Earthworm Diversity and Distribution in Kathmandu, Bagmati Province, Central Nepal

Ankit Kumar Singh*

*Department of Zoology, Mahendra Multiple Campus Nepalgunj, Tribhuvan University, Banke, Nepal

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*Corresponding author
Ankit Kumar Singh,
Department of Zoology, Mahendra Multiple Campus Nepalgunj, Tribhuvan University, Banke, Nepal.
Email: akssinghankit1@gmail.com

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Abstract

Earthworms are of ecological and economic significance and are directly related with human health through biogeochemical cycle. Such a valuable faunal group needs immediate intensified taxonomic treatment in Nepal for their sustainable use, efficient commercial production and biodiversity conservation. Systematic random sampling was used for site selection and hand sorting method was used for sample collection from the field. Collected specimen were photographed in field and preserved in ethanol for lab study with tagging. In total, study reported eight species belonging to two families Lumbricidae and Megascolecidae. External morphological features helped on identification and taxonomic key preparation. Among two sites 6 species were common and abundantly recorded from almost habitats whereas, 1/1 species were different in each site with uncommon reporting from harsh environment. Cultivated crop land with litter and compost was known to be more diverse in species richness than other habitats. Detail taxonomic study and distribution mapping is an essential for Earthworms in Nepal to complete the global database and national soil engineer documentation for organic and healthy environment.

Keywords: Distribution, diversity, earthworm, morphology, Nepal

Introduction

Growing population and excessively high waste production has put pressure on researcher to find more significant and immediate decomposer for fast and effective management of waste mostly in city areas (Pant and Yami, 2008; Mazumdar, 2012; Dhimal, 2013). Furthermore, food quality and human health has come to the forefront rising organic farming and rooftop gardening concept, intensifying the further search of suitable decomposers (Brussaard, 2007; Adhikari, 2017; Blakemore, 2018). Earthworms are major decomposer with multiple significance on improving soil properties, repairing and running biogeochemical cycles (Darwin, 1881; Barrios, 2007). It acts as the bridge linking from waste to the best. Role and importance of earthworms has been explained since 1881 by Darwin exploring their activities (Brown, 2000; Mishra and Samal, 2021). Away from its exploration for role and importance, taxonomic consideration and distribution mapping is an immense need prior to any other examinations for their conservation (Phillips, 2019; Phillips, 2021). Expedition for the earthworm collection, identification and its classification has rarely been considered in Nepal, whereas, detail taxonomic and molecular databases are even available in

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the case of European, many Asian countries and global scale (Orgiazzi, 2016; Phillips, 2019; Mishra and Samal, 2021; Marchan, 2022). Knowing exact earthworm species diversity in the community, provides better alternatives according to need and accessibility of organism in particular area for particular waste types (Mishra and Samal, 2021).

Earthworms, also known as creepy crawlies, Gadyaula (Nepali), Danbi (Newari) are most abundant worms residing on soil and feed upon dead and decaying organic matter are organic decomposers. They are also known as ‘friend of farmers’ and ‘soil engineers’, providing healthy habitat for the growth of plants and other soil organisms (Barrios, 2007; Shipitalo and Korucu, 2017; Bora, 2021). Its movement in search of food and moisture, waste feeding habit, digestive alimentary canal, casting mechanism and cleaning property are of ecological significance that keep balance on soil environment and make it suitable for further ecological interactions (Darwin, 1881; Barrios, 2007; Jaikishun, 2015). Earthworm belongs to Phylum Annelida for having truly segmented body with internal body cavity called coelom (Orgiazzi, 2016). Further it comprises species from class Clitellata and subclass Oligochaeta having nearly 11000 species under 800 genera and 38 families with about 7000 species of earthworms under 20 families (Orgiazzi, 2016; Mishra and Samal, 2021). Based on the habitat preference, earthworms were classified into three ecological groups as; Epigeic (litter inhabitants), Anecic (vertical soil inhabitants) and Endogeic (soil inhabitants) (Bouche, 1972; Jimenez and Decaens, 2000; Neilson, 2000; Orgiazzi, 2016; Shipitalo and Korucu, 2017). Their body size varies from few centimeters to meters long and are cosmopolitan in distribution except in cold dry deserts (Orgiazzi, 2016; Shipitalo and Korucu, 2017; Mishra and Samal, 2021).

