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Research Paper

# Seasonal Density of Earthworm Fauna Inhabiting Vegetable Fields Near Buddha Nullah, District Ludhiana, Punjab, India

Zoology

**KEYWORDS :** Earthworm diversity, Physico-chemical parameters, Population density, Vegetable crops.

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## ABSTRACT

*The present study was aimed to explore the diversity, distribution and seasonal population density of earthworms inhabiting vegetable crop fields in the vicinity of Buddha Nullah. Fortnightly collection of earthworms from the vegetable fields at four selected villages adjoining Buddha Nullah and reference fields at Punjab Agricultural University (PAU) campus from March 2013 to February 2014 indicated the presence of three species of earthworms belonging to family Megascolecidae these were Metaphire posthuma (Vaillant), Metaphire peguana (Rosa) and Lampito mauritii Kinberg. All these species showed their significant abundance during rainy season (July to October 2013) at all the sites. During the rainy season soil moisture content was found to be highest (ranging from 28.10 to 32.73%) along with higher contents of organic matter and organic carbon. Soil pH was towards alkaline nature (7.87 to 8.79) throughout the study areas. All the soil parameters studied showed statistically non- significant difference at sites selected near Buddha Nullah and the reference site at PAU.*

## INTRODUCTION

Earthworms are among the most important components of soil biota in terms of soil formation and maintenance of soil structure and fertility (Bhadauria and Saxena 2010). Although not numerically dominant, their size makes them one of the major contributors to invertebrate biomass in soils (Edwards 2004). They have been recognised as the most important soil engineers because they are prominently involved in regulating soil processes (Lavelle *et al* 1997, Santra and Bhowmik 2001). Approximately 4,400 species of earthworms have been identified worldwide (Sinha 2009,Tsai *et al* 2000, Blakemore 2003, Chang and Chen 2005, Blakemore *et al* 2006, Sautter *et al* 2006). Julka *et al* 2009 reported 590 species of earthworms from India. Twenty species of earthworms have been recorded from Punjab and the Union Territory of Chandigarh belonging to six families distributed evenly throughout the region (Dhiman and Battish 2006). The present study was conducted to explore the diversity, distribution and seasonal population density of earthworms from vegetable crop fields in the vicinity of Buddha Nullah, district Ludhiana, Punjab (India).

Buddha Nullah is a seasonal water stream which is highly contaminated with domestic and industrial sewage and runs through the Malwa region of Punjab, after passing through the highly populated and industrialized district Ludhiana. Hundreds of tonnes of raw sewage from Ludhiana flow into the river Sutlej every day and are distributed all over the state through irrigation canals (Anonymous, 2008). According to the State Department of Fisheries, the pollution of the Buddha Nullah has led to drastic reductions in fish yields in the river Sutlej (Prashar 1997). A great proportion (80%) of biomass of terrestrial invertebrates is constituted by earthworms which play an important role in structuring and increasing the nutrient content of the soil. Therefore, they can be suitable bioindicators of chemical contamination of the soil in terrestrial ecosystems, providing an early warning of deterioration of soil quality (Bustos and Goicochea 2002).

