J. Mountain Res. ISSN: 0974-3030
Vol. 13, (2018) 81-87

Population Dynamic and Vertical Distribution of Earthworm In Managed Soils of Tarai Bhabar Region of Kumaun, Uttarakhand

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Received: 02.10.2018; Revised: 19.10.2018; Accepted: 29.11.2018

Abstract: Earthworm population dynamics was studied in a managed soil at Kathgodam about 34 Km. from Nainital (29° 16' N Latitude and 79° 31' E Longitude; 553 m altitude) in Tarai Bhabar region of Kumaun, over a period of 24 months, from March 2005 to February 2007. A total of 597 earthworms from 240 samples were collected. Twelve species of earthworms belonging to three families were found. Family *Megascolecidae* was the dominant family with 55.1% of earthworms, *Lumbricidae* 4.2% and *Oenerodrilidae* 1.3%, *Metaphire californica* was the dominant earthworm species. Earthworm density varied from 0 to 45.6 ind.m^{-2} and biomass from 0 to 53 g m^{-2} , vertical distribution of eartworms showed that 64.8% of the total earthworm and 64.7% of the total biomass were found in the 0- 10 cm soil layer. The average yearly ratio of clitellates for two years was 1:0.65. The relationship between density and biomass with soil properties indicated positive correlationship with soil moisture, soil temperature of various levels

Keywords: Earthworm • Population dynamics • Tarai bhabar region • Kumaun • Depth distribution • Managed soil

Introduction

Terrestrial oligochaete worms, and notably earthworms are saprotrophic invertebrates which associated with healthy, productive soil and participated in the conservation of natural fertility. Earthworms dominate the invertebrate biomass where they soil fertility i.e. soil physical structure, soil organic matter dynamics, nutrient mineralization and water infiltration rates (Lavelle et al., 1992; Anderson and Ingram, 1993). India has rich native earthworm fauna that includes over 400 known species (Julka, 1998). There are reports on earthworm ecology from Orissa (Dash and Pattra, 1977); Karnataka (Bano and Kale, 1991; Blanchart and Julka, 1997); Tamilnadu (Ismail et al. , 1990); Eastern U. P. (Singh, 1997); Andhra Pradesh (Reddy et al., 1997); H. P. (Julka 1998); Meghalaya (bhadauria and Ramakrishnan, 1991). Except for some earlier reports of Kaushal et al. , (1994; 1995; 1999 a, b;) and Bisht et al. , (2003) in cultivated and forest soils in Kumaun Himalaya. This paper deal with the species composition, population dynamics, depth distribution and age structure of earthworms as a role for developing managment strategies for improving soil fertility in Tarai bhabar region in kumaun.

Materials and Methods

The study site is located at kathgodam (29° 16' N latitude and 79° 31'E longitude; 553 m altitude), climatic data from the nearest weather station (G. B. Pant Agricultural And Technical University, Pantnagar). Three crops are grown in a year; June to September (maize and paddy),October to November(Seasonal Vegetables), and December to May (Wheat). The tillage in the cropland is mechanical and the tilled depth is 5 cm. The maximum temperature ranged from 6.1°C(January) to 36.9°C (May). The average rainfall is 1400.3 mm. The relative humidity ranged from 24.0% (April) to 91.9% (January). The soil is alluvial and contains 10% sand , 67% silt and 23% clay. Soil sampl;es were collected from five random locations from 0-10 and 10-20 cm. soil depths during March 2005 to February 2007. The soil temperature recorded at 0-10 and 10-20 cm. soil layers on each sampling date by digital soil probe thermometer. Soil moisture was measured gravimetrically by drying the soil at 105°C. Soil pH was determined using the pH meter. Organic C was determined using air dried and sieved soils samples using the wet ashing method of Jackson(1958). Soil N was determined by Kjel auto Vs- KTP Nitrogen Analyser based on a Micro- Kjeldahl Technique (Misra, 1968). K was using flame Photometery.

The Earthworms were collected fortnightly by hand sorting using a quuadrat of 50×50 cm at soil depths of 0-10 cm and 10- 20 cm. and stored in plastic bags collected earthworm were separated from the soil, washed with water and immobilized by the additiona of aa few drops of alcohol to the water. The Earthworms were properly stretched and fixed in 4% formalin for 24 hrs for subsequent identification (Rozen, 1982). The worm species were further confirmed by Dr. J. M. Julka, Zoological Survey of India, High Altitude Station , Solan (H.P.) The collected specimen were classified in aclitellates and clitellates developmental stages and weighed in a single pan electronic balance.