Various study related to earthworm, vermicomposting, comparative ability of different earthworm species on organic waste conversion, suitability, efficiency and commercial production to market analyzing has been carried out in Kathmandu and other agricultural area (Pant and Yami, 2008; Devkota, 2014; Tripathi, 2016; Dhimal, 2013). However, diversity and distribution of earthworm species in Nepal or its any particular region has not been updated later than Michaelsen (1909) and Gates (1972) as associated area of India and Burmese fauna. He had collected and described 31 species from Himalayan region, with proper location of Nepal for 4 species from present Airport, Chitlang and Pharping areas and all of them were endemic. Later on, Pandey (2012) has worked on 12 earthworm species for understanding toxic metal accumulation and transfer through earthworm species to predators and other. Earthworms’ diversity has declined with intensified agriculture using chemical inputs, that slightly improved with organic manuring (Blakemore, 2018). Such a significant group of species lack intense taxonomic study on their diversity and distribution in Nepal (https://www.ksabmagar.com.np/2019/08/earthworms-of-nepal-brief-information.html). Marchan, (2022) has also emphasized on need of taxonomic proper delimitation of each taxon under the earthworm group along with number of unsolved contradictions among and in between the taxa (Ansari and Saywack, 2011). Thus, present study aimed to identify the local earthworm species along the northern and southern parts of Kathmandu district based on morphological features and figure out their distribution in different habitat.

**Materials and Methods**

Study was carried out in Machhegaun area of Chandragiri municipality ward-9 and ward-7 and ward-7 of Tokha municipality with area of 4.66, 4.41 and 0.65 sq. km respectively (CBS, 2018). Former lies in 27° 40' 15" N and 85° 15' 10" E, southern part of Kathmandu and later in 27° 45' 0" N, 85° 20' 0" E, at North. Altitude lies around 1300 to 2500 m above sea level. The vegetation type was nearly similar at both sites with forest dominated by subtropical and temperate species such as Pine (Salla), Schima wallichi (Chilaune), Myrica esculenta (Kaphal), Castanopsis indica (Katus), Zizyphus mauritiana (Bayar), and Prunus cerasoides (Painyu). Soil type sandy loam, Clay loam and silty loam with pH range between 5.5 to 6.5. Temperature ranges from 3°C in winter (Dec-Feb) to 31°C in summer (April to August) with rainfall starting from March to October with maximum rainfall in the month of July and August and average annual rainfall 1433.75 mm (CBS, 2020).

**Sampling and Collection**

Systematic Random sampling was used to decide the area for earthworm collection. All the possible habitats were listed and located in study area during preliminary visit, then randomly sample were collected in the field using hand sorting method digging 20cm×20cm×20cm hole (Edwards and Lofty, 1997). Collected specimen were examined immediately in the field for its body color and color of clitellum before preserved in 80% ethanol for further study in laboratory (Ansari and Saywack, 2011; Brown, 2017). Photographs of specimens were taken in field fixing as possible clear back ground as well as in its natural habitat using Samsung M-31 micro-camera (Photoplate 1). For each study site, collections were made separately to document species distribution in different habitat with proper tagging. Further in lab, morphological features were noted and excluded the study of internal morphology and anatomy due to lab constrains. Based on morphological features, specimens were identified using different online databases and literatures (Gates, 1972; Joshi and Dabral, 2008; Csuzdi, 2018; Chang, 2016; Brown, 2017; Podolak, 2020). Obtained information were arranged in table using Microsoft excel, 2010 and morphology based taxonomic key was presented in hierarchical chart using Microsoft word, 2010.

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**Fig. 1:** Map of study area showing municipalities.

**Photoplate 1**

- *Perichaeta morrisi*
- *Lumbricus terrestris*
- *Eisenia fetida*
- *Perionyx excavatus*
- *Copulation*
Result and Discussion

Altogether Eight species of Earthworm were recorded belonging to two families; Lumbricidae including four genera Aporrectodea, Dendrobaena, Eisenia and Lumbricus and family Megascoleidiae including two genera Perichaeta and Perionyx (Table 1). Species richness found to be low however, global database including more than 9000 surveys also had mentioned about zero to only 12 species in each survey (Phillips, 2021). It makes some relief that the study area is not in worst for earthworm diversity, which might due to its temperate location known to more diverse for earthworm than tropics and its climatic condition being more suitable for their existence (Bora, 2021; Phillips, 2021). Species richness and their density depends on soil temperature, soil pH, annual rainfall and litter (Potvin and Lilleskov, 2017; Phillips, 2021). Species identification was troublesome due to their synonymous names (Table 1) and its morphological and anatomical complexities; which implies the immediate need of extensive taxonomic treatment on earthworm species, before they disappear and misidentified for the use on commercial purpose (Jaikishun, 2015). Additionally, in another side, some invasive species of earthworm has created a great issue in European countries, which makes alert for the buying of earthworm as bait from foreign countries and checking of vermicompost if they were heat treated or not before use (Chang, 2016). Such study on invasive earthworm around the Nepal has not been reported during literature review for this study.

