the field, was first regrouped according to the type, then determined and identified by identifying at the morphological shape with the help of magnifying glass, binocular stereo microscopy. Sims and Easton (1972); Arnett and Jacques (1981); Dindal (1990); Borror *et al.* (1992); Suin (1997); Gibb & Oseto (2006); Nardi (2007) and Ruiz *et al.* (2008).

Field (in situ)

Land at each square (sampling plot) was measured for its relative humidity, temperature, and pH. The measurement of relative humidity, temperature, and pH was carried out before the soil was taken from the square. Relative humidity and pH were measured using the Soil Tester, while the soil temperature was measured using the Soil Thermometer.

Laboratorium (ex situ)

The soil sample was carried out compositely from each representative plot. The soil obtained was cleaned from the remnants of plants and other soil animals that were still present. Then, it was stirred evenly and taken and putted into a plastic bag and taken to the Oil Palm Research Center Laboratory,

Table 1. The description of planting condition in the oil plam planting area

Generation	Pre-Planting Condition	Planting Duration	Current Planting Age	Years of Application
I	Rubber Plantation	1987-present	30 years	31 years
II	Forest	1970-1995; 1995-present	22 years	47 years
III	Forest	1943-1968; 1968-1993; 1993- present	24 years	74 years
IV	Forest	1931-1956; 1956-1981; 1981-2006; 2006-present	11 Years	86 years

Source: PT. Socfindo (2017)

Indonesia, in order to analyze the physical and chemical properties of the soil, such as: Soil Water Content, organic carbon elements, Nitrogen level and soil texture. While for Bulk Density (BD) measurementwas performed by using the Ring Sampler method.

Data Analysis

Soil macrofauna types and the number of individuals of each type were calculated with several determinations, such as population density, relative density of each type, community composition, and frequency of attendance (Wallwork, 1970); (Southwood, 1966 in Suin 1997)

Statistical Analysis

Pearson Correlation Analysis (r) using SPSS version 21.00 software was conducted to determine the correlation value of total soil macrofauna density (K) values in all generations in the "Negeri Lama" oil palm plantation area with soil physical-chemical factor

Result and Discussion

Soil Macrofauna Identification

Based on the result of soil macrofauna identification in "Negeri Lama" oil plamplantion area, it was found that as many as 22 species were discovered. The result is described in Table 2 below.

Based on Table 2, it can be seen that the most soil macrofauna that commonly obtained was from Phylum Arthropoda, which consists of 4 (four) classes, namely Arachnida Class, consisting of 1 Order, 4 Families, and 6 Genus/Species; Chilopoda class (2 orders, 2 families, and 2 genus/species); Insect class (5 orders, 5 families, 8 genus/species); and Malacostraca (1 order, 2 families, and 2 genus/species). While the least soil macrofauna obtained was from the Annelida phylum, which consists of 1 (one) class, namely Chaetopods, the Oligochaeta order, consisting of 2 families and 2 genus.

The abundance of soil macrofauna from Phylum Arthropods obtained in the oil palm plantation area is due to the fact that this soil macrofauna group has a large number of species and extensive distribution in forests, shrubs, meadow, agricultural areas, lowland and highland plantations. Furthermore, it has a high tolerance range for environmental conditions, such as temperature, humidity, pH, and the presence of basic vegetation as a source of nutrients, habitats, shelter and breeding, which play a role in maintaining the balance of the soil ecosystem.

The Population Density (D) and Relative Density (RD) of soil macrofauna

The research result provides various population density and relative density of soil macrofauna discovered in oil palm plantation. The result is shown in Table 3 below.

