Biodiversity of Earthworms in Trans-Gangetic Plains of District Yamuna Nagar, Haryana

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Abstract

Based on a survey in different habitats of Yamuna Nagar from 2011-2013, earthworm diversity was assessed in six land use systems: dry deciduous Shorea robusta forest, highly degraded Acacia catechu forest, agroforestry system (Populus deltoides plantation), wheat-paddy rotation crop field, a herbal garden created after removal of A. catechu forest stand and a home garden. A total of 14 species belonging to four different families- Megascolecidae, Octochaetidae, Lumbricidae and Ocnerodrilidae were recorded. Among the 14 species, five species: Ocnerodrilus occidentalis Eisen, Lennogaster pusillus (Stephenson), Ramiella bishambari (Stephenson), Metaphire houlleti (Perrier) and Metaphire birmanica (Rosa) were reported for the first time from the State of Haryana.

Keywords*: Diversity, earthworms, Yamuna Nagar, Haryana.*

Introduction

The growth of agriculture, particularly in the Trans-Gangetic Plains (TGP) region of Indogangetic plains (IGP), has been tremendous. Known as the heartland of India's Green Revolution of 1960s, the TGP has emerged as the food bowl of the country primarily due to adoption of rice-wheat cropping system supported by high technology tillage and high inputs of chemical fertilizers and pesticides. The TGP faces the problems of soil health due to excessive inputs of chemical fertilizers and pesticides for sustaining agriculture productivity (Koshal, 2014). The remnant forests are highly degraded due to anthropogenic pressures and invasion of exotic species (Sivakumar *et. al.*, 2010). Management of earthworm populations is becoming more important for sustaining soil productivity and fertility in agro-ecosystems (Whalen *et. al.*, 1998).

Earthworms are powerful regulators of soil processes, participating in the maintenance of soil structure and the regulation of soil organic matter dynamics, and are considered as a natural resource of agronomic interest that may be used to increase sustainability of most production systems (Lavelle *et. al.*, 1997).

The response of different functional categories of earthworms to land use changes and modifications is of particular interest. Earthworms are generally grouped into three broad functional or ecological categories based on their feeding and burrowing behavior, and reproductive strategies (Bouche, 1971; Hendrix and Bohlen, 2002). (i) Epigeic earthworm species inhabit and feed on surface litter, (ii) Anecic species produce deep vertical burrows in mineral soil but browse on soil surface and are important in the burial of surface litter; (iii) endogeic species burrow horizontally and feed mainly in the rhizosphere and subsoil.

Materials and Methods

In each land use type, earthworms were sampled following the standard technique as described by Anderson and Ingram (1993). An area of 25 m × 25 m was marked in each field and 9 soil monoliths of 25cm×25cm×30cm were collected. The soil stratum was carefully hand sorted in a large tray as described by (Julka 1988). Sampling was done at two month's interval. All the earthworms were preserved in 5% formalin solution, transported, identified, counted and weighed in the laboratory.

Statistical Methods

i. Species diversity Index (H')

Index of species diversity was estimated by Shannon Wiener Index because of its wide applicability. The following formula was utilized (Shannon and Wiener, 1963).

$$H' = - \sum_{i=1}^{S} \left(\frac{ni}{N}\right) \log e \left(\frac{ni}{N}\right)$$

[Where, H' = Diversity index of species,

ni = Total number of individuals of 'i' species in the sample,

N = Total number of individuals of all the species in the sample,

S = Total number of species]

ii. Index of dominance (c)

Index of dominance was calculated as per Simpson (1949) using the formula

$$c = \sum_i^S \left(\frac{ni}{N}\right)^2$$

[Where, c = Index of Dominance,
ni = Number of individuals of 'i' species,
N = Total number of individuals of all species in the sample, S = Total number of species]

iii. Index of species richness (d)

Variety of species or index of species richness has been estimated by adopting the formula given by Margalef (1968) as follows

$$d = \frac{S-1}{\ln N}$$

iv. Index of evenness (e)

Index of evenness has been quantified by following the formula developed by Pielou (1966) as follows

$$e = \frac{H'}{\ln S}$$

[Where, e = Index of evenness,
H' = Shannon Wiener Index,
S = Total number of species]

Results

A total of fourteen species were collected from all land use types under study. Of these, three species belonged to each of genera *Eutyphoeus* and *Metaphire*, and one species was assigned to each of *Amynthas*, *Lampito*, *Lennogaster*, *Octochaetona*, *Ramiella*, *Dichogaster*, *Bimastos* and *Ocnerodrilus*. Distribution of earthworm species found in sampled land use types is given in Table 1.

Both *Metaphire posthuma* (Vaillant) and *Eutyphoeus waltoni* Michaelsen were recorded in maximum number of land use types (4 each). *M. posthuma* was found in *Acacia catechu* Forest, cultivation, herbal garden and home garden; whereas *E. waltoni* occurred in Forests of *Shorea robusta* and *A. catechu*, poplar plantation and herbal garden.