Result and Discussion

Soil Characteristics: Soil pH was acidic in both layers. The maximum soil moisture was 26.4% and 25.2% in the 0-10 cm. and 10-20 cm. soil layers, respectively. Organic C and C:N ratio decreased with increasing soil depth in both years.(Table 1).

Table 1 Average soil characteristics in the crop land at kathgodam during March 2005 to February 2007

Soil characteristics	Soil depth (cm)	
	0-10	10-20
Soil pH	6.6 ± 0.03	6.5 ± 0.06
Soil temperature(°C)	16.6 ± 1.5	16.7 ± 1.6
Soil moisture (%)	14.3 ± 1.0	14.9 ± 1.1
C (%)	1.35 ± 0.13	1.13 ± 0.05
N(%)	0.208 ± 0.001	0.205 ± 0
P (%)	0.0034 ± 0.00005	0.0029 ± 0.00005
K (%)	0.00213 ± 0.00002	0.00215 ± 0.00002
C : N ratio	5.4 ± 0.42	5.1 ± 0.28

Species composition and abundance of earthworms: A total of 597 Earthworms from 240 samples were collected from the study site. Twelve species of Earthworms belonging to three families were identified(Table 2). (*Megascolecidae*-8 species, *Lumbricidae*-3 species, *Oenerodrilidae*-1 species). Family *Megascolecida*e was the dominant family with 55.1% of Earthworms, *Lumbricidae* 4.2% and *Oenerodrilidae* 1.3% and Aclitellates 39.4% (Table 2). *Metaphire californica* was the dominant Earthworm species. The abundance and biomass of Earthworms fluctuated seasonally (Fig.1 and 2). The worm density varied from 0 ind. m^{-2} to 45.6 ind. m^{-2} (Fig.1.), and the worm biomass from 0

g m^{-2} to 53 g m^{-2} (Fig. 2). Earthworm were not encountered in the sampling from 0-20 cm. depth, during the winter season. The low density and biomass of Earthworms recorded in the present study (11.2 ind. m^{-2} and 9.2 g m^{-2}) may possibly be due to poor nutrient status. Higher abundance and biomass of Earthworms during rainy season may be related to higher reproduction and survival due to higher moisture in the soil.

Vertical distribution: Vertical distribution of earthworms through soil showed that most worms appeared mainly in 0-10 cm. soil layer in both years.

Table 2 Number of individuals of each species of earthworms collected in the cropland during March 2005 to February 2007.

Species	Number of individuals	%
MEGASCOLECIDAE		
Amynthas alexandri (Beddard)	25	4.2
Amynthas cortices (Kinsberg)	44	7.4
Amynthas gracilis (Kinsberg)	30	5.0
Metaphire anomala (Mich.)	7	1.2
Metaphire californica (Kinsberg)	85	14.2
Metaphire hhouletti (Perrier)	11	1.8
Metaphire posthuma (Vaillant)	107	17.9
Perionyx excavates (Perrier)	20	3.4
LUMBRICIDAE		
Aporrectodea caliginosa trapezoids (Duges)	10	1.7
Aporrectodea rosea rosea (Savigny)	4	0.7
Eisenia fetida (E. andrei)(Savigny)	11	1.8
OENERODRILIDAE		
Thhatonia gracilis (Gates)	8	1.3
Clitellates	235	41.9
Total earthworm	**597**	**100**

55% of Earthworms and 48.2% of biomass in wheat crop, 66% of Earthworms and 65.8% of biomass in Maize and Paddy crop, 68% of Earthworms and 70 % of biomass in seasonal vegetable crop were collected at the 0 -10 cm. soil layer. A mean of 64.8% of the total earthworms and 64.7% of the total biomass recorded in the 0-10 cm. soil layer in both years. Earthworms can be classified into three ecological groups: epigees- litter dwellers, endogees – horizontal burrowers and anecique – deep burrows (phillipson et al., 1976) is most widely used. The earthworm species are mineral-soil living since 55-68% of the specimens were recorded at 0-10 cm. soil layer was also higher than in the 10-20 cm. soil layer. Most researchers have found earthworms almost exclusively in the top 50 cm. of the soil, and most species have been found in the top 20 cm. (clapperton et al. 1997; Valle et al. 1997). The data on depth distribution of Earthworms through soil obtained in the present investigation fit this pattern for the Earthworm population as the C:N ratio at 0-10 cm. and 10-20 cm., and the organic matter content seems to be most important factor in Earthworm distribution.