Based on the results of calculations as displayed in Table 3, it is shown that the highest value of soil macrofauna density is as approximately 122.22 individuals/m^2 from 16 soil macrofauna species in Generation IV (Mineral Peat), with the planting dated from 1927-1958, 1958–1996, and 1996–present (already 3 times planting), with utilization for ± 90 years. Then, in Generation III (Mineral Peat), the total density value is 114.28 individuals/m^2 from 15 species, with the planting dated 1927–1957, 1957–1989, 1989–2012, and 2012–present (already 4 x planting) with utilization which also lasts for ± 90 years. After that, in Generation IV (Peat), the total density is recorded to be 104.76 individuals/m^2 from 15 species with planting years of 1927-1958, 1958-1996, and 1996-present (already 3 times planting) and the utilization has been conducted for ± 90 years. Finally, the lowest in Generation III (Peat) obtained a total density of 95.24 individuals/m^2 from 13 species with planting years of 1927-1957, 1957–1989, 1989–2012, and 2012–present (already 4 times planting) and utilization that has also been carried out for ± 90 years.

According to Suin (2012), a high density of soil fauna in an area indicates that the biotic and abiotic environmental factors are quite suitable for the survival of the animal's life. In the other hand, a less density of animal species found in an area, this indicates that environmental factors are not suitable and inhibit the survival of the animal.

The lowest density of soil macrofauna was found in the area of oil palm plantation of Generation III (Peat) with 95.24 individuals/m^2 from 13 species. This is due to the physical and chemical factors and environmental biology which do not support the survival of soil macrofauna, such as soil temperature (30-310C), soil moisture (73-100%) and pH (3.8-5.2). These results indicate that the environmental conditions in Generation III (peat) which are peat lands have a higher tendency to elevate its temperature, and the soil pH is more acidic compared to

Table 2. The soil macrofauna classification in "Negeri Lama" oil palm plantation area

Phylumand Class	Order	Family	Genus/Spesies	Indonesian Name	Generation/Location			
					III		IV	
					(G)	(GM)	(G)	(GM)
Annelida :								
1. Chaetopoda	1. Oligochaeta	1. Glossoscolecidae	1) *Pontoscolex corethrurus*	Earthworms	+	+	+	+
		2. Megascolecidae	2) *Pheretima* sp.	Earthworms	-	+	+	+
Arthropoda :								
1. Arachnida	1. Araneae	1. Linyphiidae	3) *Tapinopabilineata*	Spider	+	-	-	+
		2. Lycosidae	4) *Pardosaamentata*	Spider	+	+	-	-
			5) *Pardosa glacialis*	Spider	-	+	+	-
		3. Phrynidae	6) *Paraphrynusmexicanus*	Spider	-	+	+	+
		4. Sicariidae	7) *Loxosceleslaeta*	Spider	+	-	+	+
			8) *Loxoscelestaino*	Spider	+	-	-	+
2. Chilopoda	1. Geophilomorpha	1. Geophilidae	9) *Geophilus flavus.*	Centipede	+	+	+	+
	2. Scolopendromorpha	1. Scolopendridae	10) *Scolopendramorsitans*	Centipede	-	+	+	-
3. Insecta	1. Blattodea	1. Blattidae	11) *Blatta orientalis*	Ground Cockroaches	+	+	+	+
		2. Ectobiidae	12) *Blattellagermanica*	Ground Cockroaches	+	-	+	+
	2. Coleoptera	1. Tenebrionidae	13) *Helops aereus*	Beetle	-	+	-	+
	3. Dermaptera	1. Labiidae	14) *Vostax apicedentatus*	Earwig	+	-	+	-
	4. Hymenoptera	1. Formicidae	15) *Odontoponera denticulata*	Black Ant	+	+	+	+
			16) *Oecophyllalonginoda*	Red Ant	-	+	+	+
			17) *Solenopsis fugax*	Black Ant	-	+	-	+
4. Malacostraca	1. Isopoda	1. Termitidae	18) *Macrotermesgilvus*	Termite	+	+	+	+
		2. Philosciidae	19) *Philosciamuscorum*	Woodlice	-	-	+	-
Molusca :								
1. Gastropoda	1. Stylommatophora	1. Subulinidae	20) *Subulina octona*	Land Snail	+	+	-	+
			21) *Lamellaxisgracilie*	Land Snail	+	+	-	-
			22) *Lamellaxisclavulinus*	Land Snail	-	-	+	+
				Sub Total	13	15	15	16
				Total		**22**		

*P = Peat Area; MP = Mineral Peat Area; + = Present ; - = Absent other Generation III (mineral peat). This situation also affects the presence and density of soil macrofauna. According to Hanafiah *et al.* (2005), soil acidity greatly affects population and soil macrofauna activity, so that it becomes a limiting factor in its spread. The higher the acid content possessed by the soil, the fewer members of the soil macrofauna population will be discovered.

