The Bioscan 2 (2) : 113-119, 2007
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES

INFLUENCE OF VEGETATIONAL COVER ON POPULATION DYNAMICS AND BIOMASS OF A MEGASCOLOCID EARTHWORM *LENNOGASTER PUSILLUS* (STEPHENSON)

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KEY WORDS
L. pusillus
S. robusta
A. auriculaeformis
E. citriodora
Population Density
Biomass

Received on :
13.09.2006
Accepted on :
21.01.2007

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ABSTRACT
The influence of vegetational cover on earthworm population dynamics and biomass of *Lennogaster pusillus* (Stephenson) a megascolocid endemic epigeic earthworm has been studied in three tropical forests of *Shorea robusta* Roxb. ex. Gaertn. f., *Acacia auriculaeformis* A. Cunn. ex. Benth. and *Eucalyptus citriodora* Hook near Bero area, Ranchi. The maximum and minimum density (No m^{-2}) of the worm varied from 415 ± 53.19 to 75 ± 18.70 in the forest of *S. robusta*, from 745 ± 82.28 to 75 ± 27.38 in *A. auriculaeformis* while from 598 ± 25.10 to 35 ± 19.49 in *E. citriodora* respectively with a variation in biomass as g dry wt m^{-2} of the species from 0.31 ± 0.1 to 2.65 ± 0.38, from 0.41 ± 0.17 to 5.34 ± 0.86 and from 0.19 ± 0.1 to 3.72 ± 0.24 respectively. The variation in population density and biomass of *L. pusillus* in three forest types was statistically (two way ANOVA) significant, reflecting the influence of above ground biodiversity on earthworms ($F = 9.903$; $df = 2, 36$; $p < 0.001$ and $F = 8.133$; $df = 2, 36$; $p < 0.005$) respectively. The paper deals with the significance of vegetational cover on the worm and its size class.

INTRODUCTION

Earthworms represent a major group of the soil fauna and seasonal factors play an important role in explaining changes in size and biomass of their populations (Edwards and Bohlen, 2004). Because earthworm species exhibit different ecological preferences, the influence of environmental factors on population dynamics differs among earthworms of different ecological categories (Rozen, 1988). As the soil conditions that affect earthworm activity most, are temperature and moisture (Edwards and Bohlen, 2004; Tondoh and Lavelle, 2005), epigeic earthworms are probably much more affected by the season than endogeic and anecic species. Beside the climo - edaphic variables, the differences in resource availability also play an important role to determine some life history traits such as growth, size at maturity, number and size of offspring and length of life (Stearns, 1992). There is paucity of knowledge on population dynamics and variations in biomass of earthworms in deciduous forest (Fragoso *et al.* 1997; Tondoh and Lavelle, 2005) and virtually no information is available on the performance of an epigeic megascolocid earthworm (*L. pusillus*)in different forest floors which provide resource gradient.

The present communication records the population dynamics, variation in biomass, population turnover and instantaneous growth rate of *Lennogaster pusillus* (Stephenson) in three diferrent forest floors of *Shorea robusta* (Roxb. ex. Gaertn. f.), *Acacia auriculaeformis* (A. Cunn. ex. Benth.) and *Eucalyptus citriodora* (Hook) in similar climatic and geographical condition.

MATERIALS AND METHODS

Earthworm sampling and population studies were carried out in three tropical forest sites namely *Shorea robusta* forest site, *Acacia auriculaeformis* forest site and *Eucalyptus citriodora* forest site, located at Bero, Block 32.5 Km west of Ranchi town, the capital of Jharkhand. The area experiences a tropical climate with three distinct season summer, rainy and winter. The summer extends from March to Mid June, the rainy from Mid June to September and the winter from October to February. The total average rainfall was 129.92 mm and of the total rainfall about 87% fell during the rainy season. The maximum air temperature was about 37.7°C in May 2002 and minimum air temperature was about 5.2°C in Jan. 2003. The maximum humidity was 91.7% in August 2002 and minimum was 23.7% in March 2002.

No marked difference of soil texture was observed in the soil of the three different forest sites as they are located in the same area. Soil temperature (°C) and soil moisture (g%) have been measured by thermometer and oven drying method (at 100 °C for overnight) respectively. Soil organic carbon was analyzed according to the method of Walkley and Black (1934), total N - content was determined by Kjeldahl method of Jackson (1973) whereas P and K – content were analyzed following Misra (1973).

