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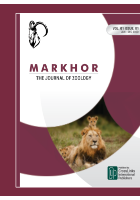

Original Article

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Impacts of Various Habitats, Soil Types, and the Range of Soil Physicochemical Variables on Earthworm Abundance Procured from the Poonch Division, Pakistan

Muhammad Umar Khan[1*], Saiqa Andleeb[2], Muhammad Fiaz Khan[1] and Rozina Ghulam Mustafa[2]

[1]Department of Zoology, Hazara University, Mansehra, Pakistan
[2]Department of Zoology, University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan

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***Corresponding Author:**
Muhammad Umar Khan
Department of Zoology, Hazara University, Mansehra, Pakistan
umar52218@gmail.com

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ABSTRACT

The present study concerns the effects of various habitats, soil types, and the range of soil physicochemical variables on the earthworm species obtained in Poonch division, Pakistan. **Objectives:** The study aimed to determine how various habitats, soils, and soil physicochemical situations influence the diversity and abundance of earthworm species. **Methods:** This study employed a descriptive observational design to examine the abundance and diversity of earthworm species across different habitats and soil types, alongside associated soil physicochemical properties, in Poonch Division, Pakistan. Earthworm species were collected by hand sorting and digging at 18 various study sites. **Results:** A total of (n = 11) species of earthworms, each belonging to eight genera and two families, were found. Out of them, the majority have been eminently found in municipal solid wastes, garden soil, and crop fields, whereas a few of them have a relatively high abundance in comparison to water resources, as compared to other species. These were various soil types observed, which are clay soil, debris soil, dry soil, loamy soil, moisture soil, and sandy soil, which also influences the availability of the earthworm species collected. Another study was the abundance of the earthworm in the various depths of soil. The proportion of the endogenic species was 38.7, epigenic 34.5, and Aneic species was 20.22, respectively. Also, the variety of physicochemical soil variables is different among the collected earthworm species. **Conclusions:** Current evidence shows that earthworm abundance depends on various habitats, the soil type, and abiotic entities of soils.

INTRODUCTION

The soils are an important natural resource that helps in sustaining millions of micro and macro-organisms, which are involved in biodegradation and soil-building activities, and this is how the biodiversity in the soils is explained. The biodiversity in the soil is important to human beings because it is the source of numerous ecosystem processes, functions, and services [1, 2]. The soil biodiversity above and below the earth not only interacts with each other, but they also mutually depend on each other [3]. The most significant species of the below-ground biodiversity is Earthworms, because of their significant contribution to soil sustainability [4]. The toxicity of the soils occupied by the earthworms determines their population density because the soil's texture determines other soil properties, the amount of soil, the nutrients at their disposal, and their Cation Exchange Capacity (CEC). An adequate number of earthworms is recorded in the light and medium soils of the loam compared with the sandy, clay, and alluvial soils [5]. Positive relationship where the content of the soil in terms of silt was seen to be related to the content of the earthworms [6]. In addition to that, the density of population of certain earthworm species, such as *Aporrectodea trapezoides*, *Aporrectodea rosea*, and

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Aporrectodea caliginosa were positively correlated to the soil clay content. The structure of the soil, including the pore size, has a very significant role in the distribution of the earthworms within the soil since any slight variation in either would cause severe imbalance in the community structure and distribution of the earthworms [7]. There is always a greater richness and diversity of the earthworm species in the continuous land, in comparison to the interrupted land, which is likely to increase with good availability of favorable soil conditions [8]. On natural land, soil health, soil moisture, soil pH, and soil organic matter are physicochemical properties of soil that impact the earthworm diversity and abundance. Conversely, the agricultural field is a disturbed land which also affects the earthworm distribution the most, along with pesticides, fertilizer, tillage, and the arrangement of the soil [9-11]. Earthworms have an impact on the biological processes of the soil and alter the degree of fertility in various ecological groups. The Anicic species survive at deep levels with mineral-enriched soil. On the contrary, the endogenic species exist in the upper layer of soil minerals, and the epigenic species inhabit the surface of the soil, making it necessary to determine the corresponding ecological class of a given earthworm species so that one can determine their effect on ecosystems [12]. The abundance of the earthworm in reference to the environment and soil composition has not been clearly studied in Pakistan.