## MATERIALS AND METHODS

Four vegetable crop fields situated at an average distance of 2-3 km from Buddha Nullah were selected to conduct the present study; these were named Site I (Dairian village), Site II (Jassian village), Site III (Choorpur village), and Site IV (Balloke village). Another site (V) was selected at Punjab Agricultural University vegetable farms as a reference. Earthworms were collected from vegetable fields fortnightly from March 2013 to February 2014. The data were compiled by season i.e., summer (March-June), rainy (July- October), and winter (November- February). Five spots per field (three half-acre fields per village,) were dug randomly (each spot = 25 x 25 x 50 cm) and hand sorted to collect earthworms. Live worms were brought to the laboratory for identification. For diagnostic and taxonomic characteristics, some earthworms were narcotized in 30% ethyl alcohol and fixed in 10% formalin for 24 hours and the rest were finally preserved in 10% formalin. These earthworms were identified to species using monographs (Gates 1972, Julka 1988). Then the identification of all the collected species was confirmed by the Zoological Survey of India Solan and the Zoological Survey of India Kolkata. Samples were collected from one square meter marked area and the number of different earthworm species were recorded per square meter area for studying the seasonal variation in relative abundance of different earthworm species was reported at study sites. The physico- chemical properties of soil from each sampling site were also analysed. Soil pH was measured by the potentiometric method (Jackson 1973), soil texture by the international pipette method (Gee and Bauder 1986), temperature at 0-15 cm depth by soil thermometer, soil moisture by oven drying at 105°C, and organic carbon and organic matter by the method of Walkley and Black (1934). The chi-square test was used to analyse the relationship among earthworm species distribution and density. The Pearson correlation was employed seasonally to find relationships between physico-chemical parameters and earthworm density. Analyses were done with SPSS version 16.0 program for windows.

## RESULTS

The total earthworm counts recorded during the one year study period were 526, 450, 413, 456 and 586 from study sites I, II, III, IV and V (reference site) respectively. The largest number of earthworms was collected from reference site V and their count was significantly different from the other four sites (Table 1). From all these sites three species of earthworms, i.e., *Metaphire posthuma* (Valliant), *Lampito mauritii* (Kinberg) and *Metaphire peguana* (Rosa) belonging to family Megascolecidae, were found as reported previously by Koul *et al* (2015). From a seasonal analysis of the data, a significantly high number ( at 1% and 5% level of significance) of earthworms / $m^2$ were observed during the rainy season compared to summer and winter seasons at all study sites. During the rainy season, population count of earthworms was 345, 285, 239, 309 and 375 at sites I, II, III, IV and V respectively.Earthworm density in summer was lower than in the rainy season and the winter season showed few earthworms at any sites. Even density by species was higher during the rainy season followed by summer then winter (Table1).

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Overall distribution of three earthworm species indicated that *M. posthuma* was predominant having relative abundance at the five sites ranging from 42.5% to 50.8%. The other species, *L. mauritii* and *M. peguana,* showed relative abundance ranging from 24.8% to 29.2% and 20.2% to 30.0% respectively (Fig.1). Species density (earthworms / $m^2$) at all sites showed highest average value of *M. posthuma* followed by *L. mauritii* and least of *M. peguana* (Table 2). Data calculations indicated higher number of earthworms / $m^2$ during rainy season at all the sites i.e. 8.63±0.39, 7.13±0.38, 5.98±0.36, 7.73±0.34 and 9.38±0.42 at sites I, II, III, IV and V respectively as compared to the other seasons. This density / $m^2$ in rainy season was followed by the one during summer and then during winter at all the sites (Table 2). Even species wise count /$m^2$ also indicated maximum number of the three identified species during the rainy season at all the sites. Site V- PAU (reference site) showed the maximum number of total earthworm /$m^2$ and also different species of earthworms/ $m^2$ as compared to the other four sites studied in the vicinity of Buddha Nullah (Table 2).