Earthworms were sampled by Monolith method and hand sorted once a month from March 2002 to September 2003 following Dash and Patra (1977) from an area of 20 x 20 x30 cm during morning hours. Sampling was confined to first week of every month. On the basis of length and clitellar development earthworms were divided into three age classes: (i) Juvenile (< 2cm, non clitellate), (ii) immature (≥ 2cm < 4cm, non clitellate) and (iii) mature (≥ 4cm, clitellate). The population was expressed as number of individual per square meter. Preservation and analysis of worms were made according to Dash and Patra (1977) and Senapati and Dash (1980).

Five replicates of freshly sampled worms were categorized into different size groups and were weighed separately after being gut evacuated and were kept in oven at 85°C for 24 hours to obtain dry weight. Gut evacuation of worms was made by keeping them half immersed in distilled water (changed every 12 hours) in glass petridish for 12 hours.

The population turnover value was determined by the ratio of maximum density to minimum density following Sahu and Senapati (1986).

Instantaneous growth rate was determined following Brafield and Llewellyn (1982).

$$IG(\%) = \frac{\log_{10} YT - \log_{10} Yt}{T - t} \times 2.3026 \times 100$$

Where t = time at the beginning of the observation, T = time at the end of the observation, YT = weight at time T and Yt = weight at time t and 2.3026 is conversion factor.

Statistical analysis of data (ANOVA) was done according to Snedecor and Cochran (1979).

RESULTS

The data on physico - chemical characteristics of three sampling sites have been setup in Table 1, 2, 3.

Population Density

In *Shorea robusta* forest floor, the total population density of *Lennogaster pusillus* was maximum of 415 ± 53.19 m^{-2} in Sept. 2002 and minimum of 75 ± 18.70 m^{-2} in Feb., 2003 with an average of 101.32 m^{-2} (Fig.1). The density of juvenile immature and adult worms ranged from 105 ± 16.43m^{-2} in Sept. 2002 to 05 ± 4.47 m^{-2} in Oct. 2002;

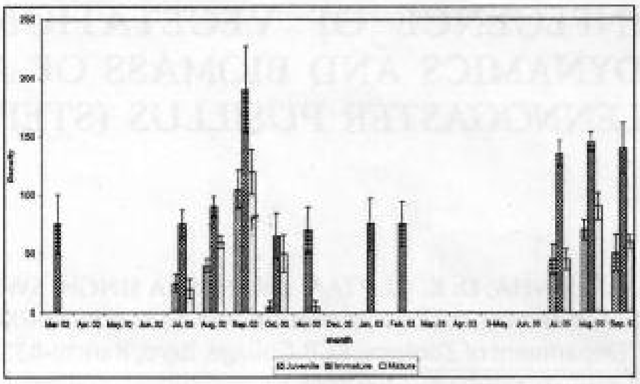

Figure 1: Seasonal dynamics of different age group density (No m^{-2} $month^{-1}$ ± SEM) of *L. pusillus* in *Shorea robusta* forest

from 65 ± 19.49 m^{-2} to 190 ± 37.05 m^{-2}; from 120 ± 19.23 m^{-2} to 05 ± 4.47 m^{-2}. The age structure of *L. pusillus* during the study period was found to be 17.66% of juvenile, 58.96% of immature and 23.38% of mature worms.

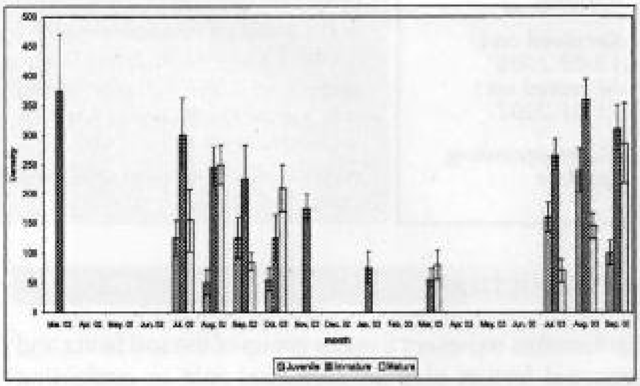

Figure 2: Seasonal dynamics of different age group density (No m^{-2} $month^{-1}$ ± SEM) of *L. pusillus* in *Acacia auriculaeformis* forest

In *Acacia auriculaeformis* forest floor, the highest total population density of *L. pusillus* was found to be of 745 ± 82.28 m^{-2} in Aug. 2003 and the lowest 75 ± 27.38 m^{-2} in Jan. 2003 with an average of 244.47 m^{-2} (Fig.2). The three size classes showed variation in population density differently in different period of time. Juvenile worm showed the maximum density of 240 ± 35.78 m^{-2} in August 2003 and minimum of 50 ± 21.21 m^{-2} in August 2002. The density of immature worm was observed in the range of 55 ± 17.89 m^{-2} (March 2003) to 360 ± 33.62 m^{-2} (Aug 2002). However the mature worm density was recorded between 70 ± 19.23 m^{-2} to 285 ± 68.04 m^{-2} in the months of July 2003 and Sept. 2003 respectively. The percentage contribution of juvenile, immature and mature worms was 18.41%, 54.03%, and 27.56% respectively.

