

Diversity of Soil Arthropods in Different Soil Stratification Layers, The National Park of Gede Pangrango Mountain, Cisarua Resort, West Java, Indonesia

Meitiyani^{1*} and A P Dharma¹

¹Departement of Education Biology Faculty of Teacher Training and Education Science, Muhammadiyah Prof. Dr. Hamka University, Jakarta, Indonesia

*E-mail: meitiyani@gmail.com

Abstract. Soil arthropods has an important role for guarding food web sustainability, so its diversity value usually exert a strong influence on the ecosystem balance. Understanding arthropods soil diversity become important in maintaining soil quality. This research aims to analyze arthropods diversity in different top soil level around mount Pangrango National Park, Cisarua Resort Bogor, West Java. Sample were collected by monolith (25cm x 25cm x 10cm) . Devided into 3 layers (A: 10-20 cm, B: 20-30 cm, and C: 30-40 cm) and collected from agriculture field, riverside area, primary forest, and secondary forest. A total 143 individuals were found consisting of 8 order and 19 family (Staphylinidae, Carabidae, Scarabaeidae, Alycidae, Formicidae, Polydesmidae, Parasitidae, tenebrionidae, Scolytidae, Curculionidae, Ptiliidae, Scydmaenidae, Alycidae, Miridae, Antrodiaetidae, Arachnidae and Drosophilidae), Formicidae and Staphylinidae are dominant with respectively 58,7% and 18,9%. Various result in diversity, richness, evenness and dominance were showed in different vertical soil level. The highest Arthropods diversity index (1,49) found at riverside in the soil layer A. Diversity index on top soil level A (0-10 cm) all showed moderate level, B level (10-20 cm) showed two moderate and two low, C level (20-30 cm) showed one moderate and 3 low. Therefore, increasing soil depth showed increasing low level of arthropods diversity index

Keywords: diversity, soil arthropods , soil layers, ecosystem balance

1. Introduction

Soil has an important role for all living matter on earth by supporting growth of vegetation, provides nutrients and water, and act as a root supporting system. Soil is also abode for living organisms such as varying type of animals that carried out crucial process on the ecosystem, performing great number of ecological niches below the ground. Soil fauna decays plant and corpse material into complex organic matter which provides energy and simple organic material known as decomposition process [1]. Therefore, their important role as a complex organic material decomposer making soil organism important to maintain soil fertility and productivity. Soil fauna (micro fauna: protozoa, bacteria, meso fauna: Acarina, Symphyla, Collembola, Diplura and macro fauna: Chilopoda, Coleoptera, Orthoptera, and Hymenoptera) perform vital functions in a number of biological processes around the rhizosphere within vicinity of decomposing organic matter. Research at Gunung Pangrango National Park in 2006 about dungbeetles at upper soil showed that the diversity of dungbeetles at the altitude 500-1000 m was the highest, may be due by many factors such as varying type of animals dan environment at that



level [2]. Biotic and physiochemical features of the soil changed from layer to layer in soil. These factors was changed the vertical distribution of soil fauna [3]. Macro faunal organism have been widely accepted as indicators of soil quality. This is due to the imporatat role of fauna regulating processes such as the formation of soil aggregates, nutrien cycling and soil aeration [4]. Arthropods is one of the most number of soil fauna. They are “litter transformers” or “ecosystem engineers”, that modify the habitat, maintain, and create habitat and modulate the availability of resources to other abundance and evenness species [5]. When the organic matter increases the soil arthropod population also increases. And during various seasons the soil arthropods showed variations in their diversity, richness, and evenness [6]. Its reasonable whether soil arthropod diversity as indicator of soil condition in different stratification soil layer. Cisarua resort at Gede Pangrango Mountain National Park has a vary terrestrial ecosystem and vary animal diversity included infauna. Many type ekosistem inside this national park, making it suitable for conducting arthropods diversity research in vertical soil. Therefore four different location are determined to be this study location which are primary forest, secondary forest, open field area at riverside, and intensif agricultural field. Studies of soil arthropods diversity in vertical stratification are important to understand arthropods diversity level in the different vertical soil condition in Resort Cisarua Gede Pangrango Mountain National Park. This study also important for understanding vital roles of soil arthropods in the ecosystem.