Seasonal recording of various soil parameters like moisture, temperature, pH, organic matter and organic carbon was also carried out. Results indicated that soil moisture was highest during the rainy season at all the sites with its percent value as 29.51±4.48, 28.10±3.90, 32.73 ±6.38, 28.96±4.23 and 32.51±3.90, at site I, II, III, IV and V respectively, thus showing no significant difference in moisture content of soils at different selected sites (Table 3). High soil moisture content in the rainy season was followed by winter and the lowest moisture was found during summer season at all the sites (Table 3). Soil temperature at all the sites showed its highest value during rainy season as it was recorded to range from 29.70±1.08 to 29.82±1.07, followed by summer (25.89±3.11 to 26.55±2.76) then winter season (12.20±1.01to 12.33±1.01 ºC; Table 3). The pH of soil was alkaline at all the sites and ranged from 7.87±0.07 to 8.79±0.06 throughout the year, with minor variation at different sites. Two other parameters of soil, organic matter and organic carbon, showed almost similar range during different seasons and at various selected sites. All the soil parameters recorded during the present study showed statistically non- significant differences among sites I, II, III and IV in the vicinity of Buddha Nullah in comparison to site V, the reference site at PAU (Table 3). The correlation studies between earthworm population density and various physico-chemical parameters showed significant positive correlation with soil temperature and moisture during summer and rainy seasons. Out of five soil parameters tested, summer temperatures showed significantly positive correlation with earthworm density at all sites (α=5%). Rainy season temperatures correlated positively and significantly at sites IV and V. Rainy season soil moisture correlated positively with earthworm density at sites II, III, and V. However other soil parameters showed statistically non-significant correlation with earthworm population (Table 4).

## DISCUSSION

Density of earthworms in a particular ecosystem is the result of interactions among a number of edaphic factors (Valle *et al* 1997). Soil habitat microclimatic or abiotic factors like moisture, temperature, pH, organic matter and organic carbon affect earthworm populations . Among various soil parameters, soil moisture plays a significant role in the occurrence and distribution of earthworm species. The highest number of all the earthworm species in the present study was observed in the rainy season, when soil moisture was maximal. Higher number of earthworms during the wet period of the year and the importance of soil moisture in relation to cocoon production, hatching and emergence pattern of earthworms has also been reported by various researcher in India (Dash and Senapati 1980, Haokip and Singh 2012, Mohan *et al* 2013). Rainfall together with relative humidity during the rainy season lead to an increased population of earthworms. Low rainfall and soil moisture in winter and summer probably decrease the population of earthworms which is consistent with the results of the present study. Thus, soil moisture content plays a major role in the fluctuation patterns of the earthworm population. The second important parameter studied was soil temperature, as the appropriate range of temperature (generally from 25-30ºC) favours reproduction of earthworms (Edwards and Bohlen 1996, Sautter *et al* 2006). However, low soil temperature may reduce earthworm population, because in winter hatching of cocoons is delayed (Timmerman *et al* 2006). The low count of earthworms in winter observed at all the sites during the present study is thus because of low temperature of soil, as also supported by Ghafoor *et al* (2008).

Earthworms generally prefer neutral soils having pH near 7.0, but some can tolerate acidic or alkaline soils also. The soil pH value recorded from various study sites varied from 7.90-8.79, which is within the range for the distribution of earthworms (Chaudhuri and Bhattacharjee 1999). The population of earthworms in an ecosystem is related to the availability of surplus organic and inorganic food in the soil in the form of organic matter and organic carbon. The values of these two parameters were higher during the rainy season as compared to summer and winter at all the study sites. High status of organic carbon and organic matter during the rainy season may be due to higher decomposition rate of litter and availability of favourable microclimatic conditions like optimum moisture content and temperature of soil, which enhance decomposition during the rainy season and in turn result in higher populations of earthworms (Haokip and Singh 2012). During the present study soil parameters of soil like moisture, temperature, pH, OM and OC were not found to differ at selected four sites near Buddha Nullah and the reference site at PAU, but the population density of total earthworms as well as three species of earthworms were found to be higher at reference site -PAU. Previous reports have indicated the contamination of Budhha Nullah stream with domestic and industrial wastes and heavy metals being added by the dyeing industries (Prashar 1997, Anonymous 2008), due to which the vegetable fields in the vicinity of Budhha Nullah have been found to be contaminated with high levels of heavy metals especially cadmium, nickel and lead (Kaur and Sangha 2014) . Thus low population density of earthworms in the vegetable fields near Buddha Nalla compared to the reference site at PAU may be attributed to heavy metal contamination at Buddha Nullah site, which needs to be further explored.

