Environment and Ecology 36 (2A) : 637—641, April—June 2018
Website: environmentandecology.com ISSN 0970-0420

The Impact of Seasonal Variation on Biomass and Reproduction of Different Earthworm Species

Anand Kumar, V. P. Sabhlok

Received 5 February 2018 ; Accepted 27 February 2018 ; Published on 13 March 2018

Abstract In order to assess the response of epigeic earthworms to seasonal changes we monitored the population dynamics of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* in a manure heap in the field during a year. Earthworms were hand-sorted from 2 m × 0.5 m × 0.6 m in length, breadth and depth of pits in November (autumn) and in January (winter), April (spring) and August (summer) to determine earthworm population dynamics as well as biomass. Seasonality had a strong effect on the density, biomass and reproductive activity of the population. The effect of seasonal variation on the biomass and reproduction was observed on different species of earthworms. The maximum numbers of cocoons, adults were recorded in *E. fetida* than *P. excavatus* and *E. eugeniae*. The rainy season was found to be better for the cocoon production and adult earthworm production in all the species as compared to the winter and summer seasons. The weight gain was recorded to be maximum i.e. 1.90 g in case of *E. eugeniae* in rainy season and maximum length was 8.10cm in case of *E. eugeniae* as compared to *E. fetida* and *P. excavatus* in rainy season. The population of *E. fetida* was characterized by a high density of individuals and the predominance of mature individuals throughout the year. Maximum density, mating activity and size of cocoons were achieved in rainy season. These results suggest that *E. fetida* and *P. excavatus* and *E. eugeniae* is able to allocate resources to biomass and reproduction in response to environmental fluctuations.

Keywords Biomass, Reproduction, Seasons, Vermicomposting.

Introduction

Earthworms are natural invertebrates of agro ecosystem belonging to the family Lumbricidae and Dominant in the temperate and tropical soils. They are hermaphrodite, both male and female reproductive organs are present in every single earthworm but self-fertilization does not generally occur. At the time of laying eggs, the sexually mature worms have a distinctive epidermal ring shaped area called the clitellum, which has gland cells that secrete material to form a viscid, girdle like structure known as cocoon. The cocoons are small, with their size varying according to species. The color of the cocoon changes gradually as it develops from the freshly laid stage to the hatching stage. Though the number of fertilized ova in each cocoon ranges from one to twenty for lumbricid worms (Stephenson 1930) yet only one or two survive and hatch (Edwards and Lofty 1972).

The most effective use of earthworms in organic waste management requires a detailed understand-

Anand Kumar*, V. P. Sabhlok
Department of Zoology and Aquaculture, CCS HAU, Hisar 125004, India
e-mail: anand_rozha@yahoo.co.in
*Corresponding author

ing of the biology of all potentially useful species (Edward et al. 1998). Reinecke et al. (1992) reported that *E. fetida* had a wider tolerance for temperature than *Eudrilus eugeniae* and *P. excavatus*. It tolerates as high as 42°C as well as low soil temperature below 5°C. Such influence of environmental factors specially temperature on the fecundity of vermicomposting earthworms are on record (Venter and Reinecke 1988 and Giraddi 2000). Besides, effect of weather parameters such as profound influence of temperature on growth and development of worms (Reinecke et al. 1992) bed moisture and the types of food substrate (Venter and Reinecke 1988) also determine the hatching success. The difference between the rates of cocoons and hatchlings production in different treatments could be related to the nutrient quality of the feed mixtures, which is one of the important factors in determining the onset of cocoon production. The growth rate has been considered as a good comparative index to compare the growth of earthworms in different feeds (Edwards et al. 1998, Vasanthi et al. 2013).

