Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Archives of Applied Science Research, 2012, 4 (5):2034-2039
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0975-508X
CODEN (USA) AASRC9

Impact of different litters on population dynamics and reproductive biology of a megascolecid earthworm *Perionyx Sansibaricus* in laboratory condition

Akanksha Singh and Manoranjan. P. Sinha*

University Department of Zoology, Ranchi University, Ranchi, Jharkhand

---

ABSTRACT

The influence of three different litters on population dynamics and reproductive biology of Perionyx sansibaricus were studied in artificial soil under laboratory condition for 21 weeks. P. sansibaricus showed highest population density of 11025 m^{-2} in mango litter culture followed by 10590 m^{-2} in culture of acacia litter and lowest 10450 m^{-2} in the culture containing eucalyptus litter. However, growth rate of population was found highest in acacia litter culture ranging from +86.9 to -2.62, followed by eucalyptus litter showing maximum of +81.8 and minimum -2.56 and lowest was observed in mango litter culture (+47.9 to -35.6).The rate of reproduction (J/A) of P. sansibaricus was highest in eucalyptus litter followed by acacia and lowest was observed in mango litter culture. These indicate that mango litter favours the increase in the earthworm's population whereas eucalyptus helps in enhancing its reproduction rate.

Keywords: *Perionyx sansibaricus*, mango, eucalyptus, acacia, population, reproduction rate

---

INTRODUCTION

Leaf litter accumulation in urban and suburban locations such as sidewalks, lawns, and playgrounds is not only an unseemly sight but adds to the overall problem of municipal solid waste disposal. In many countries, including India, leaf litter is often piled-up and set on fire. The resulting ash returns some of the NPK content of the litter to the soil but much of nitrogen, phosphorus and organic carbon gets lost. The burning of litter also adds to air pollution [1]. The transformation of chestnut burr and leaf litter mixed with solid poultry manure into compost would be a good use of both these wastes [2]. The study also explored the possibility of co-composting chestnut burr and leaf litter with solid poultry manure and its use as a fertiliser. An indigenous strain of *Eudrilus* sp., identified at the Central Plantation Crops Research Institute (CPCRI), India, was capable of decomposing the highly lignified coconut leaves effectively and efficiently into vermin-compost in a period of 75–90 days [3].

Perionyx sansibaricus Mich. is purple–red colored epigeic earthworm species with a short life cycle, mainly found in bio-gas-slurry, dung pats, composting heaps and decomposing leaf litter heaps. The industrial organic residues are candidates for the transformation of products that involve expensive disposal problems into suitable vermistabilised inputs for use in food production. Much attention has been paid in recent years to evolve low input eco-friendly technologies for industrial waste management. Now-a-days, intensive research is being pursued on the potential use of earthworms for the stabilization of natural and anthropogenic wastes. Leaf litter can be composted and the compost used as a fertilizer or soil conditioner, but the market value of the compost is not high. Due to this factor, few people in urban/suburban localities take the initiative of collecting leaf litter and generating compost from it [4,5,6,7]. On the other hand, vermicompost is priced about three times higher than compost and a favorite soil conditioner of the farmers, especially in developing countries. Apart from providing organic carbon and NPK, which a compost does, vermicompost was believed to have the additional attributes of providing enzymes and hormones which stimulate plant growth [8,9,10]. Vermicompost was also believed to be more pathogen-free than compost [11,12]. The study on the vermistablisation of mango(*Mangifera indica* L.) leaf litter with *Eudrilus eugeniae* and

Eisenia fetida shows the possibility of producing vermicompost from these organic residues [10]. In view of this, an attempt has been made in the present study to investigate the impact of three different leaf litters (Mango, Eucalyptus and Acacia) on population dynamics and reproductive biology of *Perionyx sansibaricus*.

MATERIALS AND METHODS

Earthworms (*Perionyx sansibaricus*) were sampled from a wet organically rich garbage site near Ranchi University, Morhabadi campus, located between 21º 58' N to 25º19'N L and 83º20'E to 88º4' E L at a height of 629 m above men sea level (MSL) during morning hours by monolith method [13]. Three different age and size classes of *P. sansibaricus* viz. juveniles (non-clitellate, < 2cm), immatures (non-clitellate, ≥ 2 cm < 4cm) and adults (clitellate, ≥ 4 cm) were hand sorted and used for analysis of population, biomass and reproduction [14].

