

The Diversity and Distribution of Terrestrial Earthworms in Sakaerat Environmental Research Station and Adjacent Areas, Nakhon Ratchasima, Thailand

¹Pattana Somniyam and ²Pongthep Suwanwaree

¹Faculty of Agriculture, Uttaradit Rajabhat University,
Muang District, Uttaradit 53000, Thailand

²School of Biology, Institute of Science, Suranaree
University of Technology, Muang District, Nakhon Ratchasima 30000, Thailand

Abstract: The distributions of terrestrial earthworms were studied in the Sakaerat Environmental Research Station (SERS) and adjacent areas. The earthworms and soil samples were collected in the same 30×30×30 cm³ sampling sites from four vegetation types (dry evergreen forest, dry dipterocarp forest, forest plantation and grassland) four agricultural lands (rice paddy, sugarcane, cassava and mango) and three types of residential areas (household, SERS building area and Silvicultural Research Station area). The digging and hand sorting method was used to collect the earthworms, three times during rainy season (June, August and October) in 2006. Identification of terrestrial earthworms was based on external and internal morphology. Nineteen species of five families were found in studied areas. *Pontoscolex corethrurus*, the only member of the Glossoscolecidae, had the highest population density followed, by 11 species of Megascolecidae, three species of Moniligastridae, three species of Octochaetidae and finally, *Gordiodrilus elegans*, the only species of Ocnerodrilidae, was found in only a household area. Most earthworms collected were adults. Highest population densities were found in residential areas followed by agricultural lands and forest types. The earthworm density was highly significant different in October. The highest density was in SERS (611.1 ind/m²) and the lowest was in DIF (61.1 ind/m²). The highest species diversity was 11 in SRS but the highest diversity index was 1.71 in rice paddy.

Key words: Terrestrial earthworm • Diversity • Sakaerat Environmental Research Station • Forest types • Agricultural lands • Residential areas

INTRODUCTION

Earthworms have important roles in soil physical, chemical and biological properties [1]. Earthworms eat soil organic matter and litter and increase availability of plant nutrients in their casts [2]. The nutrients can increase plant growth and yield of crops as the result [3]. These are good indications that earthworm activities and behavior interact strongly with physical, chemical and biological properties of soil. But there is still inadequate knowledge of the basic biology and ecology of earthworms, especially in Thailand. Therefore, this study will give new information on earthworms in Thailand and will be valuable resources (species richness, population distributions) for future basic and applied earthworm

research and also increase knowledge and understanding about earthworms for people who work in the field of ecology, agriculture and environmental science.

MATERIALS AND METHODS

Study Site: The Sakaerat Environmental Research Station (SERS) is the UNESCO biosphere reserve. It was established in 1967, primarily as a site for research on dry evergreen and dry dipterocarp tropical forest and was supported by the UNESCO/MAB Programme since 1978. Other vegetation types in SERS are bamboo, forest plantation and grassland. SERS is administered by the Thailand Institute of Scientific and Technological Research aiming to be a natural laboratory for students

and providing training and seminars in ecological and environmental research. SERS is located at 14°30'N and 101°55'E at an altitude of 280-762 m above sea level, covering 78 km² on the edge of Thailand's Khorat Plateau about 300 km north-east of Bangkok. The average annual temperature is 26°C, the average annual rainfall is 1,260 ml and average relative humidity is 81.9%. There are three seasons: the rainy season (May to October), winter (November to February) and Summer (March to mid-May). The wettest month is September and the driest months are from January to March.

Some 5,300 people live around SERS in 1999. They make their living from growing crops and rice but also using the forest for food and wood gathering. That leads to illegal hunting and tree cutting in the area.

The study sites (as shown in Fig. 1) consisted of four types of forest in SERS, namely dry evergreen forest (DE), dry dipterocarp forest (DIF= fired, DINF= non fired), forest plantation (PL), a grassland site (G), four types of agricultural land, including mango plantation (M), sugarcane plantation (S), cassava plantation (C) and rice paddy (R) and three types of residential areas, including house area (H), SERS building area (SERS) and Silvicultural Research Station area (SRS).

Earthworms and Soil Sampling: Earthworm and soil samples were collected in 30×30×30 cm³ by hand sorting method in June, August and October during rainy season of 2006. There are four replications per site. The external morphology keys of Gates [4] and Sims and Easton [5] were used for earthworm identifications.