2. Study sites and methods

2.1. Study sites

This research was conducted between February – April 2015 in four different location at Cisarua Resort Pangrango Mountain, Bogor, West Java. The location include: (1) agricultural field in Desa Tugu Atas, Cisarua, West Java, (2) riverside area, (3) secondary forest, and (4) primary forest.

2.2. Data collection

Soil arthropods were collected by monolith (25cm x 25cm x 10cm). There were 10 point in each study site. Samples were extracted from each monolith points and divided by three depth layers, which are 0-10cm soil depth (A), 10-20cm soil depth (B), and 20-30cm soil depth (C). The arthropods extracted from soil samples were screened by placing samples in plastic container and sorting the large size arthropods by hand manually. Soil sample then proceed using Berlesse funnel apparatus for extracting smaller size arthropod. All soil arthropods collected from each location cleaned by fresh water, then stored in 96% ethyl alcohol for further analysis.

2.3. Data analysis

Data analysis using Shannon-Weaner index equation, Shannon Evenness Index, Family Richness by Margalef and Dominance Index by Simpson (7)

Shannon-Weaner diversity index : $H' = - \sum p_i \ln p_i$

$$p_i = n_i / N$$

H' = Shannon-Weiner's index of diversity

$P_i = n_i /$, fraction of the entire population made up of takson

n = the number of individual of certain (i^{th}) takson i

N = the number of individual of all takson

Shannon Evenness Index : $E = H' / \ln S$

E = evenness index of takson

S = total number of takson

H' = Shannon-Weiner's index of diversity

Family Richness by Margalef : $DMg = (S-1) / \ln N$

DMg = richness index of takson

S = number of takson

N = total number of takson

Simpson Dominance Index : $C = \sum P_i^2$

$P_i = n_i / N$

C = dominance index

N_i = number of individuals belong to taxon i

N = total number of collected i

3. Results

3.1. Soil arthropod composition

Total 143 individuals were found consisting of 8 order and 19 family from 3 soil layers (A: 10-20 cm, B: 20-30 cm, and C: 30-40 cm), collected from agriculture field, riverside area, primary forest, and secondary forest. Horizontal observation resulting the highest number was found in the primary forest with 62 individuals, followed by riverside area (46 individuals), secondary forest (22 individuals), agricultural field (13 individuals). Vertical observation resulting in A soil layer has greater number of individuals (83), followed by B soil layer with 39 individuals, and C soil layer with 17 individuals (Table 1). In soil layer A (0 – 10 cm), all data recorded from the A layer showed 83 number of arthropods were present and grouped into 14 families and 8 orders. The highest number of family in this layer is found in the primary forest consist of 8 families and 52 individuals (Staphylinidae, Carabidae, Scarabaeidae, Alycidae, Formicidae, Geophilidae, Polydesmidae, Parasitidae), followed by riverside area 6 families and 15 individuals (Staphylinidae, Scolytidae, Ptyliidae, Formicidae, Parasitidae, Antrodiaetidae), secondary forest area with 3 families and 12 individuals (Staphylinidae, Tenebrionidae, Formicidae), and the lowest number found in agricultural field with 3 families and 4 individuals (Staphylinidae, Scydmaenidae, Drosophilidae). In soil layer B (10 – 20 cm) total soil arthropods recorded in this layer consist of 43 individuals which grouped in 8 families and 6 order. The highest number of family in this layer is 4 families found in the secondary forest area and consist of 7 individuals (Staphylinidae, Scolytidae, Formicidae, Geophilidae), same as agricultural field area (Staphylinidae, Miridae, Mycetophilidae, Arachnidae), followed by riverside area with 3 families and 26 individuals (Staphylinidae, Formicidae dan Cecidomyiidae), and primary forest with 2 families and 3 individuals (Staphylinidae dan Formicidae). In soil layer C (20 – 30 cm) recorded 4 orders and 7 families with a total of 17 individuals. The highest number of family in this layer is 4 families founded in the riverside area consist of 5 individuals, followed by primary forest with 3 families and 7 individuals (Scarabaeidae, Formicidae, and Cecidomyiidae), secondary forests which with 2 families and 3 individuals (Staphylinidae and Curculionidae) and agricultural field with 1 family and 2 individuals (Formicidae) (table 1). Horizontal observation (4 location) and vertical observation (3 soil level) showed the most dominante family is Formicidae (58.7%), followed by Staphylinidae (18.9%) (figure 1).

