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Species Composition of Dung Beetles in the Primary and Secondary Forests at Ton Nga Chang Wildlife Sanctuary

Singtoe Boonrotpong, Sunthorn Sotthibandhu and Chutamas Pholpunthin*

Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai 90112, Thailand

* Corresponding author, E-mail: schutama@ratree.psu.ac.th

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ABSTRACT: The species composition of dung beetles in primary forest and secondary forest at Ton Nga Chang Wildlife Sanctuary, Songkhla province, southern Thailand, was compared. Traps baited with pig dung were placed along line transects running through the two forest types. Species diversity and abundance of dung beetles were examined every 2 months from April 1999 to May 2000. Species diversity of dung beetles was significantly higher in the primary forest than in the secondary forest. Seven out of 20 species were found exclusively in the primary forest, namely *Microcopris reflexus*, *Oniticellus tessellatus*, *Onthophagus* near *pilularius*, *O. taeniatus*, *O. ventralis*, *O.* sp.3 and *O.* sp.4. Differences in forest structure, native animals present, and physical factors were suggested to be the factors determining species composition in the two forests. More individuals were trapped in the dry season than in the wet season in both forest types. However, seasonal effects on species diversity were not found. *Tiniocellus sarawacus* and *Microcopris reflexus*, were recorded for the first time in Thailand. *Onthophagus* sp.1 and *O.* sp.2 are expected to be new to science.

Keywords: dung beetle, species composition, primary forest, secondary forest, tropical rain forest.

INTRODUCTION

Ton Nga Chang Wildlife Sanctuary is one of the most important tropical rain forests in the southern part of Thailand, and has a high diversity of plant and animal species. For over a decade, the Sanctuary has been continually disturbed by human activities, such as rubber plantations, agriculture, and logging. These disturbances have resulted in forest fragmentation, which may lead to a reduction of species richness in the forest ecosystem.

Dung beetles (Scarabaeidae: Scarabaeinae, Coprinae) are an important group of primary decomposers in the forest ecosystem. They use dung for breeding and feeding and are beneficial in numerous ways, playing an important part in recycling nutrients by drying out the dung which will eventually give off minerals. They improve soil structure and water holding capacity by incorporating organic matter back into the soil.[32] They are also important secondary seed dispersers. As much as 90% of seeds that are defecated onto the soil surface might be destroyed by rodents and other seed-eating animals if not buried by dung beetles.[6] They play a key role in biological control by reducing the number of pests such as dung flies[1,8] in dung. Moreover, dung beetles can be used as biological indicators of changes in the ecosystem. Because of their sensitivity to changes of the physical structure of the habitat and the ease of sampling them, dung beetles have been used to determine the effects of environmental changes on the diversity and structure of the forest.[10,26] It has been reported that the physical structure of the forest appears to be an important determining factor in the structure and distribution of dung beetle communities.[2]

Dung beetles commonly found in tropical rain forests are of two main groups. The first group is the rollers (or paracoprids) which excavate balls from the main dung mass, roll them some distance away from the source and then bury or conceal them within vegetation at the surface. The second group includes the tunnellers (or telecoprids), which dig tunnels directly beneath the dung mass.[9,20]

It has been reported that disturbance of tropical rain forest results in changes in temperature, humidity, soil characteristics, and reduction of the mammal fauna.[7,10,19,25] As the dung beetles form an integral part of the forest ecosystem, it is hypothesized here that these changes will directly and indirectly affect the dung beetles which are dependent upon the mammals' droppings. Knowledge of the ecological relationships between dung beetles and the tropical rain forest in Thailand is scanty. This study, therefore, aimed to

compare species diversity, abundance, and seasonal changes of dung beetles in primary and secondary forests in order to obtain basic knowledge of the ecological relationships between dung beetles and forests in Thailand.

Materials and Methods

Study Area

This research was carried out at Ton Nga Chang Wildlife Sanctuary, Songkhla Province, which is situated between 15°33´and 16° 23´N, and 98° 33´ and 99° 07´E. Primary and secondary forests adjacent to each other were selected as study areas. These contiguous areas of primary and secondary forests are located in the lowland part of Ton Nga Chang Wildlife Sanctuary at an altitude of less than 300 m above sea level (Fig 1).

