

**Species Composition and Distribution of Earthworms in Hue City, Vietnam and Its Vicinity**

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Abstract: Background: Earthworms are the largest members of the order Opisthoptera, the class Oligochaeta of phylum Annelida. They are distributed worldwide in different habitat and beneficial components of soil fauna since they dominate the invertebrate biomass in the soil. Earthworms as an alternative protein source in poultry, cattle and fish farming. Many earthworm species have been utilized as an important source of food for cattle and poultry. Thousands of different earthworm species have been identified worldwide with reports on diversity and distribution of earthworms in various parts of the world. **Aim:** This research was carried out to determine species composition and distribution of earthworms in the pig farming areas in Hue city, Vietnam and its vicinity. **Material and methods:** *Earthworms* were collected according to the method described by Ghilliarov (1975). The collected earthworms were identified using the external morphology key of Bai (1983) and Blakemore (2002). Outcomes were expressed in terms of biomass (fresh weight in g/m²) and density (ind/m²). **Results:** Thirteen earthworm species belonging to two families Megascolecidae and Glossoscolecidae were found from study areas during our study period from December 2018 to April 2019. *P. elongata* was found in all the ten study sites, and being distributed in all the strata with the earthworm density, and the fresh weight biomass were highest. **Conclusion:** The present study will provide new insight on earthworms in the pig farming areas of Hue city, Vietnam and its vicinity and will be valuable resources such as species composition, distribution, diversity for future basic and applied earthworm research, particularly in Thua Thien Hue, Vietnam.

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Keywords: Earthworms, species composition, distribution, Hue city, Vietnam

1. Introduction

Earthworms are the members of the order Opisthoptera, the class Oligochaeta of phylum Annelida. They are distributed worldwide in different habitat and beneficial components of soil fauna since they dominate the invertebrate biomass in the soil (Thai, 1983; Thuan et al, 2018, 1994; Dung et al, 2018). Many earthworm species have been utilized as an important source of food for cattle and poultry. Thousands of different earthworm species have been identified worldwide with reports on diversity and distribution of earthworms in various parts of the world such as Tangail, Bangladesh (Bahar et al, 2015); Tripura, India (Dey et al, 2016); Puerto Rico (Gonzalez et al, 1999); northern German (Groth et al, 2013); Manipur, India (Haokip et al, 2012); Northern Puerto Rico (Lugo et al, 2006); Uttarakhand, India (Joshi et al, 2009); Santa Fe province, Argentina (Masin et al, 2018); South Africa (2015, 2012); Gulbarga, Karnataka, India (Padashetty et al, 2014); Quebec, Canada (Whalen, 2004); etc., and many areas in Vietnam: Central Vietnam (Hoi, 1996); Hai Van Pass and Ba Na Mountain Nature Reserve (Ha et al, 2012);

Hoi An, Quang Nam (Ha et al, 2013); An Giang (Tung et al, 2012), Cuu Long Delta (Tung et al, 2013), Tien River (Tung et al, 2008); Long An (Tinh, 2016); etc.

Our previous studies showed species composition and distribution of the earthworms in Binh Tri Thien region (Thuan, 1994); Southern Binh Dinh province (Thuan et al, 2012); as well as species composition and distribution of *Amyntas rodericensis* (Grube, 1879) in Hue city (Thuan et al, 2017), and their morphological variations in Thua Thien Hue province (Thuan et al, 2015). The aim of this study is to determine species composition and distribution of earthworms in the pig farming areas in Hue city, Vietnam and its vicinity, for which no data are available at present.

2. Material and Methods

The present study was conducted during December 2018 to April 2019 in ten study sites in the pig farming areas in Hue city and its vicinity, included five sites in Hue City: Huong So (16°29'30"N, 107°33'00"E); Vy Da (16°28'51"N, 107°35'48"E); An Tay (16°26'12"N, 107°36'15"E); An Cuu (16°26'57"N, 107°35'48"E); and An Dong (16°45'27"N,

107°61'18"E); and five sites in Hue's vicinity: Quang Tho, Quang Dien (16°32'19"N, 107°31'29"E); Quang Thanh, Quang Dien (16°32'27"N, 107°33'5"E); Thuy Van, Huong Thuy (16°28'58"N, 107°36'56"E); Thuy Thanh, Huong Thuy (16°28'5"N, 107°38'3"E); and Phu My, Phu Vang (16°29'40"N, 107°38'16"E) (Figure 1).



