

Diversity of earthworm species in Hoa Binh province

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Abstract. This study presents research findings on earthworm diversity and distribution in Hoa Binh Province. These results were collected and evaluated based on previous research literature and specimens previously collected in the province. A total of 36 species belonging to 10 genera and six families were recorded in Hoa Binh Province. The family Megascolecidae accounted for 27 species in three genera, followed by Acanthodrilidae with four species in two genera. The family Ocnerodrilidae was recorded with two species in two genera, and one species each was recorded in the families Almidae, Moniligastridae, and Rhinodrilidae. Eight morphological species were identified at the generic level. The family Megascolecidae had seven morphological species, and the Moniligastridae family had one morphological species. The recorded earthworm species were mainly distributed at depths of 0–20 cm in timber and bamboo forest habitats. The number of recorded species is far from reflecting the true diversity of earthworms in Hoa Binh Province. Therefore, more intensive surveys are recommended to improve our knowledge of earthworm diversity in the province.

Keywords: Biodiversity, earthworms, soil invertebrates, distribution, northern Vietnam

1 Introduction

The evolution of earthworms commenced approximately 600 million years ago and they are classified as oligochaetes, a subclass of annelids (Annelida). These organisms play a pivotal role in natural ecosystems and human life. In their natural environment, they serve as a source of nourishment for other organisms and contribute to the formation of soil [1, 2]. Earthworms are known to consume a diet consisting of decomposing plant materials, such as dry grass and dry leaves. This contributes to the high nutritional value of their droppings [2, 3]. The droppings provide a substantial amount of humus, calcium, and potassium salts, which are

readily absorbed by plants. Furthermore, they facilitate the transformation of acidic, alkaline, and/or saline soil back to a neutral state, thereby ensuring the optimal pH level for crop cultivation and development. The movement of earthworms during the process of digestion results in the creation of soil pores. These pores serve to loosen and aerate the soil, thereby creating an environment conducive to plant respiration and the absorption of oxygen. Moreover, in the domain of traditional medicine, earthworms have been utilized for the treatment of various ailments, including malaria, rheumatism, asthma, epilepsy, jaundice, and urinary stones, among others [4, 5, 6]. A number of studies have demonstrated the presence of enzymes in certain

species of earthworms that possess the capacity to dissolve blood clots, exhibit anti-inflammatory properties, counteract oxidation, and induce cancer cell death [7]. It is noteworthy that certain species of earthworm function as intermediate hosts for parasitic roundworms, which pose a threat to livestock health [8, 9]. Research on earthworms in Vietnam [10] and various regions around the Red River Delta [11], Northwest [12], Northeast [13], Binh Tri Thien [14], Quang Nam - Da Nang [15], Central South Vietnam [16], Mekong River Delta [17], and Eastern South Vietnam [6]. There are various narrow-scoped or small-cohort studies and research on have been carried out, including provinces in the Northwest region of Vietnam. Hoa Binh - a province in the Northwest region, characterized mainly by medium-low mountain terrain, hills, and valleys, is considered a transition area between the plains (where most urban ecosystems are affected) and the mountainous areas (where many ecosystems remain unaffected). The area is evaluated having significant biodiversity and contains many rare, valuable genetic resources. Hence, there is a high expectation of a remarkable diversity in not only the species composition of flora and fauna but also abundant endemic biological values.

This article presents data on the diversity of earthworm species documented in Hoa Binh province. The research results contribute to clarifying the biodiversity of the Hoa Binh province and the potential for the sustainable exploitation and utilization of these biological resources.

2 Materials and Methods

Earthworm samples were collected using the method of Górný & Grüm [18]. Samples were collected in 2024 from in the litter layer (A0), A1 (0-10 cm), A2 (10-20cm), A3 (20-30cm); in the habitats of Wood Forests (WF); Bamboo Forests

(BF); Cogon Grass Hill (CGH), and Home Gardens (HG) in 5 districts of Hoa Binh province: Kim Boi, Yen Thuy, Tan Lac, Cao Phong, Mai Chau and in Hoa Binh city. Earthworm samples were then washed in water to remove impurities. Specimens were treated using a 2% formalin solution, arranged in a stretched state, and placed in a sealed container for about 15 minutes to ensure rigidity, then preserved in formalin 4% [10].

