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Diversity and Distribution of Earthworms in a Subtropical Forest Ecosystem in Uttarakhand, India

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ABSTRACT.– Diversity and distribution of earthworms along with the various factors influencing their distribution viz. moisture content, soil temperature, pH, oxidizable organic matter, nitrogen, phosphorous, potassium and calcium were determined in a subtropical forest ecosystem in the foothills of the Shivalik Himalayas in India. Six species of earthworms representing the two families Octochaetidae and Megascolecidae, were recorded during our study period of 2007-08. Maximum density and biomass of worms recorded in the present study was 82 ± 22.5 m^{-2} and 11.2 ± 1.79 g m^{-2}, respectively.

KEY WORDS: Earthworms, Distribution, Diversity, Subtropical forest

INTRODUCTION

Earthworms are the members of the class Oligochaeta of phylum Annelida. These are one of the major macrofauna of soil and are considered as unheralded soldiers of the soil. Earthworms have the ability to improve soil structure, contribute to the breakdown of organic matter and release plant nutrients (Edwards and Bohlen,1996). Earthworms have been suggested as useful indicators of the health of soil ecosystems (Edwards and Bohlen, 1992) due to their role in soil fertility through fragmentation and mixing of the soil with mineral particles, promoting microbial activity and in the breakdown of plant organic matter. The ingested organic matter is macerated, mixed with ingested inorganic soil material, passed through the gut and excreted as a cast, which are enriched with available plant nutrients and thus enhance soil fertility. Earthworms present in an ecosystem have also been shown to decrease the severity of the soil borne fungal plant diseases (Stephens et al., 1993). Their occurrence in large numbers, wide distribution, relatively immobile nature, and being in full contact with the surrounding soil substrate are of very practical importance. Earthworms are also being used as key bio indicator organisms for testing the toxicity of chemicals in soil (Callahan, 1988; Goats and Edwards, 1988; Bouche, 1992).

Earthworms require carbon and nitrogen for their growth and reproduction, which they obtain from litter, grit and microbes (Edwards and Bohlen, 1996), C:N ratio also determines the distribution trends of worms in an ecosystem. Similarly, distribution of earthworms also depends on physical conditions including water content and availability of organic matter in the soils. The

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objective of this study was to collect information on species composition and population dynamics of earthworms from a subtropical forest ecosystem in India.

MATERIALS AND METHODS

The distribution trend of earthworm species in Uttarakhand were studied in the two wildlife sanctuaries of Rajaji National Park, in Uttarakhand state of India. These two sanctuaries included the Motichur wildlife sanctuary in the eastern region and the Chilla wildlife sanctuary lying in the western region of Rajaji National Park, located at 29° 15'–30° 15' N and 77° 55'–78° 30' E. Earthworms were collected from each location consisting of eight sites by digging five 25 x 25 x 20 cm monoliths at regular intervals of 30 days during 2007-2008 and hand sorting the worms following Anderson and Ingram (1993), these were preserved in 4% formalin for further studies. Preserved worms were identified with the help of available keys (arrangement of setae, location and size of clitellum, location of genital openings, shape and number of spermathecae, location of gizzard and prostrate gland, Julka, 1988). Cooperation of Scientists from High Altitude Field Station, Zoological Survey of India, Solan, in Himanchal Pradesh was also sought in identification and further confirmation of species. Density of earthworms was calculated as the number of individuals present per meter square. Biomass of worms was determined in an electric balance with 0.01 mg accuracy and values are given on a fresh weight basis.

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. Calcium in the soil extract was measured using Jackson's (1958) method. Soil potassium was determined using flame photometry. Organic carbon was determined following the wet digestion method as described by Walkley and Black (1934). Total nitrogen as nitrate and available phosphorous was analyzed spectrophoto-metrically as per the methods described by Anderson and Ingram (1993). 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 105^0 C and expressed as a percentage of weight of the soil samples.

RESULTS AND DISCUSSION

Species composition and distribution

A total of six species of earthworms belonging to two families were recorded from the subtropical forest ecosystem (Table 1). The five species of Octochaetidae included *Octochaetona beatrix*, *Eutyphoeus nicholsoni*, *E. incommodos*, *E. waltoni* and *E. orientallis* while Megascolecidae was represented only by *Amynthas alexandrii.* Of the six species *A. alexandrii* was collected from Motichur wildlife sanctuary only and *E. orientallis* was confined to Chilla wildlife

TABLE 1. Distribution of earthworms in two study sites of Rajaji National Park.

