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Earthworms of Doodhpathri (Budgam), Jammu and Kashmir, India

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Abstract

The study reports the diversity and seasonal population dynamics of earthworms at Doodhpathri (Budgam), based on the data collected from five different sites. A total of three earthworm species-Aporrectodea rosea rosea,, Aporrectodea caliginosa trapezoids and Octalasion cyaneum belong to family lumbricidae were recorded. Out of the three species O. cyaneum exhibited restricted distribution whereas A. r. rosea and A. C. trapezoides were present at majority of the sites. The density and biomass exhibited significant variation (F_4 = 6.66; 37.77, $P < 0.05$) within the sites and among (F_3 = 4.77; 15.08, $P < 0.05$) the seasons with higher values recorded during autumn and spring. Diversity indices- Margalef species richness (0.150-0.679), Simpson's index (0.370-0.600), Shannon diversity index (0.556-1.102) and evenness (0.872-1.033) also exhibited varied values among the sites with maximum value at site-III. Organic nitrogen showed significant variation within the sites (F_4 = 5.43, $P < 0.05$) and among the seasons (F_3 = 6.27, $P < 0.05$), within the sites in moisture (F_4 = 3.39, $P < 0.05$) and electrical conductivity (F_4 = 17.89, $P < 0.05$) whereas among the seasons in temperature (F_3 = 22.88, $P < 0.05$) and organic carbon (F_3 = 10.12, $P < 0.05$). Organic carbon, organic nitrogen along with moisture favors the diversity of earthworms whereas the temperature affects the overall population dynamics.

Keywords: Budgam, Density, Earthworms, Diversity, Doodhpathri, Seasons, Soil.

Introduction

Earthworms are considered as ‘‘ecosystem engineers’’ as their feeding, burrowing and casting activities can dramatically change the physical, chemical and biological properties of soils[1,2]. Earthworms form an important invertebrate community component in most soils in terms of their contribution to overall belowground biomass[3]. They play a major role in ecosystem functioning[4] and contribute to wide range of essential ecosystem services[5]. They are important macrofauna of the rhizosphere[6] and part of the decomposer foodweb, consume large amounts of plant remains and soil[7,8]. Earthworms mix large quantities of residues into soil and create pores through their casting and burrowing activities[9]. In different pedoecosystems they enhance the turnover of organic residues[10,11], increase the microbial activity[4,12] and therefore contribute to an enhanced mineralization and nutrient availability in soil[13,14]. Their contributions to improve soil aeration, drainage and transformation of minerals and plant nutrients to available and accessible forms make the soil favorable for crop yield[15-17].

A number of soil characteristics[1]such as pH[18], soil organic matter[19], moisture regime and nutrient status[20], soil texture[21,22], temperature[23] and salinity levels[24] have been shown to influence the distribution and population dynamics of individual species, thereby determining the composition of earthworm communities[25]. Earthworm species composition and population structures are directly affected due to the changes in land use patterns in different agro-climatic regions of India[26]. Many studies have found relationships between soil physicochemical characteristics and earthworms[1,25] but findings are variable[27]. Additionally, uncovering different environmental correlations for different geographic settings is useful for furthering our understanding of earthworm ecology[28]. The present study was carried out to study the earthworm fauna of Doodhpathri (Budgam), Jammu and Kashmir, India.

Materials and Methods

Study area: Dodhpathri is one of the most beautiful and unexplored area of the district Budgam of Kashmir Valley, Jammu and Kashmir. It is located within the geographical coordinates of 34°42'00″- 34°50'00″ N latitude and 74°24'00″-74°54'00″E longitude, with an area of 1291 km² and is about 40 Km from Srinagar city. Climate is temperate and receives heavy snowfall during winter. It is a newly discovered tourist destination of Kashmir valley and is dominated by tree species (*Pinus sp.* and *Cedrus sp.*).The year is divided into four seasons[7]-spring (March- May), summer (June-August), autumn (September-November) and winter (December-February).

Study Sites: For the present study five different sites were selected each with different vegetation types, slopes and elevation. The description of the sites areas:

Site-I (Tangnar): The site is located near the village Tangnar and is at a distance of 10 Km from Khan Sahib. It is situated at an altitude of 2250 m above the mean sea level, within the geographical coordinates of 33°40′30″N and 74°44′26″E. The site is under the cultivation of maize and apple trees.

Site-II (Parihas): The site is primarily grassland spreading over 8 Km^2 used for cattle rearing. The site lies at an altitude of 2611 m above the mean sea level, within geographical coordinates of 33°52′27″N and 74°34′33″E.