Earthworms were identified based on morphological comparison with taxonomic papers. e.g. Thai Tran Bai, Gates, Blakemore, Sims and Easton, [10], [19-23]. Morphological characters used for comparison are setal arrangement (lumbricine or perichaetine), shape (annular or saddle) and location clitellum, location of male pores, calciferous glands, penial setae, nephridia type (holoic or meroic).

3 Results and discussions

3.1 Species composition of earthworms in Hoa Binh Province

Overall, the species composition of earthworms in Hoa Binh Province was reported to include 36 species in 10 genera and six families. The family Megascolecidae had the most species, with 27 in three genera. This was followed by the family Acanthodrilidae, which had four species from two genera. The family Ocnerodrilidae was recorded to have two species belonging to two genera. Three families were recorded with only one species each: Almididae, Moniligastridae, and Rhinodrilidae. Eight new morphological species were identified at the genus level, including seven from the family Megascolecidae and one from the family Moniligastridae. Many species have reached the genus level, potentially representing new undescribed species. This highlights the need

for further in-depth morphological and molecular studies.

In each family, only the family Megascolecidae was recorded, comprising three genera. Two families, Acanthodrilidae and Ocnerodrilidae, each possessed two genera. In contrast, the remaining specimens documented a single genus each. This finding suggests that the diversity in terms of the number of genera among earthworm families in Hoa Binh province is limited.

Within each genus, *Amyntas* exhibited the highest species richness, with 23 species documented. This was followed by *Metaphire*,

which had four species, *Dichogaster* with three species, and the remaining genera, each with a single species. This finding suggests that the genus *Amyntas* exhibits the highest species diversity, while other earthworm genera demonstrate lower species diversity.

The following species of earthworm are commonly found in the province of Hoa Binh: *Amyntas aspergillum*, *A. morrissi*, *A. robustus*, *A. californica*, *A. campanulata*, *Metaphire houlleti*, and *Pontoscolex corethrurus*. The collection of species data was conducted at all six research sites in Hoa Binh province, as illustrated in Table 1.

Table 1. Species of earthworm composition in Hoa Binh province

| No. | Species | Kim Boi | Yen Thuy | Tan Lac | Cao Phong | Mai Chau | Hoa Binh city |
|------------------------|--|---------|----------|---------|-----------|----------|---------------|
| Acanthodrilidae | | | | | | | |
| 1 | <i>Dichogaster affinis</i> (Michaelsen, 1890) | | | | | + | |
| 2 | <i>Dichogaster bolau</i> i (Michaelsen, 1891) | | + | | + | | |
| 3 | <i>Dichogaster modigliani</i> (Rosa, 1896) | | + | | + | | |
| 4 | <i>Ramiella bishambari</i> (Stephenson, 1914) | + | + | | | | + |
| Almidae | | | | | | | |
| 5 | <i>Glyphidrilus papillatus</i> (Rosa, 1890) | | + | + | | + | + |
| Megascolecidae | | | | | | | |
| 6 | <i>Amyntas adexilis</i> (Thai, 1984) | + | | | | | |
| 7 | <i>Amyntas arrobustus</i> (Thai, 1984) | | + | | | | |
| 8 | <i>Amyntas aspergillum</i> (Perier, 1872) | + | + | + | + | + | + |
| 9 | <i>Amyntas acalifornicus</i> (Do et Huynh, 1991) | + | | | | | |
| 10 | <i>Amyntas munglonganus</i> (Thai & Tran, 1986) | + | | + | + | + | |
| 11 | <i>Amyntas duplicoecus</i> (Thai, 1982) | | | | | + | |
| 12 | <i>Amyntas exiguus taybacanus</i> (Thai, 1984) | | | | | + | |
| 13 | <i>Amyntas falcipapillatus</i> (Thai, 1982) | + | | | | | |
| 14 | <i>Amyntas gracilis</i> (Kinberg, 1867) | + | | | + | + | + |
| 15 | <i>Amyntas leucocircus</i> (Chen, 1933) | + | | | + | | |
| 16 | <i>Amyntas morrissi</i> (Beddard, 1892) | + | + | + | + | + | + |
| 17 | <i>Amyntas pauxillulus</i> (Gates, 1936) | | | | | + | |