The study aimed to examine the impact of habitat, soil type, and soil physicochemical properties on the abundance of earthworms in Poonch division, Pakistan, and to determine species-specific soil and habitat relationships.

METHODS

This study employed a descriptive observational design to examine the abundance and diversity of earthworm species across different habitats and soil types, alongside associated soil physicochemical properties, in Poonch Division, Pakistan. The study was conducted from March 2020 to March 2021. The earthworms were collected in the Poonch division of the administered Kashmir of the geographical coordinates of 33° 5132.18 0N and 73 o 45 34.93E at an approximate elevation of 1,638 m. Today, it consists of four districts, namely Bagh, Haveli, Poonch, and Sudhnoti. This study went to a total of four study sites in district Bagh, two in district Haveli, seven in district Poonch, and five in district Sudhnoti. The study area is highlighted in red, presenting four districts of the Poonch division (Figure 1).

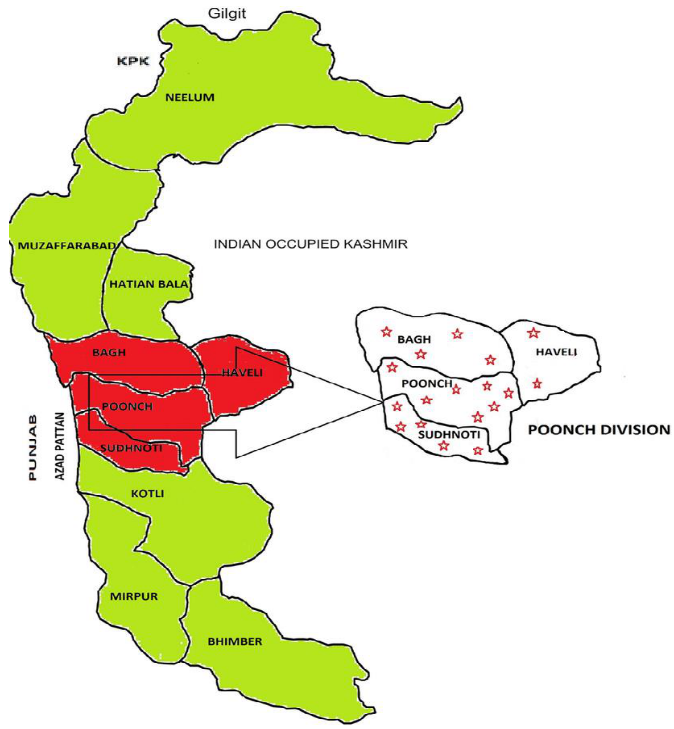

Figure 1: Map of Pakistan's Administered Kashmir, Illustrating the Study Area Along with the Study Sites

An (n = 5) plot was placed in all the localities of the study area in order to sample the earthworms, and they were typically sampled weekly by excavations based on the quadrate (5x5 square feet) technique. The visible persons were also collected using the hand sorting method [13]. The soil was divided into (0-15, 15- 30, 30-45, and 45- 60 cm) layers, abundance of earthworms and their density in different layers in terms of m2 were noted. The sampling sites were sampled based on the road connections that could be made, and at least 10-15 km distance between them, and the maximum area of the sampling site was covered. In addition, based on the convenience of data collection, the sampling sites were divided into a varying number of localities based on the total area of the site. The various habitats that were used in making collections in every locality included the crop fields, municipal solid waste, cow dung dumped area, proximity to river area, springs, stagnant water, and garden soil. Earthworm species were collected, then we placed them in plastic bags within soil, and also labeled the site, locality, and date of collection. The earthworm species collected were transferred to the Biochemistry lab, Department of Zoology, University of Azad Jammu and Kashmir, Muzaffarabad, and put in water for nearly 24 hrs. When the earthworm species were washed using tap water, it was done so as to clear the gut of the earthworms and to eliminate impurities as well as mud on the earthworm surfaces. Photographs were made after the washing of the samples and left in a 10.0 % formalin so as to harden the

