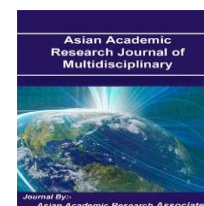




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**ABUNDANCE AND DISTRIBUTION PATTERN OF EARTHWORM IN PEATLAND
PLANTED WITH DIFFERENT AGE OF OIL PALM PLANTATION IN DISTRICT OF
SELUMA, BENGKULU PROVINCE**

DARMI*; D. BUDIANTA; SABARUDDIN***; M.R. RIDHO******

*Doctorate Student in the Environmental Sciences, Graduate Program of Sriwijaya University

**Faculty Members of Doctorate Program in the Environmental Science, Graduate Program of Sriwijaya University

***Faculty Members of Doctorate Program in the Environmental Science, Graduate Program of Sriwijaya University.

****Faculty Members of Doctorate Program in the Environmental Science, Graduate Program of Sriwijaya University

Abstract

Peat land conversion to be the oil palm plantation affects on the ecosystem changing from peatland forest to monoculture of oil palms, thus inducing alteration of soil physical, chemical and biological characteristic. Biological properties of soil getting its impact is earthworm. Those soil animals are an important role in improving soil fertility. This study aimed to analyze the abundance and distribution of earthworm in peat land with different age of oil palm growth (2 years, 10 years, 15 years, 19 years and 23 years). The results showed that only one species of earthworm was found that is *Pontoscolex corethrurus* (Oligochaeta : Glossoscolecidae) in stand of oil palm age of 2 years , 19 years and 23 years. At the location study periodically inundated known from the measurement of groundwater table depth during the study, there were not found earthworms (at stand age of 10 and 15 years). Earthworm population density of *P. corethrurus* tended to increase with enhancing the stand age of oil palms (at stand age of 2, 19 and 23 years), whereas their distribution pattern based on analysis of the Morisita index was a clustered pattern. The clustered pattern of earthworm in young age oil palm stands is stronger than at locations of palm stands of old age.

Keywords: earthworms, distribution, abundance, peat, oil palm plantations.

1.Introduction

Efforts to preserve the existence of flora and fauna in peatland under oil palm plantation is one of the important factors in supporting the sustainability of farming systems, as stated in the Regulation of the Minister of Agriculture of Indonesia no. 19 of 2011 on Guidelines for Sustainable Oil Palm Plantations in Indonesia. One group of animals that have a role in the balance of peatland ecosystem is earthworm. Lee ¹⁰⁾; Gajalaksmi and Abbasi ⁹⁾ stated that earthworms as a component in soil ecosystems contribute to improving soil fertility. Through their activities, these animals can improve soil physical and chemical properties. Earthworms consume organic materials and can enrich soil nutrients through their manure production. Study of Samaranayake and Wijekoon ²²⁾ showed that the content of N and C of *Pontoscolex corethrurus* earthworm manure was significantly higher than in the surrounding soil. As well as, pH of earthworm manure (6.6 to 7) is closer to neutral than the surrounding soil (5.8 to 6.8). Many researchers claimed that earthworms are potential as bio-indicator of soil quality ^{11, 17, 21)}

Based on the ecological function, earthworm is divided into three groups: *epigeic*, *endogeic* and *anecic* which known as Bouche's classification system. *Epigeic* earthworm with a small size, darker color, living in litter layers and consume litter (organic material) and rarely consume soil. *Epigeic* earthworms are most found in material organic substrate or in animal manure. In *endogeic* group, species that live in top soil layer of soil until the depth of 20-30 cm from soil surface dig a hole in soil and consume soil (*geophages*) with pale color and size varies. *Anecic* worms tend to have larger body sizes, and live in deeper soil layers. They consume organic material and soil mixture, and rarely appear on surface ^{1, 10)}.

Peat lands conversion for agriculture can change the shape of anaerobic forest ecosystem becomes aerobic shape as a result of decreasing in ground water table level ⁸⁾. These conditions provided opportunities for soil fauna to live and breed in peatland ²³⁾, including the earthworm population. Curry and Schmidt ⁴⁾ stated that peatland that has been reclaimed peat for 20-30 years in Ireland with favorable conditions could support the earthworm population comparable to the mineral soil fertile in but their species richness was lower (9 species) than in grasslands with mineral soil (17 species) based on study of Muldowney *et al.* ¹⁶⁾.

