Research article

Earthworm Distribution under Different Land Use Systems in Northeast of Thailand - Benefit for Land Resource Reclamation

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Abstract The aims of this paper were to study the influence of land use system type on earthworm distribution in Northeast Thailand. The experimental systems were a natural forest, a eucalyptus plantation and an organic agricultural and a conventional agricultural farming system. The effects of land use systems and their management on the distribution and characteristics of the earthworm, *Pheretima* sp. on related soil properties were investigated in the rainy season (August-September 2008) and the dry season (December 2008-February 2009) in Baan None Daung Mun, Tumbon Sa-Ead, Amphur Muang, Khon Kaen, Northeast Thailand. Earthworm populations varied and there were significant differences between systems ($p<0.05$). Numbers were highest in the natural forest followed by the organic agricultural system, lower in the conventional agricultural system and lowest in the eucalyptus plantation in the rainy season. The same result was found in the dry season but the organic agricultural system had a higher number of casts than in the natural forest. The same trend was found for earthworm cast height and cast width. The results showed that the earthworm cast width in the eucalyptus plantation was lowest in the rainy season but not significantly different in the dry season between land uses. These results suggest that land use type strongly influences the abundance and characteristics of earthworm casts in the various soil ecosystems. The results of soil analyses showed that the biological soil quality, measured as soil respiration, in soil samples from each land use type were not significantly different ($p<0.05$) from each other but was highest in the organic agriculture system and lowest in the eucalyptus plantation. The soil respiration in earthworm's casts was higher than in soil in the rainy season. The results showed that the soil properties of earthworm casts were different in each land use system. Particularly, the increase of % silt and % clay and an associated decrease of % sand was found in the earthworm cast compared with the surrounding soil in every land use system. The results for soil quality showed that the earthworm casts had higher electrical conductivity (EC), organic matter, cation exchange capacity (CEC), total nitrogen, available phosphorus, and calcium and magnesium concentrations than found in soil especially the level of available phosphorus in casts.

Keywords earthworm, land use systems, land resource reclamation

INTRODUCTION

Soils of Northeast Thailand generally have low fertility due to their coarse texture and low organic matter content. Organic matter plays a useful function in supporting plant growth and sustainability of a land-use system. The earthworm as a soil invertebrate plays an important role in cycling nutrients within the terrestrial ecosystem by decomposing organic matter, nutrient cycling and energy transformation within the food web. The changes of land use from forest to agriculture affect the biodiversity of soil invertebrates. Soil degradation is related to a decline in activity and diversity of soil fauna among other aspects. The soil biota including soil microbial biomass and soil fauna provide a means of regulating the transformation of organically bound nutrients into plant-available forms through mineralization. Dispersion of agrochemical residues from conventional agriculture into the environment has attracted a great deal of public interest over the past few decades. The widespread use and misuse of persistent pesticides has resulted in their occurrence throughout the biosphere. Contamination of land from indiscriminate use of agrochemicals has been a significant issue for Thailand. Because earthworms play a significant role in soil functioning and soil fertility, their ecological and physiological features make them excellent indicators of soil pollution compared to other terrestrial invertebrates (Bunning, 2003). However, limited study has been undertaken to monitor the ecological significance of the influence of land use systems on the earthworm distribution in Northeast Thailand. The distribution, chemical and physical properties of earthworm casts as compared to bulk soil under a range of different land use systems in Northeast Thailand was studied in this paper.

OBJECTIVE

The objective of this paper was to study the influence of four land use systems on the earthworm distribution in Northeast Thailand: (i) to investigate the potential of the earthworm as a bioindicator for the change of land use in Thai soil ecosystems; and (ii) to investigate the chemical and physical properties of earthworm casts as compared to bulk soil under a range of different land use systems as related to the distribution of the earthworm *Pheretima* sp.

MATERIAL AND METHODS

The experimental systems included in this study were a natural forest, a eucalyptus plantation, an organic agricultural and a conventional agricultural system. The effects of land use systems and their management on the distribution and characteristics of the earthworm, *Pheretima* sp. on related soil properties were investigated in the rainy season (August-September 2008) and the dry season (December 2008-February 2009) in Baan None Daung Mun, Tumbon Sa-Ead, Amphur Muang, Khon Kaen, Thailand (Fig. 1).

