SOIL SURFACE INSECT DIVERSITY OF TOBACCO AGRICULTURAL ECOSYSTEM IN IMOGIRI, BANTUL DISTRICT OF YOGYAKARTA SPECIAL REGION, INDONESIA

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Abstract— Tobacco is a valuable commodity that supports economic growth in Indonesia. Soil surface insects are important components that influence productivity of tobacco. Thus, diversity of soil surface insects needs to be studied in order to acquire information about specific roles of each species in ecosystem. This research aimed to study the soil surface insect diversity of tobacco agricultural ecosystem in Imogiri, Bantul District of Yogyakarta Special Region, Indonesia. Samples were collected by pitfall-sugar bait trap in August 2015. Result showed 5 orders, 8 families, and 17 genera of soil surface insects were found. The diversity category of soil surface insects in tobacco agricultural ecosystem was poor. Dominant genuswas *Monomorium* with dominance index score 0.07588. Percentages of insects' roles were omnivores 43%, detritivores 24%, predators 19%,and herbivores 14%.

Keywords— Diversity, Indonesia, Soil Surface Insect, Tobacco.

I. INTRODUCTION

Tobacco is one of the most important trading commodities in the world and included as high-value products for several countries, including Indonesia. Tobacco has a role in national economic growth i.e. as source of income, sources of government revenue and taxes (excise), and source of jobs for society [1]. Cultivation of tobacco depends on both abiotic and biotic factors which affect tobacco growth and development. These factors need to be analyzed to improve productivity of tobacco.

Soil surface organisms like insects have important roles in maintaining soil productivity and fertility in natural and agricultural ecosystems [2] including tobacco plantation. Therefore, the diversity of soil surface insect needs to be studied in order to acquire information about the role of each species found in tobacco agricultural ecosystem. The ecological roles of surface soil insects can be beneficial or detrimental. Soil surface insects are advantageous because of their role in the transformation of organic material in terrestrial ecosystems [3] so they contribute in the improvement of cultivated plant productivity. Instead soil surface insects are disadvantageous if their ecological roles can lead to decreased productivity of cultivated plants.

By acquiring knowledge about the role of each soil surface insect species found in tobacco agricultural ecosystem, management of soil surface insects can be conducted to improve productivity of tobacco crop.

II. MATERIALS AND METHODS

Study Area

This research was conducted in 6-26 August 2015 located in tobacco agricultural ecosystem of Dusun Kalidadap I, Imogiri, Bantul District of Yogyakarta Special Region, Indonesia ($7^{o}57'58.8"S$ $110^{o}22'03.5"E$) (Figure1). Surrounding the tobacco agricultural ecosystem there were different crop agricultural areas. Total area of observation was 3735.375 m^2.

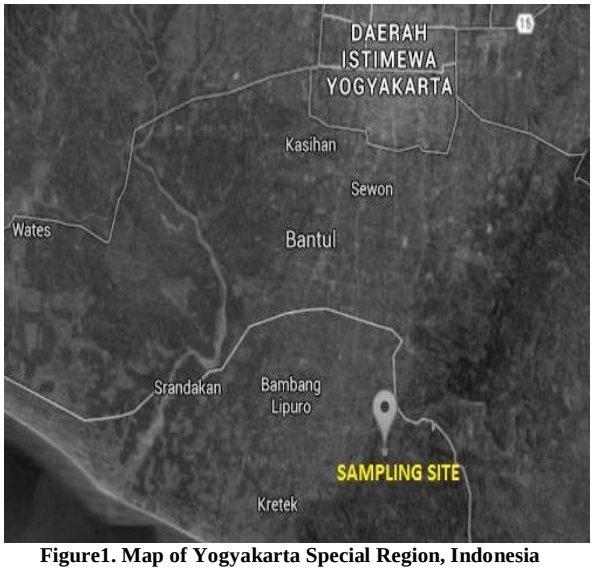


Figure1. Map of Yogyakarta Special Region, Indonesia showing sampling site

Procedures

1. Sample Collection

Samples were collected by pitfall-sugar bait trap method in six plots. Solutions used were composed of ethanol 70%, glucose, and detergent solutions with ratio 1:1:1. Traps were laid criss on soil surfaces at right and left outer sides with 10m intervals among traps (Figure2). The traps were monitored in the morning and refilled when the contents run out. Samples were collected each day and preserved in ethanol 70% solution.