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). Physico-chemical 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 85ºC for 24 h and then powdered. 2 % of leaf powders of all the plants were mixed with artificial soil in separate concrete structures (1m X 1m X 1m) constructed in a series under shed. After one week of thermo-stabilization, earthworms were inoculated in different vermibeds and were maintained at temperature 22 ± 3°C and 20% moisture condition. Numbers of juvenile, immature and mature worms were counted and weight gained by earthworms was estimated at a regular interval of 7 days up to 21 weeks.

RATE OF POPULATION GROWTH

Since *Perionyx sansibaricus* is r-selection species and shows exponential growth which was calculated by the formula.

$N_t = N_o e^{rt}$

Where,
N_t= population size after time t
N_o= population size at the beginning
t= time interval
r= rate of population growth

Rate of reproduction

The rate of reproduction was calculated following methods of Sahu and Senapati [15]. The data on earthworm cocoon production in one of the important aspects in determining the reproductive strategy of earthworms. However Sahu and Senapati [15] have indicated the possibility of utilizing juvenile: adult ratio in the absence of cocoon data giving reliable results.

RESULTS

Population Dynamics

The population density of *Perionyx sansibaricus* ranged from 850 m^{-2} to 11025 m^{-2} in culture of Mango litter during 1st and 12th week respectively. While in the culture containing Acacia litter, *P. sansibaricus* showed the minimum density of 370m^{-2} in the 1st week and maximum 10590m^{-2} during 12th week of the experiment. Comparatively, lowest density of *P.sansibaricus* was observed in Acacia litter culture varying from 745 m^{-2} to 10450 m^{-2} during 1st and 12th week of the experiment respectively.

Population structure of *P.sansibaricus* constituted juvenile of 9.50-41.0%, 6.7-48.69% of immature and adult showing 14.36-59.17% in Mango litter culture (Table 1). In Acacia litter culture (Table 3) juvenile constituted 1.36-64.51%, immature 2.05-49.93% and 13.96-83.92% of adults during the study period. While in the culture containing Eucalyptus litter (Table 2), juvenile constituted 1.48-79.3%, 12.14-57.84% immature and mature worm constituted 14.51-82.42% from 1st to 21st week of the study period.

Table 1: Population density of juvenile, immature and mature *P.sansibaricus* in mango litters medium.

No. of Weeks	Juvenile	Immature	Mature	Total no. of worms
1	850	0	0	850
2	700	175	0	875
3	550	225	130	905
4	455	250	220	925
5	225	405	465	1095
6	105	75	925	1105
7	705	525	415	1645
8	600	845	545	1990
9	490	1525	1200	3215
10	425	2300	2120	4845
11	385	2795	4610	7790
12	300	4725	6000	11025
13	4110	3310	2600	10020
14	3000	3125	2925	9050
15	2250	4005	1970	8225
16	1730	2800	3005	7535
17	1295	3510	4105	8910
18	535	2905	3035	6475
19	2300	2000	1510	5810
20	2000	3205	1700	6905
21	1200	2400	2100	5700

Table 2: Population density of juvenile, immature and mature *P.sansibaricus* in Eucalyptus litters medium.

No. of Weeks	Juvenile	Immature	Mature	Total no. of worms
1	745	0	0	745
2	710	185	0	895
3	580	215	135	920
4	470	225	240	935
5	210	405	610	1225
6	105	235	1595	1935
7	995	200	855	2250
8	825	2950	1325	5100
9	750	3550	3450	7750
10	725	3595	3565	7885
11	525	3755	5245	9525
12	155	2750	7545	10450
13	3925	2150	2075	8150
14	2700	3555	3050	9305
15	1700	3850	1650	7200
16	1525	1425	3025	6175
17	1075	1220	3895	6180
18	495	1105	3450	5050
19	2800	805	1420	5025
20	1850	1600	1500	4950
21	1215	2210	1700	5125