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specimen, and it took 24 hours. A 5.0% solution of formalin was used as a permanent preservative [14]. Sample soil in every quadrat was gathered through digging with a plastic tube, and about 2g of soil was collected as the sample. Several physicochemical characteristics of the soil, such as temperature, soil type, pH, organic matter content (OM), and the percentage of nitrogen (N%), potassium (K%), and phosphorus (P%), available were also ascertained. The soil pH was determined with the help of Luster Leaf Rapitest pH meter (chassis no. 716750 1840), soil moisture content, and temperature were also measured with the help of dial thermo-hygrometer (VWR). Determination of organic matter and percent nitrogen (N%) was by the Walkley and Black method, according to a standard procedure, in which a sample of approximately 1 gm of soil was taken in a 250 ml conical flask and then 10 ml of K2Cr2O7 and 20 ml of Conc. H2SO4 was added, and the flask was allowed to stand at room temperature for nearly half an hour. Diphenylamine indicator (1 ml) and conc. H2SO4 (10 ml) and 150 ml of distilled water were then added to the solution. The solution resulting was finally titrated with Mohr salt taken in a burette. The measurements were also taken at the beginning and at the end so as to estimate the total organic matter and percentage of nitrogen in the soil sample. Potassium, as available in soil (K), was identified by employing the ammonium acetate extraction, which involved the treatment of 1 g of soil with around 20 mL of ammonium acetate solution. The sample was then shaken gently for 30 minutes, and the extract was filtered, and the potassium concentration was then measured through a flame photometer. To analyze phosphorus, 1 g of soil was dissolved in 20 mL of sodium bicarbonate (NaHCO3) solution and swirled in an incubator over the course of 30 minutes. The suspension was then filtered using Whatman filter paper, with 5 mL of the filtrate being transferred to a 25mL conical flask. With this aliquot, 5 mL of a colour-developing reagent was reacted, and absorbance was measured on a spectrophotometer.

RESULTS

In the survey of 2019-2020, eleven species of earthworms were reported in the area, belonging to six genera and two families. Among them, seven species, Amynthas corticis, *A. gracilis*, *A. morrisi*, *A. moniliatus*, *A. hupeiensis*, *Perionyx excavatus*, and *Lampito mauritii*, were included in the family Megascolecidae, and four species, *Eisenia fetida*, *Eophila tellinii*, *Aporrectodea trapezoides*, and *Aporrectodea longa*, were placed in the family Lumbricidae. Some species, like *E. fetida*, *A. hupeiensis*, *A. corticis*, *A. longa*, *P. excavatus*, and *L. mauritii*, were very often found at the municipal solid waste sites. *A. morrisi*, *A. moniliatus*, and *E. tellinii*, on the other hand, were more commonly found in garden soils, with *A. gracilis* being the most abundant in agricultural fields. The majority of species were rarely reported in cow dung habitats, except *E. fetida. In addition*, *A. morrisi*, *A. moniliatus*, and *A. hupeiensis* were more abundant near water bodies. Interestingly, *E. fetida* showed a definite correlation with the anthropogenic settings, especially the municipal waste and cow dung locations. The Soil Types are Highlighted by Different Colors in the Figure (Figure 2).

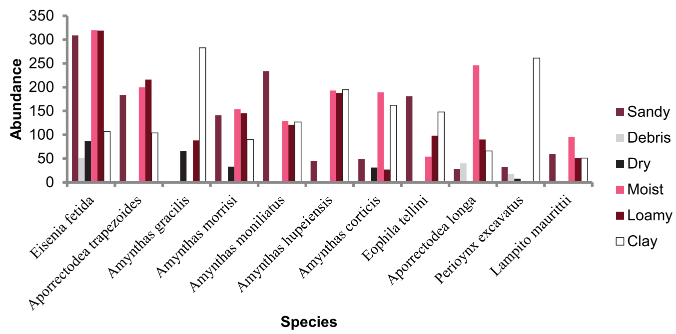

Figure 2: The Abundance of Different Identified Earthworm Species in the Various Soil Types of the Study Area

The detailed counts and overall abundance of the identified earthworm species across municipal solid waste, cow dung, water-adjacent areas, garden soil, and crop fields are summarized (Table 1).