Figure 1. Map of sampling sites in Hue city, Vietnam and its vicinity in the present study.

Earthworms were sampled in four plots (50 cm×50 cm) on each sampling site. The quadrates were explored with a spade at the depth of 0-10 cm, 10-20 cm and 20-30 cm to collect earthworms (Ghilliarov, 1975). The earthworms were hand sorted and fresh weight of earthworm was recorded after they were washed with water to remove soil and dried with paper towels. The earthworms were preserved in the Zoology laboratory at the Faculty of Biology, University of Education, Hue University, Vietnam and stored in 4% formalin for further studies. The collected earthworms were identified using the external morphology key of Blakemore (2002) and Bai (1983), counted, and weighed. Outcomes were expressed in terms of biomass (fresh weight in g/m²) and density (ind/m²).

3. Results and Discussion

Species Composition and Taxonomic Richness

The total earthworms recorded during the study period were 731 individuals. Altogether 13 species belonging to six genera (*Lampito*, *Perionyx*, *Amyntas*, *Polypheretima*, *Metaphire*, and *Pontoscolex*) and two families (Megascolecidae and Glossoscolecidae) were found from study areas (Table 1). The study showed that the family Megascolecidae was dominant. The twelve species of family Megascolecidae (with 92.31% of all species registered)

included *Lampito mauritii*, *Perionyx excavatus*, *Amyntas aspergillus*, *A. dingus*, *A. modigliani*, *A. papulosus papulosus*, *A. penichaetiferus*, *A. rodericensis*, *Polypheretima elongata*, *P. parataprobanae*, *P. taprobanae*, and *Metaphire posthuma*. The family Glossoscolecidae was represented only by *Pontoscolex corethrurus* with 7.69%.

In Vietnam, *A. dignus* seemed to be widely distributed; *A. aspergillum* and *A. papulosus papulosus* were commonly found in Northern and Central parts; *A. rodericensis* seemed to be widely distributed in the highlands and Central parts; *L. mauritii* was usually found in coastal regions; *M. posthuma* usually occurred in sandy soils; *P. excavates* was commonly used in earthworm farms, and sold as "red earthworm" for fishing and other purposes; *P. taprobanae* possibly originated in Southeast Asia (Easton, 1979) or in Papua New Guinea (Gates, 1972); *P. corethrurus* originated from the neotropical regions and was widely distributed in the world (Gates, 1972), and has been found in high density near the beach of Phu Quoc island (Thai et al, 2004); *P. elongate* was an exotic species originating from the Indonesian region (Easton, 1976). *P. parataprobanae* and *A. penichaetiferus* were only known from Vietnam (Tung et al, 2016).

Out of six genera were recorded from study areas, *Amyntas* was the genus had the highest number of species with 46.16% (6/13) and *Lampito*, *Metaphire*, and *Pontoscolex* were the genera had the lowest number of species, only one with 7.69% (1/13).

The most abundant was *P. elongata* and presented in all the ten study sites. The rarest were *L. mauritii*, found only in An Tay, and *A. penichaetiferus* found only in Quang Thai.

Ten species of earthworms distributed in six genera and two families in Hue City (three species *A. modigliani*, *A. penichaetiferus*, and *A. rodericensis* were absent), 11 species belonging to five genera and two families in Hue's vicinity (genus *Lampito* and two species *L. mauritii* and *P. taprobanae* were absent).

The sampled An Dong and Thuy Thanh sites recorded the highest species richness with 61,54% (8/13): *P. excavatus*, *A. aspergillus*, *A. dingus*, *A. modigliani*, *A. rodericensis*, *P. elongata*, *M. posthuma*, and *P. corethrurus* in An Dong; *P. excavatus*, *A. aspergillus*, *A. modigliani*, *A. rodericensis*, *A. papulosus papulosus*, *P. elongata*, *P. taprobanae*, and *P. corethrurus* in Thuy Thanh. The sampled An Tay recorded the lowest species richness with 23,08% (3/13): *L. mauritii*, *A. aspergillus*, and *P. elongata*.