Peat land clearance for preparing agricultural drainage network affects on changes in soil physical and chemical properties of peat ^{7, 20)}. Peat land reclamation with different ages has the different soil physical and chemical properties. Study of Supriyo & Maftuah ²⁷⁾ in Banana Island

of Central Borneo showed that natural peat land has a maturity level of fibric type, whereas peatlands with reclamation ages of 5 years, 10 years and 15 years, their maturity level are Sapric. Silvan *et al.*²³⁾ also stated that the increase in the age of reclaimed peat soil affected on the lives of soil mesofauna in particular. In general, the density of soil mesofauna (Enchytraidae, Collembola and Acarina) on peat soil increases correlating with the increases of peat land age after drained in Ireland forestry. Soil mesofauna density is also significantly positively correlated with the depth of ground water table in the range of 5-30 cm of the soil surface. Earthworm study in peatlands are still limited in data and are generally based on different habitat types^{2, 4, 12)}. Thus, it is needed to study the abundance and distribution of peat land's earthworms in oil palm with different strata ages. Determination of differences in stand age strata of oil palm plantation based on the differences in environmental conditions of biophysics and micro-climate to soil biota including earthworms. The purposes of this study were to analyze the abundance of earthworm populations in five locations, and determine the pattern of their distribution. The results of this study are expected to be input to management of oil palm plantations on peat lands, both in effort to manage soil fertility and to conserve an important soil fauna for the sustainability of farming systems on peatlands.

2. Material and Methods

The study was conducted on peat lands in oil palm plantations, District of Seluma, Bengkulu Province (Southern Sumatra-Indonesia). Peat lands used as the study site consisted of five stand ages oil palm which were 2 years, 10 years, 15 years, 19 years and 23 years. The location of oil palm age 2 and 10 years placed in South Seluma Regency in 4°8'56,1"-4°9'13,1" S and 102°34'24,2-102°34'53,1" E, while three others were located in Air Periukan Regency (4°0'51" – 4°3'21,2" S and 102°25'42,3"- 102°26'48,3" E). Earthworm sampling at each study site were carried out systematically consisting of 3 columns and 4 lines, thus each site has 12 samples. The sampling was conducted in April, May and June 2013 using quadratic method with size of 25x25x30 cm and using hand sorting methods. Quadratic and hand sorting method were more efficient for earthworms sampling in peat lands than treated method using formalin previously²⁾.

At the same time during the study, there is also measured level of ground water every day with using 2.5 inch of PVC pipes permanently at observation points¹⁵⁾. Ground water level is

the distance of ground water table to soil surface. It also measured the thickness of the peat, pH, temperature and soil water content at each location. Quantification of earthworms was done directly in the field and some earthworm samples taken were brought to laboratory to be identified using Stephenson's reference ²⁶⁾.

3. Calculation

Earthworm population data were analyzed by calculating the density and pattern of spread ^{14,24)} using the following formula:

$$\text{Density} = \frac{\text{Number of individuals of a species}}{\text{Total number of samples}}$$

Distribution Index of Morisita :

$$Id = n \frac{\sum X^2 - N}{N(N - 1)}$$

Notation:

n = number of plots

N = total number of individuals in the n plots

$\sum X^2$ = square of the number of individuals per plot

Id < 1 (uniform pattern)

Id = 1 (randomized pattern))

Id > 1 (clustered pattern)

Chi square test (X^2) for Morisita's index values using the following formula:

$$\text{Chi square } (X^2) = \frac{n \sum x^2}{N} - N$$

Value of Chi square (X^2) of the count (X^2) is compared to the value of X^2 table with a 95% confidence interval ($\alpha = 0.05$) and degrees of freedom ($df = n-1$). If the value of X^2 is smaller than the table value of X^2 , the results are not significantly different and the means of its distribution pattern is random.