In *Eucalyptus citriodora* forest floor showed lowest population density in comparision to two other sites where the total population density was found to be maximum of

Table 1: Average monthly values of edaphic parameters in *Shorea robusta* forest

Month	pH	Soil Temp. (°C)	Organic carbon (mg g⁻¹ soil)	Organic matter (mg g⁻¹ soil)	Nitrogen (mg g⁻¹ soil)	Phosphorous (kg hec.⁻¹ soil)	Potassium (kg hec.⁻¹ soil)
Mar. 02	6.29 ± 0.05	25.3	7.43 ± 0.04	12.80	0.64 ± 0.02	23.6 ± 0.46	145.3 ± 0.56
Apr. 02	5.93 ± 0.09	27.5	5.99 ± 0.06	10.32	0.64 ± 0.02	23.1 ± 0.29	142.9 ± 0.82
May 02	6.33 ± 0.06	28.9	5.48 ± 0.14	9.44	0.67 ± 0.03	27.9 ± 1.06	144.0 ± 0.49
Jun. 02	6.40 ± 0.03	28.42	7.43 ± 0.04	12.80	0.71 ± 0.01	29.8 ± 1.01	147.8 ± 0.60
Jul. 02	6.05 ± 0.06	28.0	8.22 ± 0.05	14.17	0.81 ± 0.02	29.5 ± 0.31	144.5 ± 0.40
Aug. 02	6.34 ± 0.03	24.3	7.62 ± 0.23	13.13	0.81 ± 0.01	28.4 ± 0.98	146.3 ± 0.83
Sep. 02	6.58 ± 0.03	24.24	7.72 ± 0.29	13.30	0.83 ± 0.02	29.7 ± 0.87	148.8 ± 0.54
Oct. 02	6.81 ± 0.03	25.21	7.78 ± 0.40	13.41	0.76 ± 0.11	28.1 ± 0.70	148.9 ± 0.79
Nov. 02	6.46 ± 0.08	22.5	6.74 ± 0.33	11.61	0.75 ± 0.01	30.5 ± 0.73	147.7 ± 0.78
Dec. 02	6.54 ± 0.04	19.54	5.96 ± 0.16	10.27	0.65 ± 0.01	27.7 ± 0.69	147.2 ± 0.29
Jan. 03	6.21 ± 0.02	19.65	5.93 ± 0.24	10.22	0.63 ± 0.01	29.1 ± 0.57	147.9 ± 0.29
Feb. 03	6.19 ± 0.02	20.32	6.47 ± 0.17	11.15	0.61 ± 0.01	27.6 ± 0.89	145.6 ± 0.54
Mar. 03	6.68 ± 0.05	22.51	6.79 ± 0.25	11.70	0.61 ± 0.01	23.6 ± 0.45	145.4 ± 0.40
Apr. 03	5.83 ± 0.04	27.71	5.88 ± 0.15	10.13	0.63 ± 0.03	24.1 ± 0.42	143.7 ± 0.92
May 03	6.50 ± 0.07	28.11	5.43 ± 0.12	9.36	0.62 ± 0.02	27.8 ± 0.77	143.4 ± 0.53
Jun. 03	6.12 ± 0.13	28.52	6.49 ± 0.12	11.18	0.72 ± 0.02	30.5 ± 0.75	147.1 ± 0.75
Jul. 03	5.84 ± 0.05	28.2	7.42 ± 0.11	12.79	0.73 ± 0.03	30.1 ± 0.60	146.7 ± 0.35
Aug. 03	6.55 ± 0.03	26.25	6.55 ± 0.15	11.29	0.76 ± 0.02	27.0 ± 0.49	148.1 ± 0.38
Sep. 03	5.81 ± 0.07	24.89	6.52 ± 0.11	11.24	0.78 ± 0.01	27.9 ± 0.62	148.0 ± 0.49

590 ± 25.10 m^{-2} in August 2003 whereas minimum of 35 ± 19.49 m^{-2} in Dec. 2002 showing an average of 158.16 m^{-2} (Fig.3). The density of juvenile worms at this site (minimum of 20 ± 10.95 m^{-2} in Oct. 2000 and maximum of 120 ± 14.83 m^{-2} during August 2003) was less than immature worms (35 ± 19.49 m^{-2}, Dec. 2002, to 325 ± 24.49 m^{-2}, Aug. 2003). The adults ranged from 35 ± 13.41 m^{-2} (Oct. 2002) to 145 ± 19.23 m^{-2} (August 2002). 15.81% juvenile, 58.57% immature and 25.62% of adult worms constitute the population structure in the study period during the present investigation.