In addition, soil macrofauna which has the highest population density value at the location of oil palm plantations for all generations is earthworms from the species of pontoscolex corethrurus. According to Fragoso *et al.* (1997), and Giller *et al.*, (1997) earthworms from the pontoscolex corethrurus species are single species that often dominate land use conversion to intensive agricultural and plantation land. This situation causes changes in the diversity of earthworms in the form of loss of native species and the emergence of exotic species. Also, Dewi *et al.* (2007) reported the results of an earthworm inventory study in Sumber Jaya, West Lampung, Indonesia on a variety of agricultural land after forest use change, found that earthworms from pontoscolex corethrurus species were the dominant species. Furthermore, Arlen (1998) discovered that pontoscolex corethrurus is a species found in many oil palm plantations.

The Presence Frequency and Constancy of Soil Macrofauna

The results of data analysis on the frequency of presence and constancy of soil macrofauna in table 4 shows that 5 soil macrofauna species were obtained, namely pontoscolex corethrurus, geophilus flavus, blatta orientalis, odontoponera denticulata and macrotermes gilvus found in all four generations with absolute, constant, accessory, and accidental categories.

The earthworm from the pontoscolex corethrurus species was found in all generations in the "Negeri Lama" plantation area with a frequency of constant presence (often) in generation III (Peat) and IV (Mineral Peat), as well as the presence of absolute (very often) is in generation III (Mineral Peat) and IV

Table 3. The population density and relative density of soil macrofauna (species/900 m^2) in "Negeri Lama" oil palm plantation area

	Species	Indonesian Name	Generation							
			III Peat		III Mineral Peat		IV Peat		IV Mineral Peat	
			D	RD (%)	D	RD (%)	D	RD (%)	D	RD (%)
1.	*Pontoscolex corethrurus*	Earthworms	14.29	15.00%	15.87	13.89%	19.05	17.39%	1333	10.53%
2.	*Pheretima* sp.	Earthworms	-	-	6.35	5.56%	6.35	5.80%	8.89	7.02%
3.	*Tapinopabilineata*	Spider	7.94	8.33%	-	-	-	-	4.44	3.51%
4.	*Pardosaamentata*	Spider	4.76	5.00%	7.94	6.94%	-	-	-	-
5.	*Pardosa glacialis*	Spider	-	-	4.76	4.17%	4.76	4.35%	-	-
6.	*Paraphrynusmexicanus*	Spider	-	-	6.35	5.56%	4.76	4.35%	11.11	8.77%
7.	*Loxosceleslaeta*	Spider	6.35	6.67%	-	-	4.76	4.35%	4.44	3.51%
8.	*Loxoscelestaino*	Spider	4.76	5.00%	-	-	-	-	8.89	7.02%
9.	*Geophilus flavus*.	Centipede	6.35	6.67%	9.52	8.33%	7.94	7.25%	8.89	7.02%
10.	*Scolopendramorsitans*	Centipede	-	-	6.35	5.56%	4.76	4.35%	-	-
11.	*Blatta orientalis*	Ground Cockroaches	7.94	8.33%	7.94	6.94%	3.17	2.90%	8.89	7.02%
12.	*Blattellagermanica*	Ground Cockroaches	11.11	11.67%	-	-	7.94	7.25%	6.67	5.26%
13.	*Helops aereus*	Beetle	-	-	6.35	5.56%	-	-	8.89	7.02%
14.	*Vostax apicedentatus*	Earwig	7.94	8.33%	-	-	6.35	5.80%	-	-
15.	*Odontoponera denticulata*	Black Ant	4.76	5.00%	9.52	8.33%	4.76	4.35%	4.44	3.51%
16.	*Oecophyllalonginoda*	Red Ant	-	-	4.76	4.17%	6.35	5.80%	4.44	3.51%
17.	*Solenopsis fugax*	Black Ant	-	-	7.94	6.94%	-	-	4.44	3.51%
18.	*Macrotermesgilvus*	Termite	6.35	6.67%	7.94	6.94%	12.70	11.59%	13.33	10.53%
19.	*Philosciamuscorum*	Woodlice	-	-	-	-	6.35	5.80%	-	-
20.	*Subulina octana*	Land Snail	4.76	5.00%	6.35	5.56%	-	-	6.67	5.26%
21.	*Lamellaxisgracilis*	Land Snail	7.94	8.33%	6.35	5.56%	-	-	-	-
22.	*Lamellaxis clavulinus*	Land Snail	-	-	-	-	4.76	4.35%	4.44	3.51%
		Total	95.24	100.00%	114.28	100.00%	104.76	100.00%	122.22	100.00%

