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Full Length Research Paper

Impact of different litters on growth and production of a megascolecid earthworm (*Perionyx sansibaricus*) in experimental condition

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The paper dealt with the impact of different litters on biomass, instantaneous growth and secondary production of *Perionyx sansibaricus* cultured in artificial soil for 21 weeks. Biomass of the *P. sansibaricus* in *Mangifera indica* litter varied from a minimum value of 30.25 to maximum value of 380.51 g dry wt/m^2, 20.34 to 340.89 g dry wt/m^2 in *Acacia auriculaeformis* litter and 30.21 to 310.43 g dry wt/m^2 in *Eucalyptus citriodora* litter. The rate of instantaneous growth reached a maximum value of 97.95 and 91.64% on 1st week for Eucalyptus and Acacia and 69.98% during 3rd week in Mango litter, but it declined to -25.52% in 13th week, -22.1% in 18th week and -14.56% in the 15th week of the experiment for Eucalyptus, Acacia and Mango respectively. Maximum secondary production was recorded in Mango litter (680.59 g dry wt/m^2/week), followed by Eucalyptus (509.95 g dry wt/m^2/week) and Acacia (484.39 g dry wt/m^2/week) respectively. The maximum value of biomass as well as secondary production of earthworm in Mango litter could be due to suitability of the active principle of Mangiferin which does not have any adverse impact on the earthworms.

Key words: Mangiferin, biomass, secondary production, instantaneous growth, litter.

INTRODUCTION

Earthworms are known to play important role in soil profile development, nutrient cycling and plant productivity. Earthworms have beneficial physical, chemical and biological effects on soil and many researchers have documented that these effects can increase the plant growth and crop yield (Edwards and Bohlen, 1996). Earthworms constitute the highest biomass among tropical soil macrofauna (Fragoso and Lavelle, 1992). Therefore, their role in soil structure and function is likely to be of great magnitude. Earthworm activity is influenced by many factors such as food quality and quantity (Lee, 1985; Edwards and Bohlen, 1992; Curry, 2004), temperature and moisture (Berry and Jordan, 2001), soil properties like pH, texture and structure (Nuutinen et al., 1998; Baker and Whitby, 2003), and multitude of biotic interactions namely competition, predation, parasitism, disease, etc (Curry, 2004). Epigeic and anecic earthworms, the functional groups most affected by litter quality are more likely to be directly influenced by the interspecific differences in plant residues; however endogeic earthworms have also shown preferences of some plant residues over others. Leaf litter is a potential, but unexploited source of nutrient inputs in agriculture. Litter decomposition enriches the soil nutrient pool and also supports the saprophagic components of soil. However, the rates of decay and pathways of decomposition are determined by a number of factors (Swift et al., 1979). The quality and quantity of litter may affect significantly the population, biomass and secondary production of earthworms. Leaf litter left on the soil contributes significantly towards protecting and enriching the soil (Dash, 1993). Several studies (Nicolai, 1988; Tian et al., 1993; Zou, 1993; Wardle, 2002) suggest

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that the chemical composition of plants, especially N, lignin contents, and phenolic compounds play a crucial role in the abundance of soil and litter fauna through their effect in palatability and decomposability. Growth and reproduction of different species of earthworms using different materials such as flax seeds (Kosteka, 1999), cattle and goat manures (Loh et al., 2005), press mud (Parthasarathi and Ranganathan, 1999) have been studied. However, little is known of the possible consequences of impact of specific litter on earthworm.

Studies have shown that taxon of a trophic level influence the diversity of other trophic level (Wills et al., 1997. Emery and Gross (2007) have reported change in below ground diversity as an influence of vegetation change while a positive cor-relation has been found between plant and soil biodiversity (Hedlund, 2003). In order to get the precise information on relationship and impact of different litters on the dominant soil fauna (the earthworm), the present project was undertaken where the impact of *Mangifera indica*, *Acacia auriculaeformis* and *Eucalyptus citriodora* litters has been studied on biomass and secondary production of Megascolecid epigeic earthworm – *Perionyx sansibaricus* in experimental condition.