| No. | Species | Kim Boi | Yen Thuy | Tan Lac | Cao Phong | Mai Chau | Hoa Binh city |
|------------------------|---|------------|-------------|---------|--------------|-------------|------------------|
| 18 | <i>Amyntas robustus</i> (Perrier, 1872) | + | + | + | + | + | + |
| 19 | <i>Amyntas</i> sp.1 | + | | | + | | |
| 20 | <i>Amyntas</i> sp.2 | + | + | | | + | |
| 21 | <i>Amyntas</i> sp.3 | + | | | + | | |
| 22 | <i>Amyntas</i> sp.4 | + | | | | | |
| 23 | <i>Amyntas</i> sp.5 | + | | + | | | + |
| 24 | <i>Amyntas</i> sp.6 | + | | | | | |
| 25 | <i>Amyntas</i> sp.7 | + | | | + | + | |
| 26 | <i>Amyntas triastriatus</i> (Chen, 1946) | | + | | + | | |
| 27 | <i>Amyntas wui</i> (Chen, 1935) | + | + | + | + | + | + |
| 28 | <i>Metaphire californica</i> (Kinberg, 1867) | + | + | + | + | + | + |
| 29 | <i>Metaphire campanulata</i> (Perier, 1872) | + | + | + | + | + | + |
| 30 | <i>Metaphire houlleti</i> (Perier, 1872) | + | + | + | + | + | + |
| 31 | <i>Metaphire posthuma</i> (Vaillant, 1876) | + | + | + | | + | + |
| 32 | <i>Polypheretima elongata</i> (Perrier, 1872) | | + | | | | |
| Moniligastridae | | | | | | | |
| 33 | <i>Drawida</i> sp.1 | + | | | | | |
| Ocnerodrilidae | | | | | | | |
| 34 | <i>Gordiodrilus elegans</i> Beddard, 1892 | + | + | | | | |
| 35 | <i>Ocnerodrilus occidentalis</i> Eisen, 1878 | | + | | | | |
| Rhinodrilidae | | | | | | | |
| 36 | <i>Pontoscolex corethrurus</i> (Müller, 1856) | + | + | + | + | + | + |
| | | N 25 | 19 | 12 | 17 | 18 | 13 |

Table 2 presents a comparative analysis of the research findings concerning the species composition of earthworms in Hoa Binh province and select other provinces. The highest number of earthworm species was found in Bac Giang province, followed by Hoa Binh province. However, the number of earthworm families was the same in both provinces. With respect to the classification of genera, the provinces of Hoa Binh and Ba Ria - Vung Tau have been observed to demonstrate a higher prevalence, with a total of

ten genera identified within their boundaries. This observation stands in contrast to the remaining provinces, which exhibit a comparatively lower number of genera. These results suggest that the diversity of earthworms in the province of Hoa Binh is relatively high.

Table 2. Earthworm diversity in some Vietnam’s provinces

| Provinces | Families | Genera | Species |
|----------------------|----------|--------|---------|
| Hoa Binh | 6 | 10 | 36 |
| Bac Giang [24] | 6 | 9 | 48 |
| Binh Dinh [25] | 6 | 8 | 33 |
| Dong Nai [26] | 3 | 7 | 24 |
| An Giang [17] | 5 | 7 | 27 |
| Ba Ria Vung Tau [27] | 5 | 10 | 26 |

3.2 Species composition of earthworms in the research sites

The data concerning the species composition of earthworms in the districts of Kim Boi, Yen Thuy, Tan Lac, Cao Phong, Mai Chau, and the city of Hoa Binh are illustrated in Table 3. The most diverse species composition was observed in Kim Boi, with 25 species from five families and six genera. Yen Thuy had the second most diverse composition, with 19 species from five families and nine genera. The Cao Phong region is home to 17 species, classified into three families and four genera. The Mai Chau area boasts 18 species, distributed across four families and five genera.