Soil samples (500 g) were taken to measure pH, moisture, organic matter, N, P and K. Soil pH were determined in a water suspension at a 2:5 soil:water ratio, on fresh samples. Soil moisture was determined by percent of the weight of fresh soil sample after dried at 105°C for 24 h [6]. The organic matter was determined following Walkley and Black [7]. Total N was analysed by the micro Kjeldahl method [6]. Available phosphorus was measured colourimetrically, based on the reaction with ammonium molybdate and development of the 'Molybdenum Blue' colour [8]. Exchangeable K was extracted by the Mehlich-3 procedure and determined by atomic absorption spectrophotometry and flame emission [9].

Data Analysis: Evenness and Shannon-Wiener index [10] were used to compare the diversity of earthworms among sites. Differences in earthworm numbers and species abundance among land use types were analyzed with

ANOVA. The Pearson correlation was employed to find relationship among soil parameters, environmental factors and earthworm density. All data were calculated by using SPSS version 14.0 program for windows.

RESULTS AND DISCUSSION

Diversity and Distribution: Nineteen species of five families (Glossoscolecidae, Megascolecidae, Moniligastridae, Octochaetidae and Ocnodrilidae) were found in this study (Table 1). Interestingly, *Pontoscolex corethrurus*, the only species of Glossoscolecidae, had the highest number of individuals and was distributed all over the areas except in dipterocarp forest and sugarcane plantation.

Many earthworm species were present in many places. Three earthworms (*P. corethrurus*, *Drawida beddardi* and *Dichogaster affinis*) were found in nine habitats. Whereas, five species (*Amyntas alexandri*, *Metaphire peguana*, *Metaphire planata*, *Metaphire posthuma* and *Dichogaster modiglianii*) were present in seven habitats. In contrast, five earthworms were very site-specific species such as *Polypheretima elongata* in sugarcane plantation, *Dichogaster bolau* in dry dipterocarp forest (fired), *Gordodrilus elegans* in household area, *A. corticis* in grassland and *A. tokioensis* species – group in dry evergreen forest.

The Southeast Asian earthworm fauna is dominated by species of Megascolecidae, Moniligastridae and some Ocnodrilidae. The most diverse and successful group of earthworm species in this region is the pheretimoid-related genera *Pheretima*, *Polypheretima*, *Metaphire* and *Amyntas*. In both natural and disturbed ecosystems, the exotic *P. corethrurus* or *Polypheretima elongata* are generally dominant [11].

SRS was the most diverse habitat for earthworms, containing 11 species, while the lowest was DIF which had only three species (Table 2). The greatest species evenness was 0.80 in DINF. The highest Shannon-Wiener index (H') was 1.71 in rice paddy and the lowest was 0.95 in mango plantation.

The species richness of all area types ranged from 3 to 11 species. They were not different from other tropical rainforests that contained 4 to 14 species. Edwards and Bohlen [3] stated that earthworm diversity ranged from 1 to 15 species, while most earthworm communities contained around 3-6 species. Generally, more species of earthworm were found in residential and agricultural areas than in the forests. Because the residential and agricultural areas are more subject to

