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Short Communication: Diversity and abundance of soil insects at Jeruk Manis Protected Forest in East Lombok (Indonesia) using several trapping methods

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Abstract. *Rohyani IS, Ahyadi H. 2017. Short Communication: Diversity and abundance of soil insects at Jeruk Manis Protected Forest in East Lombok* (*Indonesia*) *using several trapping methods. Biodiversitas 18: 809-812.* Insects are the most successful organisms because it can live in almost all types of habitats, namely water (freshwater and sea), land, air, and even in both hot and cold climates. Identification of soil insects in a certain type of habitat requires practical, easy, inexpensive, and efficient collection methods so as to obtain high abundance and diversity of soil insects. This study aims to analyze the diversity and abundance of soil insects using several trapping methods in Jeruk Manis Protected Forest in East Lombok. There are five trapping methods applied in this study; (i) pitfall trap, (ii) pitfall traps with bait, (iii) yellow pan traps, (iv) soil sampling, and (v) forest floor collection. The findings show that the overall diversity of soil insects in Jeruk Manis Protected Forest is moderate (1.44), while its evenness level is low (0.48). Soil sampling method provides diversity value of 2.36 and evenness level of 0.89, which is also the highest one among the other methods. Pitfall traps with bait give high individual number of soil insects (10.577 individuals). The highest number of soil insect orders is obtained through forest floor collection with 11 orders, while the highest number of soil insect families is obtained through pitfall trap with 30 families. The taxa of soil insects with relatively highest abundance consecutively are Hymenoptera (Formicidae), Collembola (Isotomidae, Entomobryidae), Coleoptera (Hydrophilidae, Ptiliidae, Scarabeidae), and Diptera (Drosophilidae).

Keywords: Abundance, diversity, Jeruk Manis Protected Forest, soil insects, trapping methods

INTRODUCTION

Protected forest, in general, has a very important function in the protection of life support system to regulate the water system, prevent flood, and maintain soil fertility. Jeruk Manis Protected Forest is at the height of ± 30 m asl. It is located in the southern part of Mount Rinjani National Park and is included in the development areas of national park management region II section of East Lombok. The area has abundant natural resources such as natural panorama with a very beautiful waterfall which makes it one of the tourism objects frequently visited by the public. Jeruk Manis Protected Forest is one of the habitats for langurs and eagles which are thought to be the largest population in Rinjani (Rinjani Mountain National Park 2015). Abundant natural resources have a high diversity of organism. The fertile area which is rich in organic materials makes the habitat favored by arthropods. According to Gibert and Deharveng (2002), soil arthropods diversity will form a complex food web in a soil ecosystem which has sufficient organic materials.

The insect is one of the classes in Phylum Arthropoda which is the most dominating one in its phylum. According to Ross et al. (1982), the number of insects is eleven times more than the number of other species in arthropods. Soil Insects is one of the dominant communities in the soil ecosystem. Its presence is necessary because of its ability to recast and decompose organic materials. According to Paoletti et al. (1991), invertebrates including soil insects can decipher the forest floor in the range of 1-30% and can crumble it up to 68%. The ability of soil insects in decomposing organic materials will indirectly alter the catabolism rate of organic materials' recast. The recasting process of organic materials also helps the dispersion of microbes. Passively, soil microarthropods can be a mediator for bacteria, fungi, and protozoa to pass through the digestive tract or skin, to reach a place that cannot be penetrated by the microbiota (Moore et al. 1988). Moreover, soil insects are known to play roles in recasting the organic materials provided for green plants and in the functioning of an ecosystem including the transfer process of energy and minerals, the increase of soil porosity and aeration, and lastly in being the bio-indicator of environmental quality since Collembola, Carabidae, and Staphylinidae can accumulate heavy metals in the bodies (Suhardjono 2000).

Realizing how important soil insects are in the recast process and the quality improvement of soil ecosystem, continuous research needs to be conducted. Regarding this, an effective and efficient insects trapping method with the optimal and analyzable result is necessary. According to Toda and Kitching (1999) and Borror et al. (1992), several types of research have modified some existing methods so that the result of soil insects caught can be obtained optimally, compared, and analyzed quantitatively. A good and appropriate method will make it easier to determine the

diversity and abundance of soil insects in the ecosystem. This study aims to analyze the diversity and abundance of soil insects using several insects trapping methods in Jeruk Manis Protected Forest, East Lombok, West Nusa Tenggara, Indonesia.

