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Research paper

Effects of Season on Abundance and Diversity of Soil Arthropods in Mangli Coffee Plantation Kediri Regency, East Java, Indonesia

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Abstract

The soil arthropod diversity is influenced by the season rather than the plantation age. Arthropods will respond to every aberration from normal environmental conditions, against high or low temperature thresholds to respond in many ways. The study was carried out in Mangli coffee plantation Kediri regency to determine the effect of season on the abundance and diversity of soil arthropods. In each season is an installed systematically 30 pitfall traps. The environmental factors as measured where the temperature and humidity of soil, soil organic carbon, soil organic matter, N, P and K. The soil arthropods abundance was analyzed using PCA. The soil arthropod diversity was analyzed using Shannon index, dominance and equitability. The environmental factor effect on the soil arthropod abundance was analyzed using CCA. The season is very effect on the soil arthropod abundance in Mangli coffee plantation. The Myrmica genus is very abundant in the dry season while in rainy season is Entomobrya genus. Based on PCA result, the dry season is characterized by Ponera genus while the rainy season is characterized by Entomobrya and Neoponera genus. The soil arthropod diversity in rainy season is higher than the dry season. The taxa number, individual number, Shannon diversity index and equitability in the rainy season are higher than the dry season. The most of environmental factors of Mangli coffee plantation in dry season except temperature and phosphor are higher than rainy season. Based on CCA can be known that temperature and phosphor influence the distribution of most soil arthropods in rainy season.

Keywords: *Season, abundance, diversity, arthropod, coffee*

1. Introduction

Mangli plantation is one of the coffee producers in Kediri district. The existence of plantation can affect on ecosystem sustainability. Management practice could influence to soil arthropod diversity and their function (Kinasih et al., 2016). Coffee management system may decrease soil arthropod diversity (Philpott et al., 2006).

The land use had significant impacts on the soil arthropod diversity, which ultimately affect the physical and chemical quality of soil (Begum et al., 2011). The soil arthropods play role in carbon and nutrient cycle (Brussaard et al., 2007a). The density of soil arthropod increased along with the soil fertility improvement (Cole et al., 2005). Soil arthropods can role in the soil fertility maintenance by decomposing plant biomass directly or indirectly and the effect on the soil physical structure (Culliney, 2013).

The diversity of soil arthropods is influenced by the season rather than the age of the plantation (Liu et al., 2013). Arthropods will respond to every aberration from normal environmental conditions, against high or low temperature thresholds to respond in many ways (Khaliq, 2014). The aim of the study was to determine the effect of season on the abundance and diversity of soil arthropods in Mangli coffee plantation Kediri regency.

2. Materials and Method

2.1. Study area

The soil arthropod study was conducted in Mangli Coffee plantation sub-district of Puncu, Kediri Regency, East Java, Indonesia. The plantation is located at latitude: 7°52'9.40" S 112°15'26.70" E and altitude: about 460 m above sea level.

Fig. 1: The study site at Mangli coffee plantation (Adapted from Google earth, 2016)

2.2. Sampling of soil arthropods

Soil arthropods were sampled at dry season, between September until October 2013 and at rainy season between March until April 2015.

In each season is made 3 observation stations and each station is installed 10 pitfall traps, the pitfall traps were placed systematically at 5 m intervals. Plastic cup of about 10 cm mouth diameter and 10 cm depth was filled with 10 ml 70% ethanol and 5 drops of detergent solution. The traps were buried 24 hours in the ground with the cup mouth position must be equal to the surface of the ground. The soil arthropods were preserved in 70% ethanol. The specimen was identified to the genus level based on Dindal (1990) and website: http://www.bugguide.net.

2.3. Soil analysis

The temperature and humidity of soil were measured in the field using a digital hygro-thermometer. The soil organic carbon, soil organic matter, N, P and K were determined in the laboratory by gravimetric methods.