Giraddi et al. 2008 made studies on the comparative reproductive biology of vermicomposting earthworms were taken up at the Main Agricultural Research Station, UAS, Dharwad during 2004-05, so as to assess the reproductive potential across the different seasons. *Eudrilus eugeniae* (Kingberg) was observed to have mean fecundity of 6.75 cocoons/ week (with a range of 5.4 during summer months to 7.75 during rainy season) as against 2.63 cocoons/ week (2.10 during summer to 3.00 in rainy months) seen in *Perionyx excavatus* (Perrier). Maximum population density, mating activity and the size of cocoons were achieved in spring, but the smallest cocoons were produced in winter (Monroy et al. 2006). A maximum mean weight of adult earthworms was achieved in winter at the lowest temperatures, but these large - sized earthworms showed the lowest mating activity (Kalpana et al. 1980). Temperature regimes below 15°C cause low growth rates and also affect the reproduction thereby diminishing the cocoon production and increasing incubation time. The low reproductive activity found in winter could lead to weight gain due to decrease of reproductive costs and reallocation of resources toward growth. According to this, the mean weight of the mature earthworms decreased in spring with the increasing reproductive activity (Stearns 1992).

Materials and Methods

The present research was carried out in the department of Zoology in CCS HAU Hissar. Total twelve pits measuring 2 m × 0.5 m × 0.6 m in length, breadth and depth were made under shady trees, in the open field having a temporary shed made up of straw, raised on pillars, to prevent them from direct sunlight and the rain fall. The pits were lined with bricks. Chaffed wheat straw (<2.0 cm size) was weighed and mixed with the fresh cow dung in a ration of 1 : 5 (wheat straw : cow dung). Some water was added to the wheat straw for their through mixing. Per cent moisture in the mixture was calculated by keeping 1 kg of mixture in oven at 60°C overnight and subsequently 70 kg dry weight of mixture was filled in each pit.

The pits carrying organic waste mixture was covered with gunny bags. These were watered regularly so as to maintain the moisture. One hundred healthy clitellated earthworms were weighed and released in each pit, after 15 days. Three pits for each of the earthworm species (*Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus*) were randomly selected. A map of the pits and earthworm species was prepared for record. All the pits were covered with gunny bags and were sprinkled with water @ 1–5 liters per day per pit. The experiment was conducted during three season i.e. winter (Nov–Feb, summer (Mar–Jun), and the rainy season (Jul–Oct). The earthworm sample was checked after 90 days. The total number of the adult / cocoon and the total weight and length of earthworm's were recorded. The data was subjected to statistical analysis using completely randomized design (C. R. D.).

Results and Discussion

Earthworms population and biomass

In this present experiment the reproductive biology of *E. eugeniae*, *P. excavatus* and *E. fetida* were found changed in relation to the seasonal changes. Table 1 (Fig. 1 and 2) show the maximum number of cocoons and the adult earthworms was found in rainy season

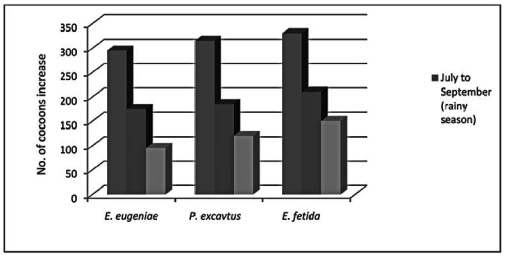

Fig. 1. Total number of cocoons of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* in relation to seasonal changes.

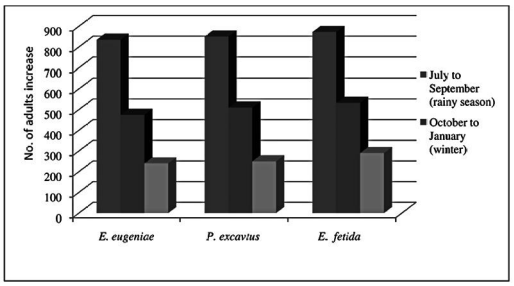

Fig. 2. Total number of adults of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* in relation to seasonal changes.