3.2. Diversity

The diversity range of arthropods in A layer (10-20 cm) showed between 1.00 – 1.49, B layer (10 – 20 cm) : 0.33 – 1.39 and C layer (20-30 cm): 0.00 – 0.96 (table 2).

4. Discussion

4.1 Soil arthropode composition

Soil Arthropods that was found in A layer is greater than B & C layer. A layer (0 – 10 cm) as top surface has more abundance of leaf cutter and litter compared with layers below. We found much plant residues in this layer almost in all study sites. Plant residues produced chemical plant through decomposition process. Chemical plants particularly N and lignin contents, play a critical role in faunal abundance in the soil that influenced faunal abundance in the soil [8]. Population of Formicidae is the most abundance family in this layer (59%), and recorded in 3 location, followed by Staphylinidae (23%), Tenebrionidae (6%). Hymenoptera and Coleoptera were the most abundance

order found in this layer. Formicidae (order Hymenoptera) mostly found in primary forest which has vary and thick layer of leaf cutter came from the forest canopy. This condition will support growth of ants and other arthropods and could be influenced soil fertility. The activity of ants clearly facilitate the decomposition of plant materials such as leaf cutter ants to soil fertility. There are two ways through which leaf cutting ants may modify soil fertility: the building and maintenance of their nests and the priduction and deposition of their organic waste products [9]. Staphylinidae from order Coleoptera was recorded in all study area in A soil layer. Beetle may be found in almost every type of habitat, and they feed on all sorts of plant and animal materials, many are predaceous, some are scavengers and a very few are parasitic [10]. Only two individuals of beetles (5.0 %) and no ant found in agricultural field, it was probably caused by the farmer always diminished litter and leaf cutter layer on the crop field area, and also used of pesticide. Intense agricultural practice affected the arthropods community leads to species dominance. Pesticide will deplete the arthropods number followed by the faster growth of microorganism, thus organism will tend to be dominant and potentially become pests [11]. In the soil layer (B: 10 – 20 cm), population of Formicidae is the most abundance family of this layer (69%), and recorded in 3 location, followed by Staphylinidae (17%) that founded in all location in this layer. Arachnidae (8%) which mostly found in agricultural field. Arachnidae generally roles as a predator of small arthropods, psocids, collembolans, and mites. Some species dwelling in the soil [12]. In soil layer (C: 20 – 30 cm) population of Formicidae is the most abundance family of this layer (9,5%), and only 12 individual of arthropods founded in this layer (8,4%). The fewer number of families and the small number of soil arthropods individual in layer C are affected by the abiotic conditions of the soil. Ground surface arthropods as biotic components in soil ecosystems are highly depend on several environmental factors. Environmental changes will affect the presence and density of the Arthropod population [13]. The air content was fewer at greater depths, this may be due the soil is more compact and has smaller pore spaces [14].