Figure 1: Rate of growth of *P.sansibaricus* in three different litters medium

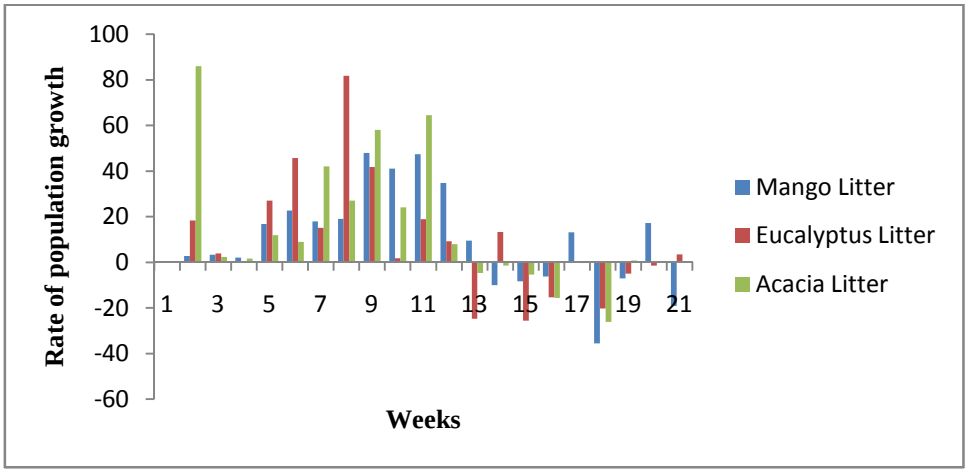


Table 3: Population density of juvenile, immature and mature *P.sansibaricus* in Acacia litters medium.

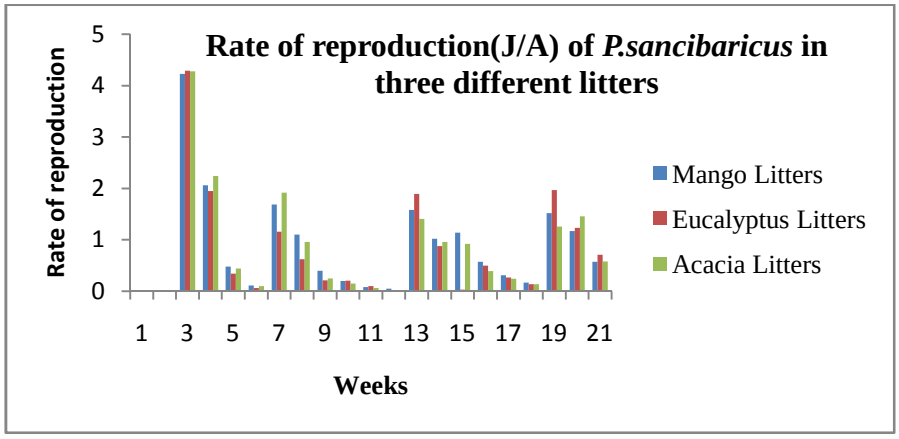
No. of Weeks	Juvenile	Immature	Mature	Total no. of worms
1	370	0	0	370
2	760	115	0	875
3	535	235	125	895
4	460	245	205	910
5	190	405	430	1025
6	95	85	940	1420
7	1100	35	570	1705
8	605	1015	630	2250
9	410	2010	1605	4025
10	395	2225	2505	5125
11	345	3705	5725	9815
12	145	2295	8150	10590
13	4095	3210	2900	10105
14	3225	3400	3325	9950
15	2510	4215	2700	9425
16	1650	2200	4200	8150
17	1105	2405	4515	8025
18	495	2180	3500	6175
19	2415	1900	1910	6225
20	1900	3050	1300	6250
21	1350	2615	2310	6275

Rate of population growth of the earthworm in three different litters is exhibited in figure 1. The rate of population growth in Mango litter culture ranged from maximum +47.9 to minimum -35.6 in the 9th and 18th week of the experiment respectively. While it varied to maximum of +81.8 on 8th week to minimum -25.6 during the 15 weeks in the Eucalyptus litter culture. Lowest rate of population growth among the three litters was observed in culture of Acacia litter ranging from +86.0 (1st week) to -26.2 (18th week) during the study period.

