

# On the Terrestrial Earthworm Fauna of Yamagata Prefecture, northeastern Japan

Yukio MINAMIYA<sup>1</sup> \*, Jun YOKOYAMA<sup>2</sup>, Tatsuya FUKUDA<sup>3</sup>

## Abstract

We conducted to collect earthworms in order to clarify the earthworm fauna of Yamagata Prefecture. We could collect 16 species belonging to two families including two undescribed species from six localities. To our knowledge, it is first time to record *Pheretima aokii*, *P. megascolidioides*, *P. micronaria* and *Aporrectodea caliginosa* from Yamagata Prefecture. Therefore, except for two species which could not identified as known species, 18 valid species of earthworms exist in Yamagata Prefecture including our result.

**Keywords :** earthworm fauna, Megascolecidae, Lumbricidae, Oligochaeta, Yamagata Prefecture

## Introduction

Earthworms are one of the most important soil animals because they play fundamental roles for organic decomposition through breakdown of litters as well as mixture of organic matters and mineral soils (Edwards, 2004). Moreover, earthworms are considered as ecosystem engineers because they change and create new habitats for other organisms through

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<sup>1</sup>: The United Graduate School of Agricultural Science, Ehime University, Monobe, Nankoku 783-8502, JAPAN

<sup>2</sup>: Faculty of Science, Yamagata University, Koshirakawa-machi 1-4-12, Yamagata 990-8560, JAPAN

<sup>3</sup>: Faculty of Agriculture, Kochi University, Monobe Nankoku 783-8502, JAPAN

\*: Author for correspondence :

Yukio MINAMIYA

The United Graduate School of Agricultural Science, Ehime University, Monobe, Nankoku 783-8502, JAPAN

Tel : 088-864-2124

e-mail : b0mf025@s.kochi-u.ac.jp

various activities (Lavelle et al., 1997); they change physical condition of the soil through making their burrow, improve soil structures, and increase water infiltration (Syers and Springett, 1983; Urbanek and Dolezal, 1992; Edwards and Shipitalo, 1998). Therefore they dramatically affect microorganisms fauna, such as soil arthropods and fungi. Casts of earthworm which were deposited inside and/or outside of the soil, stabilize carbon and nutrients (Edwards, 2004). Earthworms modify not only plant growth and vegetation structures but also the susceptibility of plants to herbivores (Scheu, 2003). Moreover, recent studies for exotic earthworms clearly revealed their impacts for whole ecosystems: they strongly exchanged physical and chemical soil characteristics, nutrient cycling and mineralization, microbial functioning, and the density and diversity of other soil invertebrates (Bohlen et al., 2004; Groffman et al., 2004; Migge-Kleian et al., 2006; Eisenhauer et al., 2007, 2009; Straube et al., 2009; Nuzzo et al., 2009; Corio et al., 2009; Costello and Lamberti, 2009). However, "earthworms" as a whole never contribute those great varieties of ecological functions and impacts for whole ecosystems. These effects of earthworms differ among species, making it important to identify species of earthworms (Bouché, 1977; Lavelle, 1983). Therefore, understanding the fauna of earthworms could provide valuable opportunities for studies of ecological functions of earthworms, earthworm communities, organic cycles of the ecosystem, and construction of terrestrial ecosystems.

Although more than 120 of earthworm species have been recognised in Japan (Ishizuka, 2001), there are some problems on the Japanese earthworm taxonomy; Ishizuka (2001) recognized 124 of *Pheretima* species in Japan, however Blakemore (2003, 2007) recognized only 53 species with many synonymies, claiming that Ishizuka (2001) is over-splitting the species. Moreover, some earthworm taxonomists suggested that there were many cryptic species remaining to be undescribed in Japan (Kobayashi, 1941; Ishizuka, 2001; Kamihira, 2004). In the present study, to avoid more confusions, we follow taxonomic definition of Ishizuka (2001) because he proposed splitted taxonomic treatments.

Although the studies of earthworm fauna in Japan have been mainly performed in northeastern parts of the country, Kamihira (2004) suggested that 27 of probably undescribed species were found in the northeastern Japan. Therefore understanding of diversity of earthworm species in the area have not been completed yet. Recently, studies of earthworm fauna in the Tohoku District are rapidly increasing (Kamihira, 2001, 2002a, b, 2003a-c, 2004; Uchida and Ihara, 2003; Minamiya et al., 2007, 2009). In Yamagata Prefecture, 14 valid species belonging to two families of earthworms had

been recorded (Ohfuchi, 1937, 1938, 1939; Kamihira, 2003a). Although Kamihira (2003a) revealed earthworm fauna based on specimens collected from 34 localities in the Yamagata Prefecture, two previously recorded species could not be collected. Therefore, additional research is needed to clarify the earthworm fauna in Yamagata Prefecture. To complement the result of Kamihira (2003a), we report earthworm fauna based on specimens collected from several localities in Yamagata Prefecture.