as compared to the winter and summer season. During rainy season 295 cocoons were laid maximum by *E. eugeniae*, 315 cocoons by *P. excavatus* and 330 cocoons by *E. fetida* but in winter season 175 cocoons were laid by *E. eugeniae*, 185 cocoons by *P. excavatus* and 210 cocoons by *E. fetida* while during summer season 95 cocoons were produced by *E. eugeniae*, 220 cocoons by *P. excavatus* and 150 cocoons by *E. fetida*. Related results and supported by some other researchers about the overall effects of the different temperatures on the life cycle of earthworms. The maximum rate of cocoon production by *E. eugeniae* was 3.6 cocoons per week at 25°C. This is a similar rate to that of *E. fetida*, which has been reported to produce 3.8 cocoons per week, but *E. fetida* reproduced most rapidly at 20°C but it is less than *Perionyx excavatus* which has been reported to produce up to 19.5 cocoons per week (Edwards and Fletcher 1988). In another study, Neuhauser et al. (1988) reported a maximum rate of cocoon production 3.8 cocoons per week at 25°C by *E. eugeniae*. Reinecke et al. (1992) reported a rate of cocoon production 3.22 cocoons by *E. eugeniae* per earthworm per week at 25°C and Knieriemen (1985) recorded a mean rate of cocoon production of three cocoons per earthworm per week. Rodriguez et al. (1986) calculated that seven cocoons were produced per earthworm per week at 30°C. Reinecke et al. (1992) reported that *E. fetida* had a wider tolerance for temperature than the *Eudrilus eugeniae* and *P. excavatus*. It tolerates as high as 42°C as well as a low soil temperature below 5°C. Such influence of the environmental factors specially the temperture on the fecundity of vermicomposting earthworms are on record (Venter and Reinecke 1988 and Giraddi 2000). Hatching percentage in both the species was significantly higher in the rainy season and in the winter months, characterized by a lower temperature (20 to 24°C) (Giraddi et al. 2008). In rainy season total number of the adult earthworms were observed to be 835 in case of *E. eugeniae*, 850 adults in case of *P. excavates* and 872 adults in case of *E. fetida*. In winter season total number of the adult earthworms was recorded to be 470 in case of *E. eugeniae*, 510 adults in case of *P. excavatus* and 535 adults in case of *E. fetida*. In summer season lowest number of the adults was recorded

Table 1. Reproductive biology of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* in relation to seasonal changes.

	Total no. of cocoons			Total no. of adults		
Treatments	*E. eugeniae*	*P. excavatus*	*E. fetida*	*E. eugeniae*	*P. excavatus*	*E. fetida*
Jul to Sep (rainy season)	295	315	330	835	850	872
Oct to Jan (winter)	175	185	210	475	510	533
Feb to May (summer)	95	120	150	240	250	290
CD (p = 0.05)	7.02	5.59	3.76	6.89	3.80	3.15

Table 2. Growth in *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* in relation to seasonal changes.

Treatments	Weight of earthworm (g)			Length of earthworm (cm)		
	E. eugeniae	*P. excavatus*	*E. fetida*	*E. eugeniae*	*P. excavatus*	*E. fetida*
Jul to Sep (rainy season)	1.90	1.60	1.20 a	8.10	6.60	5.50
Oct to Jan (winter)	1.40	1.30	1.10 a	6.50	5.10	4.40
Feb to May (summer)	1.15	0.98	0.94	5.40	4.20	3.94
CD (p = 0.05)	0.04	0.09	0.11	0.07	0.04	0.04