On the whole, the worm density was dominated by immature age group followed by mature and juvenile worms.

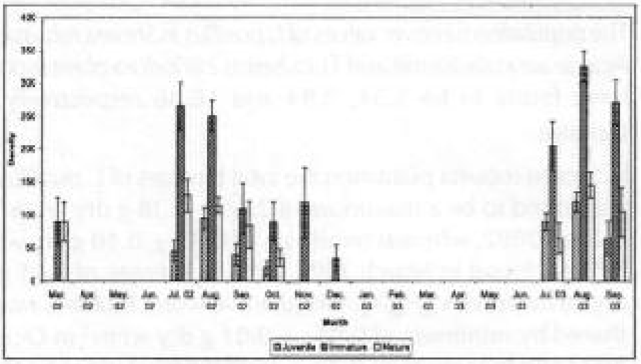

Figure 3: Seasonal dynamics of different age group density (No m^{-2} $month^{-1}$ ± SEM) of *L. pusillus* in *Eucalyptus citriodora* forest

Table 2: Average monthly values of edaphic parameters in *Acacia auriculaeformis* forest

Month	pH	Soil Temp. (°C)	Organic carbon (mg g⁻¹ soil)	Organic matter (mg g⁻¹ soil)	Nitrogen (mg g⁻¹ soil)	Phosphorous (kg hec.⁻¹ soil)	Potassium (kg hec.⁻¹ soil)
Mar.02	5.81 ± 0.05	25.25	5.30 ± 0.09	9.13	0.50 ± 0.01	22.6 ± 0.46	143.8 ± 0.87
Apr. 02	6.20 ± 0.03	27.6	5.42 ± 0.03	9.34	0.48 ± 0.01	21.6 ± 0.68	142.2 ± 0.52
May 02	6.67 ± 0.27	29.0	5.65 ± 0.12	9.74	0.46 ± 0.01	29.3 ± 0.38	144.5 ± 1.09
Jun. 02	6.37 ± 0.14	28.4	6.49 ± 0.09	11.18	0.50 ± 0.01	28.9 ± 0.20	146.5 ± 0.89
Jul. 02	6.41 ± 0.10	28.2	6.74 ± 0.27	11.61	0.47 ± 0.01	28.3 ± 0.13	145.4 ± 0.44
Aug. 02	6.17 ± 0. 14	24.6	6.72 ± 0.06	11.58	0.48 ± 0.02	27.4 ± 0.20	146.7 ± 0.60
Sep. 02	6.67 ± 0.11	24.25	6.45 ± 0.05	11.11	0.54 ± 0.02	27.3 ± 0.14	147.0 ± 0.20
Oct. 02	6.53 ± 0.11	25.0	6.60 ± 0.11	11.37	0.54 ± 0.02	29.1 ± 0.19	147.6 ± 0.36
Nov.02	6.18 ± 0.15	22.14	6.25 ± 0.11	10.77	0.54 ± 0.03	28.5 ± 0.16	147.9 ± 0.33
Dec.02	6.12 ± 0.10	19.43	6.65 ± 0.26	11.46	0.50 ± 0.03	24.9 ± 0.15	147.5 ± 0.44
Jan. 03	6.03 ± 0.18	19.8	5.70 ± 0.09	9.82	0.46 ± 0.02	27.3 ± 0.17	145.7 ± 0.37
Feb. 03	6.28 ± 0.19	20.41	5.76 ± 0.20	9.93	0.48 ± 0.01	30.1 ± 0.22	145.8 ± 0.35
Mar.03	5.83 ± 0.19	22.43	5.73 ± 0.04	9.87	0.48 ± 0.02	25.5 ± 0.29	147.0 ± 0.33
Apr. 03	6.32 ± 0.15	27.84	6.44 ± 0.42	11.10	0.49 ± 0.01	23.9 ± 0.61	145.4 ± 0.46
May 03	6.10 ± 0.11	28.23	5.50 ± 0.08	9.48	0.49 ± 0.01	25.5 ± 0.29	144.7 ± 0.49
Jun. 03	6.37 ± 0.09	28.70	6.96 ± 0.06	11.99	0.52 ± 0.01	26.9 ± 0.62	147.2 ± 0.33
Jul. 03	5.90 ± 0.18	28.4	6.53 ± 0.07	11.25	0.49 ± 0.02	27.5 ± 0.30	146.7 ± 0.24
Aug. 03	6.15 ± 0.13	26.31	6.48 ± 0.14	11.17	0.57 ± 0.01	27.9 ± 0.43	147.0 ± 0.74
Sep. 03	6.48 ± 0.07	25.0	6.59 ± 0.09	11.36	0.55 ± 0.02	27.2 ± 0.26	147.1 ± 0.62