Table 1. Earthworm species found in study sites in Hue city, Vietnam and its vicinity

Family	Genus	Species	Sampling site										
			Hue City					Hue's vicinity					
			Vy Da	An Tay	An Cuu	An Dong	Huong So	Quang Tho	Quang Thanh	Thuy Thanh	Thuy Van	Huong So	
Megascolecidae	<i>Lampito</i>	<i>L. mauritii</i> Kinberg, 1867	-	+	-	-	-	-	-	-	-	-	-
	<i>Perionyx</i>	<i>P. excavatus</i> Perrier, 1872	+	-	+	+	+	-	-	+	-	+	
	<i>Amyntas</i>	<i>A. aspergillum</i> (Perrier, 1872)	-	+	+	+	+	+	-	+	+	+	
		<i>A. dignus</i> (Chen, 1946)	+	-	-	+	+	+	+	-	+		
		<i>A. modigliani</i> (Rosa, 1889)	-	-	-	-	-	+	-	+	-	-	
		<i>A. papulosus papulosus</i> (Rosa, 1986)	+	-	-	+	+	+	+	+	+	+	
		<i>A. penichaetiferus</i> (Thai, 1984)	-	-	-	-	-	+	-	-	-	-	
	<i>Polypheretima</i>	<i>P. elongata</i> (Perrier, 1872)	+	+	+	+	+	+	+	+	+	+	
		<i>P. parataprobanae</i> (Thai et Nguyen, 1993)	+	-	+	+	+	-	+	+	+	+	
		<i>P. taprobanae</i> (Beddard, 1892)	+	-	-	-	-	-	-	-	-	-	
<i>Metaphire</i>	<i>M. posthuma</i> (Vaillant, 1868)	+	-	-	+	-	-	+	-	-	-		
Glossoscolecidae	<i>Pontoscolex</i>	<i>P. corethrurus</i> (Muller, 1857)	-	-	+	+	+	-	-	+	+	+	
Total: 2	6	13	7	3	5	8	7	7	6	8	5	7	
			10					11					

Note: (+) present; (-) absent

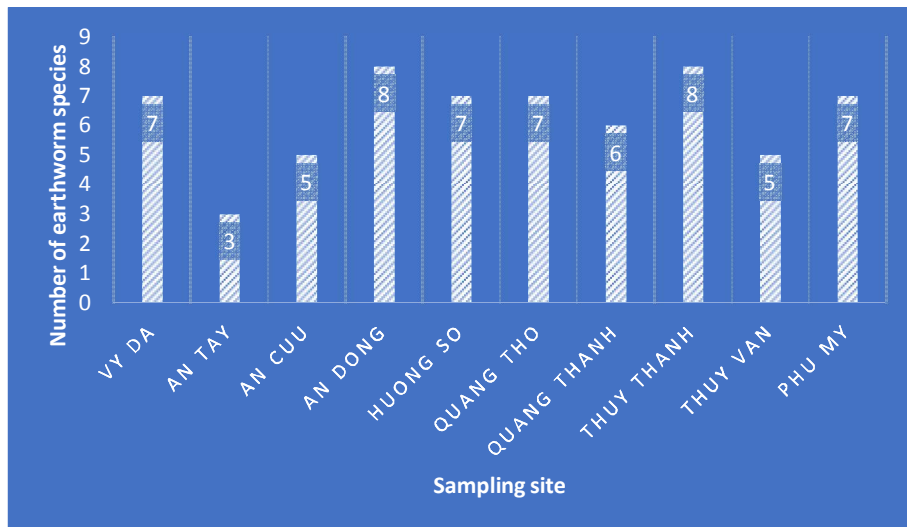


Figure 2. Distribution of earthworm species in different sampling sites in Hue city, Vietnam and its vicinity.

The number of earthworm species collected in the present study was higher and similar to that previously recorded from some other areas.