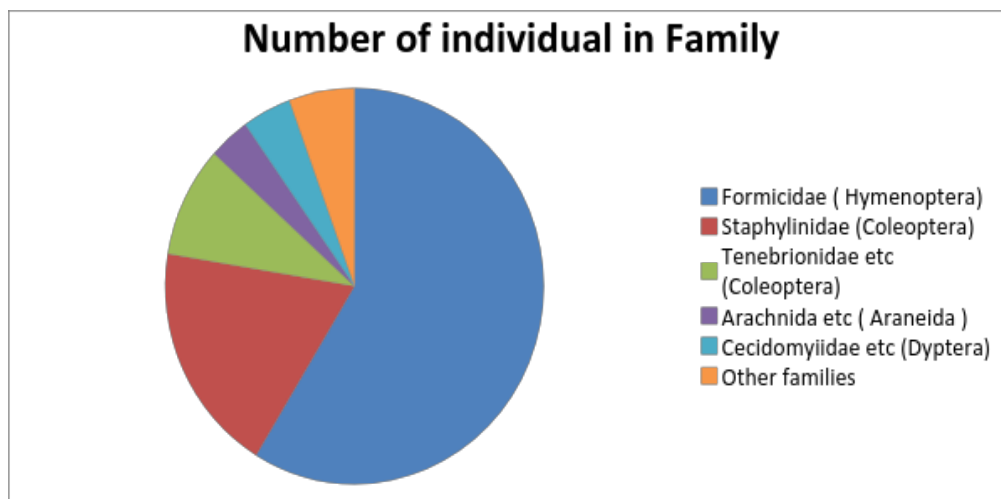


Figure 1. Soil arthropods species number in family.

4.2 Diversity

The diversity range of arthropods in soil A layer (10-20 cm) showed between 1.00 – 1.49. All study site in this layer showed moderate level. Highest diversity index in top soil layer was found in the riverside area (1.49) which has 6 families recorded. Family taxa composition in this area spread out evenly because there was no family dominance. In primary forest, we found various herbaceous plants, mostly large vegetations and has more stable ecosystem condition, but diversity in this site lower than riverside area. This may be due formicidae dominance in this site (59%). This was indicated by low evenness index lower (0.48) (figure 2). The thick layer of leafcutter on the soil surface provides the shelter and food for ants. In a diverse community, one species can perform dominance to other

species [15]. Leafcutter was organic material input for soil surface. Various environment input factor influenced dominancy of arthropod community [16].

Table 1. Composition of soil arthropods in vertical stratification.

Ordo	Family	Agricultural Field			Secondary Forest			Riverside area			Primary Forest			Sum
		A ¹	B ²	C ³	A	B	C	A	B	C	A	B	C	
Coleoptera	Staphylinidae	2	1		1	4	2	6	1	1	8	1		27
	Tenebrionidae				5									5
	Scolytidae					1		1						2
	Curculionidae						1							1
	Ptiliidae							1						1
	Carabidae										1			1
	Scarabaeidae										1		1	2
	Scydmaenidae	1												1
Hemiptera	Alycidae										1			1
	Miridae		2											2
Hymenoptera	Formicidae			2	6	1		5	24	2	38	2	4	84
Chilopoda	Geophilidae					1					1			2
Diplopoda	Polydesmidae										1			1
Mesostigmata	Parasitidae							1			1			2
Araneida	Antrodiaetidae					-		1		1				2
	Arachnidae		3			-								3
Diptera	Drosophilidae	1												1
	Cecidomyiidae								1				2	3
	Mycetophilidae		1							1				2
Total		4	7	2	12	8	3	15	26	5	52	3	7	143

¹ A = 0-10 cm

² B = 10-20 cm

³ C = 20-30 cm

Table 2. Diversity index, evenness, richness and dominance in vertical stratification.

	Agricultural Field			Secondary Forest			Riverside area			Primary Forest		
	A	B	C	A	B	C	A	B	C	A	B	C
Diversity index	1.05	1.28	0.00	1.03	1.39	0.64	1.49	0.33	1.33	1.00	0.64	0.96
Evenness	0.95	1.86	0.00	0.94	0.86	0.93	0.83	0.30	0.96	0.48	0.93	0.87
Richness	1.44	1.54	0.00	0.81	1.92	0.72	1.85	0.61	1.86	1.77	0.91	1.03
Dominance	0.37	0.30	1.00	0.43	0.31	0.56	0.26	0.85	0.18	0.55	0.56	0.42

In B layer (10 – 20 cm) between 0.33 – 1.39, the highest diversity index in this layer found in the secondary forest (1.39) which has 4 families recorded. Family taxa composition in this area spread out evenly because there was no family dominance found. Riverside area is the poor diversity in this area (0.33), this may be do also by large number of formicidae. This was indicated by dominance index (0.85) and also evenness index (0.3) (figure 3). Otherwise agriculture field with monoculture system has moderate diversity (1.28). Family taxa composition in this area spread out evenly, but we

found arachnidae only in this site. This may be do the monoculture plantation also provided a certain arthropod by litters quality [17].