The primary forest at this low land site was structured by trees with large trunks (DBH ≥10 cm). There were also trees >110 cm DBH and >40 m in height (e.g. *Tetrameles nudiflora* R. Br., *Parashorea stellata* Kurz). Their canopies covered a large area, thus allowing only minimal sunlight to reach the ground. As a result, few plant species could thrive as undergrowth.[31] The dominant trees were in the families Euphorbiaceae, Annonaceae, Dipterocarpaceae, Lauraceae and Meliaceae [31] (Fig 2a).

The secondary forest in this study is regenerated from an abandoned rubber plantation area that was left undisturbed for about 10 years. In contrast to the primary forest, plant species growing in this secondary forest, as reported by Memuang,[24] were small in diameter (DBH ≥ 10 cm). They were fast growing trees such as *Ficus fistulosa and F. racemosa,* and dense populations of undergrowth species comprising the families Zingiberaceae and Araceae were present (Fig 2b).

Collection of Dung Beetles

Three line transects, approximately 2 km long and 500 m apart, were set up starting from the secondary forest (1 km) and extending into the primary forest (1 km) (Fig 1). Dung beetles were collected using 1-litre plastic pitfall traps.[13] Each trap was buried to its rim in the soil and baited with pig dung. Pig dung was used because of its rich supply throughout the study period. In addition, it has been reported that pig dung is as attractive as human dung for sampling dung and carrion insects.[23] Four hundred grams of fresh pig dung were placed in each trap and changed daily. In order to avoid the interference of the odour from nearby traps, traps were placed at every 50 m along the length of each line.[21] The beetles were examined every two months from April 1999 to May 2000. During each 3-day visit, the baits were collected and replaced every 24 hours. The specimens were all sorted into species groups, and the species were then identified using Paulian (1945).[28] Some specimens were reconfirmed with the type specimens in Leiden Museum, The Netherlands. The numbers of individuals of each species were recorded.

Analysis

The species diversity was measured by the Shannon-Wiener Index (H') and the evenness was determined by using the ratio H'/H'_{max} where $H'_{max} = \ln S$, where S = total species number at the site.[30] Two-way analysis of variance (ANOVA) was used to test the interactions between seasons and forest types.[34] Data were then compared using one-way ANOVA[34] to test the hypotheses that there would be differences in numbers of species and numbers of individuals: (1) between seasons, and (2) between forest types.

Results

Species Richness and Abundance

A total of 20 species belonging to the 7 genera, *Microcopris*, *Copris*, *Oniticellus*, *Tiniocellus*, *Onthophagus*, *Paragymnopleurus,* and *Sisyphus*, were captured from the two different habitats at Ton Nga Chang Wildlife Sanctuary during the study period (Table 1). Species richness was found to be highest in the primary forest where all 20 species were recorded, whereas only 13 species of dung beetles were caught in the secondary forest (Table 1). The seven species found exclusively in the primary forest were *Microcopris reflexus*, *Oniticellus tessellatus*, *Onthophagus* near *pilularius*, *O. taeniatus*, *O. ventralis*, *O.* sp.3 and *O.* sp.4.

Mean numbers of individuals per collection time of the 13 species found in both forest types were not significantly different between primary and secondary forests ($P>0.05$), except for *Onthophagus* sp.2, which was significantly more abundant in the primary than in the secondary forest ($P< 0.0001$; Table 1). *Onthophagus* was found to be the most abundant and diverse species group in Ton Nga Chang Wildlife Sanctuary (Table 1).

Onthophagus sp.1 and *O.* sp.2 are expected to be new to science and are now in the process of confirmation. The two species, *Tiniocellus sarawacus* and *Microcopris reflexus,* are first recorded for the first time in Thailand.