4. Results and Discussion

4.1. Species and earthworm description

Identification result of earthworms with book guide of Stephenson²⁶⁾ showed that there is only one species of earthworms found in this location that is *Pontoscolex corethrurus* (Oligochaeta: Glossoscolecidae) as seen in Fig. 1. Morphologically, *P. corethrurus* has characteristics such as body length of 73-95 mm, body diameter of 3.5-4 mm and number of segments 194-20. Body colors were whitish and slightly browned. Prostomium and first segment drawn into seta consisted of four pairs with lumbricine type, location of each partner of anterior seta was adjacent and segment X and XI began to move away, arrangement of ventral seta was quincuncx and the posterior part was larger. Nefridiofor was on seta *c*. Klitelum was from segment XV - XVI to segment XXII or XXIII (8 or 9 segments), klitelum wall on the dorsal was thick beginning on seta *b* and had yellowish color.

P. corethrurus are classified as endogeic earthworms (*top soil species*) having a wide distribution in tropic condition^{10, 18)}. This worm type also has a high adaptability to fluctuation environmental conditions and wide tolerance to soil pH¹⁸⁾. Soil pH measured in the five study sites ranged from 4.0 up to 4.3 (Table 2). This proves that the worm *Pontoscolex corethrurus*



Figure 1. *Pontoscolex corethrurus* earthworms found in the study site

were highly tolerant at acidic pH or low pH. The existence of *P. Corethrurus* on peat land under oil palm stands related to the biological characteristics and its ability to adapt. Study results of Qudratullah *et al*¹⁹⁾; Maftuah & Susanti¹²⁾ and Somnayan and Suwanwaree²⁵⁾ showed that *P.*

corethrurus worms had high adaptability to several types of land use. *P.corethrurus* almost always exist in a variety of habitat types (forest habitat, agricultural land, abandoned land and residential areas) and in general, they have a higher density than other types of earthworms.

4.2. Density of *Pontoscolex corethrurus* earthworms

The results of this study showed that of the among five locations, earthworm *P. corethrurus* were only found in three sites i.e. location of oil palm aged 2 years, 19 years and 23 years respectively, while the other two sites were never found earthworms during the study (Table 1). The absence of earthworms on other location of 10 years and 15 years, associated with habitat conditions that were known to be periodically flooded, especially in rainy season. Fig. 2 show that the high water table for 3 months of measurement showed fluctuations. On specific sites of 10 and 15 years, from the recorded observations, the land was ever inundated by stagnant water at location 10 years by mid-June 2013 (during 3 days) and was in location of 15 years at the beginning of April 2013 (during 2 days). Flooded conditions (generally anaerobic) causing earthworms can not live in the location of 10 and 15 years. This is because earthworms need aerobic conditions for their live. Earthworms were also permanent animal that live in soil and relatively slow movement¹⁰⁾, so it is difficult to migrate rapidly when the soil in waterlogged conditions. The results of the study of Emmerling and Strunk 6) showed that earthworms of species *Aporrectodea longa* have relatively slow movement and the average of their horizontal movement ranges 7-8 cm per day. These results highly correlated with movement patterns and distribution of earthworms, as well as the ability of earthworms in response to changes in the local climate. Habitat status flooded by waterlog can be inhibit factor for earthworm growth and life, as a result, in location of oil palm with age of 10 years and 15 years (periodical waterlog), earthworms were absent.

Table 1. Earthworm Populations Density of *P. Corethrurus* on Peat lands with Different Age Strata of Oil Palm.

No	Location/Age Strata of Oil Palm	Earthworm Population Density in month (individu/m ²)			Average of Density (individu/m ²)
		April 2013	May 2013	June 2013	
1	2 years	16	13	9	13
2	10 years	0	0	0	0
3	15 years	0	0	0	0
4	19 years	28	24	23	23
5	23 years	37	33	35	35

Earthworm population density of *Pontoscolex corethrurus* on three different ages of oil palm showed variation results. During three months of observation, the highest population density with value 35 individuals/m² was found at the age of 23 years, then 23 individuals/m² on age of 19 years and the lowest with value 13 individuals/m² was obtained at age 2 years. These results indicated that there was a trend that, the older age of oil palm, the larger density of earthworm population. This correlated to variation of abiotic factors such as soil temperature and humidity in three sites (Table 2). In the land of palm stands of old age (23 years), soil temperature (28.4° C) was lower than those in location of the stand age of 19 years (31° C) and 2 years (30.5° C). This condition is associated with more dense canopy of the palm trees reducing direct sunlight penetration to the soil surface. Soil water content at three locations which earthworms exist also vary. The water content of the soil in palm stands age of 23 years = 54.1%, age of 19 years = 38.2% and at age of 2 years stand = 82.2%. These results show that, *P. corethrurus* were quite tolerant to soil water content in the range of 38.2 to 82.2%, however, these population is higher in habitats with soil moisture content average of 54.1%.