*D= Density; RD= Relative Density

(Peat). This shows that the species is quite suitable for the environmental conditions in which it lives. Wiryono and Darmi (2003) explained that pontoscolex corethrurus is an earthworm species that has extensive adaptability and tolerance to various environmental conditions. The presence of earthworm species on land with sufficiently acidic pH conditions indicates that the acidity of the soil on the land can still be tolerated by the earthworm species. According to Suin (2012), earthworms can be grouped based on soil pH. Earthworms that can only live on acidic soils are called tolerant to acids, which cannot live in acidic soils are not tolerant to acids, while those that can live on acidic and neutralsoils are called not affected by acidity of the soil. Therefore, the earthworm species found in oil palm plantation land can be classified into groups of earthworms that are not affected by soil acidity.

Centipedes of Geophilus flavus species were found in generation III (Peat Minerals) and IV (Peat) with a constant frequency of presence (often), as well as in Generation III (Peat) and IV (Peat Minerals) with the frequency of the presence of accessory (rare). Geophilus flavus is one of the species of the Chilopode class which in general has almost the same role as other soil macrofauna for helping the decomposition process in the soil. If it is decomposed, it can add nutrients to the soil. Also, as bioindicators land and predators, it plays an important role for the balance of an ecosystem (Baker, 1988).

Soil cockroaches of the blatta orientalis species were found in generation III (Peat) and generation III (Mineral Peat) with a constant frequency of presence (often), as well as in generation IV (Peat) and IV (Mineral Peat) with the frequency of presence of accessory (rare). The presence of this species on plantation land shows that the environmental conditions in plantation land are quite suitable as a habitat for life, especially the humidity factor on plantation land that is quite high (73-100%). Hadi (2011) stated that soil cockroaches are very fond of places that have high humidity in carrying out various life activities in the soil, included eating and decaying organic materials.

Ants of odontoponera denticulata species are found with a frequency of constant presence (often) at the location of generation III (Peat Mineral) planting area, and have the frequency of generation III (Mineral Peat), Generation IV (Peat), and Generation IV (Peat Minerals). The presence of ants from the Odontoponera denticulata species indicates that this species has a high adaptability to environmental conditions, and possess a fairly wide spread in the plantation area. This is in to Latumahina *et al.* (2014) stated that ants from the species of odontoponera denticulata are adaptable species and frequently found in disturbed areas, such as agricultural and plantation areas.

According to Andersen (2000), ants from the species of odontoponera denticulata have a high abundance in agricultural areas for these species are adaptable in disturbed areas adjacent to human activities. Furthermore, Wallwork (1976), stated that odontoponera denticulata can reach 70% of the land macrofauna population, so that this family can be found in large numbers and wide spread.