MATERIALS AND METHODS

This research was conducted at Jeruk Manis Protected Forest, which is included in the area of Rinjani Mountain National Park in East Lombok, West Nusa Tenggara, Indonesia. The process of data collection until identification was done from February to July 2016. The average daily temperature of the area is 22°C with humidity of about 95% and the average soil pH of 5 which is classified as sour. The dominant vegetation types found in the forest area are *Pterospermum* sp., *Myristica* sp., *Dipterocarpus* sp., *Ficus racemosa*, *Neonauclea* sp., *Myrsine* sp., *Erythrina* sp., *Anthocephalus cadamba*, and *Meliosma pinnata*. Jeruk Manis Protected Forest has chosen with the consideration that its forest floor condition is relatively flat and is still highly virgin.

The sampling of soil insects was chosen by making 100 m main transects line along the walkway. At a distance of 10 meters, additional perpendicular transect line was drawn 5 m to the right and left. At every point that had been made on the main or additional transects, insect traps were set randomly. Five trapping methods were used to collect soil insects and were divided into two allocations; insects which are active on soil surface and insects which are active in the soil. The trapping methods used for insects on the soil surface were (i) pitfall trap, (ii) pitfall traps with bait, and (iii) yellow pan traps, while the trapping methods used for soil insects in the soil were (i) soil sampling and (ii) forest floor collection. The samples of soil and forest floor were stored in a calico bag to be extracted in Berlese funnel which had been modified for seven days. There were 10 traps set randomly for each collection method with three day-installment-duration for each trap.

Identification of soil insects was done by observing their characteristics, which were then matched using key identification according to Lilies (1992), Borror et al. (1996), and Suin (1997). The identification was done up to the family level at Basic Biology Laboratory in The Faculty of Mathematics and Natural Sciences, Universitas Mataram, West Nusa Tenggara, Indonesia.

The samples obtained were then counted their number of individuals (N), their number of orders (O), and their number of families (F). The relative abundance (KR) of soil insects was calculated using the comparison between the number of i-th individual and the total number of individuals from all types of families multiplied by 100% (Magurran 1987, 2004). The diversity of soil insects was calculated based on Shannon-Wiener diversity index (H '). The type evenness was calculated based on Shannon-Wiener's evenness index (E) (Krebs 1999). The index equation is as follows:

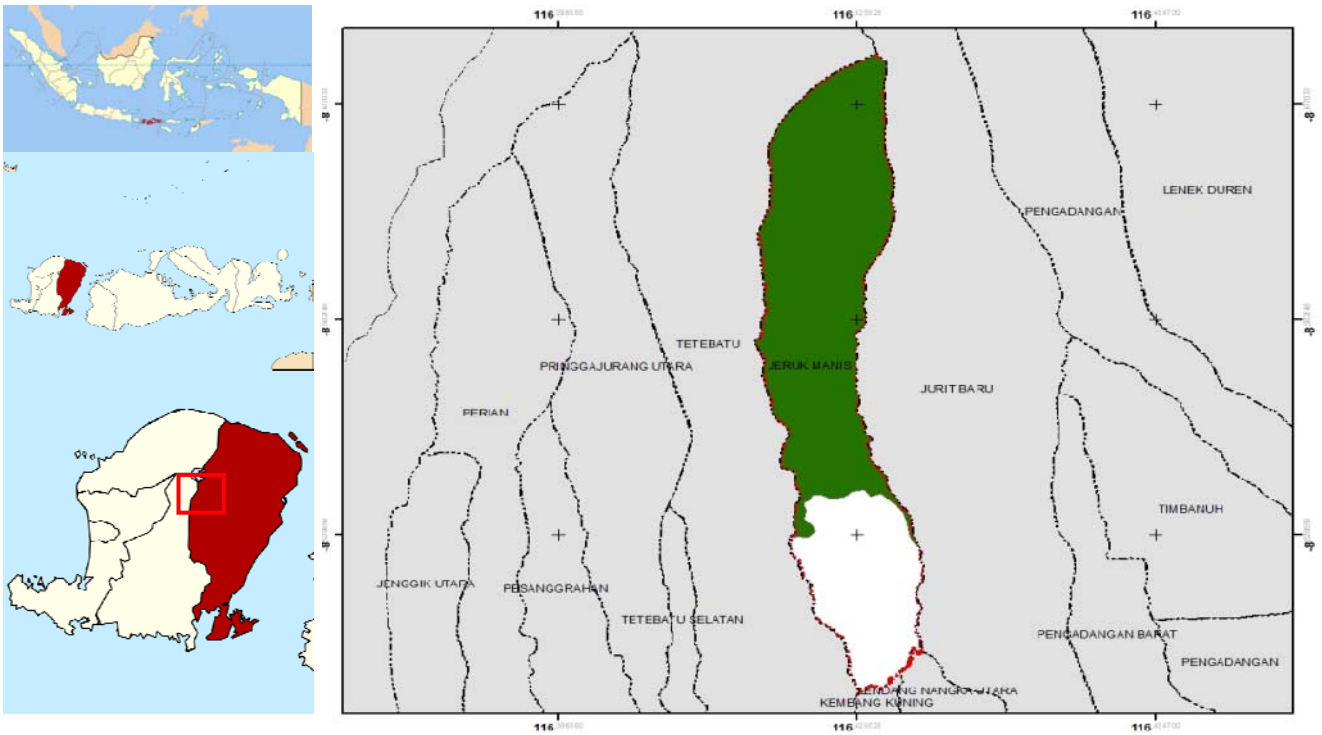

Figure 1. Research site in Jeruk Manis Protected Forest in East Lombok, West Nusa Tenggara, Indonesia

KR = ni/N x 100%
H' = -© (ni/N ln ni/N)
E = H'/ln S

Note:
ni = the i-th individuals in the family
N = The total number of individuals of all types of families
S = The number of types of families

RESULTS AND DISCUSSION

Soil insect diversity in Jeruk Manis Protected Forest in East Lombok

The findings (Table 1) show that the overall number of individual soil insects acquired is 13.699 consisting of 9 orders and 42 families. The numbers of individuals, orders, and families of each soil insect collection methods applied provided different results. The highest number of insects was obtained using pitfall trap with bait which collected 10.577 individuals. Soil sampling provided the least number of insects (102 individuals). The highest number of soil insect orders was obtained by using forest floor collection (11 orders), while the highest number of families was obtained through pitfall trap (30 families).

The high number of soil insects obtained through pitfall trap method was allegedly caused by rotten chicken meat provided as the baits which are the food source for some types of soil insects, especially for Formicidae predominantly found at the site. The amount of available food supply for the insects is the factor that affects the growth and density of soil insects. According to Andersen (2000), the existence of soil insects such as Formicidae is strongly associated with habitat condition, and some of the main limiting factors that affect that are food resources, climate, appropriate habitats for nesting, and home range. The results are consistent with the study conducted by Hasan et al. (2014) which stated that the abundant availability of nutrition/food results in the high dominance value of Formicidae in the forest. According to Rizali et al. (2002), Hymenoptera, especially Formicidae, is a taxon that is most commonly found in forest ecosystems.

Table 1. Soil insect diversity in Jeruk Manis Protected Forest in East Lombok, West Nusa Tenggara, Indonesia

Soil insect trapping method	N	O	F	H'	E
Pitfall trap	1.732	9	30	1.34	0.39
Yellow pan trap	578	7	22	1.37	0.44
Pitfall trap with bait	10.577	8	28	0.46	0.14
Soil sampling	102	7	14	2.36	0.89
Forest floor collection	710	11	23	1.68	0.54

Note: N = number of individuals, O = number of order, F = number of family, H' = diversity index, E = diversity distribution index

Forest floor collection method produced the highest number of insect orders (11 orders) compared to the other collection methods. This was because forest floor is the most preferred location by many soil insect taxa. According to Sembayang et al. (2000), the forest floor is a source of food for saprophyte group and a prowl location for carnivore groups. The existence of forest floor is very important for the survival of soil fauna. Thick forest floor can create a microclimate suitable for the soil fauna habitat. The accumulation of forest floor on the soil surface is a source of food for many organisms, particularly organisms that play a role in degrading forest floor (Rohyani et al. 2013).

Pitfall trap method provided the highest result for the number of families. This is linear with the research results obtained by Suhardjono (1997) and Rahmawati (2000). This method gives high enough results regarding the number and diversity, and it also can catch diurnal and nocturnal insects. Insects collected through pitfall trap are usually active on the soil surface and are inadvertently stuck in the trap. According to Suhardjono (1985) and Paoletti et al. (1991), this method is the most appropriate method in collecting soil fauna actively roaming on the surface of the forest floor.