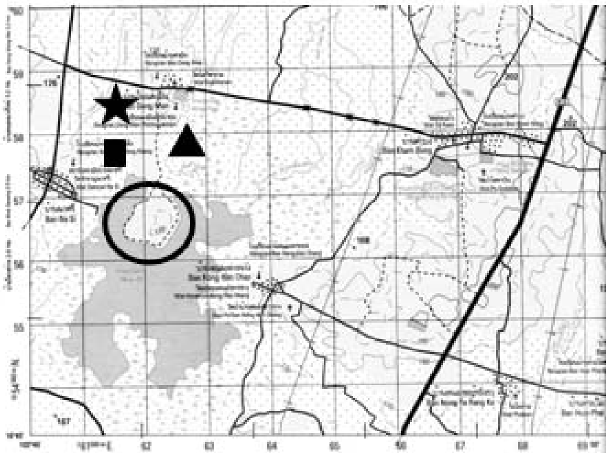

Fig. 1 Study site in Khon Kaen, Northeast Thailand, ○ natural forest, ▲ eucalyptus plantation, ★ an organic agricultural and ■ a conventional agricultural system

Soils and earthworms were collected at the four different land use systems during 2008-2009. The study area was selected from paired farms, with one utilizing organic practices (as an organic agricultural land use) and a second adjacent farm using conventional methods (as a chemical-agricultural land use). Pair-wise comparisons of two study sites were made for the agro-ecosystems in Northeast Thailand within 50 km of the city of Khon Kaen, 450 km NE from the capital Bangkok. Natural forests and eucalyptus plantations were also used as comparisons. The four different land use systems were chosen because of their similarity with respect to the pedalogical conditions and soil characteristics except for agrochemicals used, agricultural practices and management systems. Soil samples were collected and analysed for pesticide residues (organochlorine, organophosphate, carbamate and pyrethroid groups) and measurements were taken of physical and chemical properties of soil and earthworm casts. A survey of earthworm populations was conducted at each land use management site. The sampling site for each experimental system (natural forest, eucalyptus plantation, an organic agricultural and a conventional agricultural system) included 27, 9, 9, and 9 sampling sites, respectively.

RESULTS

Earthworm populations were significantly different between systems (P<0.05). They were highest in the natural forest followed by the organic agricultural system and lower in the conventional agricultural system. The lowest population was in the eucalyptus plantation in the rainy season. The same result was found in the dry season but the organic agriculture system had the highest number of casts compared with the natural forest. The same trend was found with the earthworm cast height and width (Table 1). Earthworm cast width in the rainy season was significantly greater in the natural forest and organic system compared to the conventional agricural system and the eucalyptus plantation was lowest of all. Earthworm cast width in the dry season was snot significantly different for land use excepting for the eucalyptus plantation site which was significantly lower. These results suggest that land-use types are strong factors for determining the abundance and characteristics of earthworm casts in Thai soil ecosystems.

Table 1 The number, height and width of earthworm cast of *Pheretima* sp. per square meter in different land use system and agricultural practices

Land use system	Number of earthworm cast per square meter		Earthworm cast height (cm)		Earthworm cast width (cm)	
	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season
Natural forest	20.3 ± 1.5^{a}	16.3 ± 3.9^{b}	11.3 ± 2.0^{a}	10.8 ± 2.6^{a}	3.4 ± 0.5^{bc}	4.6 ± 0.9^{a}
Organic agricultural system	9.4 ± 1.9^{c}	19.6 ± 3.8^{a}	9.4 ± 1.1^{ab}	8.0 ± 1.8^{b}	4.4 ± 0.6^{ab}	5.3 ± 0.3^{a}
Conventional agricultural system	3.2 ± 0.3^{d}	2 ± 0.5^{d}	$7.2 \pm 2.4b^{bc}$	5.0 ± 1.4^{cd}	4.8 ± 1.1^{a}	5.2 ± 1.0^{a}
Eucalyptus plantation	3.67 ± 0.6^{d}	2.3 ± 1.2^{d}	$4.5 \pm 0.4^{\mathbf{d}}$	4.1 ± 0.2^{d}	2.3 ± 0.3^{d}	2.6 ± 0.5^{cd}

Data are expressed as mean ± se (n= 20).Values indicated by different letters are significantly different (p ≤ 0.05)

The results showed that the biological soil quality expressed in terms of soil respiration in the four land use systems was not significantly different (P<0.05). However, the trend was for highest soil respiration in the organic agriculture system and lowest in the eucalyptus plantation. The soil respiration in earthworm casts was higher than in soil in the rainy season. The results showed that the soil properties of earthworm casts were different in each land use system. An increase in the % silt and % clay and decrease of % sand was found in earthworm casts compared with surrounding soil in all land use systems. As for chemical properties, the results showed that the soil in the earthworm cast had higher EC, organic matter, CEC, total nitrogen, available phosphorus, and calcium and magnesium concentrations than in soil and especially higher levels of available phosphorus. The characteristics of the soils and earthworm casts were comparable (Table 2 and 3).