### Materials and Methods

In 2008 and 2009, we conducted earthworm surveys on the six localities in Yamagata Prefecture (Fig. 1). We collected earthworms from both in the litter layer and the subsoil in the forest and adjacent roadside ditches, using rakes, trowels and shovels. Earthworms collected were anesthetized in a 30% ethanol solution, then fixed in a 99% ethanol. The external and internal morphologies of the earthworm were observed with stereoscopic microscopes (Nikon SMZ-10 and Wild M3Z). Each individual was identified to species. The species names of Megascolecidae and Lumbricidae were followed by Ishizuka (2001) and Nakamura (1972), respectively.

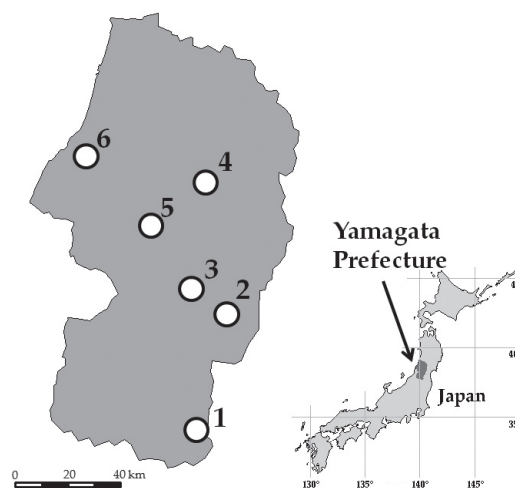


Fig. 1. Localities for earthworm sampling in Yamagata Prefecture. Numbers corresponding to those in the Table 1.

### Results and Discussion

A total of 93 specimens were collected from six localities (Fig. 1). They consisted of 14 species of Megascolecidae and two species of Lumbricidae

(Table 1). In the Megascolecidae, two species did not match diagnosis of known species by observation using both external and internal characteristics, therefore they may be undescribed species. One of them, *Pheretima* sp. 1 has two pairs of spermathecal pores in segmental furrows (6/7/8), one pair of genital markings on male pore discs, and manicate intestinal caeca. Therefore this species resembles to *P. servina* Hatai & Ohfuchi, 1937, but is distinguishable from the latter in position of male pores; male pores of *P. servina* situated close to the lateral border of 18th segment, however those of *P.* sp. 1 situated setal line of 18th segment, therefore we could not identified as known species. Moreover, *P.* sp. 2 has two pairs of spermathecal pores in segmental furrows (6/7/8), no genital markings, and manicate intestinal caeca. Unfortunately, our specimen has degraded male pores, therefore we could not identified as known species. Precise identification requires examination of more specimens of both *P.* sp. 1 and *P.* sp. 2.

At the beginning of the earthworm faunal study in Yamagata Prefecture, Ohfuchi (1937, 1938, 1939) reported that three species of *Pheretima*, *P. carnosus*, *P. heteropoda* and *P. irregularis* existed in the Prefecture. Recently, Kamihira (2003a) conducted comprehensive survey of earthworm fauna and collected 17 species belonging to three families including five species of probably undescribed species from Yamagata Prefecture, though he could not obtain *P. carnosus* and *P. heteropoda* (Table 1). In that time, totally 14 valid species without undescribed species were recorded from the Prefecture. In the present study, we recorded four additional species; *P. aokii*, *P. megascolidioides*, *P. micronaria* and *Aporrectodea caliginosa*. Therefore, from the current reckoning, there are a total of 18 earthworm species without undescribed species in Yamagata Prefecture.

*Aporrectodea caliginosa* has been reported at 10 out of 245 localities in Tohoku District (Kamihira, 2004). Some earthworm taxonomists suggested that this species is one of the cosmopolitan earthworms originated from Europe (Michaelsen, 1900) or Palaearctic (Easton, 1981), and introduced with human activities either intentional or unconscious to Japan. If exotic origin of *A. caliginosa* is true, low occurrence in the Tohoku District is not unusual situation.