Table 3: Average monthly values of edaphic parameters in *Eucalyptus citriodora* forest

Month	pH	Soil Temp. (°C)	Organic carbon (mg g⁻¹ soil)	Organic matter (mg g⁻¹ soil)	Nitrogen (mg g⁻¹ soil)	Phosphorous (kg hec.⁻¹ soil)	Potassium (kg hec.⁻¹ soil)
Mar. 02	5.66 ± 0.11	25.0	5.38 ± 0.07	9.27	0.51 ± 0.11	23.6 ± 0.49	145.1 ± 0.40
Apr. 02	5.44 ± 0.05	27.5	5.28 ± 0.06	9.10	0.49 ± 0.01	22.6 ± 0.71	143.4 ± 0.36
May 02	6.13 ± 0.03	29.21	5.76 ± 0.09	9.93	0.50 ± 0.01	25.7 ± 0.73	143.6 ± 0.40
Jun. 02	5.81 ± 0.03	28.51	6.70 ± 0.18	11.55	0.52 ± 0.01	26.7 ± 0.47	146.4 ± 0.22
Jul. 02	5.60 ± 0.08	27.5	6.23 ± 0.05	10.74	0.51 ± 0.02	26.2 ± 0.74	146.6 ± 0.45
Aug. 02	5.88 ± 0.06	24.9	6.50 ± 0.11	11.20	0.49 ± 0.03	27.0 ± 0.74	145.0 ± 0.57
Sep. 02	6.23 ± 0.05	24.1	6.68 ± 0.06	11.51	0.56 ± 0.01	27.0 ± 0.35	147.6 ± 0.42
Oct. 02	6.37 ± 0.07	25.4	6.58 ± 0.11	11.34	0.55 ± 0.02	27.4 ± 0.88	147.5 ± 0.26
Nov. 02	6.64 ± 0.05	22.9	6.31 ± 0.09	10.87	0.51 ± 0.02	27.2 ± 0.35	146.7 ± 0.70
Dec. 02	6.44 ± 0.03	19.74	5.96 ± 0.26	10.27	0.49 ± 0.01	25.0 ± 0.33	146.2 ± 0.27
Jan. 03	6.10 ± 0.03	19.71	5.75 ± 0.05	9.91	0.44 ± 0.01	26.7 ± 0.59	146.2 ± 0.29
Feb. 03	5.70 ± 0.08	20.25	6.04 ± 0.05	10.44	0.47 ± 0.01	27.6 ± 0.48	145.6 ± 0.31
Mar. 03	5.92 ± 0.02	22.6	6.21 ± 0.22	10.70	0.48 ± 0.01	22.5 ± 0.38	146.1 ± 0.81
Apr. 03	5.49 ± 0.06	27.70	5.42 ± 0.03	9.34	0.50 ± 0.01	21.7 ± 0.51	143.4 ± 0.63
May 03	5.94 ± 0.09	28.42	5.68 ± 0.19	9.79	0.48 ± 0.01	26.7 ± 0.66	143.2 ± 0.41
Jun. 03	5.82 ± 0.05	28.59	7.11 ± 0.10	12.25	0.52 ± 0.01	26.6 ± 0.74	146.3 ± 0.87
Jul. 03	5.87 ± 0.03	28.5	6.71 ± 0.06	11.56	0.48 ± 0.01	26.7 ± 0.34	146.3 ± 0.34
Aug. 03	5.81 ± 0.07	26.22	6.41 ± 0.42	11.05	0.49 ± 0.01	26.2 ± 0.41	146.4 ± 0.34
Sep. 03	6.10 ± 0.04	24.71	6.64 ± 0.22	11.44	0.53 ± 0.01	26.7 ± 0.62	147.6 ± 0.37

The population turnover values of *L. pusillus* in *Shorea robusta*, *Acacia auriculaeformis* and *Eucalyptus citriodora* plantation were found to be 5.54, 9.94 and 16.86 respectively.