MATERIALS AND METHODS

Earthworms (*P. sansibaricus*) were sampled from a wet organically rich garbage site near Ranchi University, Morhabadi campus located between 21°58' to 25° 19'N L and 83° 20' to 88° 4' E L at a height of 629 m above mean sea level (MSL) during morning hours by monolith method (Dash and Patra ,1977). Three different age and size classes of *P. sansibaricus* namely juveniles (non-clitellate, < 2 cm), immatures (non-clitellate, ≥ 2 < 4 cm) and adults (clitellate, ≥ 4 cm) were hand sorted and used for analysis of population, biomass and reproduction (Pani, 1987). Artificial soil was prepared by mixing soil, saw dust (presoaked in water for 3 weeks) and cow dung (dried and powdered) in 1:1:1 ratio (w/w in dry condition). Physicochemical analysis of artificial soil revealed that it contains 0.615% N, 9.37% organic carbon and C:N ratio was 15.2. Freshly fallen leaves of Mango, Acacia and Eucalyptus were collected and oven dried at 85°C for 24 h and then powdered. 2% of leaf powders of all the plants were mixed with artificial soil in separate concrete structures (1 × 1 × 1 m) constructed in a series under shed. After one week of thermo-stabilization, earthworms were inoculated in different vermibeds and were maintained at 22 ± 3°C under 20% moist condition. Number of juvenile, immature and mature was counted and weight gained by earthworms was estimated at a regular interval of 7 days up to 21 weeks. In case of biomass, 5 replicate of fresh worms of different size groups were weighed separately after gut evacuation and then were kept in air oven at 85°C for 24 h to obtain dry weight.

Instantaneous growth (IG) was calculated following the Brafield and Llewellyn (1982) formula:

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

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

Secondary production was calculated using Macfadyen formula that is P = Δ B + E given by Golley (1961), where Δ B represent the change in biomass of individual and E represent the elimination of the individual which died during the experiment.

RESULTS AND DISCUSSION

Production can indicate the strategy of the population in directing mass and energy to other parts of the community and ecosystem (Calow and Townsend, 1981). Variation in population density and biomass of inoculated numbers of earthworms (*P. sansibaricus*) during experimental phase are shown in Table 1. In case of Mango litter, the initial as well as maximum biomass of the earthworm as g dry wt./ m^2 was 30.25 and 380.51, followed by Acacia (20.34 to 340.89) and lowest in Eucalyptus (30.21 to 310.43) in 1st week and 12th week respectively. Suthar (2007) reported that out of three different culture material used by him, *P. sansibaricus* showed maximum biomass production rate (3.77 mg $worm^{-1}$ day^{-1}) in culture containing mixture of kitchen waste and Mango litter (1:1) which indicated suitability of mango litter for the worm similar to the present findings. In the present study, the number of earthworms and biomass increases subsequently up to 12 week and after 12th week an erratic trend in the biomass of *P. sansibaricus* was observed in culture of all the litters which might be due to the death of some adult earthworms and reproduction of the mature worms. The difference in biomass production in culture with Mango, Accacia and Eucalyptus litter shows precisely the influence of variety of leaf on growth and development of earthworm. It is a reflection of influence of specific above ground form on below ground fauna. Extensive studies carried in Southeastern Mexico, Peruvian Amazon and India revealed that trees are important in maintaining native earthworms in a system (Fragoso, 1997), suggesting that some tree species favour earthworm populations over others as has been found in the study by using different litters.

The used litters might have influenced earthworm due to different palatability, particle size, texture and physico-chemical composition. Further, the chemicals present in three different litters might have affected the growth and biomass of the earthworm. Fragoso (1997) also noted the reduction in native earthworm species as the forests were converted to fallows, crops and pastures which are manifestation of impact of above ground diversity on below ground diversity. The recorded maximum biomass (380.51, 340.89 and 310.43 g dry wt/m^2) in three different litters was considerably higher than the report of Dash and Patra (1977), Lavelle (1978) and Senapati and Dash (1981) for tropical pasture. Sarlo (2006) reported average earthworm biomass ranging from 2.56 to 2.65 g/m^2 under *Cordia alliodora* plantation and 12.37 to 13.4 g/m^2 under

Table 1. Density (no./m^2) biomass (g/m^2) and secondary production (g/m^2 week^{-1}) of *P. sansibaricus* in three different litters.