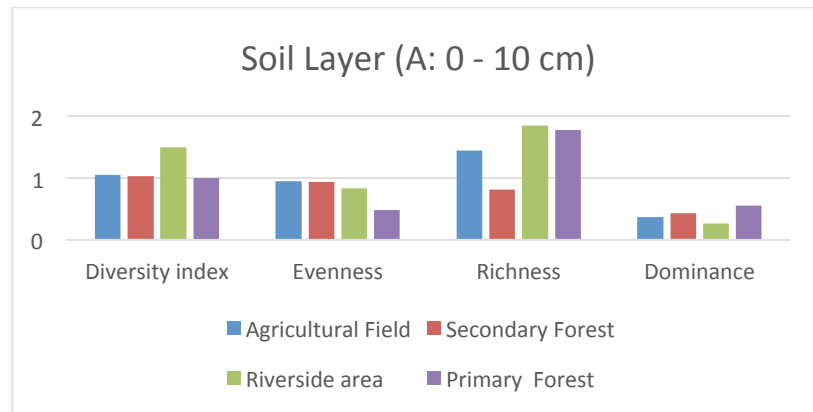


Figure 2. Diversity index in soil layer A

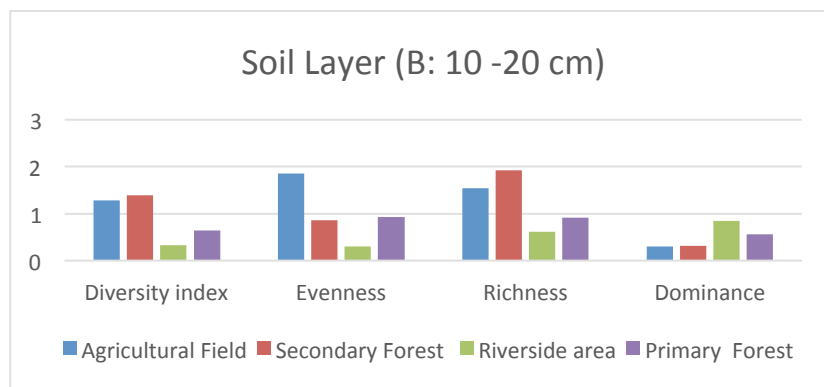


Figure 3. Diversity index in soil layer B

In C layer (20-30 cm) between 0.00 – 0.96. The highest index diversity in layer C is on riverside area with a family diversity index 1.33 (figure 4). The similarity and the dominance effects can impact the identification of patterns and the interpretation of underlying ecological processes and may thus be highly informative for our ecological understanding. Agriculture field area is the poor diversity in this area (0.0), and no individual found in this area. Application of pesticides during agricultural activities, has strong influence on the diversity and abundance of soil fauna [18].

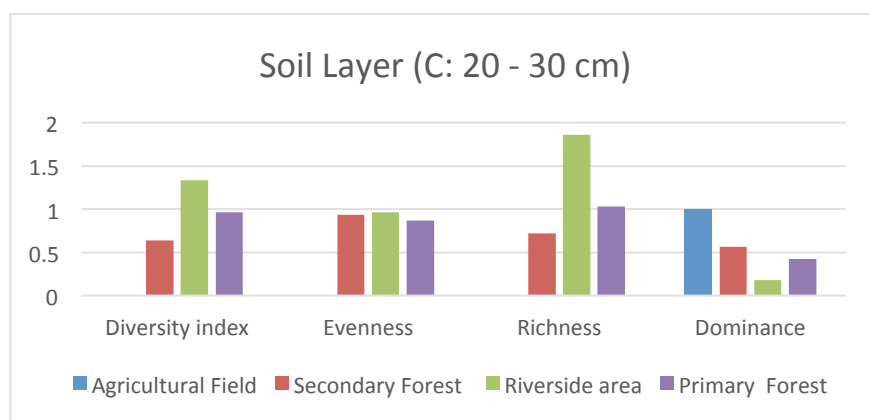


Figure 4. Diversity index in soil layer C.