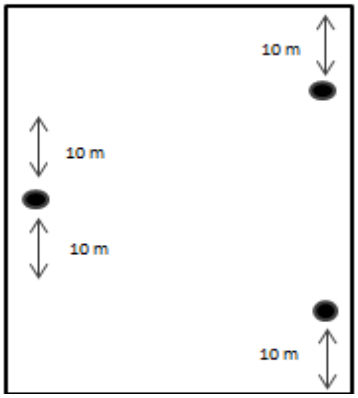


Figure2. Sampling Design in Each Plot

2. Sample Analysis

Samples were identified using binocular microscopes and insect identification books. The number of samples was enumerated by hand counters.

Data Analysis

The samples were analyzed quantitatively and qualitatively. Quantitatively, samples were analyzed by Shannon-Wiener Diversity Index, Simpson Diversity Index, Simpson Dominance Index and Shannon Evenness Index. Qualitatively, the samples were analyzed by identifying ecological roles of each species.

1) Shannon-WienerDiversity Index [4]

$H' = -\sum Pi \ln Pi$, $Pi = ni/N$

H': diversity index of Shannon-Wiener, ni: the number of individuals belong to taxon i, N: the total number of collected individuals

2) Simpson Diversity Index[5]

$S_D = 1/D$, $D = \sum n_i(n_i-1)/N(N-1)$

D: Simpson's Index, $\sum$: the sum of ni: the total number of individualsof each taxon, and N: the total number of collected individuals

3) SimpsonDominance Index[6]

$C = \sum Pi^2$, $Pi = ni/N$

C: dominance index, ni: the number of individuals belong to taxon i, N: the total number of collected individuals

4) Shannon Evenness Index[4]

$e = H'/H\ max$, $H\ max = \ln S$

e: evenness index, H': Shannon-Wiener index, S: the total number of identified taxon

III. RESULTS AND DISCUSSIONS

Below the list of samples found, consisted of 5 orders, 8 families, and 17 genera (Table1). From collection data, ants (Hymenoptera, Formicidae) found most abundant compared to the other orders as most ant species habitat wasin soil [7]. Ants have diverse role in ecosystem. These roles could be different in different species. But commonly all ants share same role in alteration of physical and chemical environment and they affect plants, microorganisms, and other soil organisms, as in [7].

Table1.Soil Surface Insects Found in Tobacco Agricultural Ecosystem

Orders	Families	Sub Families	Genera	Roles in Ecosystem	Number of Individuals
Blattodea	Termitidae	Sub Family1	*Genus*1	Omnivore, Detritivore	42
Coleoptera	Carabidiae	Brachininae	*Chlaenius*	Predator	126
Coleoptera	Carabidiae	Harpalinae	*Genus*2	Omnivore	4
Coleoptera	Curculionidae	Curculioninae	*Genus*3	Herbivore	1
Coleoptera	Scarabaeidae	Cetoniinae	*Euphoria*	Herbivore	1
Hemiptera	Reduviidae	Harpactorinae	*Rhynocoris*	Predator	9
Hymenoptera	Formicidae	Dolichoderinae	*Dolichoderus*	Predator, Detritivore	813
Hymenoptera	Formicidae	Formicinae	*Anoplolepis*	Omnivore, Detritivore	2571
Hymenoptera	Formicidae	Formicinae	*Camponotus*	Omnivore	384
Hymenoptera	Formicidae	Formicinae	*Nylanderia*	Detritivore	1417
Hymenoptera	Formicidae	Formicinae	*Paratrechina*	Omnivore	1382
Hymenoptera	Formicidae	Myrmicinae	*Monomorium*	Omnivore	2696
Hymenoptera	Formicidae	Myrmicinae	*Pheidole*	Omnivore	104
Hymenoptera	Formicidae	Ponerinae	*Diacamma*	Predator	205
Orthoptera	Acrididae	Oedipodinae	*Stethophyma*	Herbivore	2
Orthoptera	Gryllidae	Gryllinae	*Genus*4	Omnivore, Detritivore	9
Orthoptera	Gryllidae	Gryllinae	*Acheta*	Omnivore	22
Total					9788