Seven earthworm species were found in a natural reserved and disturbed subtropical forest ecosystem of Imphal-West, Manipur, India (Site I, II, and III). They belonged to 5 genera and 4 families: Megascolecidae (*Metaphire houlleti*, *Metaphire anomala*, *Amyntas corticis*, and *Amyntas morrissi*), Glossoscolecidae (*Pontoscolex corethrurus*) and Moniligastridae (*Drawida sp.*), Octochaetidae (*Eutyphoeus sp.*). The rarest species was *Eutyphoeus sp.* found only in site I; *A. morrissi* and *A. corticis* species group found only in site III (Haokip et al, 2012).

Nine earthworm species inhabiting within different vegetation types in Queen Elizabeth Park, South Africa were recored, of which only one microchaetid *Tritogenia howickiana* was indigenous to South Africa. The other eight species were peregrine, widely introduced, and belonged to four families: Megascolecidae (*Amyntas aeruginosus*, *A. corticis*, *A. gracilis*, *A. minimus* and *A. rodericensis*), Glossoscolecidae (*Pontoscolex corethrurus*), Lumbricidae (*Octolasion lacteum*) and Acanthodrilidae, Benhamiinae (*Dichogaster saliens*) (Nxele, 2012).

Twelve species were found (8 Megascolecidae, 3 Lumbricidae and 1 Moniligastridae) in a cultivated system of Kumaun Himalaya (Naik et al, 2019). Ten earthworm species belonging to five genera (*Allolobophora*, *Aporrectodea*, *Dendrobaena*, *Lumbricus*, and *Octolasion*) were recorded in corn field, hayfield and forest systems of Southwestern Quebec, Canada (Whalen, 2004).

Groth et al (2013) found eleven earthworm species belonging to five genera (*Allolobophora*, *Aporrectodea*, *Eiseniella*, *Lumbricus*, *Octolasion*) at three areas at Haseldorfer Masch and one area at Beltringharder Koog (Schleswig-Holstein, Northern Germany).

In another study, Bahar et al (2015) recored five families, nine genera include fifteen species of earthworms at different habitats in Tangai district, Bangladesh.

The study of Dey et al (2016) showed 13 species of earthworms were collected from different sampling sites of the Pineapple Agroecosystems of Tripura, India. Of which, 5 species to the family Octochaetidae (*Eutyphoeus gigas* Stephenson, *Eutyphoeus scutarius* Michaelsen, *Eutyphoeus comillahnus* Michaelsen, *Eutyphoeus gammiei* (Beddard), and *Eutyphoeus sp.*), 4 species belonged to

the family Megascolecidae (*Metaphire houlleti* (Perrier), *Metaphire posthuma* (Vailant), *Kanchuria sp.*, and *Kanchuria sumerianus* Julka), 3 species to the family Moniligastridae (*Drawida assamensis* Gates, *Drawida papillifer papillifer* Stephenson, and *Drawida nepalensis* Michaelsen), and one species to the family Glossoscolecidae (*Pontoscolex corethrurus* (Muller)).

Earthworm richness and distribution in Santa Fe province, Argentina had been studied by Masin et al (2018). Fifteen earthworm species were identified and grouped into ten genera and five families: Acanthodrilidae (*Dichogaster bolau*, *Microscolex dubius*), Glossoscolecidae (*Glossodrilus parecis*), Lumbricidae (*Aporrectodea caliginosa*, *Aporrectodea rosea*, *Aporrectodea trapezoides*, *Bimastos parvus*, *Eisenia fetida*, *Octolasion tyrtaeum*), Megascolecidae (*Amyntas gracilis*, *Amyntas morrissi*, *Metaphire californica*), Ocnodrilidae (*Eukerria saltensis*, *Eukerria rosae*, *Eukerria stagnalis*). The five earthworm species, *G. parecis*, *E. saltensis*, *E. rosea*, *E. stagnalis* and *M. dubius*, were native to South America, and the rest were introduced from Asia and Europe.