Site-III (Dobiwan): The site lies in the center of the study area at an altitude of 2611 m above sea level, within the geographical coordinates of 33°52′06″N and 74°34′43″E. A small stream flows through the area with scattered shrubs.

Site-IV (Doodhpathri): The site is a meadow spreads over 240 km^2. It is situated at 2543 m above the mean sea level, within geographical coordinates of 33°53′00″N and 74°34′05″E. It extends from Palmaidan to Ashtar and is considered as largest meadow.

Site-V (Park): The site is present within the park maintained by Doodhpathri Development Authority. It is situated at an altitude of 2550 m above mean sea level with the geographical coordinates of 32°48′00″N and 74°30′00″E. The park is used for recreational purposes.

Sampling of soil and earthworms: Sampling for soil and earthworms were carried out on monthly basis at each site during 2014-2015. Earthworms were collected by digging soil monolith (25x25x30 cm) and handsorting[1]. Earthworms were sorted into clitellates, non-clitellates (> 4 cm and without clitellum but with genital markings) and juveniles (< 4 cm, lack genital marking, tumescences and clitellum)[29] counted, weighed, preserved in 4 % formalin and then identified[7,1].

Soil analysis: Composite soil samples were analyzed for different physiochemical parameters by following methods as- soil temperature by soil thermometer and soil moisture by gravimetric method[30]; pH, electrical conductivity (EC), organic nitrogen (ON) by micro Kjeldal method[31]; soil organic carbon (OC) by Walkley and Black[32].

Diversity indices: Diversity indices were calculated by using the formulas as- Margalef species richness DMg (D = S - 1/In N, where S is number of species and N is number of individuals), Shannon diversity index H0 (H0 = -Rpi In pi, where pi the proportional abundance of the i^{th} species = ni/N), Evenness E (E = H0/In S, where H0 is Shannon diversity index and S is number of species) and Simpson's index H = ∑ (Ni/N)2 where H is Simpson's index, Where Ni is the number of individuals for all S species and N is the known total number of individuals for all S species in population were calculated for each site[33].

Statistical analysis: With the objective of evaluating significant differences within and among the sites in soil physiochemical parameters and earthworm population dynamics, data sets were analyzed by using two-way analysis of variance (ANOVA) at 0.05 % level of significance. All statistical analyses were performed using SPSS statistical software.

Results and Discussion

The study revealed occurrence of three species of earthworms among the five different sites of Doodhpathri. All the three species-*Aporrrectodea rosea rosea, Aporrrectodea caliginosa trapezoids and Octalasion cyaneum* belong to family lumbricidae and their distribution among different sites is given in Table-1. The earthworm species reported in the present study has been reported from other parts of Kashmir Valley. Najar and Khan[1,7], reported the presence of *A. r. rosea* and *A. c. trapezoids* from South, North, North-west, South-east and Central Kashmir, whereas *O. cyaneum* from Central Kashmir. The species has also been reported from the other parts/areas of western Himalayas as Paliwal and Julka[34] reported the occurrence of *A .C trapezoids* and A. *r. rosea* from Himachal Pradesh and Uttaranchal. Out of the three species, *A. r. rosea* and *A. C. trapezoids* were present at majority of sites and showed a wide range of tolerance to soil factors. Najar and Khan[7] and Tischer[35] reported *A. r. rosea* most wide spread and abundant earthworm in agricultural soils. *A. C. trapezoides* is predominant in areas disturbed by human activities[36,37]. In the present study *A. C. trapezoides* was present in both natural as well as human controlled ecosystems (agricultural) as species can tolerate harsh conditions. However, *O. cyaneum* was restricted to only one site. Sims and Gerard[37] reported that *O. cyaneum* prefers moist habitats. In the present study *O. cyaneum* is restricted to only one site, as the area is having higher levels of moisture and relatively cooler temperature and is in agreement with the reports of Najar and Khan[7,38]. The occurrence of species in a particular habitat and its absence from other exhibits the species-specific distribution of earthworms in different pedoecosystems. Similar observation was reported in the species composition of earthworms in different grasslands, cultivated and forest soils[39]. According to Mathieu et al[40] earthworms prefer habitat of high quality in terms of environmental conditions, as the habitat quality actually affects earthworm fitness[41].