Biomass

In *Shorea robusta* plantation the total biomass of *L. pusillus* was found to be a maximum of 2.65 ± 0.38 g dry wt m^{-2} in Sept. 2002, whereas minimum of 0.31 ± 0.10 g dry wt m^{-2} was found in March 2002 with an average of 0.61 g dry wt m^{-2} $month^{-1}$ (Fig.4). The juvenile worm biomass was shared by minimum of 0.01 ± 0.01 g dry wt m^{-2} in Oct. 2002 and maximum of 0.23 ± 0.03 g dry wt m^{-2} in Sept. 2002 showing an average of 0.04 g dry wt m^{-2} $month^{-1}$. The biomass of immature worm was observed in the range of 0.31 ± 0.10 g dry wt m^{-2} to 0.89 ± 0.15 g dry wt m^{-2} in the month of March, 2002 and Sept. 2002 respectively with an average of 0.28 g dry wt m^{-2} $month^{-1}$. The adult worm biomass was recorded a minimum of 0.06 ± 0.05 g dry wt m^{-2} in Nov. 2002 and maximum of 1.53 ± 0.22 g dry wt m^{-2} in Sept. 2002 at an average of 0.29 g dry wt m^{-2} $month^{-1}$. 47.54% of mature, 45.90% of immature and 6.56% of juvenile worm constitute the totaL biomass of *L. pusillus*.

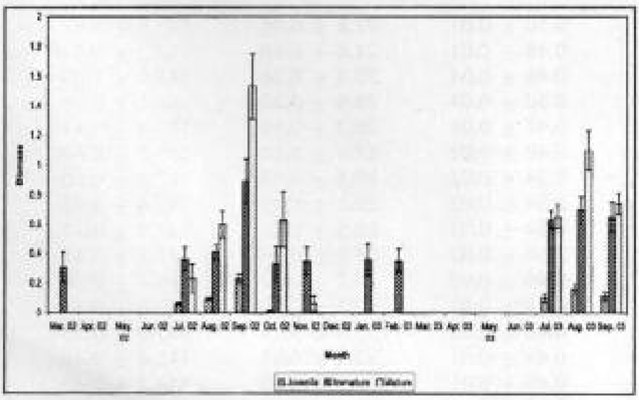

Figure 4: Seasonal dynamics of biomass(g dry wt m^{-2} $month^{-1}$ ± SEM) of different age group of *L. pusillus* in *Shorea robusta* forest

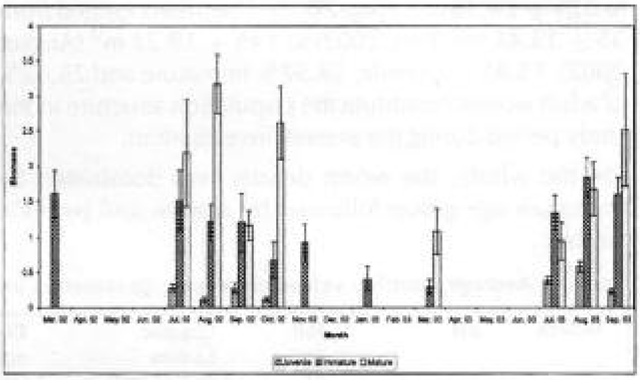

Figure 5: Seasonal dynamics of biomass(g dry wt m^{-2} $month^{-1}$ ± SEM) of different age group of *L. pusillus* in *Acacia auriculaeformis* forest

In *Acacia auriculaeformis* forest site the total biomass as g dry wt m^{-2} ranged between 0.41 ± 0.17 in Jan. 2003 to 5.34 ± 0.86 in Sept. 2003 at an average of 1.62 (Fig.5). In *L. pusillus* the biomass of juvenile worm was minimum 0.11 ± 0.04 and maximum 0.58 ± 0.08 in Aug. 2002 and Aug, 2003 respectively showing an average of 0.10 . Immature worm with a minimum biomass of 0.30 ± 0.11 was present in March 2003 and maximum of 1.84 ± 0.28 was found in Aug. 2003 at an average of 0.66 . The mature worm biomass was ranged between 0.94 ± 0.26 to 3.17 ± 0.42 in the month of July 2003 and August 2002 respectively. The average monthly biomass was found to be 0.86 .