Species Index and Evenness

The value of the Shannon-Wiener Index was higher in the primary forest (H'= 2.29) than in the secondary forest (H'= 2.03). These values were statistically compared using the method of Hutcheson.[18] It was clearly shown that species diversity of dung beetles in the primary forest is significantly higher than that in the secondary forest ($P<0.05$; Table 2). The species evenness of dung beetles was similar in both forest

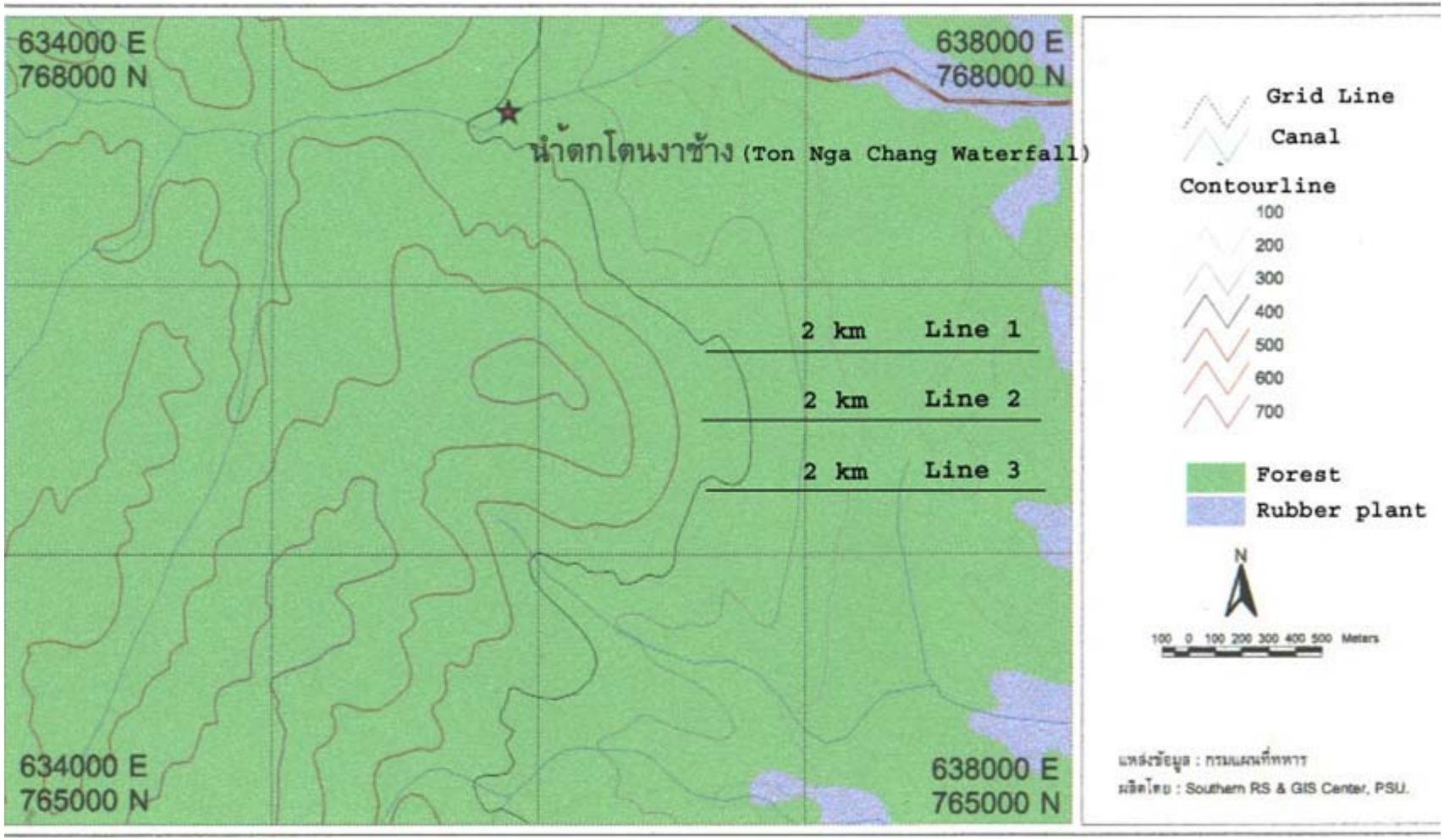

Fig 1. The study area and the three line transects at the lowland forest of Ton Nga Chang Wildlife Sanctuary (Source: Royal Thai Survey Department, Sheet 5022IV; Series L7017; Grid Zone Designation 47N)

(a)

(b)

Fig 2. Forest structures at the study area : (a) Primary forest (b) Secondary forest.