Table 1: Soil arthropods abundance in Mangli coffee plantation during observation in dry and rainy season

Class	Order	Family	Genus	Season	
				Dry	Rainy
Arachnida	Araneae	Gnaphosidae	*Drassyllus*	2	40
Arachnida	Araneae	Hahniidae	*Antistea*	0	45
Arachnida	Araneae	Hahniidae	*Calymmaria*	0	62
Arachnida	Araneae	Lycosidae	*Pardosa*	0	16
Arachnida	Araneae	Miturgidae	*Syspira*	64	6
Arachnida	Trombidiformes	Trombidiidae	*Allothrombium*	0	7
Chilopoda	Geophilomorpha	Geophilidae	*Geophilus*	1	5
Chilopoda	Scolopendromorph	Scolopendridae	*Scolopendra*	0	1
Collembola	Entomobryomorpha	Entomobryidae	*Entomobrya*	0	334
Collembola	Entomobryomorpha	Entomobryidae	*Lepidocyrtus*	0	102
Collembola	Entomobryomorpha	Entomobryidae	*Homidia*	0	7
Collembola	Entomobryomorpha	Isotomidae	*Desoria*	0	16
Collembola	Entomobryomorpha	Paronellidae	*Salina*	0	3
Collembola	Poduromorpha	Neanuridae	*Morulina*	0	45
Diplopoda	Polydesmida	Paradoxosomatidae	*Oxidus*	0	5
Insecta	Blattodea	Blattidae	*Periplaneta*	0	8
Insecta	Blattodea	Blattidae	*Shelfordella*	0	4
Insecta	Blattodea	Ectobiidae	*Blattella*	0	4
Insecta	Blattodea	Rhinotermitidae	*Coptotermes*	0	16
Insecta	Coleoptera	Carabidae	*Tachys*	0	1
Insecta	Coleoptera	Cryptophagidae	*Atomaria*	0	2
Insecta	Coleoptera	Scarabaeidae	*Serica*	113	0
Insecta	Coleoptera	Staphylinidae	*Omalium*	1	0
Insecta	Hymenoptera	Formicidae	*Neoponera*	64	135
Insecta	Hymenoptera	Formicidae	*Formica*	0	119
Insecta	Hymenoptera	Formicidae	*Odontomachus*	16	16
Insecta	Hymenoptera	Formicidae	*Myrmecocystus*	0	10
Insecta	Hymenoptera	Formicidae	*Ponera*	249	0
Insecta	Hymenoptera	Formicidae	*Myrmica*	500	235
Insecta	Orthoptera	Gryllidae	*Allonemobius*	60	7
Insecta	Orthoptera	Gryllidae	*Eunemobius*	0	35
Insecta	Orthoptera	Gryllidae	*Gryllus*	0	17
Insecta	Orthoptera	Gryllidae	*Acheta*	0	1
Insecta	Orthoptera	Gryllotalpidae	*Scapteriscus*	2	0
Insecta	Orthoptera	Tetrigidae	*Neotettix*	0	10

2.4. Data analysis

The effects of dry and rainy season on soil arthropod abundance was analyzed using Principal Component Analysis (PCA). The diversity of soil arthropods was analyzed using Shannon index (H'), dominance (D) and equitability (J). The effect of environmental factors on the abundance of soil arthropod was analyzed using Canonical Correspondence Analysis (CCA). Data analysis was performed using the software Past 3.12.