Ocnerodrilus occidentalis Eisen was found in three land use types, namely poplar plantation, cultivation and home garden. Species found in two land use types included: *Metaphire houlleti* (Perrier) in cultivation and polar plantation, *Amynthas alexandri* (Beddard) and *Eutyphoeus nicholsoni* (Beddard) in *S. robusta* Forest and poplar plantation; *Lennogaster pusillus* (Stephenson) in *S. robusta* Forest and home garden; *Octochaetona beatrix* (Beddard) in cultivation and home garden; *Ramiella bishambari* (Stephenson) in polar plantation and home garden.

Six species of earthworms were recorded in only one land use type, i.e., *Metaphire birmanica* (Rosa) in *S. robusta* Forest, *Lampito mauritii* Kinberg in cultivation, *Eutyphoeus incommodus* (Beddard) in *Populus deltoides* plantation, and *Dichogaster bolaui* (Michaelsen) and *Bimastos parvus* (Eisen) in home garden.

Table 1: Occurrence of earthworm species in different land use types in District Yamuna Nagar, Haryana during 2011-2013 [Symbols: (+) present; (-) absent].

Species/Sites	Forest *Shorea robusta*	Forest *Acacia catechu*	Plantation *Populus deltoides*	Cultivation	Herbal garden	Home garden
Family Megascolecidae						
1. *Metaphire posthuma* (Vaillant)	-	+	-	+	+	+
2. *Metaphire houlleti* (Perrier)	-	-	+	+	-	-
3. *Metaphire birmanica* (Rosa)	+	-	-	-	-	-
4. *Amynthas alexandri* (Beddard)	+	-	+	-	-	-
5. *Lampito mauritii* Kinberg	-	-	-	-	-	+
Family Octochaetidae						
6. *Eutyphoeus waltoni* Michaelsen	+	+	+	-	+	-
7. *Eutyphoeus nicholsoni* (Beddard)	+	-	+	-	-	-
8. *Eutyphoeus incommodus* (Beddard)	-	-	+	-	-	-
9. *Lennogaster pusillus* (Stephenson)	+	-	-	-	-	+
10. *Octochaetona beatrix* (Beddard)	-	-	-	+	-	+
11. *Ramiella bishambari* (Stephenson)	-	-	+	-	-	+
12. *Dichogaster bolaui* (Michaelsen)	-	-	-	-	-	+
Family Lumbricidae						
13. *Bimastos parvus* (Eisen)	-	-	-	-	-	+
Family Ocnerodrilidae						
14. *Ocnerodrillus occidentalis* Eisen	-	-	+	+	-	+
Total number of species	5	2	7	4	2	8

Species diversity indices

The variation in species diversity index (H'), dominance (C), evenness (E), and richness of earthworms is shown in Table 2.

1. Species richness

Table 2 shows that home garden was the most diverse land use type containing 8 species while *Acacia* Forest and herbal garden contained the lowest that is only 2

species. The highest Margalef (1968) species richness was 0.6 in home garden whereas 0.09 (lowest) in herbal garden. Edwards and Bohlen (1996) reported that earthworm communities contained 1 to 15 species, while earthworm species richness varied between 3 and 6 species in most habitats. During the present studies, the species richness ranged from 2-8 species between land use types. The previous studies on different land use systems in the neighboring areas also revealed more or less similar pattern of species richness; 5-6 species in the foothills of Uttaranchal (Joshi and Aga, 2009), 3-5 species in the Punjab plains (Mohan *et. al.*, 2013), 4-7 species in Haryana plains (Sharma and Bhardwaj, 2014).

Forest ecosystems usually had greater species diversity than anthropogenic habitats like pastures, cultivated and agroforestry systems (Fragoso *et. al.*, 1999) due to their complexity and availability of a variety of niches for earthworms to establish themselves (Edwards and Bohlen, 1996; Bartz *et. al.*, 2014). However, higher species richness during the present studies was recorded in more impacted sites, viz., home garden (8 species) and poplar plantation (7 species), as compared to natural forests of *S. robusta* (5 species) and *A. catechu* (2 species). High number of species in home garden appeared to be due to presence of peregrine species (both exotic and native), whereas poplar plantation had near native species as well as exotic and native peregrine species. The low number of species in *A. catechu* forest was probably due to its degraded nature and also due to quality of its leaf litter, which is high in lignin and polyphenol contents, known to be least preferred by most species of earthworms (Ganesh *et. al.*, 2009). Earthworm species richness in herbal garden also comprised of 2 species, which was expected as it was created by clearing a portion of *A. catechu* forest about 10 years ago.