Table 1: Distribution and density of earthworm

	Forest habitats				Agricultural habitats					Residential habitats			
Earthworm													
Family/species	DE	DIF	DINF	PL	G	R	S	C	M	H	SERS	SRS	Average
Glossoscolecidae													
<i>Pontoscolex corethrurus</i>	55.6	0.0	0.0	182.4	100.9	30.6	0.0	62.0	106.5	70.4	148.2	99.1	71.3
Megascolecidae													
<i>Amyntas alexandri</i>	0.9	0.0	0.0	0.0	3.7	0.0	2.8	1.9	0.0	1.9	0.9	2.8	1.2
<i>Amyntas corticis</i>	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
<i>Amyntas tokioensis</i>													
<i>species- group</i>	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
<i>Amyntas sp1</i>	0.0	27.8	2.8	0.0	0.0	3.7	0.0	1.9	0.0	0.0	0.0	0.9	3.1
<i>Amyntas sp2</i>	3.7	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
<i>Metaphire bahl</i>	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	23.2	13.9	36.1	33.3	9.9
<i>Metaphire houletti</i>	3.7	0.0	0.0	0.9	0.0	8.3	13.0	7.4	0.0	0.0	0.0	0.9	2.9
<i>Metaphire peguana</i>	0.0	6.5	6.5	0.0	0.9	0.0	0.0	0.9	2.8	0.0	50.0	13.0	6.7
<i>Metaphire planata</i>	0.0	0.0	0.9	0.0	0.0	37.0	34.3	19.4	11.1	4.6	0.0	37.0	12.0
<i>Metaphire posthuma</i>	0.0	0.0	0.0	0.0	4.6	18.5	31.5	0.9	2.8	35.2	0.0	0.9	7.9
<i>Polypheretima elongata</i>	0.0	0.0	0.0	0.0	0.0	0.0	65.7	0.0	0.0	0.0	0.0	0.0	5.5
Moniligastridae													
<i>Drawida beddardi</i>	16.7	0.0	1.9	2.8	28.7	0.0	0.9	0.0	2.8	0.9	17.6	2.8	6.3
<i>Drawida sp1</i>	0.0	0.0	0.0	0.0	0.0	7.4	0.0	11.1	0.0	0.0	0.0	0.0	1.5
<i>Drawida sp2</i>	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	22.2	0.0	2.2
Octochaetidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Dichogaster affinis</i>	1.9	0.0	16.7	1.9	17.6	0.9	4.6	1.9	0.0	0.0	7.4	2.8	4.6
<i>Dichogaster modiglianii</i>	11.1	0.0	0.0	7.4	24.1	0.9	0.0	3.7	0.0	0.0	2.8	1.9	4.3
<i>Dichogaster bolau</i>	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Ocnerdriidae													
<i>Gordiodrilus elegans</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.4	0.0	0.0	11.0
<i>Juvenile and unknown</i>	1.9	0.0	0.0	0.9	13.0	14.8	8.3	2.8	4.6	10.2	5.6	10.2	6.0

DE = dry evergreen forest, DIF = dry dipterocarp forest-fired, DINF= dry dipterocarp forest-non fired, PL = forest plantation, G = grass land, M = mango plantation, S = sugarcane plantation, C = cassava plantation, R= rice paddy, H= household area, SERS = SERS office building area and SRS = office building area of Sakaerat Silvicultural Research Station

Table 2: Species Diversity and evenness of earthworms in different habitats

Index	Forest habitats				Agriculture habitats					Residence habitats		
	DE	DIF	DINF	PL	G	R	S	C	M	H	SERS	SRS
Species richness	8.00	3.00	6.00	5.00	8.00	9.00	8.00	10.00	6.00	6.00	8.00	11.00
Evenness	0.64	0.65	0.80	0.59	0.68	0.78	0.77	0.63	0.53	0.67	0.70	0.62
Species Diversity('H)	1.33	0.72	1.43	0.96	1.41	1.71	1.60	1.45	0.95	1.20	1.45	1.50

DE = dry evergreen forest, DIF = dry dipterocarp forest-fired, DINF= dry dipterocarp forest-non fired, PL = forest plantation, G = grass land, M = mango plantation, S = sugarcane plantation, C = cassava plantation, R= rice paddy, H= household area, SERS = SERS office building area and SRS = office building area of Sakaerat Silvicultural Research Station

Table 3: The Earthworm Density in Sakaerat Environmental Research Station and Adjacent Areas, 2006

Area types	June		August		October		Average
	Ind/m ²	S.E	Ind/m ²	S.E	Ind/m ²	S.E	
DE	47.2	32.8	163.9	36.7	77.78c	32.7	96.3
DIF	16.7	16.7	33.3	19.8	61.11c	21.5	37.0
DINF	8.3	8.3	0.0	0.0	97.22c	41.4	35.2
PL	111.1	29.8	194.4	79.2	283.33bc	139.4	196.3
G	94.4	29.6	258.3	24.2	230.56bc	11.5	194.4
R	111.1	44.7	130.6	27.4	138.89bc	26.6	126.9
S	250.0	124.9	169.4	78.5	100.00c	45.8	173.2
C	130.6	65.2	105.6	44.1	105.56c	18.4	113.9
M	175.0	98.6	113.9	65.6	172.22bc	95.2	153.7
H	94.4	40.2	133.3	63.5	183.33bc	54.9	137.0
SERS	8.3	8.3	252.8	183.4	611.11a	120.4	290.7
SRS	72.2	54.5	150.0	50.2	358.33b	112.9	193.5
Average	93.3	17.6	142.1	21.1	201.6	28.8	145.7

DE = dry evergreen forest, DIF = dry dipterocarp forest-fired, DINF= dry dipterocarp forest-non fired, PL = forest plantation, G = grass land, M = mango plantation, S = sugarcane plantation, C = cassava plantation, R= rice paddy, H= household area, SERS = SERS office building area and SRS = office building area of Sakaerat Silvicultural Research Station