Table 2. Abiotic Factors on Peat lands with Different Age Strata of Oil Palm.

No	Location/Age strata of Oil Palm	Peat Thickness (cm)	Soil pH	Soil Temperature (°C)	Soil Water Content (%)
1	2 years	268,7	4,3	30,5	82,2
2	10 years	92,7	4,3	29,4	82,9
3	15 years	146,7	4,1	30,6	73,4
4	19 years	25,0	4,0	31,4	38,2
5	23 years	15,7	4,3	28,4	54,1

The depth of peat in study location also vary. The older oil palm plantations tend to have the peat thickness that is thinner, this was due to the occurrence of subsidence of peat land. The increasing age also indicated an increase in oil palm age of peat land reclamation, thus it caused changes in the physical and chemical properties of these soils. Silvan *et al.*²³⁾ stated that the increase in age after drained peat lands can improve structure of soil mesofauna community to match the soil fauna communities on dry land with the same type of vegetation.

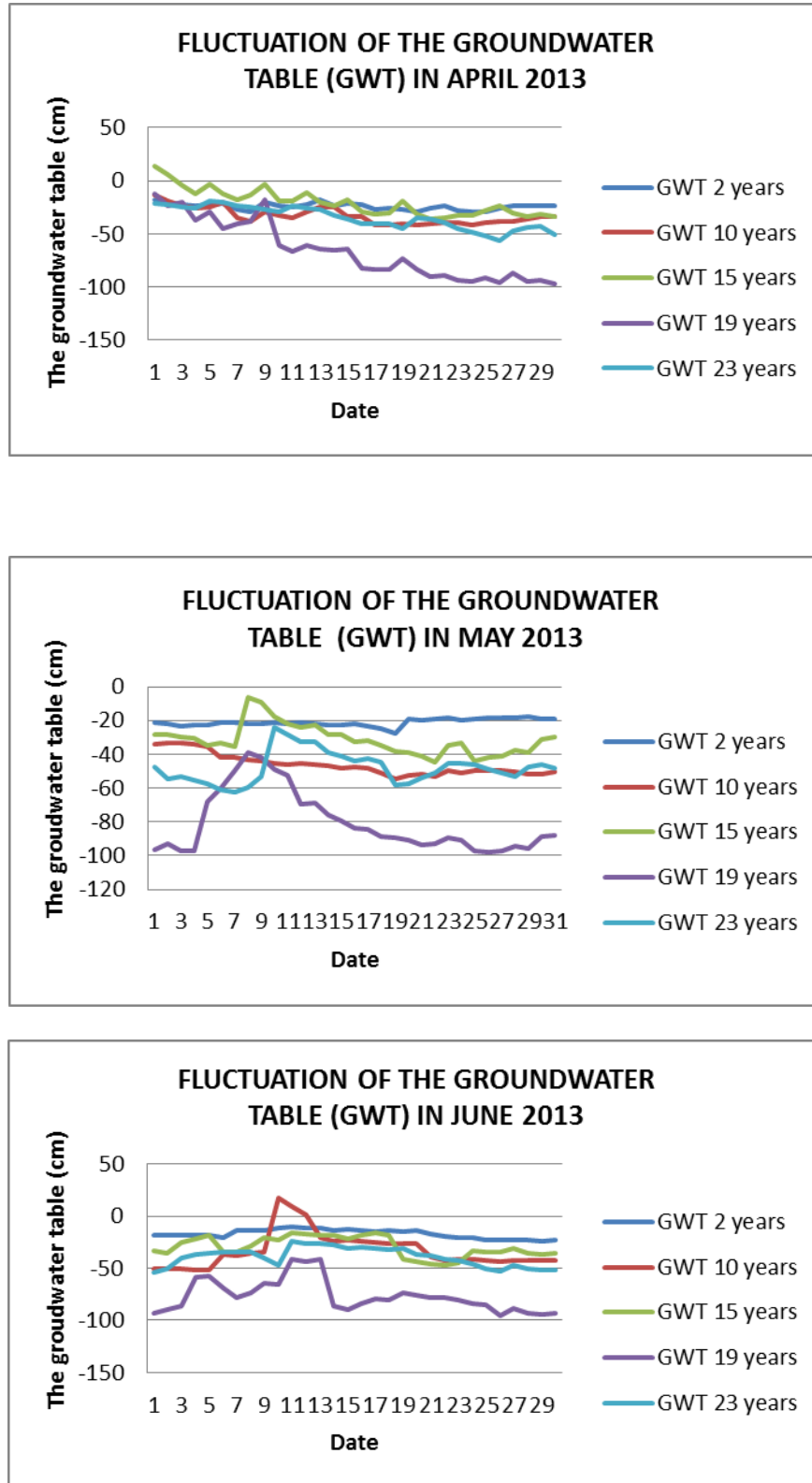


Figure 2. Fluctuation of Groundwater table on Peat Lands with

Different Age Strata of Oil Palm

4.3. Distribution Pattern of *Pontoscolex corethrurus* Earthworms

The patterns of distribution of earthworms in this study were analyzed using Morisita index (Id). At the age of 2 years, Morisita index value (Id) is 4.1; at the age of 19 years Id = 2.5 and at the age of 23 years Id value = 1.5 (Table 3). That results showed that distribution of *P. corethrurus* at three study locations with Morisita Index >1, were categorized as clustered. To test the accuracy of index value, Chi Quadrat test was used. Results of X^2 value in stand age of 2 years = 12.21; at age of 10 years = 115 and at age of 23 years = 75.48 years. Value of $X_{2\text{ count}} > X_{2\text{ table}} (p=0.05)$ in these three sites is 49.77 meaning significantly different from a random pattern. Thus distribution patterns of earthworm populations tended to be clumped in three locations.

Table 2. Morisita Index (Id) of *P. Corethrurus* earthworms on Peat land with Different Strata Age of Oil Palm.

No	Location/Age strata of Oil Palm	Morisita Index (Id)	Patterns of Distribution
1	2 years	4,1	Clustered pattern
2	19 years	2,5	Clustered pattern
3	23 years	1,5	Clustered pattern

Ket :

Id <1 (uniform pattern)

Id =1 (random pattern))

Id > 1 (clustered pattern)

