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Diversity and Distribution of Earthworms Species in Guru Nanak Dev University Campus, Amritsar, Punjab, India

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Abstract

The present study deals with the survey of the Guru Nanak Dev University Campus from the month of August 2009 to July 2010 to explore its earthworm's diversity and distribution both qualitatively and quantitatively. Qualitatively earthworms fauna included six genera belongs to three different families viz. Megascolecidae (Metaphire posthuma, Amynthas morrisi and Lampito mauritii), Octochaetidae (Eutyphoeus incommodes and Octochaetona beatrix) and lumbricidae (Bimastos parvus). Metaphire posthuma was the dominant species among all and present at all the study sites. B. Parvus had the maximum mean density of 53.25±6.75 individuals per m^2 where as L. mauritii had the least density of 5.8±7.11 individuals per m^2. Maximum abundance was seen in rainy season in least disturbed shady area rich in vegetation. Correlation between various physico-chemical parameters and different earthworm species were studied and found that they were positively correlated with soil temperature, moisture, pH, organic carbon and organic nitrogen (at 5% level of significance). Values of Margalef's index (R_1=0.58) and Menhinicks index (R_2=0.16) were found highest at site I and lowest (0.29 and 0.10) at site II respectively. Simpson index (I=1.01) was found highest at site III and lowest (0.40) at site 1. Shannon's-Weiner's index (H') value's (1.59) was found highest at site 1 and lowest (1.08) at site II. Maximum species evenness (0.99) was recorded at site 1 while minimum (0.63) at site III.

Keywords: Earthworms, physico-chemical parameters, correlation, population density, diversity.

Introduction

Earthworms, the member of class Oligochaeta in the phylum Annelida are one of the major macrofauna of soil. The Greek philosopher, Aristotle, named them the 'Intestine of Earth', but till now they are actually considered as the 'unheraled soliders of the soil'. Earthworms have great ability to improve soil structure, to breakdown organic matter and release plant nutrients[1]. Around 4000 species of earthworms are known to occur globally and from India so far 418 species, referable to 67 genera and 10 families, have been reported[2]. Further earthworms have gained renewed scientific attention in India and abroad because of their wide application in the production of vermincompost, bioremediation of soil and as a source of readily digestible animal protein for domestic animals. Earthworms are also being used as key bio-indicator organism for testing toxicity of chemicals in the soil as they concentrate the toxic chemicals in their tissues[3- 5]. The purpose of present study was therefore to explore the campus area of Guru Nanak Dev University Amritsar, Punjab for presence and distribution of various earthworms species.

Material and Methods

The present study was carried out in campus area of Guru Nanak Dev University during August 2009 to July 2010 in four study sites viz. site 1 (A-B type houses), site II (Nursery), site III (near water treatment plant) and site IV (crop fields). All these sites lie at 31°38' N to 74°49' E and at an altitude of 233m above sea level. Sampling of earthworms and soil were done by using the tropical soil biology methodology[6].

Collection of worms: At each site a plot of 10 × 10 m^2 were randomly selected for earthworm sampling as well as soil sampling. Six sub-plots of 1 × 1 m^2 are again selected. Eighteen 25 × 25 × 30 cm^3 soil monoliths were randomly sampled from each replicate plot at regular monthly intervals in all the study sites. Sampling were done with the help of a spade till a depth of 16 cm and worms were picked with hands. Some worms were preserved in 5% formalin for taxonomic identification. Earthworms were identified with the help of key and monograph[7- 8]. And these identified species were got confirmed from Dr. J. M. Julka, former scientist at Zoological Survey of India at Calcutta. Composite soil samples were collected from each experiment site and standard procedures were followed in analyzing the soil samples. Accordingly soil pH was measured using a digital pH meter. Organic carbon was determined following the wet digestion method[9]. Total organic nitrogen was analyzed spectrophoto-metrically[10]. The average soil temperature at 0.2m soil depth was measured using soil thermometer and moisture content of fresh soil samples was determined after oven drying them at 105°C and expressed as a percentage of weight of the soil samples.