Table 1. Mean number of individuals per collection time of each dung beetle species in the primary forest and the secondary forest collected from April 1999 - May 2000.

Subfamily	Tribe	Species	Mean number of individuals (X ± S.E.) Primary forest	Secondary forest	F	P
Coprinae	Coprini	*Microcopris reflexus*	15.8 ± 6.5	0.0	5.97	0.035*
		Copris carinicus	171.3 ± 15.6	179.0 ± 11.6	0.16	0.701 ns
		C. spinator	125.2 ± 11.3	117.5 ± 17.2	0.14	0.717 ns
	Oniticellini	*Oniticellus tessellatus*	16.5 ± 3.9	0.0	17.40	0.002**
		Tiniocellus sarawacus	55.8 ± 6.9	46.7 ± 6.3	0.96	0.350 ns
	Onthophagini	*Onthophagus babirussoides*	995.0 ± 94.4	1036.8 ± 86.5	0.11	0.751 ns
		O. incisus	93.5 ± 14.1	53.5 ± 15.2	3.74	0.082 ns
		O. mulleri	260.7 ± 24.1	204.3 ± 36.3	1.67	0.225 ns
		O. near *pilularius*	23.3 ± 6.5	0.0	12.73	0.005**
		O. rugicollis	766.8 ± 82.0	621.7 ± 33.4	2.69	0.132 ns
		O. rutilans	26.8 ± 5.2	15.7 ± 7.1	1.62	0.232 ns
		O. taeniatus	39.8 ± 6.8	0.0	34.18	0.000***
		O. ventralis	23.8 ± 5.6	0.0	17.85	0.002**
		O. sp.1	423.0 ± 58.9	342.3 ± 57.3	0.96	0.350 ns
		O. sp.2	98.7 ± 16.2	14.3 ± 2.5	26.33	0.000***
		O. sp.3	15.2 ± 5.6	0.0	7.48	0.021*
		O. sp.4	50.8 ± 7.4	0.0	47.07	0.000***
Scarabaeinae	Gymnopleurini	*Paragymnopleurus maurus*	274.3 ± 95.3	245.8 ± 142.7	0.03	0.871 ns
	Sisphini	*Sisyphus thoracicus*	774.7 ± 266.6	882.8 ± 307.4	0.07	0.796 ns
		S. sp.1	717.3 ± 228.1	565.2 ± 197.1	0.26	0.625 ns

ns = not significantly different (P>0.05), * = P<0.05, ** = P<0.01, *** = P<0.001

Table 2. Shannon-Wiener index and evenness of dung beetle in the primary forest and the secondary forest.

Indices	Primary forest	Secondary forest	P
Shannon – Wiener index	2.29	2.03	0.05*
Evenness	0.76	0.79	

types.

Seasonal Changes of Dung Beetles

Two-way analysis of variance showed that there was no combined effect of forest type and season on the abundance and diversity of dung beetles in the study area ($P > 0.05$).

Dung beetle abundance and species in the primary and secondary forests were compared between the dry (January-June) and wet (July-December) seasons. The results showed that season had a significant effect on number of individuals for both forests, as there were many more individuals in the dry season than in the wet season (Table 3). In the primary forest, the mean number of individuals in the dry season (334.6 ± 13.7) was significantly greater than in the wet season (200.6 ± 7.5) ($P < 0.0001$). For the secondary forest, the mean number of individuals in the dry season (320.2 ± 8.7) was also much greater than in the wet season (167.3 ± 8.7). However, seasonal changes exerted no effect on the number of species of dung beetles in the two forests ($P > 0.05$; Table 3).