2. Shannon diversity Index

There was difference in H' in each land use type. The result showed that the highest (1.57) index of diversity was found in Forest *Shorea robusta* and the index decreased to 1.54, 1.16, 0.63, 0.59 in *Populus deltoides* plantation, home garden, herbal garden and cultivation respectively. The lowest (0.41) index was found in *Acacia catechu* Forest.

High species diversity index (H') and species evenness (e) were observed in deciduous *S. robusta* forest (H'= 1.57; e = 0.98) and deciduous poplar plantation under agroforestry (H' = 1.54; e = 0.79). These habitats provided increased complexity and were considered most suitable for earthworm inhabitation and colonization. The findings agreed with those of Blanchart and Julka (1997) and Rahman *et. al.* (2011) from other parts of India, and Whalen (2004) from elsewhere. High values of species diversity index and evenness at these land use types indicated high species richness and nearly equal abundance of all species in response to abundant food and suitable edaphic factors as compared to intensively managed crop field (H'= 0.59; e = 0.27) and highly degraded

Acacia catechu forest (H'= 0.41; e = 0.10). Similar conclusions were drawn by Nunes *et. al.* (2006) and Rahman *et. al.* (2011). Several studies concluded that diversity of soil invertebrates increased from annuals crops to agroforestry systems and natural forest ecosystems (Fragoso and Lavelle, 1992; Blanchart and Julka, 1997; Rahman *et. al.*, 2011; Bhadauria et al., 2014).

Species diversity index was also high (H'= 1.16) in home garden, which could be related to higher soil moisture due to regular watering of lawn and flower beds and periodic input of organic manure. This was in conformity with the observations of Najar and Khan (2011) for vegetable and flower gardens in Jammu and Kashmir and Singh *et. al.* (2016) for gardens and nurseries in Punjab.

The decline in the density of anecic *E. waltoni* in *A. catechu* forest may be related to transformation of forest to agro system (herbal garden). The highest similarity index (51.09%) of these sites might be due to the similarity of environmental factors between them. Herbal garden was created by clearing a portion of *Acacia catechu* about 10 years ago. Species richness in both the habitats comprised of 2 species each. (i) Anecic *Eutyphoeus waltoni* of Indian origin and (ii) Endogeic and exotic *Metaphire posthuma*; the only difference being *E. waltoni* had higher density in *A. catechu* whereas *M. posthuma* had become predominant in herbal garden. Similar observations were made by Bartz *et. al.* (2014) in Brazilian native secondary forests and pastures established after forest clearing that allowed survival of native earthworm species and also colonization and predominance of exotic species.

3. Pielou Species evenness

The highest (0.98) evenness was seen in *Shorea robusta* Forest and it declined from 0.91 to 0.55 in herbal garden, *Populus deltoides* plantation, *Acacia catechu* Forest and home garden respectively. The lowest (0.43) index was recorded from cultivation.

4. Dominance index

The highest (0.78) dominance index was reported from *Shorea robusta* Forest which decreased from 0.76 to 0.24 in *Populus deltoides*, home garden, herbal garden, cultivation and Forest *Acacia catechu* respectively.

Table 2: Diversity Indices of Earthworms in different land use types in District Yamuna Nagar, Haryana.

Land use type	Species richness (n)	Index of diversity (H')	Index of dominance (c)	Index of species richness (d)	Index of evenness (e)
Forest *Shorea robusta*	5	1.57	0.78	0.40	0.98
Forest *Acacia catechu*	2	0.41	0.24	0.10	0.59
Plantation *Populus deltoides*	7	1.54	0.76	0.54	0.79
Cultivation	4	0.59	0.35	0.27	0.43
Herbal garden	2	0.63	0.44	0.09	0.91
Home garden	8	1.16	0.62	0.60	0.55

Discussion

Altogether, 14 species of earthworms belonging to the families Megascolecidae, Octochaetidae, Lumbricidae and Ocnerodrilidae were recognized. They were distinguished into two groups: i) Exotic species: *Bimastos parvus* (Eisen), *Ocnerodrilus occidentalis* Eisen, *Dichogaster bolaui* (Michaelsen), *Amynthas alexandri* (Beddard), *Metaphire birmanica* (Rosa), *M. houlleti* (Perrier) and *M. posthuma* (Vaillant); ii) Native species (Indian origin): *Lampito mauritii* Kinberg, *Octochaetona beatrix* (Beddard), *Lennogaster pusillus* (Stephenson), *Ramiella bishambari* (Stephenson), *Eutyphoeus incommodus* (Beddard), *E. nicholsoni* (Beddard) and *E. waltoni* Michaelsen. Among them, five species: *O. occidentalis* Eisen, *L. pusillus* (Stephenson), *R. bishambari* (Stephenson), *M. houlleti* (Perrier) and *M. birmanica* (Rosa) were new records for the state of Haryana.

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