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Dung beetle assemblages in three human-modified landscapes in northeastern Thailand

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Abstract Dung beetles are good indicators of various terrestrial ecosystems. Their number and diversity usually associated with environmental factors. The dung beetle assemblages in degraded forest was investigated in plantation forest and agricultural land as well as their relationship with temperature, rainfall and soil properties. Results showed that a total of 3,634 dung beetles from 1 order, 1 family and 10 genera were captured. The most common genus was *Copris* (35.14%), followed by *Onthophagus* (22.62%), *Heliocopris* (14.45%) and *Onitis* (14.42%), respectively. Most dung beetles were captured from agricultural land (1,653; 45.49%) followed by plantation forest (1,028; 28.29%) and degraded forest (953; 26.22%). The number of dung beetles was not different among seasons (F = 3.126, df = 2, p > 0.05). The highest number of dung beetles was found in the summer followed by the rainy season and the winter, respectively. The number of dung beetles had positive correlation with temperature (r = 0.73, p < 0.01) and had negative correlation with soil potassium (r = - 0.7, p < 0.01). However, there were no relation between the number of dung beetles and rainfall, soil phosphorus, soil types, soil pH and organic matter.

Keywords: Dung beetle, diversity, degradged forest, plantation, farm, Thailand

Introduction

Anthropogenic disturbance on natural ecosystems resulted in habitat fragmentation and degradation. In many areas, forests have been transformed into agricultural lands including pastures, fruit plantations and crops. Consequently, habitat alteration leads to changes in biodiversity (Didham *et al*., 1996; Lawton *et al*., 1998). Then, many studies have focused on the richness and distribution of forest species on habitat modification by humans (Nichols *et al*., 2007).

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Dung beetles play many important roles in ecological processes such as dung decomposer and seed disperser (Scheffler, 2005; Shahabuddin *et al*., 2005). Some beetles dig the tunnels that increase nutrient cycling, soil aeration and hydration (Slade *et al*., 2007; Nichols *et al*., 2008). Dung beetle assemblage and abundance generally rapid response to habitat degradation (Klein, 1989) and environmental change (Viegas *et al*., 2014). Thus, they always considered as ecological indicators of various terrestrial ecosystems, especially in human-modified landscapes (Halffter and Favila, 1993; Davis, 2000; Davis *et al*., 2001).

More understanding of human-modified landscapes for biodiversity conservation is required. In this study, dung beetle assemblages in degraded forest (DF), plantation forest (PF) and agricultural land (AL) in northeastern Thailand were examined. In addition, the relationship between beetles and temperature, rainfall and soil properties were also investigated. The data on composition of dung beetles and their relation with ecological factors from this study provides a better understanding ecological processes under human-modified landscapes, which help in conservation planning outside protected areas

Materials and methods

Study area

This study was performed at Suranaree University of Technology (SUT) in Nakhon Ratchasima province (14.8729°N, 102.0237°E), Northeastern Thailand. The altitude is about 250 m above sea level. SUT covers about 1,120 hectares including academic zone, residential areas for staff and students, hospital, university farm, natural forests, plantation forests and degraded forests. The degraded forests were dry dipterocarp and mixed deciduous forests that forest floor is covered by grass and small bamboo. Plantation forest has been proceeded since the year 2000 and the two major plants are mango and rubber trees. The other plants in plantation forests are fast-growing trees including *Eucalyptus camaldalensis*, *Acacia mangium*, *Leucaena leucocephala* (Thammathaworn *et al*., 2006). SUT farm covers large area on the campus and provides livestock, fruits, fish and horticultural products. Major livestock in the farm are cattle, swine and poultry.

Sampling protocol

Dung beetle collection was conducted monthly from October 2014 to September 2015. Three baited pitfall traps were placed in each study site, DF, PF and AL, at SUT (Figure 1). Traps were set up 12 hr in day time (6 am - 6 pm) and 12 hr in night time (6 pm - 6 am). Collected dung beetles were counted and identified at the sites but unidentified beetles were further investigated in the laboratory at SUT. Then, beetles were released at the trapping areas.

Soil were collected at trap locations and analyzed for soil types, pH, phosphorus, potassium and organic matter at the SUT laboratory. Temperature and rainfall data were recorded at the meteorological station, nearby the study site.

Figure 1. Study sites at Suranaree University of Technology (SUT), northeastern Thailand. (Google earth, 2018)

Data analysis

Diversity of dung beetles was investigated using Shannon-Wiener index (Shannon and Weaver, 1949). Differences in beetle abundance among habitats and seasons were analysed using ANOVA. Pearson's correlation was employed to find the relationship between environmental factors and beetle abundance. All data were statistical analysed using SPSS program version 18 for windows (IBM, USA).

Results

Environmental factors

The mean temperature between October 2014 to September 2015 was 28.11 ±2.3 C. The highest temperatures were recorded in April and June 2015 (30.2 C) and the lowest temperature was found in January 2015 (23.7 C). The average annual rainfall was 91.4±110.97 mm. The highest rainfall was 284.2 mm in August 2015 and the lowest rainfall was 0.4 mm in December 2014.

The soil texture in all habitats was sand, silt and clay but the soil proportion differed among habitats. Moreover, there were statistically significant difference in soil textures among habitats ($p < 0.01$) (Figure 2). Potassium, phosphorus and pH were highest in AL followed by PF and DF, respectively. Organic matter was highest in DF and lowest in PF (Table 1). Potassium, phosphorus and pH were statistically significant differences among habitats ($p < 0.01$) but organic matter was not different among habitats ($p > 0.05$).