Results and Discussion

In the present study an attempt has been made to know the distribution and relative abundance of earthworms in Guru

Nanak Dev University Campus, Amritsar Punjab, during the month of August 2009 to July 2010. Six species of earthworms belonging to six genera and three familys viz. Megascolecidae (*Metaphire posthuma, Amynthas morrisi and Lampito mauritii*), Octochaetidae (*Eutyphoeus incommodes* and *Octochaetona beatrix*) and lumbricidae (*Bimastos parvus*) were found. The various morphological and anatomical features of these species are shown in table 1. *M. posthuma* was the dominant species contributing 21.89% in site 1, 40.85% in site II, 25.62% in site III and 27.72% in site IV. *O. beatrix* was the second most abundant species contributing 16.5% in site 1, 33.79% in site II, 19.18% in site III and 21.82% in site IV. The next dominant earthworm was *A. morrisi*, contributing 21.5% in site1, 25.34% in site II, absent in site III and 25.16% in site IV. *L.mauritii* was the fourth dominant earthworm found in site 1 (18.8%) and site IV (25.27%). While *E. incommode* and *B. parvus* were found in site 1 (21.12%) and site III (55.19%) respectively. All the six species viz. *Metaphire posthuma, Amynthas morrisi, Lampito mauritii, Eutyphoeus incommodes, Bimastos purvus* and *Octochaetona beatrix* showed maximum population density during the rainy season, followed by summer and were least in winter. Mean value of *O. beatrix* during the rainy season was 19.66 m^{-2}, 31.33 m^{-2}, 17.75 m^{-2} and 27 m^{-2} in site I, site II, site III and site IV respectively. *M. posthuma* showed 30.33 m^{-2}, 39.33 m^{-2}, 28.33 m^{-2} and 26.33 m^{-2} in site 1, site II, site III and site IV respectively. *A. morrisi* exhibited 25.3 m^{-2}, 26 m^{-2} and 24.5 m^{-2} in site 1, II and IV respectively. The mean value of *E. incommodes* and *B. parvus* were 24 m^{-2} in site 1 and 52 m^{-2} in site III respectively as shown in table 5. The maximum temperature were recorded during summer season and its mean values were 30.70 °C, 27.47°C and 28.19°C and 28.32°C in site 1, site II, site III and site IV respectively. The minimum temperature were recorded during winter in all the selected sites. The percentage of soil moisture of site 1 in three different seasons were 18.14%, 34.11% and 23.57% in summer, rainy and winter season respectively. Similarly in site II, the percentage of soil moisture 25.37%, 34.23% and 27.21 in summer, rainy and winter season respectively. In site III and site IV, the percentage of soil moisture were 21.29%, 29.11% and 22.36% (in site III) and 20.11%, 29.80% and 22.17% (site IV) in summer, rainy and winter season respectively. The soil pH is slightly alkaline in nature and ranged between 7.3 to 8.4. Soil organic carbon ranged between 1.78% (site III) to 3.65% (site II). Soil organic nitrogen was higher during rainy season and its value ranged between 0.26% (site 1) to 1.73% (site II) as shown in table 3. A total of 3729 individuals belonging to 6 species were found in the study area table 6. They belong to the following three families i.e. Megascolecidae, Octochaetida and Lumbricidae. Five species of earthworms distributed in two families and five genera in site I, three species belonging to two families and three genera in site II, three species belonging to three families and three genera in site III and four species belonging to two families and four genera in site IV were found throughout the study period table 2. The most abundant species *were M. posthuma* and *O. beatrix* found in all the study sites. The rarest among them were *B. parvus* and *E. incommode*. In the present investigation, the population structure of earthworms show seasonal variation which were found to be affected by several microclimateic or abiotic factors of the soil ecosystem such as soil moisture content, soil temperature, soil pH, organic carbon and organic nitrogen. Among the different physico-chemical factors, soil moisture content play a significant role in the occurrence and distribution of earthworm species. The important of soil moisture content in relation to population of earthworms in India were studied[19- 22]. The highest no. of all the earthworms species during the study period were observed in the rainy season (June-August). Actually the mean relative humidity increases in the month of July and August during rainy season. Presence of surplus food and less change in microclimate during the monsoon period favour the earthworm species in a particular area[23]. Abundance of earthworms species depends upon the habitat type[24]. The maximum species diversity and species richness of earthworms was found in organic matter viz. Crop field, A-B type houses, plant nursery and least abundance was seen in disturbed area viz. Water treatment plant and inner area of field. It was noticed that *M. posthuma* and *O. beatrix* were found in large no in the flowerbeds, boundaries of field, grassland and gardens in all the selected sites. These species were distributed in all pedoecosystems with their abundance in the garden of Jodhpur district of Rajasthan[25]. These species were also found in the garden, flowerbeds and lawns of western Himalayas[26]. Therefore, it seems that these species can tolerate a wide range of environmental conditions. *A. morrisi* and *L.mauritii* were moderately abundant and were distributed in garden, lawns and manure heaps and litter waste in our study. These two species have been reported from the garden and lawn of Jodhpur district[25]. B.parvus was seen in restricted habitat of soil rich in organic waste and sewage. *B.parvus* was also studied in the region with decaying plants material and soil rich in organic waste in Punjab[27]. The flora in a particular area determine the relative abundance of the earthworms species[28]. Similarly in the present study also the earthworm was related to vegetation type. The sites having the same vegetation type had similar earthworm fauna. Earthworms were more in area having *Dalbergia sisoo* and *Ficus religiosa* trees as shown in table 8. It seems that the leaves of these plants being rich in protein favour population build up of worms when taken as a feed.