In total biomass of *L. pusillus* the % contribution of juvenile, immature and mature worm was 6.17%, 40.74% & 53.09% respectively. In *Eucalyptus citriodora* forest site the total worm biomass as g dry wt m^{-2} ranged between 0.19 ± 0.11 (Dec. 2002) to 3.72 ± 0.26 (August 2003) at an average of 1.076 (Fig.6). The biomass of juvenile worm of *L. pusillus* was ranged from 0.05 ± 0.03 to 0.09 ± 0.03 was observed in the month of Oct. 2002 and August 2003 respectively with an average of 0.664. Immature worm had a range of 0.19 ± 0.11 in Dec. 2002 and 1.50 ± 0.06 in August 2003 at an average of 0.44 . The mature worm biomass was minimum of 0.44 ± 0.17 in Oct. 2002 and maximum of 2.03 ± 0.43 in July 2002. 0.568 was the average monthly biomass of mature worm. 5.59% juvenile, 41.26% immature and 52.7% mature worm constitute the biomass structure of *L. pusillus* in the study site.

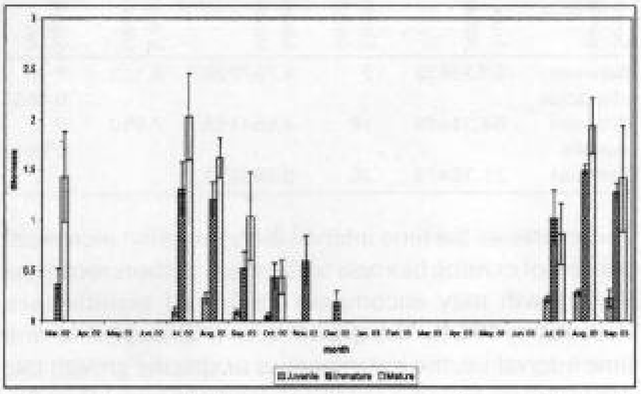

Figure 6: Seasonal dynamics of biomass(g dry wt m^{2} month^{-1} ± SEM) of different age group of *L. pusillus* in *Eucalyptus citriodora* forest

Instantaneous growth rate

The instantaneous growth rate in percentage in *S. robusta* ranged between (-) 100.50 (Oct. 2002) to 87.92 (Sept. 2002), *A. auriculaeformis* with minimum of (-) 131.59 (Nov. 2002) and maximum of 42.64 (Aug. 2003) and *E. citriodora* showing minimum of (-) 114.99 in Nov. 2002 and maximum of 56.23 in Aug. 2003 (Table 4).

DISCUSSION

Comparison of population density of earthworm in different habitats is an important aspect of population ecology to reach at some general conclusions and also to make generalization. The population density of earthworm varies considerably in different habitats and different geographical regions. Fundamentally the high and low population density depends upon habitat suitability and prevailing climatic conditions. Higher density of epigeic earthworm like *E. foetida* (14600m^{-2}) was reported by Elvira *et al.* (1996), in a habitat with large quantities of organic matter. Similarly in the present study the higher density of *L. pusillus*, an epigeic megascolocid earthworm was found in *Shorea robusta* forest site which was having higher concentration of organic matter in comparison to *Acacia auriculaeformis* and *Eucalyptus citriodora* forest site (Table 1, 2 & 3). The maximum density generally occurs in base rich grasslands and mull wood land soils and minimum in acid soils, moor land and raw humus (Peterson, 1982). Density in cultivated soil and pasture usually fall between these two extremes.

Table 4: Instantaneous growth rate (IG %) of different age group of *L. pusillus* in *S. robusta*, *A. auriculaeformis* and *E. citriodora* plantation

Month	*S. robusta*	*A. auriculaeformis*	*E. citriodora*
Mar. 02			
Apr. 02			
May 02			
Jun. 02			
Jul. 02			
Aug. 02	52.60	11.80	-12.36
Sep. 02	87.92	-53.48	-61.10
Oct. 02	-100.50	-26.55	-57.33
Nov. 02	-87.11	-131.59	-43.82
Dec. 02			-114.99
Jan. 03			
Feb. 03	-2.81		
Mar. 03			
Apr. 03			
May 03			
Jun. 03			
Jul. 03			
Aug. 03	35.08	42.64	56.23
Sep. 03	-26.74	26.66	-28.76

Apart from the breeding behaviour, factors like soil type, climate, vegetational cover and altitude may bring a seasonal difference in the density of earthworm population. In the present study a considerable variation in population of *L. pusillus* has been recorded (Fig. 1,2 & 3) which reflects the influence of vegetational cover on earthworm population. Seasonality had a strong influence on the growth and reproduction of earthworm and consequently on the age structure of the population (Monroy *et al.*, 2006) During the present study, the population of L. pusillus was restricted to rainy season and no stage of size class was found during peak winter and summer (Fig. 1,2 & 3). The information about the size class structure of population of earthworm is scanty. Satchell (1967), Lavelle (1975, 1978), Watanabe and Tsukamato (1976), Dash and Patra (1977) and Sinha *et al.*, (2003a) have reported that juvenile and immature worms occupy a large proportion of earthworm population throughout the year. From Tropical agroecosystem of Ranchi, Sinha *et al.*, (2003 a) reported a similar trend of age structure for *O. occidentalis*. The proportion of immature to adult depends upon the time of the year. During active breeding period, juvenile and immature dominate the population. In the present investigation during rainy season, in all three forest site (*S. robusta, A. auriculaeformis* and *E.* citriodora) the proportion of juveniles and immature increased rapidly indicating hatching of cocoons present in the soil.