Deep distribution of earthworms

Depth distribution of earthworms showed that earthworms appeared mainly in the 0-10 cm soil layer with the highest species number (13 species), density (38.13 ind/m²), and fresh weight biomass (46.39 g/m²). The lowest species number (6 species), earthworm density (7.07 ind/m²), and fresh weight biomass (6.73 g/m²) were observed in the 20-30 cm soil layer. (Table 2, Figure 3, and Figure 4). In the 0-10 cm soil layer, earthworm density, and fresh weight biomass of *P. elongata* were highest (9.67 ind/m², 10.40 g/m²) and those of *A. papulose papulose* were lowest (0.13 ind/m² and 0.07 g/m², respectively). In the 10-20 cm soil layer, earthworm density, and fresh weight biomass of *P. elongata* were highest (6.72 ind/m² and 10.09 g/m², respectively) and those of *P. excavatus* were lowest (0.10 ind/m² and 0.03 g/m², respectively). In the 20-30 cm soil layer, earthworm density and fresh weight biomass of *P. elongata* were highest (3.20 ind/m² and 3.12 g/m², respectively) and those of *L. mauritii* were lowest (0.14 ind/m² and 0.03 g/m², respectively). On the other hand, in the earthworm communities, *P. elongata* was found to be the species being distributed in all the strata of pig farming areas in Hue city, Vietnam and its vicinity (Table 3).

Table 2. Species number, earthworm density, and fresh weight biomass of earthworms in different soil depths at the study areas in Hue city, Vietnam and its vicinity.

Table 1.

Soil deep (cm)	Number of species	Earthworm density (ind/m ²)	Biomass (g/m ²)
0-10	13	38.13	46.39
10-20	10	25.73	36.75
20-30	6	7.07	6.73

Table 3. Distribution of earthworm species in different soil strata in study area

S.No.	Earthworm species	Deep (cm)		
		0-10	10-20	20-30
1	<i>L. mauritii</i>	+	+	+
2	<i>P. excavatus</i>	+	+	-
3	<i>A. aspergillum</i>	+	+	+
4	<i>A. dignus</i>	+	+	-
5	<i>A. modigliani</i>	+	+	+
6	<i>A. papulosus papulosus</i>	+	-	-
7	<i>A. penichaetiferus</i>	+	-	-
8	<i>A. rodericensis</i>	+	+	+
9	<i>P. elongata</i>	+	+	+
10	<i>P. parataprobanae</i>	+	-	-
11	<i>P. taprobanae</i>	+	+	-
12	<i>M. posthuma</i>	+	+	-
13	<i>P. corethrurus</i>	+	+	+

Note: (+) present; (-) absent

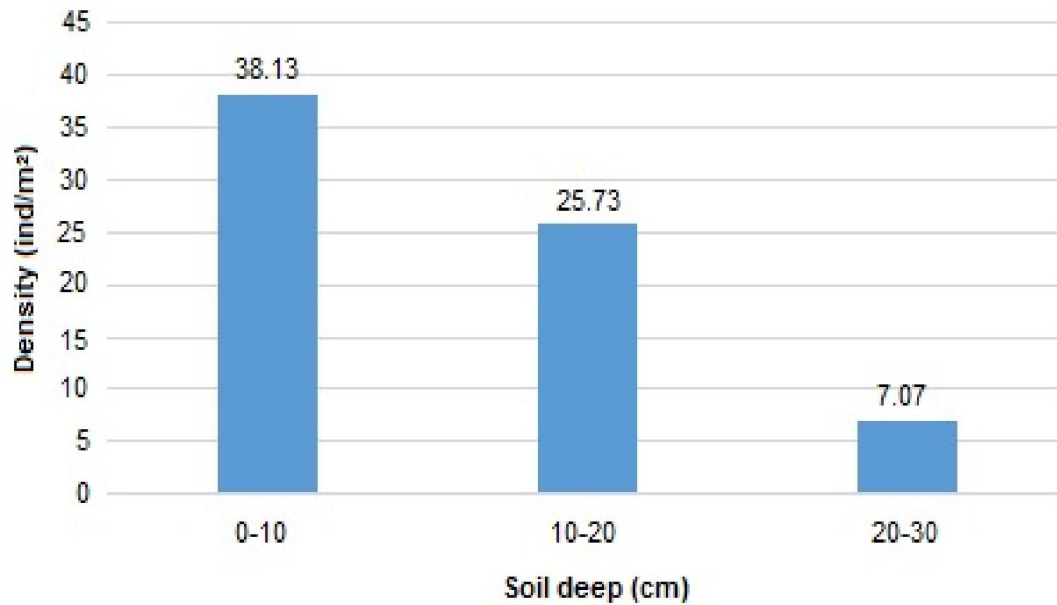


Figure 3. Earthworm density in different soil strata at the study areas in Hue city, Vietnam and its vicinity.