Reproductive Biology

In Mango litter culture, the rate of reproduction varied from 4.23-0.05 in the 3rd and 12th week of the experiment respectively. The rate of reproduction was >1 during 3rd, 4th,7th,8th, 13th,14th,15th,19th and 20th week of the study period as shown in figure 2. While in the culture of Acacia litter, the rate of reproduction of *Perionyx sansibaricus* showed maximum of 4.28 (12th week) and minimum 0.01(1st week). However, it was >1 in the 3rd, 4th, 7th, 13th, 19th and 20th week of the experiment. Whereas the rate of reproduction was 4.29 in the 3rd week and minimum 0.06 during the 6th week of the study period in Eucalyptus litter culture. During 3rd, 4th, 7th, 13th, 15th, 19th and 20th week of the experiment, it was >1.

Figure 2: Rate of reproduction(J/A) of *P.sansibaricus* in three different litters medium



DISCUSSION

Population density

Population biology provides the first basic information about any species and is regulated by both biotic and abiotic factors. Climate, habitat, food and other organisms including individuals from its own species and other species together affect the natality and mortality and thus the population in quality and quantity [16].Discontinuity and alteration of animal population with regard to time, space and stress has been long recognized [17]. Assessment of

population in an ecosystem is therefore highly essential which is achieved through determining the density, dynamics, and age structure, natality and mortality parameters.

Very few reports are available on the population density of earthworm under the influence of litters or substrates under laboratory condition. Here efforts have been made to study the population dynamics of *P.sansibaricus* under the influence of 3 different litters (Mango, Acacia and Eucalyptus) in laboratory condition. In the present study population density of *P.sansibaricus* was different in different litters, culture medium and highest was observed in the culture of mango litters ranging from 850-11025 m^{-2}, followed by Acacia (370-10590 m^{-2}) and lowest (745-10450 m^{-2}) in culture containing Eucalyptus litter. Similar population density (375-10050 m^{-2}) of *P.sansibaricus*, at garbage site of Ranchi university, Ranchi [18]. The highest population density ranging from 8030-12617 m^{-2} so far has been reported while working on *Dichogaster bolaui* from upland grazed pasture receiving kitchen waste and dung deposit site receiving dung from nearby area [15]. However, massive production of *Pontoscolex corethrurus* was observed in cultivation beds containing wood residue (saw dust) resulting in 12000 worms in a $1m^2$ surface [19]. Higher density of *Pontoscolex corethrurus* inoculated as adult was reported in Simarouba litter and mixed litter culture of Simarouba litter and Cedrelinga litter than Cedrelinga litter alone. They revealed that high densities at the end of experiment was due to the fact that inoculated individual (adult/juvenile) managed to survive and reproduce. A decline of 22.0% in *Drawida wilsi* population in experimental plots irrigated with rice mill waste water was observed [20]. They revealed that the decline was due to alkaline nature of rice mill waste water (pH-8) containing high amount of total phenols, silica, TSS (530mg/l), BOD (450mg/l) and Sodium (235mg/l). Decrease in earthworm numbers close to paper mill factory [21] and tannery factory [22] has also been well reported. These sites had also a very high level of pH, silica, organic matter and polyphenols. A low density of earthworm from Eucalyptus plantation site rich in polyphenolic substances has also been reported [23]. In our case, highest population density of *P.sansibaricus* among all the three litters was observed in mango litter culture and lowest in culture of Eucalyptus litter. The variation in the population density might be due to the difference in chemical contents of different litters. In Mango litter, Mangiferin (xanthone), a natural pigment favored the earthworms to increase their numbers and polyphenol substances in Eucalyptus caused the decline in population density of *P.sansibaricus*. The rate of population growth was found to be the highest in Acacia litter culture among all three litter culture medium, might be due to the better nutrient availability. Reports on population growth rates of earthworm in different culture medium are very scanty. In the present study, the rate of population growth was highest in Acacia litter culture followed by Eucalyptus litter and lowest in culture of Mango, might be due to the low polyphenol content in Acacia litter and high in Mango litter. We also observed that the youngest age group *i.e.* juveniles, forming the smallest component of the total population, indicate rapid transformation and/or high mortality and/or discontinuous reproduction resulting in instability in age structure