Termites from macrotermes gilvus species were discovered in Generations III (Peat), Generation IV (Peat Minerals) and IV (Peat) with a constant frequency of presence (often), and are found in Generation III (Peat Minerals) with the frequency of the presence of accessory (rare). Tho (1992) stated that termites from Macrotermes gilvus species are termites which are widely spread in Southeast Asia, mainly found in Indonesia, Malaysia and Thailand. Furthermore, Tarumingkeng (2005) explained that Macrotermes gilvus type termites have natural habitat in natural forest areas where the influence of temperature, humidity and rainfall is relatively stable. But with global climate change and changes in natural forest habitat conditions, it is possible to change its distribution. Termites are a very important part in recycling plant nutrients through the process of disintegration and decomposition of organic material from wood and plant litter (Nandika *et al.,* 2003). Furthermore, Vongkaluang *et al.* (2007) explained that several factors that determine the presence of termites, such as requiring high humidity with an optimum development range of 75-90%, temperature range 15-38 ^{o}C, and high rainfall with 3000-4000 mm/year.

Soil macrofauna from other species has a frequency of attendance that is classified as accidental (very rare) to accessory (rare). This condition is caused by having poor ability to adapt to environmental conditions, and having a wide spread in this area of oil palm plantations. Suin (1989) explained that the life of soil fauna is highly dependent on their habitat, since the presence frequency of soil fauna in an area is largely determined by environmental factors and land management system. Moreover, Handayanto and Khairiyah (2009) stated that each of the soil macrofauna species has a different dependence on the environmental conditions of the soil in terms of energy supply and nutrition for its growth.

Macrofauna

Soil macrofauna that can live and reproduce well which can be used as bioindicator of soil quality in the "Negeri Lama" oil palm plantation area was found and categorized into 3 species, namely *Pontoscolexcorethrurus*, *Blattellagermanica*, and *Macrotermesgilvus*. *Pontoscolexcorethrurus,* was found in 4 locations of 2 plantation generations then followed by *Macrotermesgilvus* species in Generation IV (Peat) and Generation IV (Mineral Peat), while Blattellagermanica was discovered on ly in Generation III (Peat).

Pearson Correlation Analysis (r)

Correlation analysis was conducted on the value of population density of soil macrofauna with soil physical-chemical factors which greatly influenced the density of soil macrofauna populations obtained in each generation on oil palm plantations in the "Negeri Lama" plantation area using SPSS version 21.00 software. The result is described in Table 4.

In Table 5, it can be seen that from the results of the Pearson correlation test between soil physical and chemical factors with the total K values of soil macrofauna from the four generations, the correlation values vary for each parameter of soil physical-chemical factors. Based on the correlation of the value of soil macrofauna density to soil physi-

Table 4. The presence frequency (PF) and constancy of soil macrofauna in "Negeri Lama" oil palm planting area

Species		Indonesian Name	Generation							
			III Peat		III Mineral Peat		IV Peat		IV Mineral Peat	
			PF (%)	Constancy	PF (%)	Constancy	PF (%)	Constancy	PF (%)	Constancy
1.	*Pontoscolex corethrurus*	Earthworms	71.43%	Constant	85.71%	Absolute	100.00%	Absolute	71.43%	Constant
2.	*Pheretima* sp.	Earthworms	-	Accessory	42.86%	Accessory	57.14%	Constant	42.86%	Accessory
3.	*Tapinopabilineata*	Spider	42.86%	Accessory	-	-	-	-	28.57%	Accessory
4.	*Pardosaamentata*	Spider	42.86%	Accessory	71.43%	Constant	-	-	-	-
5.	*Pardosa glacialis*	Spid er	-	-	42.86%	assesori	42.86%	Accessory	-	-
6.	*Paraphrynusmexicanus*	Spider	-	-	57.14%	Constant	42.86%	Accessory	57.14%	Constant
7.	*Loxosceleslaeta*	Spider	42.86%	Accessory	-	-	42.86%	Accessory	28.57%	Accessory
8.	*Loxoscelestaino*	Spider	42.86%	Accessory	-	-	-	-	57.14%	Constant
9.	*Geophilus flavus*.	Centipede	42.86%	Accessory	57.14%	Constant	57.14%	Constant	42.86%	Accessory
10.	*Scolopendramorsitans*	Centipede	-	-	42.86%	Accessory	42.86%	Accessory	-	-
11.	*Blatta orientalis*	Ground Cockroaches	57.14%	Constant	57.14%	Constant	28.57%	Accessory	42.86%	Accessory
12.	*Blattellagermanica*	Ground Cockroaches	71.43%	Constant	-	-	57.14%	Constant	42.86%	Accessory
13.	*Helops aereus*	Beetle	-	-	42.86%	Accessory	-	-	42.86%	Accessory
14.	*Vostax apicedentatus*	Earwig	71.43%	Constant	-	-	57.14%	Constant	-	-
15.	*Odontoponera denticulata*	Black Ant	42.86%	Accessory	57.14%	Accessory	42.86%	Accessory	28.57%	Accessory
16.	*Oecophyllalonginoda*	Red Ant	-	-	42.86%	Accessory	42.86%	Accessory	28.57%	Accessory
17.	*Solenopsis fugax*	Black Ant	-	-	71.43%	-	-	-	28.57%	Accessory
18.	*Macrotermesgilvus*	Termite	71.43%	Constant	42.86%	Accessory	71.43%	Constant	57.14%	Constant
19.	*Philosciamuscorum*	Woodlice	-	-	-	-	42.86%	Accessory	-	-
20.	*Subulina octana*	Land Snail	42.86%	Accessory	42.86%	Accessory	-	-	42.86%	Accessory
21.	*Lamellaxisgracilis*	Land Snail	57.14%	Constant	42.86%	Accessory	-	-	-	-
22.	*Lamellaxis clavulinus*	Land Snail	-	-	-	-	42.86%	Accessory	28.57%	Accessory