Earthworm species	Motichur Wildlife Sanctuary	Chilla Wildlife Sanctuary
Eutyphoeus oreintallis	√	√
E. incommodes	√	√
E. nicholsoni	√	√
E. waltoni	√	√
Octochaetona beatrix	√	√
Amynthas alexandrii	√	

sanctuary only, rest of the four species, *O. beatrix*, *E. nicholsoni*, *E. incommodos* and *E. waltoni,* were recorded from both the study areas.

The higher number of species of worms were recorded during rainy season as compared to early winter and summer season. The maximum density and biomass of earthworms was recorded during rainy season from Motichur wildlife sanctuary which was 82 ± 22.5 m^{-2} and 11.2 ± 1.79 g/m^{-2}, respectively, while the maximum values for the density and biomass from the Chilla sanctuary were 17 ± 2.16 m^{-2} and 2.87 ± 0.31 g/m^{-2}, respectively (Table 2). Earthworm density was maximum during rainy season in both the study areas.

It has been reported that large scale destruction of natural forests has severely affected the diversity of earthworms (Bhaduria and Ramkrishnan, 1991). Similarly the slash and burn system in the forests of Meghalaya has been found responsible for reduction of original forest species of earthworms (Darlong and Alfred, 1991). The various other studies carried out by different workers time to time in different parts of the world also support the present observation that the higher density of worms is found during rainy season (Lavelle,1973; Rozen 1982; Valle et al., 1997). In India, Dash and Senapati (1980); Julka (1986 a, b); Bhadauria and Ramakrishnan (1989, 1991); Blanchart and Julka (1997) have also recorded higher number of earthworms during wet periods.

Physicochemical parameters of soil

The average atmospheric temperature from January to June ranged between 10 °C to 34 °C whereas average soil temperature recorded was 29.02 ± 0.5 °C in Motichur area and 29.4 ± 0.2 °C in Chilla area. Earthworm population density at a specific site is the result of the interaction of a number of factors of which moisture is of greater importance (Valle et al., 1997). In the present study a higher soil moisture level was recorded from the Motichur area, which was 26.6 ± 0.3 %, this may be responsible for maximum density of worms (82 ± 22.5 m^{-2}) recorded from this area. Low moisture content (13.66 ± 0.6 %) was recorded in the soil from Chilla sanctuary (Table 3). The pH of soil recorded was 6.02 ± 0.11 in the Motichur area and 6.4 ± 0.08 in Chilla area. Senapati (1993) has pointed out that the calciferous gland present in the gut of earthworms discharges amorphous calcium

TABLE 2. Density (m^{-2}) and biomass (gm^{-2}) of earthworms recorded from the two study sites.

Sites	Number of species	Density (adults+ juveniles) individuals m^{-2}	Biomass (adults + juveniles) g m^{-2}
Motichur Wildlife Sanctuary	5	82 ±22.55	11.2 ±1.79
Chilla Wildlife Sanctuary	5	17 ±32.16	2.87 ±0.31

TABLE 3. Average pedological characteristics of the two study sites

Soil Characteristics	Motichur Wildlife Sanctuary	Chilla Wildlife Sanctuary
Soil pH	6.4 ±0.08	6.02 ±0.11
Total Nitrogen(%)	0.75 ±0.15	0.58 ±0.11
Organic matter (%)	5.13 ±1.2	4.09 ±0.56
Phosphorous (%)	0.34 ±0.06	0.23 ±0.03
Potassium (%)	0.90 ±0.03	0.63 ±0.01
Calcium(%)	0.23 ±0.01	0.19 ±0.03
Soil temp(°C)	29.02 ±0.5	29.4 ±0.2
Soil moisture (%)	26.6 ±0.3	13.66 ±0.6

carbonate particles coated with mucus into esophagus which intern influences the pH of the soil. The average value recorded for nitrogen was 0.75 ± 0.15 % in Motichur area and 0.58 ± 0.11 % in Chilla area, the average organic matter recorded was 5.13±1.2 % from the Moticur area and 4.09 ± 0.56 % from the Chilla area. The values recorded for phosphorous were 0.34 ± 0.06 % and 0.23 ± 0.03 % in Motichur and Chilla areas, respectively. For potassium values recorded were 0.90 ± 0.03 % and 0.63 ± 0.01 % in Motichur and Chilla areas respectively. The values recorded for calcium was 0.23 ± 0.01 % in Motichur area and 0.19 ± 0.03 % in Chilla area. The above observations on various soil parameters show a more favourable soil condition for worms in Motichur wildlife sanctuary as compared to Chilla wildlife sanctuary, this is the reason that a higher value of density and biomass of worms has been recorded from this area. Phillipson et al. (1976) and Baker et al., 1993 have also reported that 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.

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