Correlation between earthworm species and physico-chemical factors of soil such as temperature, moisture, pH, organic carbon and organic nitrogen is studied as shown in table 4. The correlation studies between earthworms population density and physico-chemical parameters showed positive significant correlation with soil temperature, moisture, pH, organic carbon and organic nitrogen. The species diversities, richness and equitability index's were analysed using the following indices of Shannon-Wiener index (H')[11], Simpson index (I)[12], Margalef's index (R_1)[13], and Evenness index (E)[14]. Analysis of data revealed that maximum species diversity and richness in term of Shannon-Wiener index (H') and Margalef's index (R_1) were found in site 1 and minimum at site II. Value of Evenness (E)

was higher at site 1 while low at site III as given in table 7. Maximum species richness in terms of Margalefs index (R_1=0.58) and Menhinicks index (R_2=0.16) was recorded at site 1 while minimum (R_1=0.29) and (R_2=0.10) at site II respectively. Similarly, maximum species diversity in terms of Shannon-Weiner index (H'=1.59) and Simpson index (I=1.01)) was found in site 1 and site 3 and minimum (H'=0.70 and I=0.40) at site 3 and site 1 respectively. Maximum species Evenness (Equitability index) was recorded at site 1 and minimum at site III as shown in table 7. Earthworms species diversity index and Simpson's index (I) varied from 0 to 1 gives the probability that two individuals drawn from a population belonged to the same species. Shannon's index (H') combines species richness and species evenness components as one overall index of diversity. Higher values of these index's indicated greater species diversity, hence it showed higher species diversity at site 1. Further higher values of species richness at site 1 showed abundant food and suitable physico-chemical factors compared to other sites. Differences in various chemical properties of soil viz. pH, organic matter, nitrogen, phosphorus, potassium, and calcium are the factors which are highly responsible for the distribution and abundance of earthworms in the soil of an area[29- 30].

Table-1
Important morphological and anatomical features of various earthworm species found in the study sites

S. No	Species	Colour	Total segments	Prostomium	Clitellum		Spermathecae	
					Segment No.	Type	No. of pairs	Segments
1	*Amynthas morrisi*[15]	Dark red	107	Epilobus	14-16	Annular	2	5/6-6/7
2	*Lampito mauritii*[16]	Light pink	182	Prolobus	14-17	Annular	3	6/7-8/9
3	*Metaphire posthuma*[17]	Light brown	116	Epilobus	14-17	Annular	4	5/6-8/9
4	*Octochaetona beatrix*	Light pink	177	Epilobus	13-17	Annular	2	8 &9
5	*Bimastos parvus*[18]	red	82	Epilobus	24-30	Saddle shaped	Absent	Absent
6	*Eutyphoeus incommodes*	Very light red	146	Proepibolus	13-18	Annular	1	7/8