Each species found had its own specific roles in ecosystem. Members of Termitidae family eat leaves, woods, dead leaves, and roots [8]. *Chlaenius* bettles are members of Carabidae family which are predators that eat other insects and earthworms [8]. *Harpalinae* beetles are omnivores that eat seeds, fruit pulps, and small insects [9]. Members of Curculionidae family are herbivores which range from narrowly to broadly

oligophagous [10]. *Euphoria* beetles live on plants such as flowers, pollens, and fruits [11]. *Rhynocoris* bugs are frequently found on plants and are predators of many animal species [12]. *Dolichoderus* ants are both predators of smaller animals including insects and detritivores of organic materials [13]. Besides, these ants have role in pest management as they transfer *Trichoderma* fungi into particular pests [14].*Anoplolepis* ants gain nutrients from available resources including grains, seeds, arthropods, decaying matters and vegetations [15], [16]. They may rely heavily on carbohydrate-rich nutrient sources such as plant nectar and honeydew-producing sap sucking insects (especially Hemiptera insects) [17]. *Camponotus* ants are omnivorous [18]. Nectar and Homoptera honeydew are the most frequently exploited by *Camponotus*[19]. *Nylanderia* species are detritivores and inhabit a wide array of habitats from deserts to rainforests, their highest species diversity in forested and warmer environments though [20]. *Paratrechina* ants are omnivorous as they consume both live and dead insects, honeydews, fruits, plant exudates, and other varieties of foods [21],[22]. These ants have ability to live in disturbed, dry, and pretty humid area [22]. *Monomorium* ants are omnivorous as they consume a wide variety of foods including honeydews and are cosmopolites in society [23], [24],[25]. *Pheidole* ants are omnivorous, feeding on sweet liquids such as honeydews, dead insect, and soil invertebrates [26]. They are found both in subtropics and tropic areas [22]. *Diacamma* major food consisted of termite, although bugs, cockroaches, grasshopper, cricket, spider and other species of ants [27]. *Stethophyma* grasshoppers are herbivore which can be the most devastating enemies to society if their populations grow so huge [28]. Gryllidae crickets are usually found in moist soil, on the ground, bushes and trees. Their foods are seeds, seedlings, roots, and dead insects [8],[29]. *Acheta* crickets are omnivorous that eat various kinds of foods i.e. vegetable matter and other insects [30]. Half of the ant genera had honeydew as one of food sources including *Monomorium* and *Anoplolepis* genera which members found most abundant. It might explain the large presence of Aphid colonies on tobacco crops in research area. The ants had mutualism symbiosis with the Aphid colonies that destructed the crops and their honeydew residues cause secondary infection by fungi [31], [32].

Table2shows scores of 4 indexes calculated in analysis. Based onthe score of Shannon-Wiener Diversity Index, soil surface insect diversity in tobacco agricultural ecosystem was poor. This score agrees with Simpson Diversity Index which put their diversity in poor category. This resultcan be understood as despite the large number of samples found, *Monomorium* ants dominated the other generawith score 0.07588. Based on Shannon Evenness Index, soil surface insects were distributed adequately evenly.

Table2. Indexes of Soil Surface Insects

Index	Index Scores
Shannon-WienerDiversity Index	1.83833
Simpson Diversity Index	5.13205
Simpson Dominance Index	0.07588
Shannon Evenness Index	0.64882

Figure3 shows role percentages of soil surface insects. Omnivores were the most dominating group as this group mainly composed ofant genera with food preferences consists of both plants and animals. Herbivores were the smallest group found. This group consisted of Curculioninae beetles, *Euphoria*beetles, and *Stethophyma* grasshoppers.

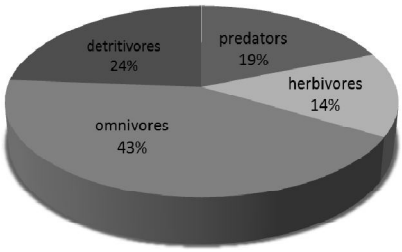


Figure3. Role Percentages of Soil Surface Insectsin Tobacco Agricultural Ecosystem

Below arerecords of air temperature and humidityfluctuations during sample collections. From the Figure4 and Figure5, it is known that the temperature range from 26.5 to 29.7 degree Celcius while the humidity range from 50.2% to 74.8 %.

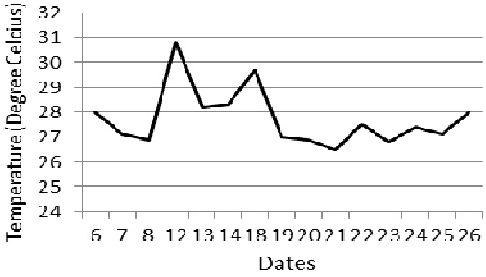


Figure4. Air Temperature during Sample Collection

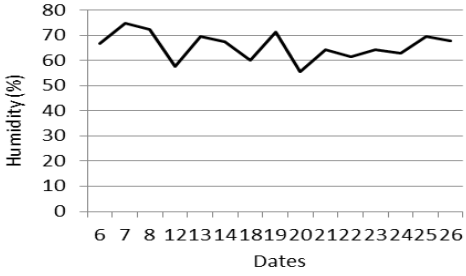


Figure5. Air Humidity during Sample Collection

Insects are able to live in air temperature range from 15 to 45 degree Celcius [33]. Optimum air temperature for insect living is 25 degree Celcius [16] and optimum air humidity for insect living range from 73 to 100% [34] thus the air temperature and humidity during observation period provided adequate conditions for soil surface insects to live.