*Pheretima aokii* was described in 1999 from Tokyo (Ishizuka, 1999b). Previously, only one record was reported from Tohoku District, from Sendai City, Miyagi Prefecture (Minamiya et al., 2009). This record is the most northern record of *P. aokii*. In this study, we found one individual of *P. aokii* from Kaminoyama City, Yamagata Prefecture and this is the second

authorized record of this species from Tohoku District. However, one of the author (Y.M.) found this species from several localities of Aomori Prefecture (unpublished data), therefore more intensive survey is needed to clarify distribution of this species.

Conversely, *Pheretima micronaria* has been reported widely in the Tohoku District (Kamihira, 2004). This species is characterized by four pairs of spermathecal pores in segmental furrows between 5th, 6th, 7th, 8th and 9th, spermathecae without diverticulum, two paired sucker type genital markings situated on just inside of the lines of male pores, each pair close to the intersegmental lines and simple intestinal caeca (Goto and Hatai, 1898; Ishizuka, 2001). Although Kamihira (2003a) did not report *P. micronaria* from Yamagata Prefecture, we found 16 individuals belonging to this earthworm from three localities, indicating that this species is not rare species in the Prefecture.

*Pheretima megascolidioides* is a characteristic species among species belonging to genus *Pheretima* and possesses male pores on the 19th segment, whether other species possesses those on the 18th segment. This species is found from various localities of Japan, including Honshu, Shikoku and Kyushu (Kobayashi, 1941), as well as in southern Korea (Song and Paik, 1971). This earthworm has been found only three localities in the Tohoku District; two were in Miyagi Prefecture (Hatai, 1924; Kamihira, 2003b; Minamiya et al., 2007) and the other in Fukushima Prefecture (Kamihira, 2003c). Therefore, the northern limit of the distributional range of the species has been considered as Miyagi Prefecture. However, this is the first record of *P. megascolidioides* collected from sea of Japan side of Tohoku district.

This species inhabits the deep soil layer (Ishizuka, 1999a, 2001) and it is difficult to obtain this earthworm due to needs digging soil with shovel. Therefore, more intensive survey focus on the earthworms inhabiting deep soil layer is needed.

In summary, we could collect 16 earthworm species belonging to two families including two undescribed species from Yamagata Prefecture. To our knowledge, it is first time to record *P. aokii*, *P. megascolidioides*, *P. micronaria* and *A. caliginosa* in Yamagata Prefecture. Therefore, except for two species which could not identified as known species, totally 18 valid earthworm species were recorded from Yamagata Prefecture. Nevertheless, we also could not obtain *P. heteropoda* which previously reported from Yamagata Prefecture. More comprehensive survey for earthworm fauna of Yamagata Prefecture is needed.

Table 1. Earthworm collected from each locality in Yamagata Prefecture

Species	1. Yonezawa City Karyasu	2. Kamioyama City Kabutoishi	3. Yamagata City Kashiwagura	4. Funagata Town	5. Nishikawa Town Yumiharidaira	6. Tsuruoka City Fujisawa	Previously published data*
Megascoleciidae							
<i>Pheretima acincta</i> (Goto and Hatai, 1899)			○		○		4
<i>P. agrestis</i> (Goto and Hatai, 1899)	○		○		○		4
<i>P. aokii</i> Ishizuka, 1999		○					
<i>P. carmosa</i> (Goto and Hatai, 1899)					○		1
<i>P. communissima</i> (Goto and Hatai, 1899)					○		4
<i>P. divergens</i> (Michaelsen, 1892)	○		○		○		4
<i>P. heteropoda</i> (Goto and Hatai, 1898)					○		1
<i>P. hilgendorfi</i> (Michaelsen, 1892)			○		○		4
<i>P. irregularis</i> (Goto and Hatai, 1899)	○	○		○	○		2, 3, 4
<i>P. marenzelleri</i> Cognetti, 1906	○		○		○		4
<i>P. megascolidioides</i> (Goto and Hatai, 1899)	○				○		
<i>P. micronaria</i> (Goto and Hatai, 1898)	○	○	○		○	○	4
<i>P. tappensis</i> Ohfuchi, 1937							
<i>P. vittata</i> (Goto and Hatai, 1898)			○		○		4
<i>P. yunoshimensis</i> Hatai, 1930					○		4
<i>P. sp. 1</i>	○	○					
<i>P. sp. 2</i>	○						
Lumbricidae							
<i>Allolobophora japonica</i> (Michaelsen, 1891)						○	4
<i>Eisenia foetida</i> (Savigny, 1826)							
<i>Aporrectodea caliginosa</i> (Savigny, 1826)	○						4

\* : Previously published data: 1, Ohfuchi (1937); 2, Ohfuchi (1938); 3, Ohfuchi (1939); 4, Kamihira (2003a).

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