Rate of reproduction

Reproduction plays a significant role in the life processes and helps in successful establishment of any population in the ecosystem. The quality and palatability of food and bedding directly affect the survival, growth rate and reproduction potential of earthworms [10 ,24]. The ratio of total cocoon to the adults and total juvenile to adults in all the sample occasions didn't show significant difference, indicating the use of juvenile: adult ratio in the absence of cocoon data [25] which has been followed in the present work. In the present work, the rate of reproduction showed variation in different litters culture medium showing highest (0.06-4.29) in Eucalyptus litter culture followed by Acacia (0.01-4.28) and lowest (0.05-4.23) in the culture of Mango litter. On the basis of alternate method(J/A), the rate of reproduction for *Dichogaster bolaui* at dung deposit site has been recorded as 2.18 during December and 2.95 in July [25]. In a study it was reported that the rate of reproduction (cocoon per adult) of *Drawida wilsi* at the time of peak cocoon density was found to be 1.05 in plots irrigated with rice mill's waste water. They found 32.25% inhibition in the reproduction rate due to irrigation by rice mill waste water having high pH, silica and organic matter content [20]. maximum reproduction rate of *P.sansibaricus* in VLL (vegetable waste + leaf litter) as compared to farmyard wastes and other agricultural wastes [26]. The author observed consistent trend of earthworm reproduction rate, related to initial N-content of the substrate but there was no clear effect of C: N ratio of composted material on earthworm cocoon numbers. In another study the authors found that cocoon production rate was directly related to the type of earthworm species as well as the nature of worm feed stuff [27]. Although they didn't found any sort of relationship between cocoon hatchling success with the type of culture material, but hatchlings number per cocoon was directly related with the quality of substrate. The above study suggests that earthworm production can be managed by using feedstuff having higher nitrogen contents with low C: N ratios. Palatability of different types of litter to earthworms may depend on nitrogen and carbohydrate content, and presence of polyphenolics such as tannins [28]. They prefer materials with a low C/N ratio, such as clovers to grasses which have a higher C/N ratio [29]. Colonization of litter residues by microorganisms also increases palatability, as does leaching of feeding inhibitors [30]. The growth and reproduction of earthworm are highly influenced by quality and availability of feed, various physiochemical parameters etc [4, 31, 32]. Reproduction in earthworm require O, C, N and P which is obtained from litter, grit and microbes [5, 6, 19]. The *P.sansibaricus*

grow faster when feeding on N rich diet such as vegetable waste and leaf litter and *Eisenia foetida* in leguminous leaf litter also observed difference in rates of cocoon production could be related to the biochemical quality of the feeds, which is an important factor in determining the time taken to reach sexual maturity and onset of reproduction [10, 33, 34]. Feeds which provide earthworms with sufficient amount of easily metabolizable organic matter and non-assimilated carbohydrates, favours growth and reproduction of earthworms. But the findings of the present experiments,contradicts it. The density of *P.sansibaricus* was found to be lowest but highest rate of reproduction in Eucalyptus litter culture among all the litters. Therefore it can be conclusively stated that Eucalyptus litter is also a supporting medium for the reproduction of the earthworm.