Table 1: Abundance of Earthworm Species in Different Habitats of Poonch Division

Species	Municipal Solid Waste	Cow Dung	Near Water	Garden Soil	Crop Fields	Overall Abundance (%)
Eisenia fetida	375	360	60	145	240	16.89%
Aporrectodea trapezoides	170	175	80	240	180	12.09%
Amynthas gracilis	75	98	40	125	159	4.98%
Amynthas morrisi	145	85	128	170	120	7.11%
Amynthas moniliatus	145	125	130	160	112	9.61%
Amynthas hupeiensis	148	40	120	127	112	7.82%
Amynthas corticis	170	60	170	110	174	9.79%
Eophila tellinii	165	102	62	185	125	9.14%
Aporrectodea longa	142	105	50	120	175	8.47%
Perionyx excavatus	125	105	74	86	46	6.24%
Lampito mauritii	153	48	0	19	26	3.52%

Different soil types recorded in the study—sandy, debris, dry, moist, loamy, and clay—affected the abundance of earthworm species. Species like *E. fetida*, *A. trapezoides*, *A. longa*, and *A. morrisi* were more abundant in sandy, moist, and loamy soils, whereas *A. gracilis*, *P. excavatus*, and *E. tellinii* were predominantly found in clay soils. Dry and debris soils harbored very few earthworms. Analysis of soil

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depth preferences showed that among the eleven species, endogeic species accounted for 38.7% (*A. trapezoides*, *A. corticis*, *A. gracilis*, *A. morrisi*, *A. moniliatus*), epigeic species 34.5% (*E. fetida*, *P. excavatus*, *E. tellinii*), and anecic species 20.22% (*A. hupeiensis*, *A. longa*, *L. mauritii*) (Figure 3).

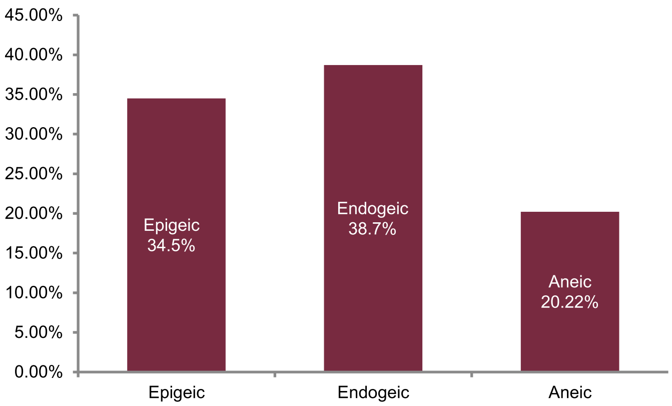

Figure 3: Percentage of the Abundance of Different Categories of Earthworms Recorded in Different Soil Depthsof Poonch Division

The range of physicochemical soil variables for the different earthworm species is presented in table 2. Most species were found in slightly acidic to slightly alkaline soils, except *L. mauritii*, which was confined to slightly acidic soils. Maximum soil moisture (38.2–55%) was recorded for *E. fetida*, *A. trapezoides*, *A. moniliatus*, *A. hupeiensis*, and *A. longa*, while the highest soil temperature (26.2–33°C) was observed for *A. trapezoides* and *A. corticis*. Certain species, including *A. morrisi*, *A. moniliatus*, and *A. hupeiensis*, were found in sites with high organic matter (1.22–4.9), whereas *E. fetida*, *A. gracilis*, *A. morrisi*, and *L. mauritii* were in sites with high soil nitrogen (0.05–4.23%). High soil phosphorus (0.001–0.035%) was noted for *E. fetida*, *A. trapezoides*, *A. moniliatus*, and *A. longa*, while high soil potassium (0.004–0.032%) was recorded for *E. tellinii* and *P. excavates* (Table 2).