The Hoa Binh city is home to 13 species, falling into four families and five genera. Tan Lac is characterized by its minimal composition, comprising 12 species from three families and four genera. The species recorded were only found at one, two, or three research sites; several species was found at all the research sites, e.g. *Amyntas aspergillum*, *Amyntas morrisi*, *Amyntas robustus*, *Amyntas wui*, *Metaphire californica*, *Metaphire campanulata*, *Metaphire houlleti* (Table 1). Consequently, Kim Boi displays the most diverse species composition and numerous species yet to be identified, indicating the possibility of future discoveries.

Table 3. Number of earthworm species in different districts of Hoa Binh province

| Index | Kim Boi | Yen Thuy | Tan Lac | Cao Phong | Mai Chau | Hoa Binh city |
|-------------------------|---------|----------|---------|-----------|----------|---------------|
| Total Number of Species | 25 | 19 | 12 | 17 | 18 | 13 |
| Number of species | 8 | 1 | 1 | 2 | 2 | 1 |
| Number of genera | 6 | 9 | 4 | 4 | 5 | 5 |
| Number of families | 5 | 5 | 3 | 3 | 4 | 4 |
| Shannon index H' | 3.22 | 2.95 | 2.49 | 2.83 | 2.89 | 2.57 |

The species diversity, expressed by the Shannon index H', shows that earthworms collected in Kim Boi city exhibit relatively high diversity with H' = 3.22. Other sites show moderate diversity levels with $3 > H' > 2$.

Research on species composition similarity across study sites revealed that Kim Boi district and Cao Phong district have higher similarity in earthworm species composition. This is the fact that both areas are close to each other and share

same topology and forest types. The remaining sites are relatively similar to each other, with Hoa Binh city and Tan Lac showing the greatest similarity (Figure 1).