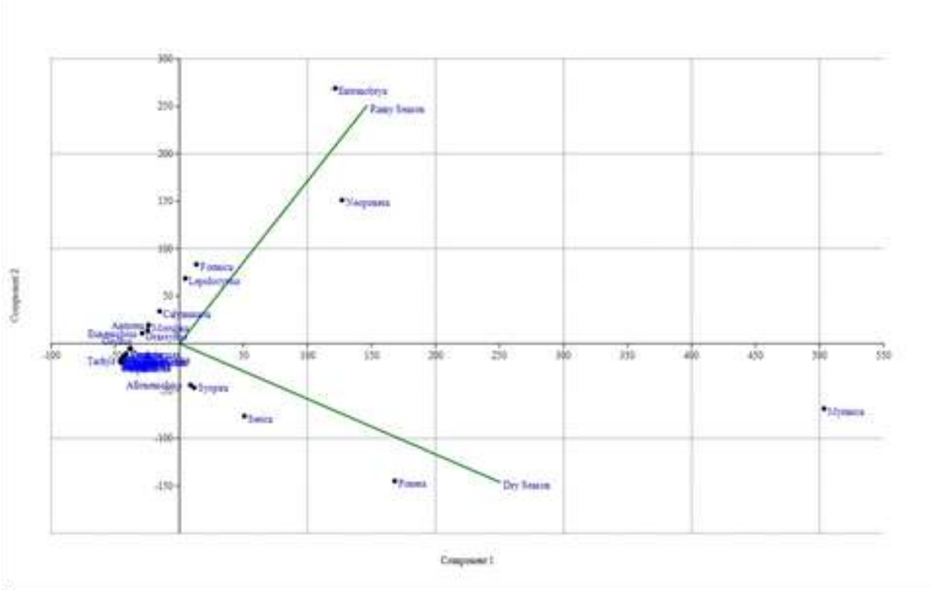

Fig. 2: PCA biplot of soil arthropod abundance in dry and rainy season

3. Result and Discussion

The soil arthropod specimens that collection during the sampling period on Mangli coffee plantation are identified to genus (Table 1). The highest abundance of soil arthropods in the dry season is Myrmica genus, then follow by Ponera genus, while in rainy season Entomobrya genus has highest abundance follow by Myrmica genus.

Arthropods suitable to characterize the habitat. The diversity and abundance of arthropods are an integrated component to evaluate the ecosystem (Olfert et al., 2002). Based on PCA result (Fig. 2) shows that the dry season is characterized by Ponera genus while the rainy season is characterized by Entomobrya and Neoponera genus.

The Myrmica and Ponera genus are ant group. The ant diversity is positively correlated with temperature. Hot climate can change the diversity of ant species (Folgarait, 1999). Ant species can use as biological indicators. The composition of ant species varies throughout the habitats (Delabie et al., 2009; Chen et al., 2011; Gollan et al., 2011).

The Entomobrya genus is collembola group. The high temperatures can increase heat stress and ultimately cause collembola death (Birkemoe & Leinass, 2000). Collembola diversity correlated with habitat diversity (Sousa et al., 2004). The decrease of collembola abundance in the intensive farming system has important effects on soil fertility (Bedano et al., 2006). Collembola have an important role in the soil material circulation and improve physical and chemical properties of the soil (Chen et al., 2007).

Soil arthropods are more diverse in the rainy season than the dry season. There are 3 classes, 5 orders, 8 families and 11 genera in the dry season while in rainy season 5 classes, 12 orders, 20 families and 31 genera (Fig. 2).

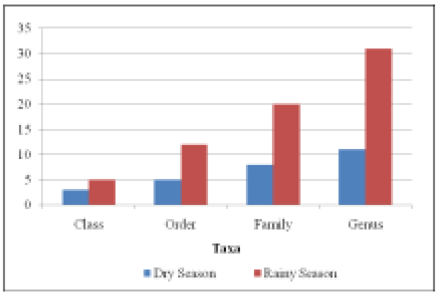

Fig. 3: Comparison of taxa number

This study showed that soil arthropod diversity in rainy season is higher than the dry season. The taxa number, individual number, Shannon diversity index and equitability in the rainy season are higher than dry season (Table 2).

Table 2: Soil arthropod diversity

Parameters	Season	
	Dry	Rainy
Taxa (S)	11	31
Individuals (N)	1,072	1,414
Shannon (H')	1.53	2.45
Dominance (D)	0.29	0.13
Equitability (J)	0.64	0.71

There are many plants and trees in the rainy season than the dry season that give a suitable habitat for soil arthropods. The plants and trees will create a compatible environment for soil arthropods and could attract soil arthropods to dwell over there (Esenowo et al., 2014).