Soil sampling method gave the highest index value of diversity and evenness index of soil insects, while pitfall trap with bait gave the lowest diversity index. This result is different from the one obtained by Sahabuddin (1998) in which the diversity of arthropods in pine forest taken using soil sampling method was apparently lower compared to the other diversity taken using pitfall trap. Results obtained by Sembayang et al. (2000) showed that the diversity of arthropods in tomato garden and open area of ex-pine forest using soil sampling method provided varied results from 24-41 species, while pitfall trap gave the higher result. This condition is in line with the statement from Subahar (2000) that the diversity of soil arthropods community is strongly influenced by the method of trap used.

Shannon-Wiener diversity index overall in protected forests by using five trapping methods was included in moderate category (H'= 1.44), meaning that the productivity of soil insects at Jeruk Manis Protected Forest in East Lombok is fairly good with fairly balanced ecosystem conditions and moderate ecological pressure level. Shannon-Wiener evenness index (E = 0.48) is categorized as low, meaning that at some collection methods used, there were soil insects which were dominant, subdominant, and most dominant which thus makes the evenness in protected forest low. According to Odum (1998) and Reece et al. (2013), the dominance of a population causes the other populations defeated, which thus reduces the community's population. A decrease in the populations of making up community also means a decrease the diversity of the community.

The relative abundance of soil insect family Jeruk Manis Protected Forest, East Lombok

Soil insect taxa that have the highest relative abundance consecutively are Hymenoptera (Formicidae), Collembola (Isotomidae, Entomobryidae), Coleoptera (Hydrophilidae, Ptiliidae, Scarabeidae), Diptera (Drosophilidae) (Table 2). Insect taxa that are always found in every sampling method are Collembola (Isotomidae, Entomobryidae, Hypogastruridae), Orthoptera (Gryllidae), Coleoptera (Ptiliidae, Scarabeidae), Diptera (Drosophilidae, Phoridae) and Hymenoptera (Formicidae) (Table 2). Those overall taxa are a group that has the most members in the community of soil insects. According to Borror et al. (1992), such group of insects has many numbers of tribes which are active on the soil surface. The result of this study is similar to results obtained by Adianto (1993) in Tangkuban Perahu Nature Forest. This also showed that the five methods of collecting soil insects could be used to collect the taxa with different levels of relative abundance.

Table 2. The relative abundance of soil insect family Jeruk Manis Protected Forest, East Lombok, West Nusa Tenggara, Indonesia