The proportion of large sized immature and adult increased during early winter indicating the growth of individuals in the population in all three forest sites. It appears that the low reproductive activity found in winter leads to weight gain due to decrease of reproductive costs and reallocation of resources toward growth (Stearns, 1992) During the present study, it has been found that earthworm population was dominated by immature population (63.98% in *S. robusta,* 48.78% in *A. auriculaeformis* and 58.57% in *E. citriodora* forest site). This investigation is in agreement with the previous observations of Van Rhee (1965, 1967). The ratio of immature: mature individual ranging from 5 to 25 has been reported for *Aporrectodea caliginosa* from Holland by Van Rhee (1965). The immature: mature ratio seems to be influenced by climo-edaphic factors as for the same species *A. caliginosa* two different range of ratios have been reported from two different locations. In present investigation also different range of ratio have been reported for *L. pusillus* from three different forest sites, in *S. robusta* between 1.30 to 14, in *A. auriculaeformis* 0.002 to 3.78 while from 1.00 to 3.15 in *E. citriodora* forest site. The narrow range of variation in the immature: mature ratio during present study, however, may be attributed to both the climo-edaphic factorial influence as well as the species specific features related with fecundity or reproductive strategy.

Among the three age groups, the immature were always higher than the both juvenile and adult indicating the slow transformation of immature to mature but relatively higher transformation of juvenile to immature. This observation gives an idea of rapid growth in early stage followed by a slower growth pattern before becoming adult.

The population turnover value is maximum (16.86) in *E. citriodora* and minimum (5.54) in *S. robusta* which reflects that the edaphic conditions of *S. robusta* are more suitable for the earthworm as there is least difference between maximum and minimum population density in the habitat.

L. pusillus was found in all three different forest sites.The variation in population density and biomass of *L. pusillus* in the three forest sites was statistically (two way ANOVA) significant reflecting the influence of above ground biodiversity on earthworms ($F = 9.903$; $df = 2, 36$; $p < 0.001$ and $F = 8.133$; $df = 2, 36$; $p < 0.005$, Table 5).

The expression of soil animal population in terms of biomass is more meaningful than numbers (Edwards, 1962). Biomass is equivalent to the term standing crop. A growth curve results when simply the weight is plotted at each interval of time but a common and useful alternative is to calculate the instantaneous growth rate.

Table 5: ANOVA test of *Lennogaster pusillus* at three different plantation and different months

Population density

Source of variation	Sum of square	Degree of freedom	Mean square	Variation ratio F	Significance
Between plantation	197445.6	2	98722.81	9.903	P < 0.001
Between months	1954726	18	108595.9	10.893	P < 0.001
Residual	358871.1	36	9968.64		

Biomass

Source of variation	Sum of square	Degree of freedom	Mean square	Variation ratio F	Significance
Between plantation	9.535653	2	4.767826	8.133	P < 0.005
Between months	84.31475	18	4.684153	7.990	P < 0.001
Residual	21.10475	36	0.586243		

This expresses the time interval (here monthly) increment per unit of existing biomass while many authors recognise that growth may encompass repair and maintenance (Needham, 1964). The growth rate with respect to unit time interval i.e. the instantaneous or specific growth rate calculated for *Perionyx sansibaricus* ranged from (-)113.8% to 332.4% (Sinha *et al.*, 2003 b). In case of *L. pusillus* in the present study IG (%) has been recorded varying between (-)100.50 to 87.92 in *S. robusta*, (-)131.59 to 42.64 in *A. auriculaeformis* and (-)114.99 to 56.23 in *E. citriodora* (Table 7, 8 & 9). The variation in IG appears to be the impact of habitat suitability for the earthworm.

On the basis of the present study it can be concluded that the forest floor under *S. robusta* is the most suitable for *L. pusillus* as has been indicated by high population density, biomass and IG in comparison to the *A. auriculaeformis* and *E. citriodora* forest floors. Further the megascolocid earthworm is the only species available in all the three habitats, reflecting its wider range of adaptability.

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