## CONCLUSIONS

Three species of earthworms belonging to family Megascolecidae (*M. posthuma, L. mauritii* and *M. peguana*) were found in the study sites. Maximum earthworm abundance was observed during the rainy season because of favourable soil moisture, temperature and organic matter. Population density of earthworms vary significantly among the seasons, thus climate and physico-chemical characteristics of soil play a significant role in earthworm distribution and their density.

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**Table 1. Total seasonal population count of earthworm species at different study sites.**

| Sites | Seasons | Number of earthworms | | | Total (n=120) | Grand Total | Chai Square Value |
|---|---|---|---|---|---|---|---|
| | | *M. posthuma* | *M.peguana* | *L.mauritii* | | | |
| Site I | Summer | 94 | 31 | 45 | 170 | 526 | 9.78* |
| | Rainy | 171 | 75 | 99 | 345 | | |
| | Winter | 2 | 6 | 3 | 11 | | |
| Site II | Summer | 76 | 26 | 51 | 153 | 450 | **14.94**** |
| | Rainy | 145 | 83 | 57 | 285 | | |
| | Winter | 7 | 1 | 4 | 12 | | |
| Site III | Summer | 74 | 42 | 45 | 161 | 413 | 12.24* |
| | Rainy | 105 | 72 | 62 | 239 | | |
| | Winter | 3 | 7 | 3 | 13 | | |
| Site IV | Summer | 86 | 19 | 41 | 146 | 456 | 12.07* |
| | Rainy | 145 | 72 | 92 | 309 | | |
| | Winter | 0 | 1 | 0 | 1 | | |
| Site V | Summer | 77 | 61 | 68 | 206 | 586[s] | 7.09* |
| | Rainy | 169 | 113 | 93 | 375 | | |
| | Winter | 3 | 2 | 0 | 5 | | |

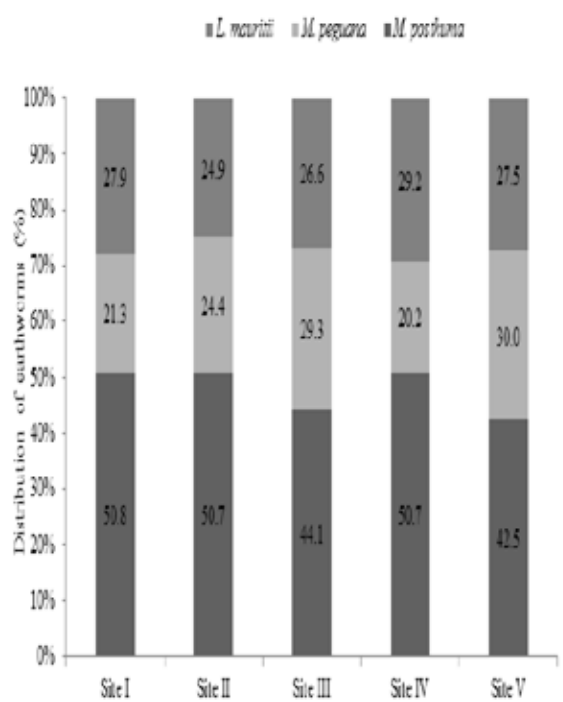
- Site I- Dairian Village, Site II– Jassian Village, Site III- Choorpur Village, Site IV-Balloke Village and Site V-PAU (reference site)

- n represents the number of times samples taken / $m^2$

- **S** refers to the significant difference in earthworm's total count at reference Site V as compared to other four sites

- *Values are significant during rainy season at 5% level of significance ($p<0.05$)

- **Values are significant during rainy season at 1% level of significance ($p<0.01$)




Site I- Dairian Village, Site II- Jassian Village, Site III- Choorpur Village, Site IV- Balloke Village, Site V- PAU (reference site)

**Fig. 1. Overall distribution of earthworms at different study sites.**

**Table 2. Seasonal population density of earthworm species at different study sites.**

| **Earthworm species (/$m^2$)** | **Sites** | **Seasons** | | |
|---|---|---|---|---|
| | | Summer | Rainy | Winter |
| *M.posthuma* | Site I | 2.35±0.34[S] | 4.28±0.47 | 0.05±0.05[S] |
| | Site II | 1.90±0.32[S] | 3.36±0.46 | 0.18±0.07[S] |
| | Site III | 1.85±0.30 | 2.63±0.51 | 0.08±0.05[S] |
| | Site IV | 2.15±0.29 | 3.63±0.45 | 0.00±0.00[S] |
| | Site V | 1.93±0.29[S] | 4.23±0.54 | 0.08±0.04[S] |
| *M.peguana* | Site I | 0.78±0.16 | 1.88±0.22 | 0.15±0.07[S] |
| | Site II | 0.65±0.14[S] | 2.08±0.37 | 0.03±0.03[S] |
| | Site III | 1.05±0.18 | 1.80±0.25 | 0.18±0.11[S] |
| | Site IV | 0.48±0.10[S] | 1.80±0.24 | 0.03±0.03[S] |
| | Site V | 1.53±0.21[S] | 2.83±0.35 | 0.05±0.03[S] |
| *L.mauritii* | Site I | 1.13±0.22 | 2.48±0.35 | 0.08±0.06[S] |
| | Site II | 1.28±0.27 | 1.43±0.19 | 0.10±0.06[S] |
| | Site III | 1.13±0.29 | 1.55±0.22 | 0.08±0.05[S] |
| | Site IV | 1.03±0.17 | 2.30±0.23 | 0.00±0.00[S] |
| | Site V | 1.70±0.33 | 2.33±0.25 | 0.00±0.00[S] |
| Total | Site I | 4.25±0.27[S] | 8.63±0.39 | 0.28±0.06[S] |
| | Site II | 3.83±0.26[S] | 7.13±0.38 | 0.30±0.06[S] |
| | Site III | 4.03±0.27 | 5.98±0.36 | 0.33±0.06[S] |
| | Site IV | 3.65±0.23[S] | 7.73±0.34 | 0.03±0.01[S] |
| | Site V | 5.15±0.28[S] | 9.38±0.42 | 0.13±0.03[S] |

- Site I- Dairian Village, Site II– Jassian Village, Site III- Choorpur Village, Site IV-Balloke Village and Site V-PAU (reference site),
- S refers statistically significant difference of values during that particular season in comparison to rainy season

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**Table 3. Physico-chemical parameters of soil from vegetable fields at selected sites of district Ludhiana during different seasons.**