In general, a gradual decrease in family richness in relation to soil depths was observed. These reported outcomes supports the influence of soil depth on the species composition and diversity of soil insects.

5. Conclusion

Various result in diversity, richness, evenness and dominance were showed in different vertical soil level. The highest Arthropods diversity index (1.49) found at riverside in the soil layer A. Diversity index on top soil level A (0-10 cm) all showed moderate level, B level (10-20 cm) showed two moderate and two low, C level (20-30 cm) showed one moderate and 3 low. Therefore, increasing soil depth showed increasing low level of arthropods diversity index

Acknowledgements

We thank to institutions who contribute in this research: Gede Pangrango Mountain National Park staff West Java Indonesia, Research and Development Departement of University Muhammadiyah Prof. Hamka and Entomology Departement of LIPI Cibinong.

References

- [1] Haneda N F and Sirait B A 2012 *Silviculture Tropical Journal* **3**(3) p161
- [2] Kahono S, Setiadi L K 2007 *Biodiversitas* **7**(4) 118-122
- [3] Sheikh A A, Lone G M, Rehman N Z, Tariq A B, Muneer A S, Bhat M A and Nabi S Un. 2016 *J. Entomol. Zool. Stud.* **5**(1) 843
- [4] Siqueira G M, Silva E F F and Paz-Ferreiro J 2014 Land use intensification effects in soil arthropod community of an entisol in pernambuco state, Brazil *Scientific World Journal* 2014 Article ID 625856
- [5] Jones C G, Lawton J H and Shachak M 1994 *Oikos* **69** 373–386
- [6] Bini B, Sanal Kumar M G and Vinod P 2016 *International Journal of Scientific and Research Publications* **6**(1) 261
- [7] Odum E P 1994 *Fundamental Ecology* Samingan T (Yogyakarta : Gadjah Mada University Press) p179
- [8] Tian *et al.* 1993 *Soil biology and Biochemistry* **25**(6) 731-737
- [9] Farji-Brener A G and Tadey M 2009 *Contributions of Leaf-cutting Ants to Soil Fertility: Causes and Consequences* Lucero D P and Boggs J E (New York : Nova Science Publishers) p81–91
- [10] Donald J B and Dwight M D 1992 *An Introduction to the Study of Insect* (Yogyakarta : Translation Copy right. Gadjah mada university Press) p456
- [11] Samudra F B, Izzati M and Purnaweni H 2013 *Richness and Soil Arthropods Diversity in Organic Vegetables Fields “Urban Farming”* (Semarang : Prociding Nasional Conference of Environmental and Resources Management, ISBN 978-602-17001-1-2) p190
- [12] Chakravarthy A K and Sridhara S 2016 *Economic and Ecological Significance of Arthropods in Diversified Ecosystems* (Singapore : Springer Science+Business Media DOI 10.1007.) p29-43
- [13] Nurhadi 2011 Soil Surface Arthropods Composition di sriwijaya Plant Area Palembang *Jurnal Ilmiah Ekotrans Universitas Ekasakti Padang* p 1-11
- [14] Rotimini J and Uwagbae M 2014 *Eur. Int. J. Sci. Technol.* **3**(5) 16
- [15] Suheriyanto D 2008 *Insect Ecology* (Malang : UIN-Malang Press)
- [16] Bargett, Richard D and Roger C 1998 *Appl. Soil Ecol.* **10** 270
- [17] Warren M W and Zou X 2001 *Forest Ecology and Management* p161-171
- [18] Arroyo J and Iturrondobeita J C 2006 *Eur. J. Soil. Biol.* **42** 259-269