Table-2
Distribution of earthworms in four study sites of campus

Earthworm species	SITE I	SITE II	SITE III	SITE IV
Metaphire posthuma,	+	+ +	+	+
Amynthas morrisi	+	++	-	+ +
Lampito mauritii	+	-	-	+
Eutyphoeus incommodes	++	-	-	-
Octochaetona Beatrix	+	++	+	+
Bimastos parvus	-	-	++	-

– = Absent, ++ = High population density, + = Low population density

Table-3
Physico-chemical parameters of the soil in four sites (1, II, III and IV) of campus

Sites	Seasons	Soil temp.	Moisture	pH	Organic carbon	Nitrogen
Site 1	Summer	30.70	18.14	7.5	2.35	0.28
	Rainy	23.48	34.11	7.7	2.39	0.37
	Winter	18.40	23.57	7.3	2.27	0.26
Site II	Summer	27.47	25.37	8.1	3.52	1.54
	Rainy	21.34	34.23	8.2	3.65	1.73
	Winter	17.26	27.21	8.0	3.38	1.36
Site III	Summer	28.19	21.29	8.2	1.80	0.90
	Rainy	22.52	29.11	8.4	2.02	1.12
	Winter	18.23	22.36	8.3	1.78	0.87
Site IV	Summer	28.32	20.11	7.9	2.25	0.84
	Rainy	22.41	29.80	8.0	2.38	0.97
	Winter	18.20	22.17	8.1	2.21	0.81

Table-4
Correlation studies between population density of earthworms (m^{-2}) and abiotic factors in Site 1,II, III and IV

Earthworm species	Sites	Temperature	Moisture	pH	Organic carbon	Nitrogen
Metaphire posthuma	1	0.672	0.571	0.586	0.599	0.749
	II	0.926	0.604	0.736	0.414	0.753
	III	0.644	0.525	0.568	0.536	0.791
	IV	0.828	0.883	0.784	0.843	0.859
Amynthas morrisi	1	0.772	0.625	0.572	0.530	0.670
	II	0.919	0.770	0.593	0.330	0.907
	III	-	-	-	-	-
	IV	0.783	0.742	0.572	0.889	0.828
Lampito mauritii	1	0.820	0.590	0.593	0.616	0.824
	II	-	-	-	-	-
	III	-	-	-	-	-
	IV	0.560	0.554	0.825	0.592	0.803
Eutyphoeus incommodes	1	0.818	0.527	0.625	0.508	0.728
	II	-	-	-	-	-
	III	-	-	-	-	-
	IV	-	-	-	-	-
Octochaetona beatrix	1	0.599	0.617	0.696	0.530	0.830
	II	0.704	0.712	0.935	0.319	0.635
	III	0.729	0.567	0.639	0.644	0.836
	IV	0.875	0.794	0.947	0.889	0.773
Bimastos parvus	1	-	-	-	-	-
	II	-	-	-	-	-
	III	0.766	0.516	0.532	0.592	0.855
	IV	-	-	-	-	-

Table-5
Seasonal variation of population density of earthworms m^{-2} in Site 1, II, III and IV. (Mean ± S.D)

Earthworms species	Sites	Seasons			
		Summer	Rainy	Winter	Annual
Octochaetona beatrix	1	15.75±10.28	19.66±1.69	9.8±4.83	14.25±7.87
	II	23.25±7.79	31.33±1.24	21±5.51	24.33±7.11
	III	14.75±1.66	17.75±2.6	11±2	14.16±3.64
	IV	19.75±5.35	27±3.26	13.4±4.22	18.91±6.99
Metaphire posthuma	1	17±6.36	30.33±3.39	17.2±3.96	20.41±7.46
	II	32.75±9.17	39.33±1.69	20.4±5.31	29.41±9.70
	III	17.66±4.18	28.5±8.41	11±3.89	18.5±9.55
	IV	25.75±12.8	26.33±4.64	13.4±2.65	20.75±10.10
Amynthas morrisi	1	23.5±9.23	25.33±2.05	9.8±4.83	14.25±7.87
	II	25±7.07	26±2.16	12.8±2.4	20.10±7.69
	III	-	-	-	-
	IV	23.33±2.05	24.5±6.68	11.6±2.41	18.83±7.48
Lampito mauritii	1	23.5±5.12	24±2.16	5.8±7.11	16.25±10.44
	II	-	-	-	-
	III	-	-	-	-
	IV	24±2.16	30.25±5.62	16.8±4.53	23.08±7.35
Eutyphoeus incommodes	1	21.33±4.02	24±3.53	12.4±1.35	18.08±5.60
	II	-	-	-	-
	III	-	-	-	-
	IV	-	-	-	-
	1	-	-	-	-
	II	-	-	-	-
Bimastos parvus	III	53.25±6.75	52±2.16	34±10.4	44.9±12.14
	IV	-	-	-	-