REFERENCES

[1] SA Abbasi, E V Ramasamy. Biotechnological methods of pollution control, Orient Longman (Universities Press of India Ltd), Hyderabad, India,,**1999**, p 168.
[2] D Georgakakis, T.H Krintas, *Bioresour. Technol*., **2000**, 72, 227–233.
[3] Prabhu, S.R., Subramanian, P., Bidappa, C.C. and Bopaiah, B.M.. *Indian J. Coconut*, **1998**, 29, 79–84.
[4] N Karmegam, T Daniel *Flora and Fauna*, **1999**, 5, 51–52
[5] N Karmegam, T Daniel, *Indian J. Environ. Ecoplann* , **2000**, 3, 111–116
[6] N Karmegam T Daniel *Environmentalist* , **2009**, 29, 287–300.
[7] M Prakash; M, Jayakumar, N Karmegam., *J. Appl. Sci. Res*, **2008**, 4(1), 53–57
[8] RM Atiyeh, S Lee, CA Edward, NQ Arancon ,JD Metzger, *Bioresour. Technol.* **2002** 84, 7-
[9] HI Chaoui, LM Zibilsk, T Ohno, *Soil Biol. Biochem*, **2003**, 35, 295–302
[10] S Gajalakshmi, EV Ramaswamy, SA Abbasi, *Bioresour. Technol* , **2005**, 96, 1057–1061.
[11] MM Szczech, *J. Phytopathol*, **1999**, 15, 155–161.
[12] K Slocum, *Worm Digest* , **2002**, 23, 27-28.
[13] MC Dash, UC Patra. *Rev. Ecol. Biol. Sol*., **1977**, 14, 461- 471.
[14] SC Pani. Aspects of ecological studies on tropical earthworms in irrigated agricultural systems of Orissa. India. PhD thesis Sambalpur University, Orissa India, **1987**.
[15] SK Sahu, BK Senapati, *Trop Ecol*, **1988**, 29, 6-14.
[16] EP Odum. *Fundamentals of ecology*. WB Savnders Toppan Co Ltd, Tokyo Japan, **1971**.
[17] C Elton. *Animal Ecology*, Academic press New York, **1927**.
[18] MP Sinha, R Srivastava, *SUJST*, **2001**, 13, 64-68.
[19] P Lavelle, *Naturaleza y Recursos*, **1998**, 34(1):28-4
[20] A Padhan, SK Sahu, *Int.J.Res.Rev.Applied.Sci*., **2011**, 6(2), 138-146.
[21] PC Mishra, S Sahoo, *Ecol. Environ. Con.*,**1997**, 3, 49-61.
[22] NV Nandakumar, Tannery and Chromate industrial effluent on soil, animals and plants. In: Mishra PC (ed) *Soil Pollution and soil organisms*. Ashis Publ House, New Delhi, **1989**, 149-170.
[23] MW Warren, W Zou, *Forest Ecol Mngt* , **2001**, 5811: 1-11.
[24] G Tripathi, P Bhardwaj, *Bioresour. Technol*, **2004**, 92, 215-218.
[25] SK Sahu, SK Mishra, BK Senapati, *Proc. Indian Acad. Sci*, **1998**. 97, 239-250.
[26] S Suthar, *Bioresource Tech*., **2006**, 97, 2474-2477.
[27] S Suthar and S Ram, *Int. J. Environ. Waste Mgm.t*, **2008**, 2, 584–600.
[28] JE Satchell, Lumbricidae. In: Burges, A. and F. Raw (eds.). *Soil Biology*. Academic Press. New York, NY. **1967**, 259- 322.
[29] E Ruz Jerez, PR Ball, RW Tillman, The role of earthworms in nitrogen release from herbage residues. In: Jenkinson, D.S. and K.A. Smith (eds.). *Nitrogen Efficiency in Agricultural Soils*. **1988**, 355-370.
[30] J Cortez, R Hameed, MB Bouche, *Soil Biol. Biochem*, **1989**, 21(4),491- 497.
[31] RD Kale, K Bano, Time and space relative population growth of earthworm *Eudrilus eugeniae*. *Advances in management and conservation of soil fauna* (Veeresh, G.k., Rajagopal, D and Vivaktamath, CA. (Eds.,)] Bangalore, **1991**, 659-665.
[32] G Manimegala, S Sarojini, G Gunasekaran, M Prakash, K Parthasarthi, S .Ananthakrishnasamy. *J Nat. Sci.* **2008**, 7 (2), 295-300.
[33] CA Edwards, Breakdown of animal, vegetable and industrial organic wastes by earthworms. – In: Edwards, C.A. and Neuhauser, E.F. (eds.): Earthworms in waste and environmental management. SPB Academic Publishing, Hague, **1988**, 21–31
[34] CA Edwards, PJ Bohlen. Biology and Ecology of Earthworms., Chapman and Hall publication, London, **1996**, 3, 202-217.