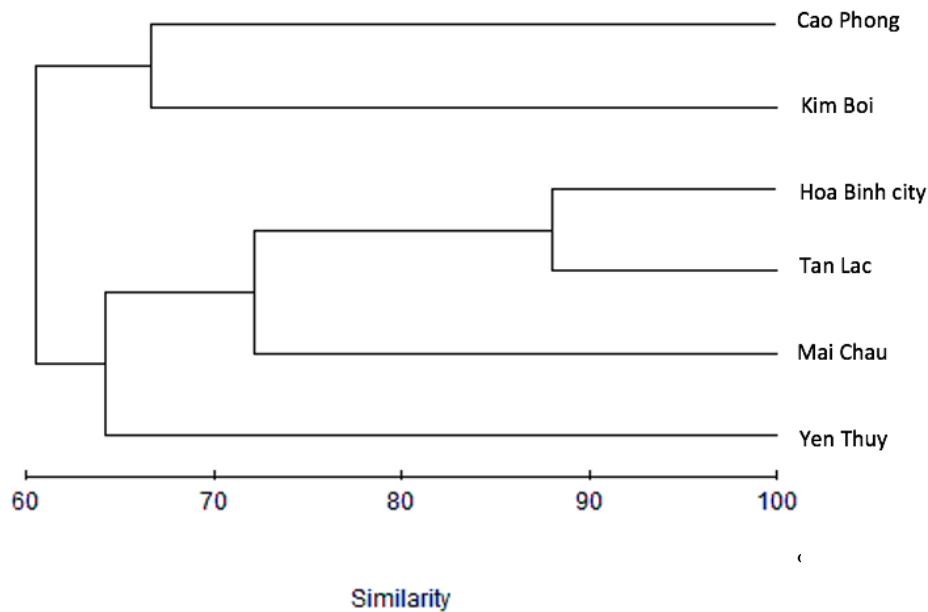


Figure 1. Similarity of earthworm species among studied sites

3.3 Earthworm distribution in Hoa Binh province

The study's findings in Hoa Binh province suggest that the family Megascolecidae exhibits the highest number of recorded species, with a total of 28 species (accounting for 75.68% of all species collected). This result is consistent with the findings of previous studies and the distribution patterns of earthworms. Vietnam is located in a primary distribution area of the two families Megascolecidae and Moniligastridae; hence, the recorded species from the family Megascolecidae are primarily found in mountainous regions (*A. gracilis*, *A. robusta*, *A. leucocirca*, *A. falcipapillata*) or hill regions (*A. wui*) in Northern Vietnam. It has been documented that other species are prevalent in the Red River Delta, with a high frequency of occurrence in anthropogenic habitats within mountainous regions (*A. morrisi*, *M. californica*). Among the other species, *Gordiodrilus elegans* is a diminutive species commonly found in anthropogenic habitats, while *Pontoscolex corethrurus* is a widely distributed species in Vietnam.

Distribution by soil depth

No earthworm species were specifically found living in the litter layer. All 9 species encountered in the litter were transferred from the surface soil. However, a few species, such as *A. leucocirca* and *A. falcipapillatus* were commonly found in decaying wood. Layers A1 and A2 are concentrations of earthworm species, with all 36 species collected in these layers. The study results also align with observations regarding the distribution depths of earthworms in the Northwest region [12] and the Northeast [13]. The layer A1 contains much organic matters, which are the food of earthworms. Therefore, it is no double that more species can be found in this layer.

Distribution by habitat

Among 4 different habitats, the Wood Forest had the largest number of species (29 species), compared to Bamboo Forests (22 species) and Home Gardens (13 species). The Cogon Grass hill had the least (4 species).

There are 9 species unique to Wood Forests: *Amyntas munglonganus*, *A. exiguus taybacanus*, *A. falcipapillatus*, *A. leucocircus*, *Amyntas* sp.2, *Amyntas* sp.5, *Dichogaster bolau*i, *D. modigliani*, and *Glyphidrilus papillatus*. There are two species unique to shrub forests: *Amyntas duplicoecus* and *Dichogaster affinis*.

The two species that have been identified as endemic to the Cogon Grass Hill area are *Amyntas* sp.1 and *Drawida* sp.1. The analysis revealed that no species were exclusively present in Home Gardens; rather, they were found in other habitats as well. The number of species encountered in three habitats was nine, while the

number of species found in two habitats amounted to 12. The Cogon Grass Hill exhibited the lowest number of species and forms (4), yet 75% of the species recorded were identified only to the genus level (3 forms). In fact, sampling in this area proved to be extremely challenging, with numerous sampling pits yielding no specimens. Consequently, without patience and a concerted effort to broaden and increase the number of sampling pits, the samples would have been inadequate. The results yielded a low number of species; however, the high rate of species forms indicates a need for thorough investigation with these species and habitats.

Table 4. Earthworm species composition in litter and soil layers across different habitats in Hoa Binh province

| Ref | Layers | (A0) | | (A1-A2) | | | |
|------------------------|-----------------------------------|------|----|---------|----|-----|----|
| | Species composition Habitats | WF | BF | WF | BF | CGH | HG |
| Acanthodrilidae | | | | | | | |
| 1 | <i>Dichogaster affinis</i> | | | | + | | |
| 2 | <i>Dichogaster bolau</i> i | | | + | | | |
| 3 | <i>Dichogaster modigliani</i> | | | + | | | |
| 4 | <i>Ramiella bishambari</i> | | | + | + | | |
| Almidae | | | | | | | |
| 5 | <i>Glyphidrilus papillatus</i> | | | + | | | |
| Megascolecidae | | | | | | | |
| 6 | <i>Amyntas adexilis</i> | + | | + | + | | |
| 7 | <i>Amyntas arrobustus</i> | | | + | + | | + |
| 8 | <i>Amyntas aspergillum</i> | | | + | + | | + |
| 9 | <i>Amyntas californicus</i> | + | + | + | + | | + |
| 10 | <i>Amyntas munglonganus</i> | | | + | | | |
| 11 | <i>Amyntas duplicoecus</i> | | | | + | | |
| 12 | <i>Amyntas exiguus taybacanus</i> | | | + | | | |
| 13 | <i>Amyntas falcipapillatus</i> | + | | + | | | |
| 14 | <i>Amyntas gracilis</i> | + | | | + | | |
| 15 | <i>Amyntas leucocircus</i> | + | | + | | | |
| 16 | <i>Amyntas morrisi</i> | | | + | + | | + |