Age structure: Only two age classes i. e. aclitellates and clitellates were considered for determining the age structure of earthworms. The average yearly ratio of clitellates for two years was 1:0.65. (Table 4). As a rule, in annual cycles of the ratio of aclitellates to clitellates, the number of adults is below 50% of the total count for any species. Juveniles were recorded throughout the year with peaks coinciding with the rainy seasons in the present study. This is similar to what has been

reported for *Millsonia anomala* (Lavelle, 1978) and *Lumbricus terrestris* (Daniel, 1992). In the present study, mature individuals were found throughout the year. This characteristic is typical for species within endogeic oligohumic category (Lav elle, 1979; Lee 1985).

Table 3 Vertical distribution of earthworm number (individuals) and biomass (g) in the managed soil during March 2005 to February 2007. (Figures in parentheses are percentage values)

Year	0-10 cm soil layer		10-20 cm soil layer	
	Number	Biomass	Number	Biomass
Wheat crop				
March 2005-Feb. 2006	10 (71.4)	7.9 (58.5)	4 (28.6)	5.6 (41.5)
March 2006- Feb. 2007	5 (38.5)	5.6 (37.8)	8 (61.5)	9.2 (62.2)
Mean	55.0	45.0	45.0	51.8
Maize and paddy crop				
March 2005- Feb.2006	162 (70.7)	187.8 (71.8)	67 (29.3)	73.9 (28.2)
March 2006- Feb 2007	145(61.2)	154.3(59.7)	92 (38.8)	104.2 (40.3)
Mean	66.0	65.8	34.0	34.2
Seasonal vegetables crop				
March 2005- Feb.2006	46 (59.0)	64.9 (62.7)	32(41.0)	38.6 (37.3)
March 2006- Feb 2007	20 (77.0)	26.1 (77.4)	6(23.0)	7.6 (22.6)
Mean	68.0	70.0	32.0)	30.0
Total worms of three crops				
March 2005- Feb.2006	218 (68.0)	260.6 (68.8)	103 (32.0)	118.1 (31.2)
March 2006- Feb 2007	170 (61.6)	186.0 (60.6)	106 (60.6)	121.0 (39.4)
Mean	64.8	64.7	35.2	35.3

Table 4 Age structure of earthworms in the managed soil during March 2005 to February 2007.

Year	No of Earthworms		Clitellates: Aclitellates ratio
	Clitellates	Aclitellates	
Wheat crop			
March 2005-Feb. 2006	6	8	1: 1.33
March 2006- Feb. 2007	4	9	1 : 2.25
Mean	10	17	1 : 1.7
Maize and paddy crop			
March 2005- Feb.2006	140	89	1:0.64
March 2006- Feb 2007	123	114	1:0.93
Mean	263	203	1:0.77
Seasonal vegetables crop			
March 2005- Feb.2006	66	12	1:0.18
March 2006- Feb 2007	23	3	1:0.13
Mean	89	15	1:0.17
Total worms of three crops	212(66.0)	109 (34.0)	1:0.51
March 2005- Feb.2006	150(54.3)	126 (45.7)	1:0.84
March 2006- Feb 2007	362(60.2)	235 (39.8)	1:0.65
Mean			