	Mango litter				Acacia litter				Eucalyptus litter			
Weeks	**Density**	**Biomass**	**∆ B**	**E**	**Density**	**Biomass**	**∆B**	**E**	**Density**	**Biomass**	**∆B**	**E**
I	850	30.25	--	--	370	20.34	--	--	745	30.21	--	--
II	875	50.1	19.85	--	875	50.86	30.52	--	895	80.46	50.25	--
III	905	100.37	50.27	--	895	70.77	19.91	--	920	130.81	50.35	--
IV	925	150.56	50.19	--	910	120.39	49.62	--	935	150.31	19.50	--
V	1095	158.18	7.62	--	1025	150.28	29.89	--	1225	175.46	25.15	--
VI	1105	170.34	12.16	--	1420	170.91	20.63	--	1935	189.71	14.25	--
VII	1645	195.08	24.74	--	1705	192.23	21.32	--	2250	198.35	8.64	--
VIII	1990	200.08	5.00	--	2250	220.65	28.42	--	5100	210.89	12.54	--
IX	3215	229.18	29.10	--	4025	290.98	70.33	--	7750	260.76	49.87	--
X	4845	300.02	70.84	--	5125	305.01	14.03	--	7885	250.33	--	10.43
XI	7790	325.23	75.21	--	9815	321.89	16.88	--	9525	300.84	50.51	--
XII	11025	380.51	54.28	--	10590	340.89	19.00	--	10450	310.43	9.59	--
XIII	10020	360.21	--	20.30	10105	315.42	--	25.47	8150	240.49	--	69.94
XIV	9050	370.92	10.71	--	9950	280.68	--	34.74	9305	270.25	29.76	--
XV	8225	320.64	--	50.28	9425	260.81	--	19.87	7200	250.56	--	19.69
XVI	7535	300.53	--	20.11	8150	250.96	--	9.85	6175	240.34	--	10.22
XVII	8910	370.41	69.88	--	8025	250.52	--	0.44	6180	250.12	9.78	--
XVIII	6475	320.77	--	49.64	6175	200.83	--	49.69	5050	220.92	--	29.2
XIX	5810	310.34	--	10.43	6225	210.28	9.45	--	5025	210.92	--	10.00
XX	6905	320.2	9.86	--	6250	203.37	--	6.91	4950	200.44	--	10.48
XXI	5700	310.08	--	10.12	6275	210.79	7.42	--	5125	220.24	19.8	--

Hura crepitans plantation in Sardinilla region of Buena Vista. The higher side of biomass production might be due to favourable culture condition and sufficiency to litter component as relationship between earthworm number and biomass with litter mass has been established in natural condition (Sarlo, 2006). Many authors recognize that growth may encompass repair and maintenance (Needham, 1964) while production includes only increase in biomass or change in body constituent. As growth is essentially quantitative, its most important property is its rate which varies considerably. The maximum and positive values of change in biomass (∆ B) was observed in 11th week for Mango (75.21) and Eucalyptus (50.51) while it is maximum and in between the 2nd in 9th week for Acacia litter (∆ B = 70.33). The growth rate with respect to time interval that is the instantaneous or specific growth rate calculated for *P. sansibaricus* varied from -14.56 (15th week) to 69.98% (3rd week) in Mango litter, -25.52 (13th week) to 97.95% (1st week) in Eucalyptus and -22.10 (18th week) to 91.64% (1st week) in Acacia (Figures 1 to 3).

Various environmental factors affect the growth and reproduction and hence growth rate declines or increases at different time interval (Sinha et al., 2003). The variation in the IG of *P. sansibaricus* in the present study appears to be the impact of the organic matter content for the culture medium. According to Fayolle et al. (1997) among the different variables necessary for earthworm growth and production, it seems that the type of food is most important. In general, the proportion of N or even C-to-N ratio of the feeding material appeared to be an important factor for influencing the worms' activity. Garcia and Fragoso (2002) also reported influence of feeding source on growth and reproduction performance of *Pontoscolex corethurus* and *Amynthas cortices*. They concluded that despite of C-to-N ratio of the feeding material the concentration of polyphenols and related compounds were more important for controlling earthworm activities. The C:N ratio for the present culture medium was very suitable for the worm. The flow of energy and materials through an animal population can be quantified by determining its secondary production, the accumulation of biomass through growth and reproduction. Furthermore, analysis of secondary production can be used to test ecological hypothesis about animal populations. Maximum secondary production (g dry wt/m^2/week) was observed in Mango litter with a value of 680.59 followed by Eucalyptus (509.95) and Acacia (484.39) Figure 4. On the contrary to the biomass data, the differences in the secondary production in the litters were due to more elimination in Eucalyptus leaf containing culture. Whalen (2000) has reported that secondary production of *Aporrectodea* spp. was 3.47 to 16.14 g ash-free dry weight (AFDW) m^{-2} year^{-1} and of *Lumbricus* spp. was