The density and biomass of earthworms is given in Figure-1. Density exhibited significant variation ($F_4 = 6.66$, $P < 0.05$) within the sites and among ($F_3 = 4.77$, $P < 0.05$) the seasons. The density of earthworms varied from 5±0.09 to 35±2 with a maximum number recorded during autumn followed by spring and minimum during winter (Figure-1a). The biomass of earthworms showed significant variation ($F_4 = 37.77$, $P < 0.05$) within the sites and among ($F_3 = 15.08$, $P < 0.05$) different seasons. The biomass of earthworms varied from 0.80±0.05 to 2.73±0.01 g/m^2 (Figure-1b) with a maximum value also recorded during autumn followed by spring and minimum during winter. Earthworm population density and biomass varied significantly among the sites and during different seasons with maximum value recorded during the spring and autumn whereas minimum during winter and could be due to optimum moisture and temperature conditions that prevails during spring and autumn. This is supported by the work of Najar and Khan[7]; Callaham and Hendrix[42] as they reported earthworms were most abundant during spring and autumn. Earthworm population density was lowest during winter at all the sites and might be attributed to low temperature as it delays cocoons hatching and is supported by Timmerman et. al[43] and low earthworm density during winter is due to low temperature[1].

Soil moisture, pH, temperature, organic nitrogen, electrical conductivity and organic carbon play important role in the distribution of earthworms[1,44]. The physiochemical characteristics of soil at different sites is given in Figure-2. No significant variation in soil pH was recorded within the sites (F_4 = 0.87, P < 0.05) and among different seasons (F_3= 0.23, P < 0.05). pH varied from 5.21±0.10 at site-III during summer and 5.49±0.11 at site-I during summer (Figure-2a) and falls in moderate acidic range. According to Chaudhuri and Bhattacharjee[45] earthworms are mostly recorded in pH range of slightly acidic to moderate alkaline. Thus pH recorded in the present study is very much in the suitable range for the distribution of earthworms.

Soil moisture (%) recorded during the study ranged from 23.32±3 at site-1 during summer to 43.33±6 at site-III during spring (Figure-2b) with significant variation within the sites (F_4 = 3.39, P < 0.05) and no significance among the seasons (F_3 = 2.24, P < 0.05). Population density was lower during summer at all the sites. One of the reasons might be low moisture content of soil, as fecundity of earthworms is greatly influenced by low soil moisture content. Schmidt and Curry[46] also reported low population density with low soil moisture content. Further Najar and Khan[1,7] also reported absence of earthworm in pedoeco systems with low moisture content.

Soil temperature (°C) is give in Figure-2c and range from 0.99±0.02at site-IV during winter to 17.35±2 at site-I during summer with significant variation among the seasons (F_3 = 22.88, P < 0.05) whereas no significance within the sites (F_4 = 1.86, P < 0.05). Low earthworm density was recorded during the winter at all the sites followed by summer. The low temperature could be attributed to lower density during winter and corroborates the findings of Najar and Khan[1,7].

The range of EC (mS/m) is given in Figure-2d and showed significant variation within the sites (F_4 17.89, P < 0.05) however no significance among the seasons (F_3 = 1.02, P < 0.05). EC exhibited a range of 0.82±0.01 at site-IV during spring to 1.52±0.01 at site-I during autumn. EC is the indicator of different salts concentration in the soil and plays vital role in earthworm metabolism.

Organic carbon recorded during different sites is given in Figure-2e and showed significant variation among the seasons (F_3 = 10.12, P < 0.05), with no significance within the sites (F_4 = 0.50, P < 0.05). The mean value ranged from 1.93±0.02% at site-III during summer to 2.69±0.10% at site-III during autumn. Soil organic carbon play important role in the distribution of earthworms as it determines the nature of food which and plays important role in distribution[44,47].

Organic nitrogen showed significant variation within the sites (F_4 = 5.43, P < 0.05) and among the seasons (F_3 = 6.27, P < 0.05), with lowest value 0.8±0.02 recorded at site-V during spring to 1.2±0.01 at site-IV during summer (Figure-2f). The low nitrogen content of soil is often considered as critical factor, since it limits the distribution of earthworms in many temperate ecosystems[48] however in the present study the nitrogen was present in moderate range and plays important role in population dynamics of earthworms[1,7].