as compared to other season. 240 adults were found in case of *E. eugeniae*, 255 adults in case of *P. excavatus* and 290 adults in case of *E. fetida*. Same of the study also observed other scientist Viljoen and Reinecke (1992) also repoted a high mortality of *E. eugeniae* at temperatures above 30°C after 20 days. Loehr et al. (1985) also found that this species could not withstand temperatures above 30°C and that the best survival was at 20°C. Madge (1969) reported that *E. eugeniae* could survive only for one hour at 37°C and one day at 34°C. Rates of growth of *E. eugeniae* were very poor at 15°C as compared with those of *E. fetida* which grew very fast at 15°C as at 20°C or 25°C and much slower growth was there at temperatures above 25°C. Maximum biomass production by *E. eugeniae* occurred at 25°C and 30°C. Knieriemen (1985) reported that *E. eugeniae* could stay alive at 15°C but it did not grow. Viljoen and Reinecke (1992) reported the highest rates of growth of *E. eugeniae* at 29°C whereas Loehr et al. (1985) determined 25°C as the optimal temperature for the growth of this species.

Earthworms growth

Maximum weight and length gain was observed in the rainy season as compared to the winter and the summer season. Table 2 shows the growth in *E. eugeniae*, *P. excavatus* and *E. fetida* a low gain in weight and length was observed during summer season. In rainy season 1.90 g weight was gained by *E. eugeniae*, 1.60 g by *P. excavatus* and 120 g by *E. fetida*. In winter season 1.40 g weight was gained by *E. eugeniae*, 1.30 g by *P. excavatus* and 1.10 weights by *E. fetida*. During the summer season 1.15 g weight was gained by *E. eugeniae*, 0.98 g by *P. excavatus* and 0.94 g weight by *E. fetida*. As far as the length is concerned there was an increase 8.10 cm in *E. eugeniae*, 6.60 cm in *P. excavatus* and 5.50 cm by *E. fetida*, in the rainy season. During winter season 6.50 cm length was recorded in case of *E. eugeniae*, 5.10 cm in case of *P. excavatus* and 4.40 cm length in case of *E. fetida*. During summer season however length 5.40 cm was recorded in case of *E.eugeniae*, 4.20 cm in case of *P. excavatus* and 3.94 cm length in case of *E. fetida*. Similarly maximum mean weight of the adult earthworms was achieved in winter, at the lowest temperature, but these large-sized earthworms showed the lowest mating activity during this period (Kalpana et al. 1980). The waste decomposition and the earthworm production were associated strongly with the quality of the substrate especially with the chemical as well as biological composition of the substrate (Suthar 2006). Maximum mean weight of the adult earthworms was achieved in winter at the lowest temperatures, but these large-sized earthworms showed the lowest mating activity (Kalpana et al. 1980). Temperature regimes below 15°C not cause only low growth rate but also affect the reproduction and thus diminishing the cocoon production and increasing the incubation time. The low reproductive activity found in winter could lead to a weight gain due to decrease of reproductive costs and reallocation of resources toward growth. According to this, the mean weight of the mature earthworms decreased in spring with the increasing reproductive activity (Stearns 1992).

References

Edwards CA, Dominguez J, Neuhauser EF (1998) Growth and reproduction of *Perionyx excavatus* (Perr.) (Megascolecidae) as factors in organic waste management. Biol Fertil Soils 27 : 155—161.

Edwards CA, Fletcher KE (1988) Interactions between earthworms and microorganisms in organic-matter breakdown. Agric Ecosyst Environ 24 : 235—247.

Edwards CA, Lofty JR (1972) Biology of earthworms. Ch-

apman and Hall, London.
Giraddi RS (2000) Influence of vermicomposting methods and season on the biodegradation of organic wastes. Ind J Agric Sci 70 : 663—666.
Giraddi RS, Gundannavar KP, Sunitha ND (2008) Reproductive potential of vermicomposting earthworm. *Eudrilus eugeniae* and *Perionyx excavatus* as influenced by seasonal factors. Karnataka J Agric Sci 21 (1) : 38—40.
Kalpana DL, Hartenstein R, Neuhauser EF (1980) Physicochemical requirements in the environment of the earthworm *Eisenia foetida*. Soil Biol Biochem 12 : 347—352.
Knieriemen D (1985) Biomass production through the propagation of thermophilic earthworms. In : Bittner A (ed). Animal Research and Development. