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Biodiversity of Soil Arthropods of Bhagwan Birsa Zoological Park, Ranchi, Jharkhand

Anupama Singh, AmitaHembrom & Braj Kishore Sinha
Deptt of Zoology, S S M College, Ranchi University, Ranchi
Email: b_kishoresinha@yahoo.co.in

Abstract : The study aimsto measure the biodiversity, abundance and diversity of soil arthropod community of zoological parks. The surface soils of five stations of the BhagwanBirsa Zoological Park were collected by set ecological methods by standardized unit cells of quadrate and corers. Quantity and quality of the soil arthropods were assessed (Density, abundance, Importance value index (IVI) and Shannon diversity index–H'). The chemical and physical characteristics of the soil differed little in all the stations. The density of the texaincreased during rains and diversity index ranges from2.1 to 2.2. The important taxa were Isoptera, Coleoptera, Hymenoptera, Acari, Collembolans, especially the Entomobryomorpha and Poduromorpha.

Keywords: Biodiversity, soil arthropods, zoological park, quadrates, corer, relative abundance, Shannon diversity index

Introduction

Biological parks are created for ex-situconservation of flora and fauna (Agrawal, 1998; Singh, Singh, & Gupta, 2008).BhagwanBirsa Biological Park (BBBP) – commonly called as BirsaMunda Zoological Park, Ranchi is no exception to this dictum and it also provide interface to the people in order to generate awareness.The park has been setup in a pristine sal (*Shorearobusta*) forest.The habitat and soil fauna conservation is byproduct conservation management practices, which unknowingly provides protection and maintenance of gene pool of macro, meso and micro soil arthropods.

According to Edgar (1992), soil is a complex system, depending on the size, arrangement of the soil particles, availability of air, water, and available nutrients,determines what different groups of living organisms will live successfully there. Further, it is hypothesized that normally, in the forest floors (in our case the park), fresh plant material is produced regularly and seasonally, on the park floor, the active animals, utilize dead plant matter as their main source of food, which consequently regulates the diversity and variation of the soil fauna in general and soil arthropods in particular(Wallwork, 1976 and Curry, 1994).

Scientific work to measure the abundance of soil arthropods in the various forest communities and forest ecosystemsis not uncommon (Marshall *etal*. 1994, Adeduntan *etal*. 2005,Adeduntan, 2009 and Adeduntan, 2013), but serious efforts are needed to evaluate impact ofanthropogenic activities on litter and soil arthropods of biological parks, unfortunately, little is known. They are excellent candidates for studying human activity impacts (McIntyre *et al*., 2001; Santorufo *et al*. 2012). Further, soil arthropods quickly respond to soil disturbances and can be considered as valuable indicators of soil disturbances (Nahmani and Lavelle, 2002).

Present study was carried out in theBirsaMunda Zoological Park, which was a protected forest before it's inception in 1986.It was opened to the public in 1994. The park is divided into two zone divide by the National Highway 33 (Fig. 1). One zone has been under extensive human activitieswith management practices and interventions for tourist attractions. The other zonehas been left undisturbed. As a consequence the botanical species are left undisturbed within this area (Sharma, Nathawat and Pandey, 2002).

The number and diversity of arthropods on earthhave attracted entomologists to understand their role in ecological functions and services in the past and studies on the zoological parks, especially of the above ground, is also not uncommon. There has been work on the arthropod's diversity of soil and their roles in recycling of nutrients of large biological parks and landscapes (Garkoti and Singh 1992; Theodore and Jaqueline, 1997; Behra, 2000; Behra et al. 2000; Glesne, Brenner and LaBonte, 2000; Pramanik*et al.* 2001; Roy and Behra 2002; Gupta, and Roget, 2004; Culliney, 2013).

Present paper intends to report the biodiversity, quantitative and qualitative species composition of the soiland their physical and chemical parameters (i.e., ambient temperature, relative humidity, soil temperature, pH, soil Organic carbon, nitrogen, phosphate and potash) of five stations selected inBhagwanBirsa Zoological Park (BBZP), Ranchi, Jharkhand.

Materials and methods

Geographical Area of the study

BBZP lies within the latitude of 23° 27' 30" to 23°28'7" N and longitude of 85° 27'42" E. It covers a total area of 104 hectares bounded partially on two sides by the Sapahi River. The park is divided into two zones-area with tourist and introduced alien plant and animal species and the other part is undisturbed and with least anthropogenic activities

Soil sampling

In 2010, samples were collected from five collection station across the Zoological Park to have representation of the microhabitats from randomized 10 quadrants of 1x 1m unit cell by pitfall traps, observations and sweeping for soil macroarthopod and by the help of soilcorer (0-10 cm depth and 10 cm in diameter) for mesoarthopod, at a regular interval during the whole study period in three different seasons.

Chemical and physical analysis

The chemical and physical analysis was performed after mixing the soil samples of the quadrates for each site to obtain homogeneous sample. The soil was characterized for pH by electrometric method (Santorufo et al. 2012), organic carbon, nitrogen, potassium and phosphates by known conventional methods.

Soil Arthropod community analysis

The analysis of the soil arthropod community of the five stations of the park, collected from different quadrates, was subjected to eight modified Berlase-Tullgreen funnel and the products were grouped to different taxonomic orders and families following Lewis and Taylor (1979).

$$H' = -\sum_{i=1}^{s} p_i \log p_i$$

Biological index

Shannon- Weaver (1948) functions (equation 1) and importance value index were calculated for the each five stations of the BBZP,having management interventions and tourist influx for amusement.

Where, H'= an estimate of the diversity of total population of individuals in the species pool, s = the number of species, P_i= the proportion of the total number of individuals consisting of the i^{th} species.

All statistical analysis was carried on MS Excel ver.2010.

Results

Soil physical and chemical parameters

It is implicit from table 1 that the ambient temperature varied between 16°C – 30°C, relative humidity was as high as 70 per cent and as low as 59 per cent. The soil temperature was about 29°C to 30 °C and the pH was between 5.3 to 5.6 and acidic in nature.

The highest per cent of the soil organic carbon (SOC) was encountered in Station 1 and lowest in Station II. The highest amount of potassium was observed in Station II (71 Kg/ ha), whereas station IV was having highest amount of potash. Nitrogen was highest in Station 1of the BBZPduring the study period (Table 2& Fig 2a, 2b, 2c, & 2d).

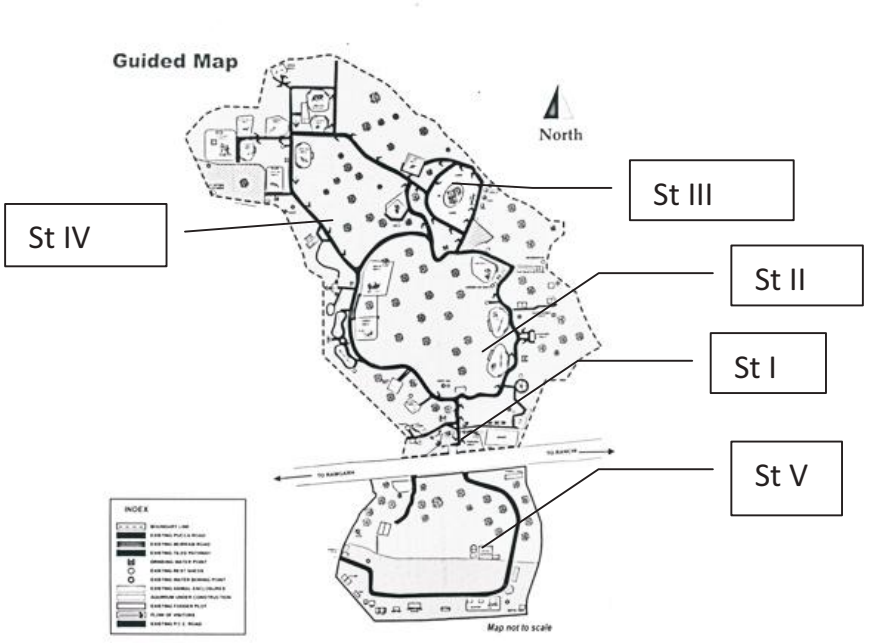
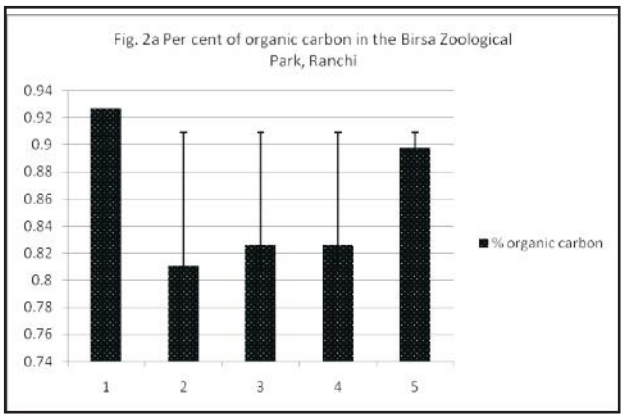


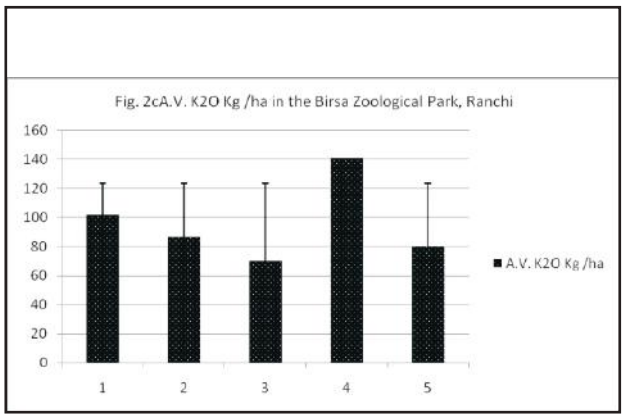
Table 1. Ambient temperature*, relative humidity, soil temperature* and pH of the study area

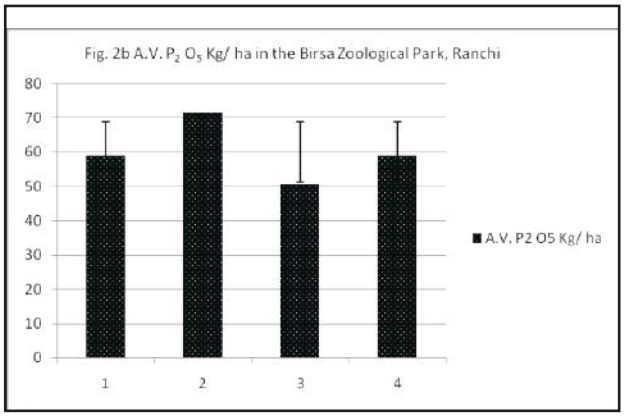
Year	Ambient Temp		RH	Soil Temp	Soil pH
	Max	Min			
2010	30.16	16.81	58.63	30.35	5.64
2011	29.06	15.77	70	29.36	5.3

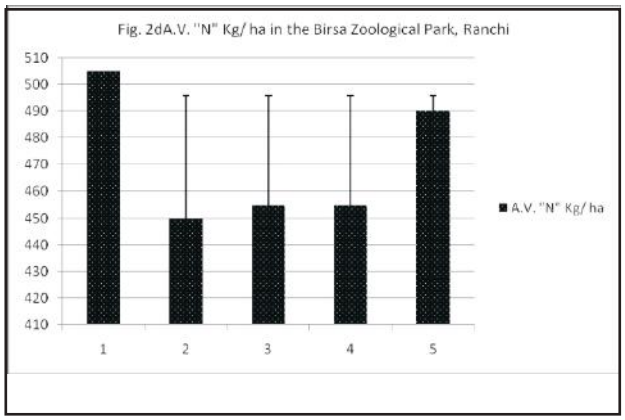
Table 2. OC, potassium, phosphate and nitrogen of the study area

Stations	% Soil organic carbon	A.V. P_2O_5 Kg/ ha	A.V. K_2O Kg /ha	A.V. "N" Kg/ ha
I	0.927	58.97	102.22	505
II	0.811	71.8	86.62	450
III	0.826	50.64	70.47	455
IV	0.826	58.92	140.95	455
V	0.898	35.89	79.9	490









Soil arthropod analysis

Total 2216 soil macro and meso arthropods were collected from five stations across the BBZPduring the study area. The number of soil arthropods ranged from 117-144 per sample during winter and highest 151-180 during rains, corresponding with approximate densities ranging from11700to 14400individuals $m^{-2}$and highest 15100 – 18000 individuals $m^{-2}$of surface soil (Fig. 3). The density was highest during the rainy season. Further, the density was highest in the station number five, which is having least anthropogenic activity, during rainy season.

Ten major taxonomic groups were identified from the collected 2216 individuals of arthropods. The collections of different taxonomic groups from all five stations of the BBZP have been presented in the table 3. The maximum number of taxonomic group identified, out of all the 5 stations,was in station no.V and minimum in station no. I. The most abundant taxa were the Coleoptera, Hymenoptera, Isoptera, Entomobryomorpha, Poduromorpha, other Collembolans and Acarina.

Table 3. Mean and SD of the total collected soil arthropods from five stations of the Birsa Zoological Park, Ranchi

SN	Name of the Soil Arthropods	St I		St II		St III		St IV		St V	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Isoptera	1.042	±0.832	1.208	±0.401	0.744	±0.116	0.518	±0.567	0.833	±0.401
2	Coleoptera 1	2.167	±0.954	2.208	±0.401	2.167	±0.473	2.542	±0.732	2.375	±0.450
3	Coleoptera11	1.750	±0.330	2.042	±0.505	1.542	±0.721	1.792	±0.563	1.875	±0.330
4	Coleoptera 111	1.875	±0.25	1.833	±0.260	1.583	±0.190	2.208	±0.360	2.333	±0.260
5	Hymenoptera1	2.292	±0.688	2.333	±0.563	2.363	±0.532	2.274	±0.359	2.708	±0.507
6	Hymenoptera 11	1.917	±0.473	1.792	±0.629	2.125	±0.450	1.958	±0.401	2.250	±0.216
7	Collembola	2.417	±0.629	2.500	±0.5	2.250	±0.25	2.125	±0.216	2.339	±0.181
8	Entomobryomorpha	1.500	±1.192	1.708	±0.616	1.708	±0.763	1.667	±0.721	1.792	±0.732
9	Poduromorpha	1.500	±0.544	1.458	±0.710	1.750	±0.901	1.792	±0.641	1.750	±0.625
10	Acari	1.417	±0.641	1.625	±0.450	1.833	±0.260	1.875	±0.450	1.268	±0.729

Among the texa, Coleoptera, Hymenoptera and Collembola were ubiquitous and their relative abundance was similar in all investigated soils (Fig.4), whereas the number and IVI of Acari, Collembolans, especially the Entomobryomorpha and Poduromorpha was lowest (Table 4).

Importance value index (IVI) and Shannon diversity index was calculatedand it was observed that in all Stations Hymenoptera I had highest IVI except for station I where Coleoptera had highest IVI, whereas Isoptera had lowest IVI in all the sampling stations (Table 4). Shannon diversity of Station II, III, and IV falls in the similar category and has the DI highest, whereas the Station I and V falls in the same category as they have the lowest DI (Table 5).

Fig. 3. Density of the soil arthropods in the different seasons of the five collection stations of the Birsa Zoological Park, Ranchi

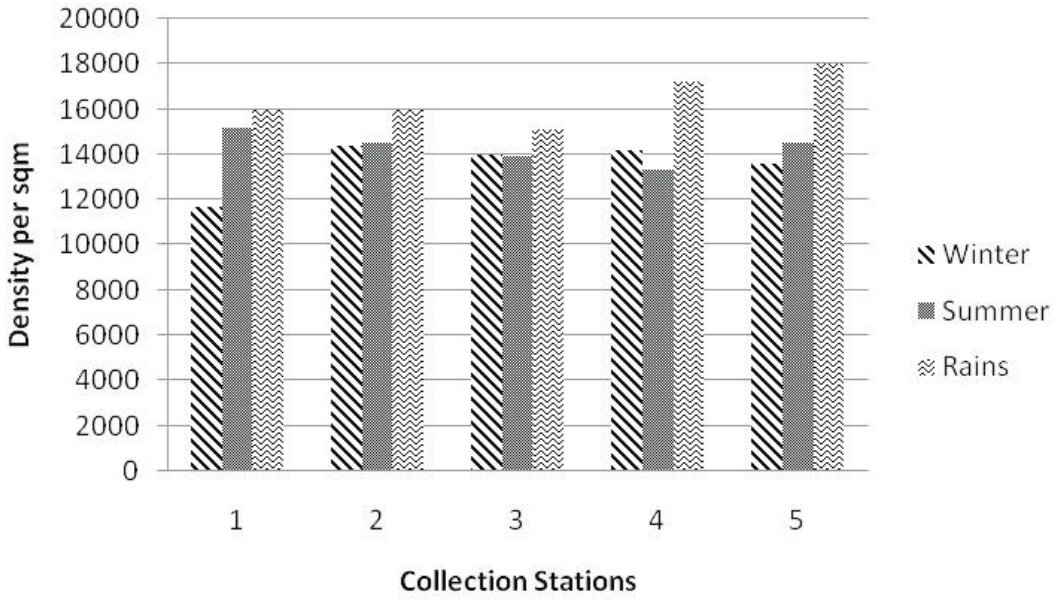


Fig. 4 Relative abundance of the soil arthropod texa in the Birsa Zoological Park, Ranchi

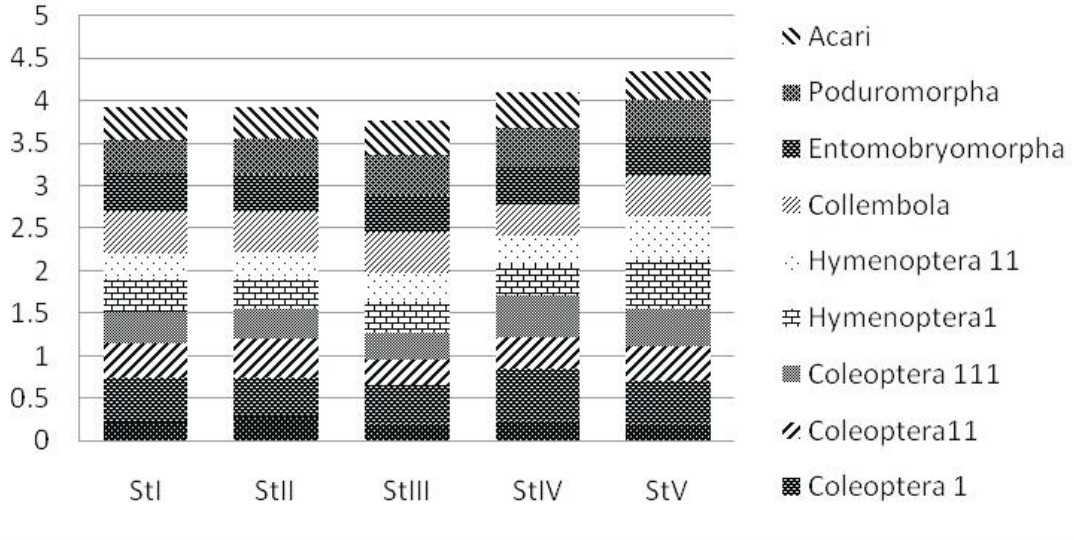


Table 4. Importance Value Index (IVI) of all the collected arthropods from different sites during study period of the Birsa Zoological Park, Ranchi

Name of the Soil Arthropods	St I	St II	St III	St IV	St V
Isoptera	0.1555	0.173473	0.158381	0.158381	0
Coleoptera 1	0.4267	0.365727	0.371691	0.371691	0.364093
Coleoptera11	0.3296	0.33926	0.371691	0.371691	0.377971
Coleoptera 111	0.3296	0.33926	0.303953	0.303953	0.336337
Hymenoptera1	0.4109	0.418662	0.398786	0.398786	0.367386
Hymenoptera 11	0.3951	0.365727	0.368	0.368	0.364093
Collembola (oths.)	0.3464	0.326026	0.331048	0.331048	0.364093
Entomobryomorpha	0.1067	0.208356	0.195492	0.195492	0.253068
Poduromorpha	0.2771	0.239016	0.210553	0.210553	0.294702
Acari	0.2225	0.224495	0.290405	0.290405	0.278257

Table5. Shannon diversity Index of all the five site of the Birsa Zoological Park, Ranchi

Name of the Soil Arthropods	St I	St II	St III	St IV	St V
Isoptera	-0.1154	-0.13242	-0.11901	-0.11901	0
Coleoptera 1	-0.2952	-0.26724	-0.27105	-0.27105	-0.26182
Coleoptera11	-0.2441	-0.25224	-0.27105	-0.27105	-0.26913
Coleoptera 111	-0.2441	-0.25224	-0.23026	-0.23026	-0.246
Hymenoptera1	-0.2880	-0.29298	-0.28457	-0.28457	-0.26182
Hymenoptera 11	-0.2803	-0.26724	-0.26373	-0.26373	-0.26182
Collembola (oths.)	-0.2540	-0.24414	-0.24789	-0.24789	-0.26182
Entomobryomorpha	-0.0696	-0.16058	-0.14979	-0.14979	-0.18685
Poduromorpha	-0.2102	-0.18522	-0.16355	-0.16355	-0.21888
Acari	-0.1685	-0.17329	-0.22069	-0.22069	-0.20881
	-2.16944	-2.22757	-2.22159	-2.22159	-2.17694
Shannon Diversity of the community	**2.16944**	**2.2276**	**2.2216**	**2.2216**	**2.1769**

Discussions

Investigations of the soils collected from different stations of the Park area, their chemical and physical characteristics strongly differ. This is because the pedogenetic substrates are similar; the differences in concentration of the soil organic carbon (SOC), nitrogen (N), potassium (K) and phosphate (P) of the investigated soil could be attributed to various causes, such as management practices interventions and other anthropogenic activities in the BBZP.

The soil differed in soil arthropods density (highest in station V and lowest in station I).There is no major difference in the texa composition of the all five stations except for the station V. Abundance and density, better than texa richness, reflects the trend of the soil chemical and physical characteristics. Therefore it is supposed that individual abundance and density are more affected by soil properties than texa richness, as also reported by Nahmani and Lavelle (2002).

There is not much variation in the Shannon index of all the sampling stations of the park. The H' values<2 and >2.5 can be attributed to disturbances and the K-strategists in the park area as the park has been established in a protected area.

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