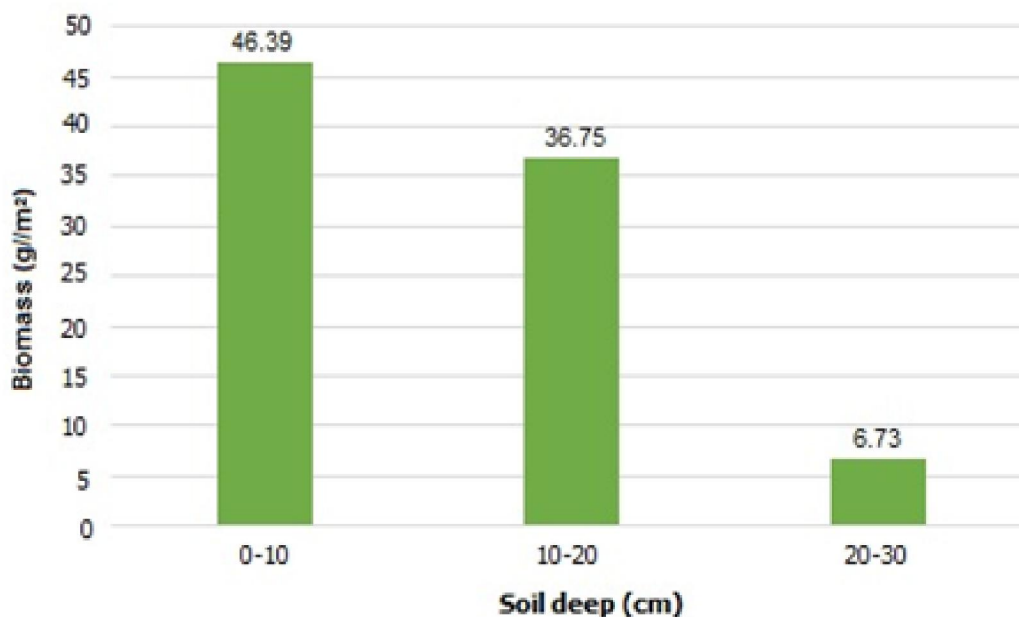


Figure 4. Earthworm biomass in different soil strata at the study areas in Hue city, Vietnam and its vicinity.

The earthworm density that we found in the pig farming areas in Hue city and its vicinity were within the range reported for the cultivated system of Kumaun Himalaya (0-214.4 ind./m²) (Naik et al, 2019); the tropical wet forest in Puerto Rico (0.06-123 ind/m²) (Gonzalez et al, 1999); the pineapple agroecosystems of Tripura, India (0.05-115.52 ind/m²) (Dey et al, 2016); and the subtropical forest ecosystem in Uttarakhand, India (17-82 ind/m²) (Joshi et al, 2009). The values were smaller than those observed in *Spathodea campanulata* Beauv. forests in Northern Puerto Rico (53-128 ind/m²) (Lugo et al, 2006), and the corn field, hayfield and forest systems of southwestern Quebec, Canada (46-177, 138-224, and 124-253 ind/m², respectively) (Whalen, 2004).

In terms of biomass, the values we found were within the range of data reported for forests in Northern Puerto Rico (33-64g/m²) (Lugo et al, 2006), the cultivated system of Kumaun Himalaya (0-74.8 g/m²) (Naik et al, 2019); and higher than that those in Northern German wet grassland (4.9-8.7 g/m²) (Groth et al, 2013); in the forest, in the hayfield, in the corn agroecosystem of Southwestern Quebec, Canada (2.0-14.1, 2.2-10.7, and 1.1-12.7 g/m², respectively) (Whalen, 2004).

In summary, our study will provide new insight on earthworms in the pig farming areas of Hue city, Vietnam and its vicinity and will be valuable resources such as species composition, distribution, diversity for future basic and applied earthworm research, particularly in Thua Thien Hue, Vietnam.

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