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REFERENCES

[1] Rachmat, M. and Nuryanti, S. 2009. Dinamika Agribisnis Tembakau Dunia dan Implikasinya bagi Indonesia. *Forum Penelitian Agro*. Vol. 27: 73-91.

[2] Ruiz, N. and Lavelle, P. 2008. *Soil Macrofauna Field Manual; Technical Level*. Food and Agriculture Organization of the United Nations. Rome.

[3] Swift, M .J. and Anderson. 1979. *Decomposition Terestrial Ecosystem* Vol. 5 Blackwell Scientific Publication. London.

[4] Bitton, G. 1998. *Formula Handbook for Environmental Engineers and Scientist.* John Wiley and Son Inc. Florida.

[5] Villacampa, Y. and Brebbia, C. A. 2011. *Ecosystems and Sustainable Development*, 7th Edition. WIT Press. Southampton.

[6] Dash, M. C. and Dash, S. P. 2009. *Fundamentals of Ecology*, 3rd Edition. McGraw Hill Education Private Limited. New Delhi.

[7] Folgarait, P. J. 1998. Ant Biodiversity and Its Relationship to Ecosystem Functioning: A Review. *Biodiversity and Conservation*7: 1221-1244.

[8] Morganstern, L., Hogan, K., and Berkowitz, A. 1994. *Who Eats What: A Guide to Food Web Clues in Schoolyard Habitats.*Institute of Ecosystem Studies.

[9] Borcherding, R., Paarmann, W., Nyawa, S. B., and Bolte, H. 2000. How to be A Fig Beetle? Observations of Ground Beetles (Col., Carabidae) Associated with Fruitfalls in a Rain Forest of Borneo. *ECOTROPICA* 6: 169-180.

[10] Anderson, R. S. 1993. Weevils and Plants: Phylogenetic versus Ecological Mediation of Evolution of Host Plant Associations Curculioninae (Coleoptera: Curculionidae). *Mem. Ent. Soc. Can.* 165:197-232.

[11] Landolt, P. J. 1990. Trapping the Green June Beetle (Coleoptera: Scarabaeidae) with Isopropanol. *Florida Entomologist* 73: 328-330.

[12] Weirauch, C., *et al.* 2014. An Illustrated Identification Key to Assassin Bug Subfamilies and Tribes (Hemiptera: Reduviidae). *Canadian Journal of Arthropod Identification* 26:1-115.

[13] Riyanto. 2007. Kepadatan, Pola Distribusi dan Peranan Semut pada Tanaman di Sekitar Lingkungan Tempat Tinggal. *Jurnal Penelitian Sains* 10 (2): 241-253.

[14] Anggraeni, T., Umrah, Esyanti, R. R., and Aryantha, I. N. P. 2014. *Promoting Dolichoderus thoracicus* as an Agent to Disperse *Trichoderma* sp., a Fungus that Controls the Black Pod Disease, Central Sulawesi – Indonesia. *J. Math. Fund. Sci.* 46 (1): 411 – 49.

[15] Haines, I. H., Haines, J. B., and Cherrett, J. M. 1994. The Impact and Control of the Crazy Ant, Anoplolepis longipes (Jerd.), in the Seychelles in O'Dowd, D. J. Green, P. T. and Lake, P. S. 1999. Status, Impact, and Recommendations for Research and Management of Exotic Invasive Ants in Christmas Island National Park. *Report to Environment Australia*.

[16] Ness, J. H. and Bronstein, J. L. 2004. The Effects of Invasive Ants on Prospective Ant Mutualists. *Biological Invasion* 6: 445-461.

[17] Holway, D. A., Lach, L., Suarez, A. V., Tsutsui, N. D., and Case, T. J. 2002. The Causes and Consequences of Ant Invasions. *Annu. Rev. Ecol. Syst.* 33: 181-233.