Ordo	Family	Relative abundance of soil insects				
		Pitfall trap	Yellow pan trap	Pitfall trap with bait	Soil sampling	Forest floor collection
Diplura	Diplura	0.17	0.00	0.00	4.90	5.21
Collembola	Isotomidae	0.81	2.94	0.19	13.73	56.06
	Entomobryidae	1.04	1.56	0.26	5.88	11.27
	Hypogastruridae	0.29	1.21	0.08	3.92	0.70
	Symphypleona	0.00	0.00	0.00	4.90	0.14
	Neanuridae	0.06	0.00	0.00	0.98	0.99
	Pseudachorutinae	0.00	0.35	0.09	0.00	0.00
Orthoptera	Gryllidae	0.58	1.04	0.25	13.73	0.28
	Tettigoniidae	0.00	0.35	0.00	0.00	0.00
	Acrididae	0.17	0.00	0.00	0.00	0.00
	Phasmatidae	0.00	3.11	0.00	0.00	0.00
Blattodea	Blattidae	0.00	0.00	0.01	0.00	0.28
Coleoptera	Hydrophilidae	12.82	4.50	3.36	0.00	1.27
	Carabidae	0.06	0.00	0.00	0.00	0.00
	Staphylinidae	0.06	0.00	0.00	0.00	0.14
	Nitidulidae	0.06	0.00	0.03	0.00	0.00
	Ptiliidae	15.82	4.15	0.93	7.84	2.25
	Scarabaeidae	3.75	2.42	0.80	8.82	1.13
	Cucujidae	0.12	0.00	0.00	0.00	0.00
	Cleridae	0.17	0.00	0.02	0.00	0.00
	Halticidae	0.06	0.00	0.00	0.00	0.00
	Cerambycidae	0.17	0.00	0.59	0.00	0.00
	Nabidae	0.00	0.00	0.01	0.00	0.00
	Lycidae	0.00	0.00	0.03	0.00	0.00
	Buprestidae	0.00	0.00	0.02	0.00	0.00
	Tenebrionidae	0.00	0.00	0.01	0.00	0.00
	Anthicidae	0.00	0.00	0.01	0.00	0.00
Diptera	Dolichopodidae	0.12	0.00	0.00	0.00	0.00
	Cecidomyiidae	0.00	0.00	0.00	4.90	1.13
	Drosophilidae	1.15	2.25	0.75	5.88	0.28
	Phoridae	0.29	0.69	0.30	0.98	0.56
	Sphaeroceridae	0.12	0.00	0.09	0.00	0.00
	Chloropidae	0.17	0.17	0.00	0.00	0.00
	Rhagionidae	0.06	0.00	0.00	0.00	0.00
	Agromyzidae	0.29	2.25	0.18	0.00	0.00
	Tipulidae	0.00	0.17	0.00	0.00	0.00
	Tachinidae	0.00	0.52	0.02	0.00	0.14
Hymenoptera	Formicidae	61.03	70.93	91.78	21.57	10.99
	Mymaridae	0.00	0.35	0.00	0.00	0.00
	Braconidae	0.06	0.17	0.00	0.00	0.42
	Tenthredinidae	0.00	0.00	0.01	0.00	0.00
	Apidae	0.00	0.00	0.00	0.00	0.28
Isopoda	Isopoda 1	0.17	0.52	0.01	0.00	0.42
Oligochaeta	Oligochaeta 1	0.17	0.00	0.00	0.00	1.13
Larva		0.00	0.00	0.18	1.96	0.85
Others		0.17	0.35	0.00	0.00	4.08

Order Hymenoptera (Formicidae) is one of the orders of the highest relative abundance which were obtained using the five soil insect trapping methods. Order Hymenoptera (Formicidae) or ants is known as one of the insects that have a high level of resistance to environmental changes. These conditions make it as one of the indicators of agroecosystem (Peck et al. 1998) as well as indicators of environmental assessment programs, such as forest fires, disturbance to vegetation, deforestation, mining, waste disposal and land use factor (Wang et al. 2000). Formicidae is a group of fauna living on the soil surface which also likes moist, warm, and protected places (Wallwork 1970; Setiadi 1989). Besides that, Formicidae is also social insects which colonize and is divided into several castes, namely kings, queens, soldiers, and workers (Wilson 1971). Formicidae, in exploiting its food sources, can act as a predator, carnivores, fungivores, and herbivores. This condition makes it found using all trapping methods.

Insect collection using pitfall trap generated high relative abundance not only for Hymenoptera (Formicidae) but also for a Coleoptera (Hydrophilidae, Ptiliidae). Hydrophilidae is a family that is found in ponds or streams, its presence on the forest floor is usually for pupation process in a hole under the ground. The results of this study differ from results obtained by Maulinda (2003) in which the families most captured with pitfall trap method is Scarabaeidae and Staphylinidae. Both are groups of insects which are active on the soil surface and acts as a predator for organisms that exist on the forest floor.

The Order Orthoptera (Gryllidae) produced the highest relative abundance if collected by soil sampling method. Family Gryllidae is one group of insects that live in various habitats; wet or dry, especially shaded (Lilis 1994). This taxon usually lays the eggs in the soil or paste them in the plants, so it is very likely for the taxon to be collected by using soil sampling method. This method is typically used to collect soil insects that live or are active in the soil. Soil insects were obtained by first extracting the soil samples in Berlese funnel for seven days, usually, soil insects will fall by gravity into pitfall container with alcohol.

Forest floor collection gave the highest relative abundance results for orders Collembola (Isotomidae, Entomobryidae). Forest floor is one of the important factors affecting the availability of soil Collembola. Forest floor is a source of food and a place to live for soil Collembola. Soil Collembola has vertical diversity distribution along with the soil depth level. Collembola is most commonly found in the soil surface layer (0 to 2.5 cm) that contains lots of litter and humus (Rohyani, 2012). Fungi and waste organic materials as soil Collembolan food are most commonly found in this layer.

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