Soil arthropods play a role in the decomposition of leaf litter (Yang & Chen, 2009). The decomposer diversity affects the quality and quantity of litter during decomposition (Moore et al., 2004).

Table 3: Environmental factors

Parameters	Season	
	Dry	Rainy
Temperature (ºC)	27.38	30.00
Humidity (%)	82.16	79.00
pH	6.37	4.8
Organic Matter (%)	8.79	2.57
Organic Carbon (%)	6.77	1.5
N (%)	0.77	0.15
P_2O_5 (mg/100)	18.29	48.43
K_2O (me/100)	33.58	0.17

The most of environmental factors of Mangli coffee plantation in dry season except temperature and phosphor are higher than rainy season (Table 3). Based on CCA (Fig. 5) can be known that the temperature and the phosphor influence to the distribution of most soil arthropods in rainy season. The soil temperature is a limiting factor in the presence and abundance of diverse groups of arthropods (Begum et al., 2011).

The diversity is low in many cases are the result of environmental disturbance. Environmental hot/ wet can cause stress and effect on the soil biodiversity. The high or low biodiversity relates to environmental stress (Brussaard et al., 2007b). Arthropod diversity related to stress factors. Changes in the ecosystem affect the arthropod community through the formation of niche and distribution (Schweiger et al., 2005).

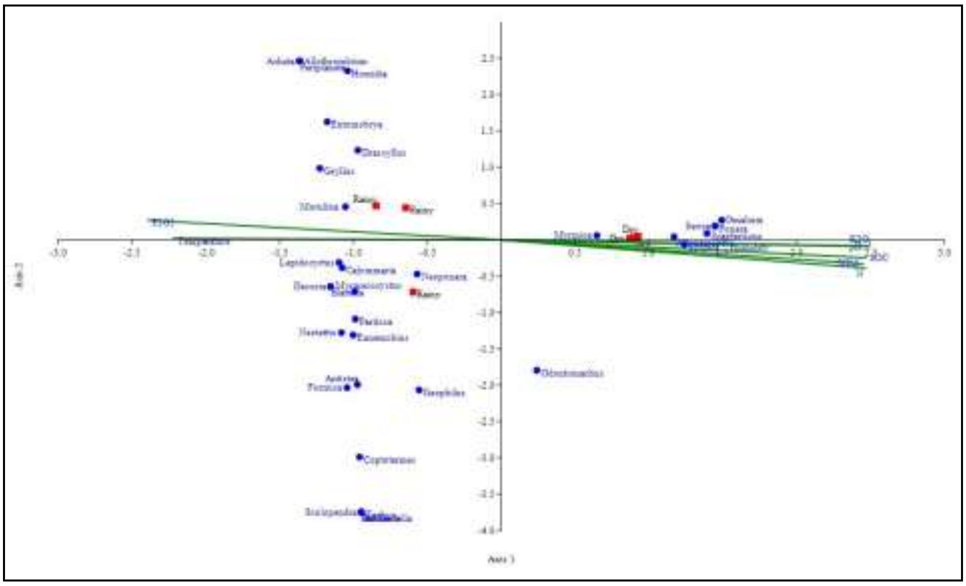

Fig.5: CCA between soil arthropod abundance with environmental factors in dry and rainy season at each observation station

4. Conclusion

The season is very affect on abundance of soil arthropods in Mangli coffee plantation. The Myrmica genus is very abundant in the dry season while in rainy season is Entomobrya genus. Based on PCA result, the dry season is characterized by Ponera genus while the rainy season is characterized by Entomobrya and Neoponera genus.

The diversity of soil arthropods in rainy season is higher than the dry season. The taxa number, individual number, Shannon diversity index and equitability in the rainy season are higher than the dry season.

The most of environmental factors of Mangli coffee plantation in dry season except temperature and phosphor are higher than rainy season. Based on CCA can be known that temperature and phosphor influence the distribution of most soil arthropods in rainy season.

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