| Ref | Layers | (A0) | | (A1-A2) | | | |
|-----|----------------------------------|----------|----------|-----------|-----------|----------|-----------|
| | Species composition Habitats | WF | BF | WF | BF | CGH | HG |
| 17 | <i>Amyntas pauxillulus</i> | | | + | + | | + |
| 18 | <i>Amyntas robustus</i> | + | | + | + | | + |
| 19 | <i>Amyntas</i> sp.1 | | | | | + | |
| 20 | <i>Amyntas</i> sp.2 | + | | + | | | |
| 21 | <i>Amyntas</i> sp.3 | | | + | + | | |
| 22 | <i>Amyntas</i> sp.4 | | | + | | | + |
| 23 | <i>Amyntas</i> sp.5 | | | + | | | |
| 24 | <i>Amyntas</i> sp.6 | | | + | | + | |
| 25 | <i>Amyntas</i> sp.7 | + | | | + | | |
| 26 | <i>Amyntas triastriatus</i> | | | + | + | | |
| 27 | <i>Amyntas wui</i> | | | | + | | + |
| 28 | <i>Metaphire californica</i> | + | + | + | + | | + |
| 29 | <i>Metaphire campanulata</i> | | | + | | | |
| 30 | <i>Metaphire houlleti</i> | | | + | + | | + |
| 31 | <i>Metaphire posthuma</i> | | | | + | | + |
| 32 | <i>Polypheretima elongata</i> | | | + | + | | |
| | Moniligastridae | | | | | | |
| 33 | <i>Drawida</i> sp.1 | | | | | + | |
| | Ocnerodrilidae | | | | | | |
| 34 | <i>Gordiodrilus elegans</i> | | | | + | | + |
| 35 | <i>Ocnerodrilus occidentalis</i> | | | + | + | | |
| | Rhinodrilidae | | | | | | |
| 36 | <i>Pontoscolex corethrurus</i> | | | + | + | + | + |
| | Number of species | 9 | 2 | 27 | 22 | 4 | 13 |

Wood Forests (WF); Bamboo Forests (BF); Cogon Grass Hill (CGH), and Home Gardens (HG)

4 Conclusion

A total of 36 species in 10 genera and 6 families were recorded in Hoa Binh Province. There were also 8 morphologically new species identified at the genus level, with 7 morphological species in the family Megascolecidae and 1 morphological

species in the family Moniligastridae. The recorded earthworm species were mainly distributed at depths of 0-20 cm and primarily in the habitats of timber forests and shrub forests.

With high diversity of topology, Hoa Binh province is believed to have more earthworm species (compared to 36 recorded species). It

suggests that more intensive surveys may reveal more species and better knowledge on earthworm's distribution and ecology in Hoa Binh Province.