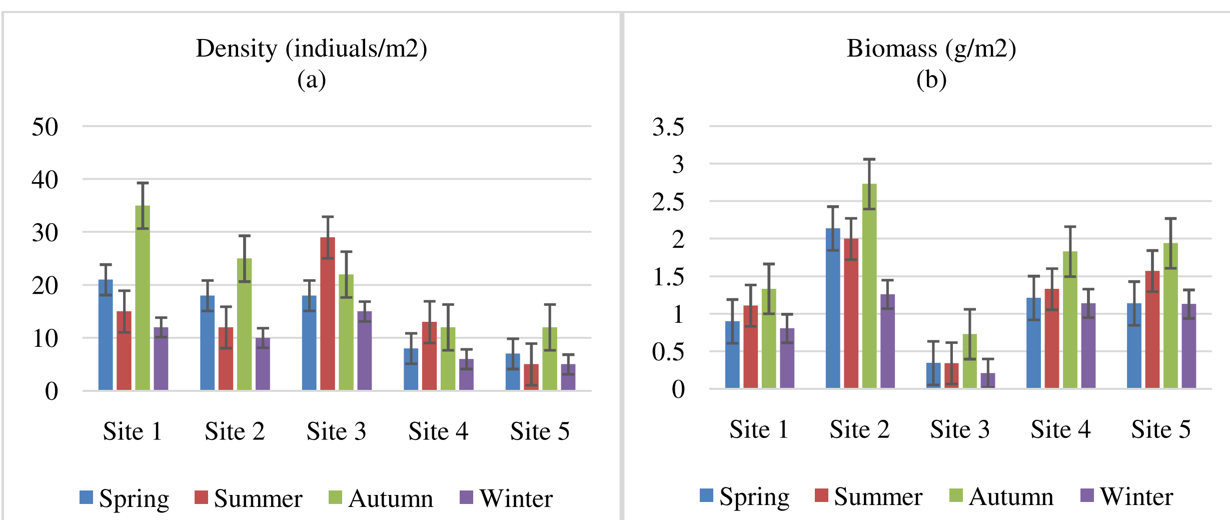

Figure-1
Density and biomass of earthworm at different sites during different seasons

The diversity indices are given Figure-3. Shannon diversity varied from 0.645 at site-IV to 0.1.12 at site-III, Simpson's showed a value of 0.453 at site 4 and 0.6 at site-III, evenness ranged from 0.953 at site-IV to 1.003 at site-III and Margalef exhibited a value between 0.151 at site-I to 0.679 at site-III. Shannon diversity index, Margalef species richness and evenness are higher at site-III and could be related to higher carbon, moisture and nitrogen content of soil. Similarly finding was also reported by Tripathi and Bhardwaj[49] as favorable edaphic characteristics increases the species diversity[1] and is supported with the findings that earthworm diversity exhibits positive correlation with soil moisture, organic carbon and nitrogen[7,50,51].