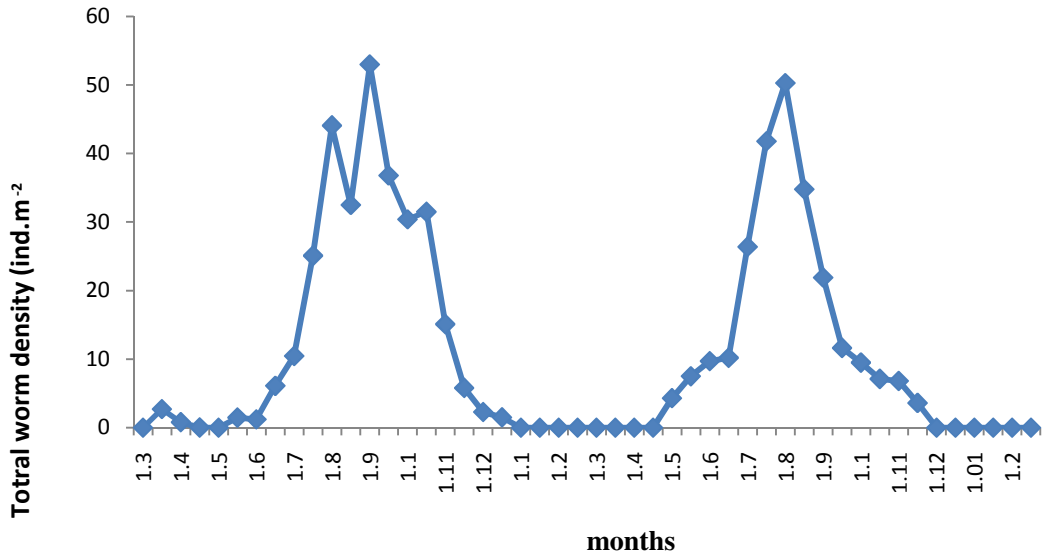

Figure 1 Variation in the total worm density (ind. m^{-2}) of earthworm during March 2005- February 2007.

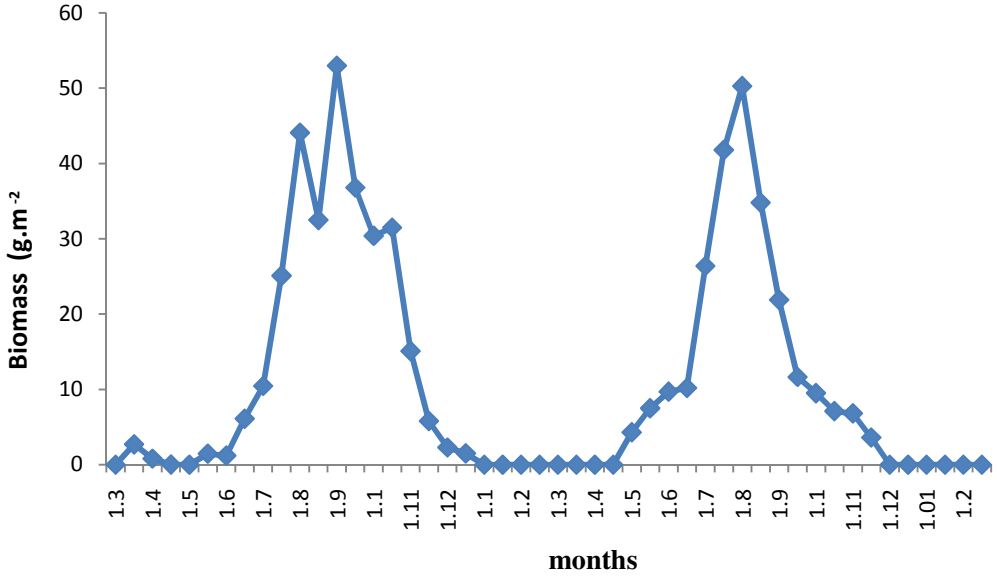

Figure 2 Variation in the biomass (g. m-2) of earth worm during March 2005 to February 2007

Earthworm/ soil properties relationship: The relationship between density and biomass with soil properties indicated positive corelationship with soil moisture, soil temperature of various levels. Correlation coefficients for monthly values of soil properties and Earthworms are summarized in Table 5.wormdensity and biomass were significantly positively correlated (r= 0.993; p<0.01); soil temperature and worm density (r = 0.907; p< 0.01); soil temperature and worm biomass (r= 0.885; p <0.01); soil moisture and worm biomass (r = 0.896; p< 0.01). Significant correlations observed between earthworm density and biomass with soil properties mainly soil moisture, soil C, soil temperature and soil pH influence the abundance of Earthworms in the managed soils of Tarai bhabar region of kumaun.

Table 4 Correlation coefficients 'r' of total worm density (ind. m^{-2}) and total worm biomass (g m^{-2}) with soil properties at 0-20 cm soil depth in the managed soil depth during March 2005 to Feb. 2007 (n = 24)

Parameters	Worm biomass	Soil pH	Soil Tem.	Soil moisture	Soil C	Soil N	Soil P	Soil K
Worm density	0.993*	-0.154	0.912*	0.907*	0.212	-0.002	-0.078	0.248
Worm biomass		-0.118	0.885*	0.896*	0.169	0.058	-0.0639	0.234
Soil pH			-0.171	-0.119	-0.122	-0.158	-0.198	-0.169
Soil moisture				0.862	0.222	0.089	-0.080	0.229
Soil temperature					0.225	-0.129	-0.075	0.291
Soil C						-0.145	-0.114	-0.107
Soil N							-0.085	-0.472**
Soil K								-0.341**

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