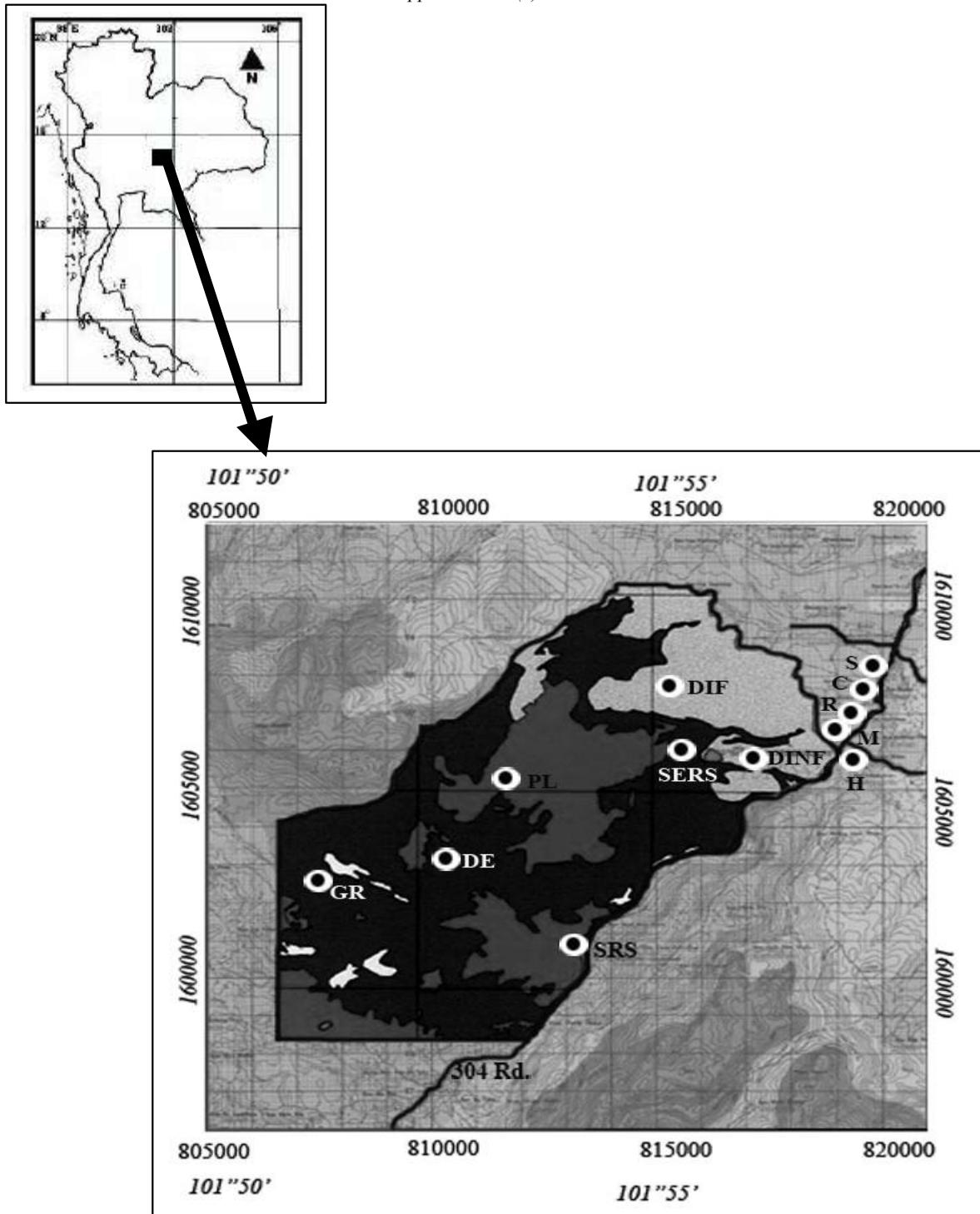


Fig. 1: SERS Location and Earthworm Collecting Sites
 DE = dry evergreen forest, DIF = dry dipterocarp forest-fired, DINF= dry dipterocarp forest-non fired, PL = forest plantation, G = grass land, M = mango plantation, S = sugarcane plantation, C = cassava plantation, R= rice paddy, H= household area, SERS = SERS office building area, and SRS = office building area of Sakaerat Silvicultural Research Station