Discussion

Species Richness and Abundance

In this study, dung beetle species in the primary forest were found to differ distinctly from those in the secondary forest, and the mean number of species in the primary forest was higher.

Sawangchote[31] and Memuang[24] reported that the structure of the two forests was different and this might affect the areas for feeding and taking refuge of wild animals. Information obtained from the Ton Nga Chang Wildlife Sanctuary's Development Plan revealed that the wild animals in the primary forest were wild boar (*Sus scrofa*), barking deer (*Muntiacus muntjak*), and many species of rodents. Wild animal species were reported to be less diverse in the secondary forest than in the primary forest. Thus, if food resources (animal droppings) are normally a limiting factor for dung beetles,[17,29,33] then the decrease in wild animal species in the secondary forest should directly decrease the number of dung beetle species in this habitat.

Recent studies have shown that the activities of dung beetles are regulated by physical factors such as temperature, humidity, soil type and vegetation cover.[7,10,19] It was suggested that these factors directly affect the dung beetles by altering the properties of animal droppings which are ephemeral and patchily distributed resources. As a consequence, physical factors may act as indirect determinants of the dung beetle abundance. Previous work on species diversity in different forest structures has revealed different

Table 3. Mean number of individuals and mean number of species (± S.E.) per collection time in the dry season and the wet season.

Forest	Mean number of individuals				Mean number of species			
	DrySeason(n=3)	Wet season(n=3)	F	*P*	DrySeason(n=3)	Wet season(n=3)	F	*P*
Primary forest	334.6 ±13.7	200.6 ± 7.5	73.9	0 .000***	14.8 ± 0.3	15.8 ± 0.4	3.6	0.060 ns
Secondary forest	320.2± 8.7	167.3± 8.7	153.7	0.000***	10.6 ± 0.2	10.9 ± 0.2	0.6	0.434 ns

ns = not significantly different ($P>0.05$), * = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$

results. Klein reported 55 species of dung beetles in four different forest fragmentation habitats in Central Amazonia,[19] whereas only 21 species were found from the Atlantic forest fragmentation study in Brazil.[22] It is suggested that diversity of habitats, animals and physical factors may be the determining factors of species diversity and abundance of the dung beetles in this study.

Six out of the seven species found exclusively in the primary forest were tunnellers. This is congruent with data reported by Doube.[5] Of those 13 species found in both primary and secondary forests, only two species, in the genus *Copris,* were tunnellers. They have been reported as dominant nocturnal dung beetle species in tropical forests of Southeast Asia.[2,12,14] *Copris* is classified as a generalist because of its ability to change its feeding habit from dung-feeding to carrion-feeding when droppings are scarce.[14] This adaptive ability might explain the appearance of this genus in both forest habitats.

Tiniocellus sarawacus and *Microcopris reflexus* are reported in Thailand for the first time. Both species have been reported along the Indonesia-Malaysia-Thailand borders but not within Thailand.[11,15]

This finding will shed light on the missing link of dung beetle species in Thailand, and will be of significance to the study of the geographical distribution of dung beetles. The discovery of two new species in the genus *Onthophagus*, once confirmed, will add to the list of dung beetles found in tropical rain forests.

Seasonal Changes of Dung Beetles

Season exerted an apparent effect upon the abundance of dung beetles. More individuals were trapped in the dry season than in the wet season. However, effects of the season on the number of species were not confirmed. This might be attributable to rainfall which caused severe damage to the food resources of the dung beetles. Another possible explanation is related to the beetle's nesting behaviour.[16] Some species of dung beetles might require specific conditions for nesting. For example, *Sisyphus* species was found to favour a habitat with high temperature and low humidity.[3,4] Parrmann and Stork [27] also reported effects of seasonal change on the abundance of dung beetles.

It can be concluded from this study that differences in species composition of dung beetles between primary and secondary forests are probably the result of differences in forest structure and physical characteristics.

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