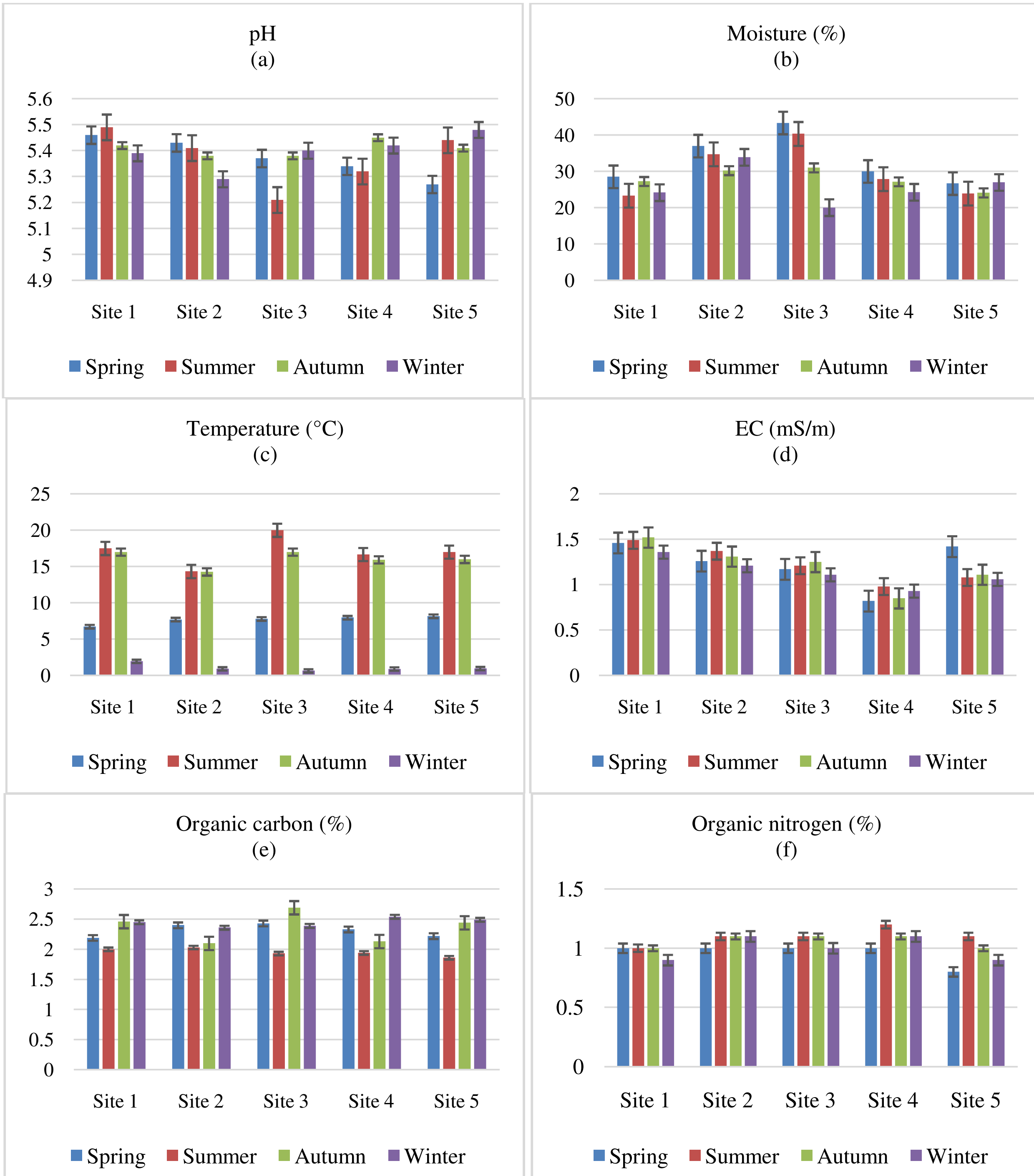

Figure-2
Soil physiochemical characteristics at different sites during different seasons

Table-1
Distribution of Earthworm species at various sites

Species	Family	Site-I	Site-II	Site-III	Site-IV	Site-V
Aporrectodea rosea rosea	Lumbricidae	+	+	+	+	+
Aporrectodea caloginosa trapezoides	Lumbricidae	+	+	+	+	+
Octalasion cyneum	Lumbricidae	-	-	+	-	-

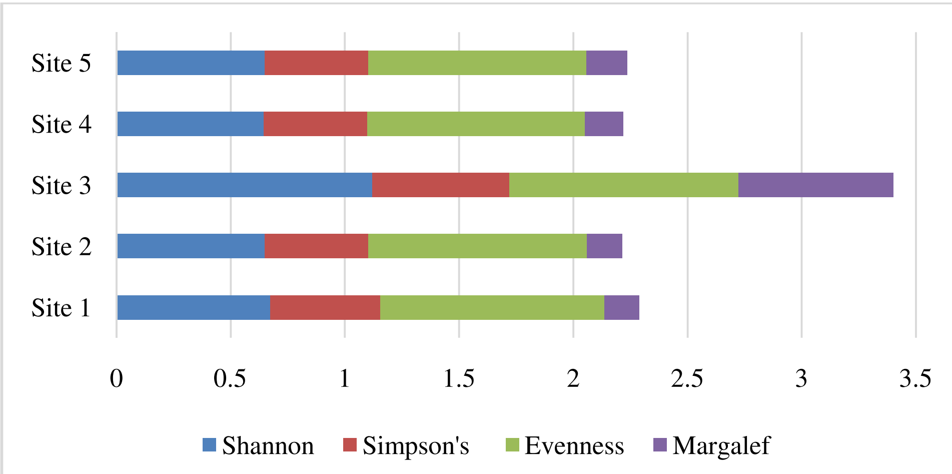

Figure-3
Diversity indices at different sites

Conclusion

The earthworm species reported in the study were endogeic (*A. r. rosea*, *O. cyaneum* and *A. c. trapezoides*. Species *A. c. trapezoids* and *A. r. rosea* exhibited a wide range of distribution and may be due tolerance to wide range of edaphic factors where as *O. cyaneum* exhibited restricted distribution as the species prefers specific edaphic factors such as low temperature and moderate moisture. Earthworm density and biomass varied among the sites and among seasons, thus seasons play important role in distribution of earthworms as it affects the soil physiochemical characteristics which in turn plays significant role in their population dynamics. Sites with optimum soil moisture, organic carbon and nitrogen favors the earthworms resulting in higher earthworm diversity.

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