*PF= Presence Frequency

*Accidental (Very Rare)= 0–25%; Accessory (Rare) =25–50%; Constant (often) = 50 – 75 %; Absolute (Very Often) = > 75%

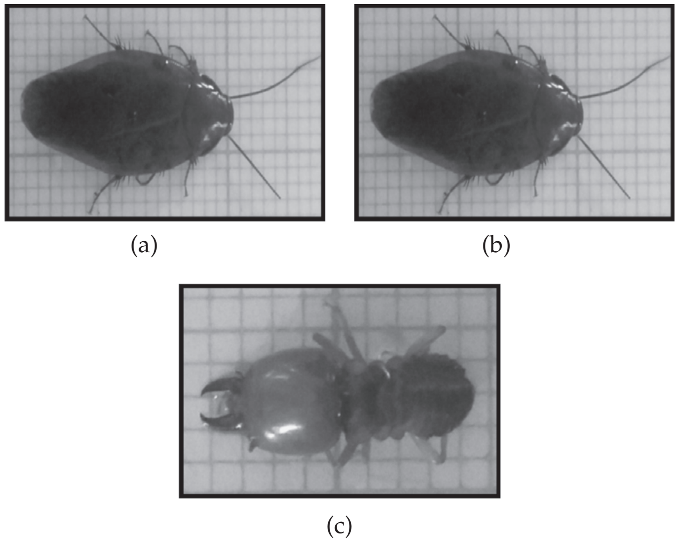

Fig.1. The photograph of : a) *Pontoscolex corethrurus*, b) *Blattellagermanica* and c) *Macrotermesgilvus*

Table 5. The analysis result of pearson correlation on population density (D) towards physical and chemical factors in "Negeri Lama" oil palm planting area

Correlation Value	Parameters			
	Temperature	Soil Humidity	Soil Acidity (pH)	Carbon-Organic Content
r	-0,272	+0,106	+0,301	-0,636

cal-chemical factors obtained as follows.

Temperature

The results of the correlation analysis of the values of soil macrofauna density obtained in all generations of oil palm plants in the "Negeri Lama" planting area with respect to soil temperature (29-31^{o}C), which is the optimal temperature range for soil macrofauna life, shows correlation with negative result or opposite, with values of -0.272. This value belongs to the category of low correlation value (Usman and Akbar, 2000). Moreover, these results indicate that each temperature increase can reduce the density value of soil macrofauna in the "Negeri Lama" planting area. Soil temperature is one of the soil physics factors that greatly determines the presence and density of soil organisms, so the soil temperature will determine the level of decomposition of soil organic matter. Land temperature fluctuations are lower than air temperature, and soil temperature is very dependent on air temperature. The temperature of the topsoil fluctuates in one day and one night and depends on the season. The fluctuation also depends on the weather conditions, the topography of the area and the state of decomposition in the soil (Suin, 2006).