Morisita index values at three study sites (2 years, 19 and 23 years old) tended to decrease with increasing stand age of oil palm. This suggests that in the location of young age oil palm stands, clumped pattern of earthworm distribution is stronger than at locations of palm stands of old age. Changes in the distribution patterns of earthworms is related to changes in habitat condition or peat soils with increasing stand age or the age of the land after the oil drained. At the location of stands of palm age 2 years, the condition of the ground is still unstable and in some places still found logged stump, while the location of stands of old age (23 years) soil condition is stable, solid and resemble the mineral soil. In connection with this, Mathieu ¹³⁾ stated that in general, the distribution of animals including earthworms is influenced by habitat quality,

population density and environmental homogeneity. Test results of Caro *et al.*³⁾ showed that habitat quality is more real influence on the spread of endogeic earthworm. Besides the changes in the distribution pattern of earthworms can also be associated with better population growth in line with changes in the peat soil with increasing age of oil palm stands along peat soil still meet the requirements of live earthworms. Eijsackers⁵⁾ also suggests that the spread of earthworms in a field is determined by the ability of the active movement of earthworms. Period (time) is directly proportional to the distance spread of the spread of earthworms in a field.

5. Conclusions

Earthworms in peatlands under oil palm in Seluma District of Bengkulu Province consists of only one type, namely *Pontoscolex corethrurus* (Oligochaeta : Glossoscolecidae). These earthworms were found in the location of stands of oil palm age 2 years, 19 years and 23 years with a population density tending to increase with increasing stand age of oil palms. At the location periodically inundated (location of stands of palm age 10 years and 15 years), there were not found earthworms. The distribution of *P. corethrurus* earthworms in each stratum of palm stand (age 2 years , 19 years and 23 years) showed a clustered pattern. The clustered pattern of earthworm in young age oil palm stands is stronger than at locations of palm stands of old age .

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