Table 2: Soil Physicochemical Parameter Ranges Associated with the Distribution of Recorded Earthworm Species

Species	pH	Moisture (%)	Temp (°C)	OM	n (%)	P (%)	K (%)
Eisenia fetida	6.8–7.12	38.2–55	27–33	1.4–4.9	0.05–4.23	0.001–0.035	0.007–0.031
Aporrectodea trapezoides	6.8–7.12	38.2–55	26.2–33	1.3–4.9	0.06–4.23	0.001–0.035	0.006–0.031
Amynthas gracilis	6.81–7.1	42.2–55	28.14–30.4	1.72–4.7	0.05–4.23	0.002–0.0035	0.006–0.031
Amynthas morrisi	6.8–7.03	42.2–55	26.2–31	1.22–4.9	0.05–4.23	0.001–0.006	0.004–0.031
Amynthas moniliatus	6.8–7.12	38.2–54	27–33	1.22–4.9	0.06–3.83	0.001–0.035	0.004–0.021
Amynthas hupeiensis	6.8–7.03	38.2–55	27–31	1.22–4.9	0.06–4.23	0.001–0.006	0.004–0.021
Amynthas corticis	6.8–7.1	42.2–54	26.2–33	1.4–4.9	0.05–2.24	0.001–0.006	0.007–0.021
Eophila tellinii	6.8–7.1	44–55	26.2–31.25	1.22–4.9	0.06–4.23	0.002–0.009	0.004–0.032
Aporrectodea longa	6.8–7.12	38.2–54	27–31	1.3–4.9	0.06–2.24	0.001–0.035	0.007–0.032
Perionyx excavatus	6.8–7.1	42.2–52.3	28–31.25	1.22–3.21	0.05–1.65	0.002–0.006	0.004–0.032
Lampito mauritii	6.8–6.94	42.2–55	28–30.4	1.97–4.7	0.05–4.23	0.003–0.006	0.007–0.031

DISCUSSION

E. fetida was also found to prefer artificial dwelling, which agrees with another previous research done by Kousar *et al.* and Kavle *et al.* [14, 15]. Abundance differences with Vodounnou *et al.* may be a result of regional differences in the availability of habitats [16]. Other species, such as *P. excavatus* and *L. mauritii*, were also found to flourish in municipal solid waste, which was in agreement with Kuma *et al.* [17]. It has a moderate occurrence of *A. morrisi* around waterways, which is congruent with Thounaojam *et al.* [18]. The abundance difference between soil types shows a preference for certain species in organic content and moisture. Some of the studies indicated that *A. hippieness* prefers sandy soils on riverbanks, although in this work, it is distributed in a more extensive area, probably due to the presence of accumulated organic matter in gardens and crop fields [19]. The texture of soils also had a great impact on the distribution of species, with dry and debris soils being unfavorable to most of the species. There were species functional groups which are consistent with ecological theory: endogeic species live in deep layers of soil, epigeic species are parasites, and anecic species burrow. The changes in physicochemical ranges of the soils were mostly observed to vary depending on the local climate and land use, as well as the agricultural activities. Comparison with the previous literature was found to be generally agreeable on pH tolerance as well as soil nutrient preferences, but organic matter and moisture tolerance were found to be divergent [20]. In general, species distribution, soil type, and physicochemical characteristics have a combined impact on the abundance and ecological distribution of earthworms in the Poonch division, which supports the need for habitat-specific management methods to preserve the soil biodiversity.

CONCLUSIONS

On the basis of the present findings, we concluded that the municipal solid wastes and gardens are considered suitable habitats for most of the earthworm species as compared to near-water areas. Moreover, the abundance of different earthworm species was comparatively higher in loamy, moist, and clay soil types than in dry and debris soils. The endogeic earthworms were predominantly found in the study area, while aneic species had the least abundance. Additionally, the range of soil physicochemical

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variables also varies among the collected earthworm species. The present study only presents baseline data about the ecological interactions of different earthworm species; however, a multidimensional research approach is needed for a deeper analysis.

Authors Contribution

Conceptualization: MUK
Methodology: MUK, SA
Formal analysis: SA
Writing and Drafting: MFK, RGM
Review and Editing: MUK, SA, MFK, RGM

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

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