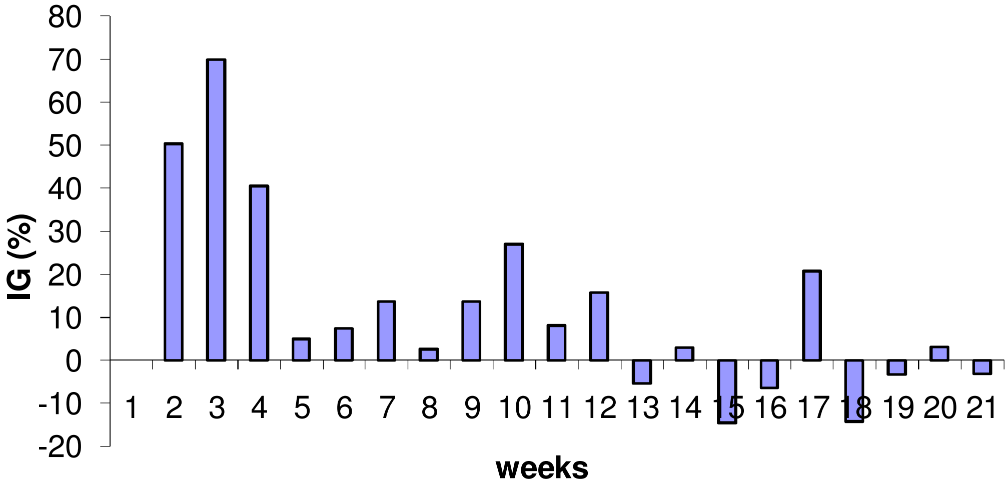

Figure 1. Instantaneous growth of *P. sansibaricus* in Mango litter.

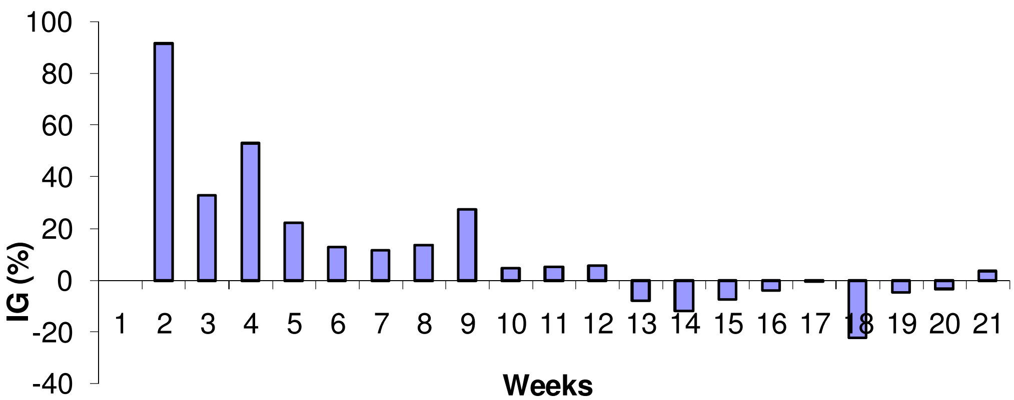

Figure 2. Instantaneous growth of *P. sansibaricus* in Acacia litter.