Table-6
Showing the total number of earthworms in different seasons of the year in the four sites

Earthworm species	Season	Site 1	Site II	Site III	Site IV
	Summer	38	71	63	61
Octochaetona beatrix	Rainy	88	101	66	108
	Winter	45	93	41	48
Metaphire posthuma	Summer	42	105	91	67
	Rainy	118	162	94	125
	Winter	76	92	37	57
Amynthas morrisi	Summer	53	80	0	77
	Rainy	107	111	0	102
	Winter	51	41	0	47
Lampito mauritii	Summer	65	0	0	104
	Rainy	79	0	0	111
	Winter	15	0	0	62
Eutyphoeus incommodus	Summer	79	0	0	0
	Rainy	90	0	0	0
Bimastos parvus	Winter	27	0	0	0
	Summer	0	0	171	0
	Rainy	0	0	216	0
	winter	0	0	152	0

Table-7
Showing species richness, diversity and evenness of six earthworms species at four study sites

Indices	Index	Site 1	Site II	Site III	Site IV
Species Richness	(R_1)	0.58	0.29	0.33	0.43
	(R_2)	0.16	0.10	0.15	0.12
Species Diversity	(I)	0.40	0.68	1.01	0.50
	(H')	1.59	1.08	1.70	1.38
Species Evenness	(E)	0.99	0.98	0.63	0.99

Table-8
Various habitat and relative vegetation of sites 1, II, III and IV

Sites	Earthworm Species	Habitat	Relative vegetation
Site 1(A-B type house)	*Metaphire posthuma, Amynthas morrisi, Lampito mauritii , Eutyphoeus incommodes* and *Octochaetona beatrix*	2, 4, 5 and 10	*Eugenia jambolana, Ficus sp., Capsicum sp., Hibiscus esculattus, Mimosops lengia, Dalbergia sisoo, Imperata cylindrical* and *Clerodendron sp.*
Site II (Nursery)	*Metaphire posthuma, Amynthas morrisi* and *Octochaetona beatrix*	1, 2, 3, 4 and 5	*Dalbergia sisoo, Eucalyptus tree, Eugenia jambolana, Ficus religiosa* and *Cycas revolute*
Site III (Water treatment plant)	*Metaphire posthuma, Amynthas morrisi* and *Bimastos parvus*	6, 7 and 8	*Imperata cylindrical, Alstonia spp. Grasses* and *Dalbergia sisoo*
Site IV (Crop fields)	*Metaphire posthuma, Amynthas morrisi, Lampito mauritii* and *Octochaetona beatrix*	6, 2 and 9	*Dalbergia sisoo, , Ficus religiosa, Clerodendron spp., Mimosups lengia, Quisquallis spp.* and *Taberarea montana*.

Where 1= Earth around potted plants, 2=leaf litter, 3= flowerbeds, 4= garden soil, 5= shaded area, 6=soil rich in organic matter, 7= sewage area, 8=debris, 9= grassland and 10= vegetable field.

Conclusion

Six species of earthworms belonging to six genera and three familys viz. Megascolecidae (*Metaphire posthuma, Amynthas morrisi and Lampito mauritii*), Octochaetidae (*Eutyphoeus incommodes* and *Octochaetona beatrix*) and lumbricidae (*Bimastos parvus*) were found in the study sites. Maximum abundance were seen in monsoon period in area rich in organic waste and moisture while were least in winter.

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