Table 4: The Correlations among Earthworm Density and Environmental Factors

	Earthworm density	Soil Moisture	Soil pH	Temperature	Rain fall	N	P	K	Soil OM
Soil Moisture	0.24**								
Soil pH	0.14	0.05							
Temperature	-0.15	-0.08	0.19*						
Rainfall	0.20**	0.17*	-0.14	-0.70**					
N	0.23**	0.16	-0.18*	-0.15	0.29**				
P	0.1	0.06	0.39**	-0.01	-0.01	-0.01			
K	0.11	0.02	0.25**	0.17*	-0.06	0.19*	0.25**		
Soil OM	0.17*	0.17*	-0.11	-0.06*	0.23**	0.66**	0.24**	0.32**	
Soil C/N	0.05	0.07	0.01	-0.39**	-0.02	-0.14	0.30**	0.26**	0.52**

Pearson correlation coefficient: *, **, significant at $P < 0.05$ and $P < 0.01$, respectively

species introduction, so they get the exotic species. Nevertheless, these habitats might have many kinds of food resources which supported many earthworm species.

Earthworm Density: A total of 2,044 earthworms were collected in all studied areas. Of these, 1,966 individuals were identified to species and 78 were unidentified. All earthworm specimens were divided into 3 age groups, adult (1,382 individuals), juveniles (393 individuals) and sub-adults (269 individuals).

The highest earthworm density was *P. corethrurus* (average 71.3 ind/m²; Table 1.) followed by *Metaphire planata* (average 12.0 ind/m²) and *Metaphire bahli* (average 9.9 ind/m²). The lowest were *Amyntas corticis* and *Amyntas tokioensis* species-group (average 0.1 ind/m²).

As shown in Table 3, the numbers of earthworm were highest in October (201.6 ind/m²) followed by August (142.1 ind/m²) and June (93.3 ind/m²) respectively. Edwards and Bohlen [15] stated that when the rain began, the population consisted of juvenile individuals. The mature earthworms were found one month later and predominated to the end of wet season.

Earthworm densities were highest in residential areas followed by agricultural lands and forest types. The earthworm density was significantly different in October. The highest density was in SERS (611.1 ind/m²) and the lowest was in DIF (61.1 ind/m²), as shown in Table 3.

The earthworm densities were positively significant correlated ($p < 0.05$) with soil moisture, rainfall, total nitrogen and organic matter (Table 4). However, they were not correlated with temperature, phosphorus, potassium and C/N ratio.

Environmental factors cannot explain the earthworm density in our sites. The differences depend on earthworm species in each habitat, especially an exotic one. The density of *P. corethrurus*, which is well adapted to human disturbed areas, was 24% in rice paddy and up to 92% in

forest plantation. This species alone contributed to the high earthworm density in residential, agricultural, grassland and forest plantation areas.

CONCLUSION

A total 2,044 individuals of 19 earthworm species were found in this study. They belonged to the following five families: Glossoscolecidae, Megascolecidae, Moniligastridae, Octochaetidae and Ocnerodrilidae. The 19 species were *P. corethrurus*, *A. alexandri*, *A. corticis*, *A. tokioensis* species-group, *Amyntas sp1*, *Amyntas sp2*, *M. bahli*, *M. houlleti*, *M. peguana*, *M. planata*, *M. posthuma*, *P. elongata*, *D. beddardi*, *Drawida sp.1*, *Drawida sp.2*, *Di. affinis*, *Di. modiglianii*, *Di. bolau* and *Gordiodrilus elegans*. The most abundant was *P. corethrurus*, which was present in every forest type except dipterocarp forest. The rarest were *A. corticis* and *A. tokioensis* species-group, found only in grassland and dry evergreen forest respectively. The adult stage was most abundant, followed by juveniles and sub-adults. Population densities were highest in October followed by August and June. The earthworm density was highest in residential areas followed by agricultural lands and forests. The earthworm density was significantly different among sites in October. The highest density was in SERS (611.1 ind/m²) and the lowest was in DIF (61.1 ind/m²). The highest species diversity and species richness of earthworms were found in rice paddy and around the Silvicultural Research Station offices respectively. The evenness of earthworm was highest in unburned dipterocarp forest. The exotic *P. corethrurus* was found in every habitat except in dry dipterocarp forest and sugarcane plantation. *Polypheretima elongata* was found only in sugarcane plantation while *Gordiodrilus elegans* was found only in household area. Environmental factors, such as soil moisture, rainfall, total nitrogen and organic matter, were very important for earthworm management.

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