[18] Gorosito, N. B., Zipeto, G. and Folgarait, P. J. 1997. Las Preferencias Alimenticias de *Camponotus puctulatus* en Pasturas Naturales e Implantadas. XVIII Ecological Meeting of the Argentinean Society, Buenos Aires, Argentina in Folgarait P. J., Perelman S., Gorosito N., Pizzio R. and Fernndez J. 2006. *Camponotus punctulatus* Ant's Demography: A Temporal Study across Land-Use Types and Spatial Scales. *Insect. Soc*. 54 42-52: 43-50.

[19] Retana, J., Bosch, J., Alsina, A., and Cerdá, X. 1987. Foraging Ecology of the Nectarivorous Ant *Camponotus foreli* (Hymenoptera, Formicidae) in a Savanna-Like Grassland. *Misc. Zool.*, 11: 187-193.

[20] LaPolla, J. S., Brady, S. G., and Shattuck, S. O. 2011. Monograph of *Nylanderia* (Hymenoptera: Formicidae) of the World: An Introduction to the Systematics and Biology of the Genus. *Journal Zootaxa* 3110: 1-9.

[21] Bolton, B. 1997. *Identification Guide to The Ant Genera of The World*. Harvard University Press. London.

[22] Latumahina, F. S., Musyafa, Sumardi and Putra, N. S. 2013. Keragaman Semut pada Areal Pemukiman dalam Hutan Lindung Sirimau Kota Ambon. *Jurnal Agroforestri* 8 (4): 261-268.

[23] Alder, P. and Silverman, J. 2005. Effects of Interspecific Competition Between Two Urban Ant Species,*Linepithema humile*and*Monomorium minimum*, on Toxic BaitPerformance. *J. Econ. Entomol.* 98(2): 493-501.

[24] Edwards, J. P. 1986. *The Biology, Economic Importance, and Control of the Pharaoh's Ant,* Monomorium pharaonis *(L.) in Bradleigh Vinson, ed. Economic Impact and Control of Social Insects.* Praeger. New York.

[25] Nickerson, J. C., Harris, D. L. and Fasulo, T. R. 2014. *Pharaoh Ant,* Monomorium pharaonis *(Linnaeus) (Insecta: Hymenoptera: Formicidae).* IFAS Extension. Gainesville.

[26] Warner, J and Scheffrahn, R. H. 2010. *Bigheaded Ant,* Pheidole megacephala *(Fabricius) (Insecta: Hymenoptera: Formicidae: Myrmicinae).* IFAS Extension. Gainesville.

[27] Karpakunjaram, V., Nair, P., Varghese, T., Royappa, G., Kolatkar, M., and Gadagkar, R. 2003. Contributions to the Biology of the Queenless Ponerine Ceylonense Emery (Formicidae). *Bombay Nat. Soc.* Vol. 100 (2 and 3). p. 539.

[28] Latchininsky, A., Sword, G., Sergeev, M., Cigliano, M. M., and Lecoq, M. 2011. Locusts and Grasshoppers: Behavior, Ecology, and Biogeography. *Psyche* Vol. 2011:1-4.

[29] Gawalek, M., Dudek, K., Ekner-Grzyb, A., Kwieciński, Z., and Sliwowska, J. H. 2014. Ecology of the Field Cricket (Gryllidae: Orthoptera) in Farmland: The Importance of Livestock Grazing. *NORTH-WESTERN JOURNAL OF ZOOLOGY* 10 (2): 1-8.

[30] Resh, V. H. and Carde, R. T. 2003. *Encyclopedia of Insects.* Academic Press. London.

[31] Agus. 2011. *Buku Panduan Budidaya Tembakau Virginia.* Surabaya.

[32] Tegelaar, K., Hagman, M., Glinwood, R., Pettersson, J., and Leimar, O. 2011. Ant– Aphid Mutualism: the Influence of Ants on the Aphid Summer Cycle. *Oikos* 121: 61–66.

[33] Jumar. 2000. Entomologi Pertanian. Rineka Cipta. Jakarta in Apituley, F. L., Leksono, A. S., Yanuwiadi, B. 2012. Kajian Komposisi Serangga PolinatorTanaman Apel (*Malus sylvestris* Mill) di Desa PoncokusumoKabupaten Malang. *El-Hayah* Vol. 2:1-12.

[34] Borror, D. J., Triplehorn, C. A., and Johnson, N. F. 1992. *Pengenalan Pelajaran Serangga* translated by Soedjono, S. P. and Brotoeidjojo, M. D., 6th Edition. Gadjah Mada University Press. Yogyakarta.

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