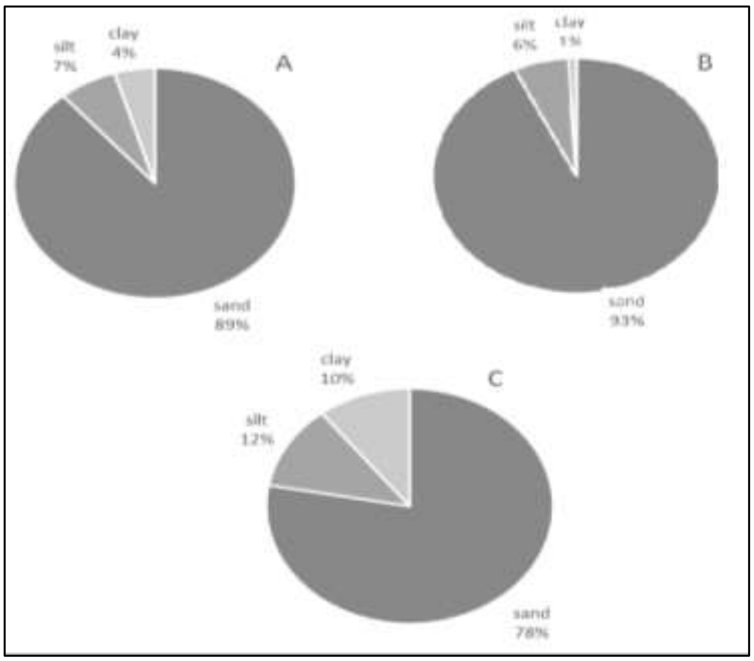

Figure 2. The soil textures in degraded forest (A), plantation forest (B) and agricultural land (C) at SUT from October 2014 to September 2015

Table 1. Soil potassium, phosphorus, organic matter and pH in degraded forest (DF), plantation forest (PF) and agricultural land (AL) at SUT from October 2014 to September 2015

Habitat	**Potassium (ppm)**	**Phosphorus (ppm)**	**Organic matter (%)**	**pH**
DF	156.75±82.06	21.35±13.3	2.81±1.3	7.12±0.44
PF	60.08±18.13	16.11±14.85	1.62±1	6.05±0.57
AL	356.04±267.85	86.37±55.95	2.40±1.34	7.57±0.6

Dung beetle assemblage in three human-modified landscapes

A total of 3,634 dung beetles were collected during October 2014 to September 2015 in three different habitats at SUT, which belonged to 1 order, 1 family and 10 genera. The most common beetle genus was *Copris* (35.14%) followed by *Onthophagus* (22.62%), *Heliocopris* (14.45%) and *Onitis* (14.42%), respectively.

Number of dung beetle was highest in AL (45.49%) followed by PF (28.29%) and DF (26.22%), respectively. (Table 2). Dung beetle abundance differed between AL and both PF and DF ($p < 0.05$). Nevertheless, no statistical differences in beetle abundance between PF and DF ($p > 0.05$). Diversity of beetles in AL, PF and DF were 1.7, 1.72 and 1.64, respectively.

Table 2. Dung beetle assemblages in degraded forest (DF), plantation forest (PF) and agricultural land (AL) at SUT from October 2014 to September 2015

Order	**Family**	**Genus**	**Habitat**		
			AL	**PF**	**DF**
Coleoptera	Scarabaeidae	*Copris*	564	381	332
		Onthophagus	379	248	195
		Heliocopris	291	90	144
		Onitis	239	118	167
		Aphodius	59	97	80
		Sisyphus	43	38	13
		Paragymnopleurus	36	23	22
		Caccobius	20	31	-
		Catharsius	18	2	-
		Parachorius	4	-	-
Total (%)			1,653 (45.49%)	1,028 (28.29%)	953 (26.22%)

Correlation between dung beetle assemblage and environmental factors

Dung beetle abundance in this study was not different among seasons ($F = 3.126$, df = 2, $p > 0.05$). The highest number of dung beetles was found in the summer followed by the rainy season and the winter, respectively. The number of dung beetles had positive correlation with temperature ($r = 0.73$, $p < 0.01$) and had negative correlation with soil potassium ($r = - 0.7$, $p < 0.01$). However, there were no relation between the number of dung beetles and rainfall, soil phosphorus, soil types, soil pH and organic matter.

Discussion

Naturally, dung beetles rely on mammalian dung as food resource (Nichols, 2009). Similar to this study which showed that dung beetles preferred AL more than PF and DF. These data are supported the study of Barbero *et al*. (1999) who reported that species and number of dung beetles increased along higher density of livestock. In addition, Shahabuddin *et al*. (2005) revealed that diversity of dung beetles statistically significant increase from natural forest to open habitat in Lore Lindu Natural Park, Indonesia. It may be because abundance of mammals in natural forest occur more than in open habitat. However, Nichols *et al*. (2007) reported that number of dung beetles in secondary forest, logged forest and agroforestry was higher than in pasture and open habitat. It can be explained that habitat complexity has effect on dung beetle abundance.

There was no difference in abundance of beetles among seasons in this study. This data similar to the study of Boonrotpong *et al.* (2004) which showed that abundance of dung beetle was not different among seasons in primary and secondary forests at Ton Nga Chang Wildlife Sanctuary, southern Thailand. In contrast, many previous studies revealed that insect decomposers varied among seasons (Pimpasalee, 2000; Andrade *et al*., 2011; Liberal *et al*., 2011). Thus, the data on dung beetle abundance among seasons still need more studies.

Temperature and potassium are the factors that effect on dung beetle abundance in this study. Other studies also documented environmental factors have effects on dung beetle abundance and diversity such as rainfall, temperature (Damborsky *et al*., 2015) and soil texture, vegetation type and mammals (Hanski and Cambefort, 1991). The difference of various environmental factors that effect on dung beetle abundance and diversity may be because of diverse of study sites.

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