| Parameters | Sites | Seasons | | |
|---|---|---|---|---|
| | | Summer | Rainy | Winter |
| Moisture (%) | Site I | 16.15±1.15 | 29.51±4.48 | 21.13±1.06 |
| | Site II | 16.56±1.17 | 28.10±3.90 | 21.65±1.53 |
| | Site III | 17.14±0.87 | 32.73±6.38 | 21.49±1.09 |
| | Site IV | 17.27±1.10 | 28.96±4.23 | 22.62±1.20 |
| | Site V | 17.66±0.80 $^{NS}$ | 32.51±3.90 $^{NS}$ | 22.16±0.99 $^{NS}$ |
| Temperature ($^0$C) | Site I | 25.89±3.11 | 29.70±1.08 | 12.33±1.01 |
| | Site II | 25.93±3.10 | 29.73±1.08 | 12.27±1.01 |
| | Site III | 25.89±3.12 | 29.82±1.07 | 12.22±1.02 |
| | Site IV | 26.55±2.76 | 29.78±1.08 | 12.20±1.01 |
| | Site V | 25.93±3.12$^{NS}$ | 29.76±1.09$^{NS}$ | 12.22±1.01$^{NS}$ |
| pH | Site I | 8.53±0.05 | 7.97±0.07 | 8.79±0.06 |
| | Site II | 8.40±0.19 | 8.27±0.11 | 8.16±0.14 |
| | Site III | 8.20±0.12 | 7.90±0.04 | 7.87±0.12 |
| | Site IV | 8.73±0.05 | 8.30±0.04 | 8.27±0.07 |
| | Site V | 8.83±0.14 $^{NS}$ | 8.37±0.11$^{NS}$ | 8.73±0.10$^{NS}$ |
| Organic matter (%) | Site I | 1.32±0.08 | 1.31±0.12 | 1.31±0.14 |
| | Site II | 1.20±0.10 | 0.99±0.04 | 1.12±0.11 |
| | Site III | 1.18±0.04 | 1.32±0.13 | 1.13±0.11 |
| | Site IV | 0.74±0.05 | 1.06±0.06 | 0.73±0.04 |
| | Site V | 1.25±0.06$^{NS}$ | 1.41±0.04$^{NS}$ | 1.41±0.09$^{NS}$ |
| Organic carbon (%) | Site I | 0.77 ± 0.05 | 0.76 ± 0.07 | 0.76± 0.08 |
| | Site II | 0.70 ± 0.12 | 0.58 ± 0.02 | 0.65± 0.04 |
| | Site III | 0.69±0.02 | 0.77±0.07 | 0.66±0.06 |
| | Site IV | 0.43±0.02 | 0.62±0.04 | 0.43±0.03 |
| | Site V | 0.73±0.04$^{NS}$ | 0.82±0.05$^{NS}$ | 0.82±0.08$^{NS}$ |

- Site I- Dairian Village, Site II– Jassian Village, Site III- Choorpur Village, Site IV-Balloke Village and Site V-PAU (reference site)
- NS- refers statistically non-significant difference of values at sites I, II, III and IV in comparison to site V (reference site)

**Table 4: Seasonal correlation studies between population density of earthworm (m$^2$) with physio-chemical paramaters at different study sites.**

| Parameters | Sites | Correlation coefficient | | |
|---|---|---|---|---|
| | | Summer | Rainy | Winter |
| Moisture (%) | Site I | 0.092 | 0.707 | -0.338 |
| | Site II | 0.024 | 0.895** | -0.180 |
| | Site III | 0.116 | 0.791* | -0.279 |
| | Site IV | 0.450 | 0.676 | -0.395 |
| | Site V | 0.150 | 0.792* | -0.407 |
| Temperature ($^0$C) | Site I | 0.944** | 0.365 | 0.567 |
| | Site II | 0.926** | 0.609 | 0.494 |
| | Site III | 0.929** | 0.692 | 0.402 |
| | Site IV | 0.895* | 0.740* | 0.495 |
| | Site V | 0.926** | 0.734* | 0.511 |
| pH | Site I | 0.082 | 0.266 | -0.024 |
| | Site II | -0.079 | 0.117 | -0.000 |
| | Site III | -0.034 | 0.051 | -0.107 |
| | Site IV | -0.077 | 0.085 | -0.098 |
| | Site V | 0.077 | 0.082 | -0.414 |
| Organic matter (%) | Site I | -0.058 | 0.440 | 0.167 |
| | Site II | -0.049 | -0.086 | 0.510 |
| | Site III | -0.153 | 0.070 | 0.479 |
| | Site IV | -0.108 | 0.198 | 0.436 |
| | Site V | -0.095 | 0.092 | 0.056 |
| Organic carbon (%) | Site I | -0.058 | 0.440 | 0.167 |
| | Site II | -0.049 | -0.086 | 0.510 |
| | Site III | -0.153 | 0.070 | 0.479 |
| | Site IV | -0.108 | 0.198 | 0.436 |
| | Site V | -0.095 | 0.092 | 0.056 |

- Site I- Dairian Village, Site II– Jassian Village, Site III- Choorpur Village, Site IV-Balloke Village and Site V-PAU (reference site)
- *Values are significant during rainy season at 5% level of significance (p<0.05)
- **Values are significant during rainy season at 1% level of significance (p<0.01)

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