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References

1. Edwards CA, Arancon NQ. Biology and ecology of earthworms. New York: Springer; 2022.
2. Edwards CA, Arancon NQ. The Role of Earthworms in Organic Matter and Nutrient Cycles. In: Edwards CA, Arancon NQ, editors. Biology and Ecology of Earthworms. New York: Springer US; 2022. p. 233-74.
3. Huang M, Zhao C, Zou Y. Increased grain amino acid content in rice with earthworm castings. Applied Sciences. 2019;9(6):1090.
4. Ding S, Lin X, He S. Earthworms: a source of protein. Journal of Food Science and Engineering. 2019;9:159-170.
5. Singh J. Role of earthworm in sustainable agriculture. Sustainable Food Systems from Agriculture to Industry. 2018:83-122.
6. Tung NT. Earthworm fauna of the Mekong Delta [dissertation]. [Hanoi]: Hanoi National University of Education; 2013.
7. Cooper L. Earthworms: harnessing one of nature's cancer killers. Oncology News International. 2010;19(7):1-3.
8. Adenaike EA, Esomonu IB. Assessment of gastrointestinal parasites and lung worms in pig in some local government areas of abia state. Dutse Journal of Pure and Applied Sciences. 2020;6(2):409-19.
9. Lap B, Tan ND. Some characteristics of the epidemiology of pig lungworm disease in the Central region and prevention measures. Journal of Agriculture and Food Technology. 1993;32(375):326-328.
10. Bai TT. Earthworms of Vietnam (Systematics, fauna, distribution and zoogeography) [dissertation]. [Lomonosov]: Lomonosov University, Russia; 1983.
11. Mui TT. Earthworm fauna of the Red River Delta [dissertation]. [Hanoi]: Hanoi National University of Education; 1985.
12. Nhuong DV. Earthworm fauna of Northwestern Vietnam. [dissertation]. [Hanoi]: Hanoi National University of Education; 1994.
13. Trien LV. Earthworm fauna of the Northeast of Vietnam [dissertation]. [Hanoi]: Hanoi National University of Education; 1995.
14. Thuan NV. Earthworm fauna of Binh Tri Thien [dissertation]. [Hanoi]: Hanoi National University of Education; 1994. (in Vietnamese)
15. Ha PTH. Earthworm fauna of Quang Nam - Da Nang [dissertation]. [Hanoi]: Hanoi National University of Education; 1995.
16. Hoi HTK. The fauna, position of earthworms in the mesofauna group and the problem of their use in the South Central of Vietnam [dissertation]. [Hanoi]: Hanoi National University of Education; 1996.
17. Tung NT, Phuoc NTK, Thuan HM. The diversity and distribution of eathworms in An Giang province. CTU Journal of Science. 2012;22a:143-153.
18. Gorny M, Grüm L, Amesterdam E, Warsaqw P. Methods in Zoology. 1993;156(5):368.
19. Blakemore RJ. Cosmopolitan Earthworms: An Eco-taxonomic Guide to the Peregrine Species of the World. Canberra, Australia: VermEcology; 2002.
20. Edwards CA, Bohlen PJ. Biology and ecology of earthworms. Third edition, Biology and ecology of earthworms. Third edition. London: Chapman & Hall; 1996.
21. Gates GE. Burmese earthworms: An introduction to the systematics and biology of megadrile oligochaetes with special reference to Southeast Asia. Transactions of the American philosophical Society. 1972;62(7):1-326.
22. Sims RW, Easton EG. A numerical revision of the earthworm genus *Pheretima* auct. (Megascolecidae: Oligochaeta) with the recognition of new genera and an appendix on the earthworms collected by the Royal Society North Borneo Expedition.

- Biological Journal of the Linnean Society. 1972;4:169-268.
23. Easton EG. A revision of the 'acaecate' earthworms of the *Pheretima* group (Megascolecidae: Oligochaeta): *Archipheretima*, *Metapheretima*, *Planapheretima*, *Pleionogaster* and *Polypheretima*. Bull. Br. Mus. Nat. Hist. (Zool.). 1979;35:1-126.
 24. Binh TTT, Ha NT. The species composition and density of earthworms in some landscapes in Northern Vietnam. Journal of Biology, 2014,36(3): 295-300.
 25. Thuan NV, Hai TN. The species composition and distribution characteristics of earthworms in the south of Binh Dinh province. Hue University Journal of Science. 2008;49:183-189.
 26. Nam NQ, Than NV, Trong DC, Nhan LV, Tung NT. Species diversity of earthworms in Dong Nai province, Vietnam. Journal of Biology. 2019;41(2se1&2se2):117-129.
 27. Tung NT, Nam NQ, Ai TT, Hau NP. Diversity and distribution of earthworms in Ba Ria - Vung Tau province. CTU Journal of Science. 2017;53:96-107.