Table 2 The physical soil properties of soil and earthworm cast in rainy season in different land use systems

Land use system	Bulk density (g/cm^3)		Saturated hydrolic conductivity (cm/h)		Particle density (g/cm^3)		Porosity (%)		Soil Moisture (%)	
	soil	cast	soil	cast	soil	cast	soil	cast	soil	cast
Natural forest	1.40±0.19[a]	1.39±0.04[a]	0.33±0.29[a]	0.47±0.49[c]	2.54±0.05[ab]	2.62±0.09[ab]	45±0.07[a]	47±0.03[a]	20.61±4.75[ab]	28.30±4.44[a]
Organic agricultural system	1.49±0.07[a]	1.45±0.12[a]	0.79±0.84[a]	0.92±0.71[bc]	2.50±0.08[b]	2.62±0.07[ab]	40±0.03[a]	45±0.05[a]	22.84±2.71[a]	26.96±6.22[a]
Conventional agricultural system	1.49±0.09[a]	1.36±0.08[a]	1.62±2.48[a]	2.66±2.32[a]	2.54±0.12[ab]	2.60±0.06[ab]	41±0.06[a]	48±0.03[a]	18.64±2.55[ab]	31.95±4.20[a]
Eucalyptus plantation	1.58±0.05[a]	1.35±0.13[a]	1.16±0.54[a]	2.98±2.22[a]	2.53±0.06[ab]	2.68 ±0.03[a]	41±0.01[a]	47±0.03[a]	12.81±6.30[b]	23.43±3.43[a]

Table 3 The chemical soil properties of soil and earthworm cast in rainy season in different land use systems

Land use system	pH (1:1)		EC(1:5) dS/m		OM (%)		T-N (%)		Avail.P (ppm)		Exch.K (ppm)	
	soil	cast	soil	cast	soil	cast	soil	cast	soil	cast	soil	cast
Natural forest	5.14±0.75[a]	5.41±0.62[a]	0.03±0.01[a]	0.05±0.00[a]	1.60±0.21[a]	2.96±1.05[a]	0.08±0.01 [a]	0.15±0.05[a]	8.38±2.38[ab]	9.46±3.12[b]	32.67±5.69[a]	42.67±4.16[a]
Organic agricultural system	5.00±0.46[a]	6.16±0.31[a]	0.04±0.00[a]	0.06±0.03[a]	1.07±0.61[ab]	1.90±1.50[a]	0.05±0.03[ab]	0.10±0.07[a]	24.36±17.97[ab]	39.42±24.97[ab]	47.67±26.39[a]	119.00±25.51[a]
Conventional agricultural system.	5.19±0.35[a]	5.68±0.54[a]	0.04±0.02[a]	0.06±0.03[a]	1.06±0.44[ab]	2.63±1.34[a]	0.05±0.02[ab]	0.13±0.07[a]	35.58±26.73[a]	42.13±22.08[a]	94.67±87.65[a]	165.33±135.2[a]
Eucalyptus plantation	4.76±0.03[a]	5.99±0.06[a]	0.03±0.00[a]	0.06±0.01[a]	0.71±0.03[b]	1.66±0.09[a]	0.04±0.00[b]	0.08±0.00[a]	3.68±0.83[b]	9.22±0.85[b]	42.33±3.06[a]	77.67±4.04[a]

CONCLUSION

The earthworm, *Pheretima* sp., has the potential to be a soil bioindicator that can be used to assess and monitor land use change, soil pollution, soil health and ecosystem functioning under different land use systems and management practices. Chemical analysis of contaminated soil can be expensive and uninformative regarding environmental hazards associated with polluted soil. The use of biomonitoring to evaluate hazardous agrochemical contaminated sites provides a direct, inexpensive, and integrated estimate of the impact of the contaminant on the ecosystem. Therefore, the role of soil biota and biodiversity should be urgently recognized as important tools for improved knowledge and management practices for soil conservation and sustainable land use in Thailand. Sustainable agriculture involves the successful management of agricultural resources to satisfy human needs while maintaining and enhancing environmental quality and conserving natural resources for future generations. Improvement in agricultural sustainability will require the optimal use and management of soil fertility and soil physical properties. Both rely on soil biological processes and soil biodiversity. This implies that management practices which enhance soil biological activity and thereby build up long term soil productivity and health are beneficial (FAO, 2004). This study found that earthworms could improve biological, physiological and chemical properties of soil. Moreover, earthworm casts contain valuable nutrients that are very useful for increasing soil fertility and plant production. Earthworm conservation should be undertaken for beneficial land resource reclamation.

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