All the morphological characteristics were of taxonomic significance and were noted for each species including their habitat preference from each site (Table 2). Morphological characters as mentioned in the study such as body length, color, clitellum length and color were of significant use for species identification and further studies since they are user friendly and useful for field study (Ansari and Saywack, 2011). Taxonomic key based on external morphology was prepared for the reported species (Fig. 2). Taxonomic features included here might be significant for use in identification (Jaikishun, 2015).

Occurrence of different earthworm species in different habitat shows their feeding preference and distribution in Kathmandu (Table 3). Seven species reported from each side among which 6 were common to both sites and one in each were different and unreported from other site. Gates (1972) and Julka (1993) had also mentioned about distribution of these species in Nepal in their work on Burmese and Indian earthworms respectively. Half of the species have been previously included by Pandey (2012) as frequently occurring species of earthworm in Nepal. Four European and four Asian species recorded with saddle and annular clitellum respectively (Chang, 2016). Unreported species from one another place implies their habitat preference or nutrient specificity or effect of environmental determinants (Kumar, 2021). Some epigetic species reported from crop field might be due to recent use of manure for new crop or might be ploughing of lawn with former crop residues underside and similar types of species were reported from cultivated and non-cultivated abandoned land by Singh (2020). Animal dung was dominated by Eisenia species and its large population actively working on cow dung. Similar study has shown abundant distribution of these species from all types of selected collection habitats (Singh, 2016). Species- habitat preference was also claimed by Tripathi and Bhardwaj (2004). Very few species reported from the rocky and gravel filled lawns which might be due to dryness, less litter, and rough surrounding. However, presence of unique earthworms even in such a harsh condition claims their wide range of adaptive feature (Brun and Danieli, 2020). Diverse species were obtained from crop field and kitchen garbage composting which might be due to regular moist condition along the habitat by irrigation or kitchen waste water deposition making the environment suitable for earthworms. It might also be due to native species being more frequent (Fragoso., 1999). Eisenia species were abundantly reported from most of the habitat such as litter deposited crop fields, animal dung, and abandoned land, which shows their wide range of distribution which might be due to their voracious feeding habit and efficient vermicomposting nature with other species and can be recommended for easy culture in temperate region such as Kathmandu (Devkota, 2014; Tripathi, 2016). Eisenia fetida was known to be used regularly for the organic waste treatment in city area of Nepal (Dhimal, 2013).

In general talk with local farmers, animal dung was known to be in regular use for different crops as fertilizer with later added chemical fertilizers in the area (Pant and Yami, 2008). Concept of organic farming has been introduced but not regulated properly and continuously due to easy availability of chemical fertilizer in comparison to organic manure for large scale application. Pest and diseases were another reason claimed by farmers as reason behind the use of synthetic products. Crop land using organic manure and synthetic fertilizer may have different status of earthworm diversity, activity and density, which can be the objective for further study in this field.
Fig. 2: Key to species based on external morphology
[Note: Black text presents characteristics and red text indicates Species]
Table 1: Earthworm species and their synonyms with family

| Family         | Name of Species       | Synonyms*                                                                 |
|----------------|-----------------------|---------------------------------------------------------------------------|
| Lumbricidae    | Aporrectodea caliginosa | Alolobophora caliginosa Savigny, (1826); Enterion caliginosum Savigny, (1826); Nicodrilus caliginosus Savigny, (1826); Lumbricus communis subsp. pellucidus Eisen, (1871); Alolobopora inflata Michaelsen, (1899); Nicodrilus caliginosus var. paratypicus Bouche, (1972); Aporrectodea caliginosus subsp. alternisetosus Bouche (1972). |
| Lumbricidae    | Dendrobaena veneta    | Alolobophora veneta Pink, (1886); Eisenia veneta Pink, (1886); Eisenia zebra Michaelsen, (1903) |
| Lumbricidae    | Eisenia fetida        | Alolobophora foetida Savigny, (1826); Eisenia fasciata Backlund, (1948); Eisenia foetida Savigny, (1826); Enterion fetidum Savigny, (1826); Lumbricus annularis Templeton, (1836) |
| Lumbricidae    | Lumbricus castaneus   | Enterion castaneum Savigny, (1826); Lumbricus josephinae Kinberg, (1866) |
| Lumbricidae    | Lumbricus festivus    | Enterion festivum Savigny, (1826) |
| Lumbricidae    | Lumbricus terrestris  | Aporrectodea terrestris Savigny, (1826); Enterion terrestris Savigny, (1826); Lumbricus agricola Hoffmeister, (1843) |
| Megascolecidae | Perichaeta morrisi    | Amynthas mauritiana Beddard, (1892); Amynthas morrisi Beddard, (1892) |
| Megascolecidae | Perionyx excavatus     | -                                                                         |

*Synonyms were retrieved from gbif.org online database, Orgiazzi, 2016; and Shipitalo and Korucu, 2017.