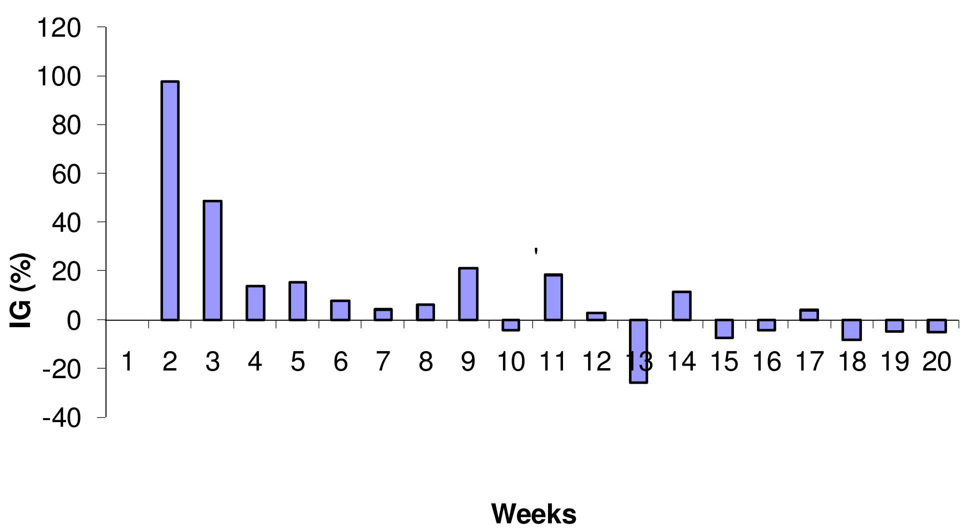

Figure 3. Instantaneous growth of *P. sansibaricus* in Eucalyptus litter.

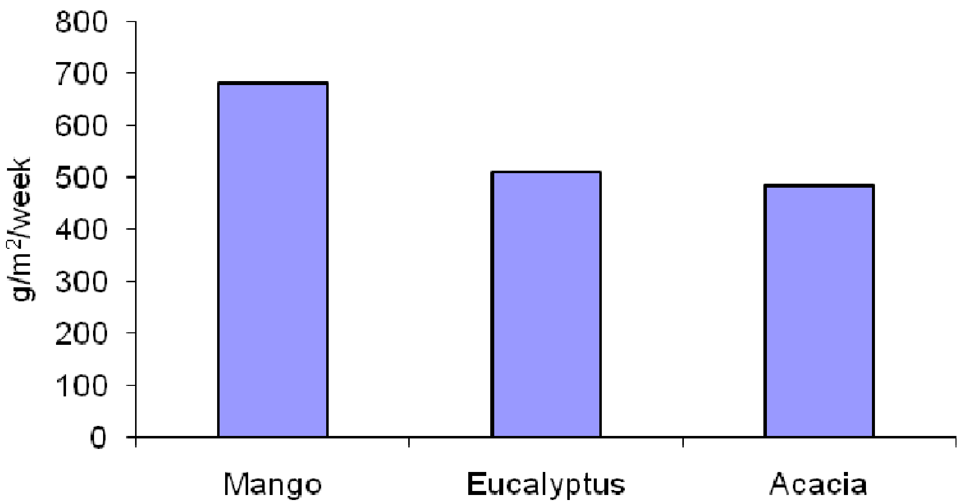

Figure 4. Secondary production of earthworms (g/m^2/week) in three litters.

6.09 to 18.11 g AFDW m^{-2} year^{-1} in corn agroecosystem whereas results of this experiment shows highest secondary production of 680.59 g dry wt/m^2/week in Mango, followed by Eucalyptus (509.95 g dry wt/m^2/ week) and lowest in culture of Acacia litter (484.39 g dry wt/m^2/week).

The maximum value of biomass as well as secondary production of earthworm in Mango litter could be due to suitability of the active principle of Mangiferin which does not seem to have any adverse impact on the earthworms. The results on population, instantaneous growth, bio-mass and secondary production of *P. sansibaricus* vary precisely reflect significant impact of the above ground diversity on below ground diversity even in experimental condition when a particular litter has been taken. It is not questionable that plant diversity controls the earthworm density and diversity rather, the experiment emphasizes that the plant traits are more important than plant diversity in determining the abundance and activity of earthworms. The results from this study have important implications for nature restoration strategies both for natural habitats and disturbed habitats especially in mining area where the reclamation is going on. The dominance of unsuitable plants may lead to local extinction of earthworms. Hence, for natural restoration, such aspects should be taken into consideration.

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