Soil Humidity

The results of the correlation analysis of the values of soil macrofauna density obtained in all generations of oil palm plants in the "Negeri Lama" planting area against soil moisture (73-100%) provide a positive correlation or unidirectional with 0.106. This value is included in the category of very low correlation values (Usman and Akbar, 2000). From these results, it can be stated that if soil moisture rises, the density of soil macrofauna will also increase, and if the humidity drops (too low) then the density of soil macrofauna will decrease. Sukarsono (2009) explained that the temperature and soil moisture has an important role in the land environment and as the most important part of life. Temperature gives the effect of limiting the growth of an organism due to the condition, but moisture has a more critical effect on the organism at extreme high or extreme low temperatures. Besides the soil moisture also greatly affects nitrification, higher humidity is better for soil animals than low humidity. Decreasing a type of soil fauna will result in a species that dominates in that area.

Soil Acidity (pH)

The correlation analysis results of the value of soil macrofauna density obtained in all generations of oil palm plants in the area of the "Negeri Lama" planting area against the acidity (pH) of the soil (3.8-5.9) showed a positive correlation or unidirectional with 0.301. However, the increase and decrease in pH cannot directly indicate an increase and decrease in the number of soil macrofauna species. This is because the pH scale is not linear and limited (Hariyanto *et al.,* 2008). Handayanto and Hairiah (2009) explained that most soil fauna likes pH ranges from 6-7 because of the high availability of nutrients. Soil pH conditions that are too acidic and basic can interfere the life of soil macrofauna, but Suin (2012) explained that there are soil macrofauna that can live in acidic pH conditions and can also be found in basic conditions.

Carbon-Organic Content

The results of the correlation analysis of the values of soil macrofauna density obtained in all generations of oil palm plants in the "Negeri Lama" area of organic C (6.21-25.91%) showed a negative or opposite correlation, with a value of - 0.604. This value is included in the category of sufficient correlation values (Usman and Akbar, 2000). From these results, it indicates that each increase in the value of C-organic can reduce the density of soil macrofauna in the "Negeri Lama" planting area. Each increase in the value of organic C can increase the population density of soil macrofauna.

According to Suin (2012), soil organic matter greatly determines the population density of soil organisms, one of which is soil macrofauna. It is found that the higher the organic content of the soil, the more diverse soil fauna found in an ecosystem. The composition and type seemed to determine the type of soil fauna found in the area and the number of available litter determines the density of soil fauna. Organic material is a remnant of plants and animal soil organisms, both those which have been decomposed.

In this ecosystem, it was discovered that the correlation of the C-Organic soil value was inversely proportional to the density of soil macrofauna. This is due to the condition of the land in the "Negeri Lama" plantation area which is an area of peat soil that has organic carbon and high temperature values, and also has a sufficiently acidic soil pH value, so that the decomposition process does not take place optimally. In result, this causes limited land macrofauna in accordance with the range of tolerance to environmental conditions in the garden area.

Conclusion

As many as 22 soil macrofauna species grouped into 3 phyla, 6 classes, 10 orders, 16 families, and 19 genes were identified in the "Negeri Lama" planting area of oil palm. The presence of soil macrofauna in the four generations consists of 5 species, namely Pontoscolex corethrurus, Geophilus flavus, Blatta orientalis, Odontoponera denticulata, and Gilvus Macrotermes. Moreover, the highest population density value was indicated in Generation IV (Mineral Peat) plantation area with 122.22 species/m^2, while the lowest was found in Generation III (Peat) plantation area with 95.24 species/m^2. To sum up, a negative correlation between the values of soil chemical and physical factors, namely Temperature and C-Organic to the population density of soil macrofauna was found, while in the other hand, the positive correlation between the value of soil chemical and physical factors, namely moisture and soil pH was determined.

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