Table 2: Morphological variation among Earthworm species including habitat preference

| Species Name          | Ecological group | Body Color          | BL (mm) | B W | Segment Epitome Color | Head Shape Color | CS (mm) | CL (mm) | CW (mm) | SS | TP | TP shape |
|-----------------------|------------------|---------------------|---------|-----|-----------------------|-----------------|---------|---------|---------|----|----|----------|
| Aporrectodea caliginosa Savigny | Endogeic         | Pink/green          | 60-100  | 2   | 70-100 Epilobic Pale Pink | Saddle          | 23      | 5-7     | 3       | Close | 29-30 Swelling |
| Dendrobaena veneta Rosa | Compost          | Pinkish-reddish brown | 100-200 | 5   | 100-130 Epilobic Dark Pink | Saddle          | 27      | 6-8     | 4       | Wide | 29-31 Swelling |
| Eisenia fetida Savigny | Compost          | Red with yellow band | 60-80   | 4   | 80-100 Epilobic Pale Yellow | Annular         | 22      | 6-11    | 2       | Close | 27-31 Thin band |
| Lumbricus castaneus Savigny | Epigec           | Dark brown          | 80-130  | 4   | 100-120 Tanylobic Dark Red | Saddle          | 27      | 4-6     | 3       | Close | 28-31 Dark band |
| Lumbricus festivus Savigny | Epigec           | Pale red            | 70-90   | 3   | 70-90 Tanylobic Pale Yellow | Annular         | 30      | 6-7     | 3       | Close | 32-35 Banded |
| Lumbricus terrestris Linn. | Epigec           | Pale blue           | 70-130  | 4   | 90-120 Epilobic Orange | Saddle          | 26      | 6-8     | 3       | Wide | 29-30 Swelling |
| Perichaeta morrisi Bedd. | Endogeic         | Brown               | 80-100  | 3   | 80-90 Epilobic Brownish Grey | Annular         | 23      | 5-6     | 3       | Close | 24-25 Thin band |
| Perionyx excavatus Perr. | Compost          | Red with yellow thin band | 70-100  | 3   | 80-100 Epilobic Orange | Annular         | 23      | 4-5     | 2       | Close | 27-29 Thin band |

(Note: BL- Body Length; BW- Body Width; CS- Clitellum Shape; CL- Clitellum Length; CW- Clitellum Width; SS- Setae Spacing; TP- Tubercula Pubertatis)
Table 3: Distribution of different earthworm species along the various habitat in both the Municipalities

| Name of species          | Chandragiri Municipality |           |           |           |           | Tokha Municipality |           |           |           |           |           |
|--------------------------|--------------------------|-----------|-----------|-----------|-----------|-------------------|-----------|-----------|-----------|-----------|-----------|
|                          | Animal dung | Kitchen garbage | Crop field | Abandoned land | Gravel and sandy lawn | Animal dung | Kitchen garbage | Crop field | Abandoned land | Gravel and sandy lawn |
| Aporrectodea caliginosa   | -           | -           | +          | +          | -          | -                 | -           | -           | +          | +          | +          |
| Dendrobaena veneta       | +           | +           | -          | -          | -          | +                 | +           | +           | +          | -          | -          |
| Eisenia fetida           | +           | +           | +          | +          | -          | +                 | +           | +           | +          | -          | -          |
| Lumbricus castaneus      | -           | +           | +          | -          | -          | Unreported         | -           | -           | -          | -          | -          |
| Lumbricus festivus       | -           | -           | +          | +          | +          | -                 | -           | -           | +          | -          | +          |
| Lumbricus terrestris     | -           | +           | +          | +          | -          | -                 | +           | +           | -          | -          | -          |
| Perichaeta morrisi       | -           | -           | -          | -          | +          | -                 | -           | -           | +          | +          | +          |
| Perionyx excavatus       | Unreported   |              |            |            |            | +                 | +           | +           | -          | -          | -          |

(Note: “+” indicates presence of species; “-” indicates absence of species)
Conclusion
Study revealed good number of earthworm species from small area and initiation of morphology based taxonomic key will be further helpful in species identification during similar work. Abundant distribution of most species along all types of habitats and unique distribution of some species in particular harsh environment showed diverse distribution and adaptive capability of earthworms.

Conflict of Interest
The authors declare that there is no conflict of interest with present publication.

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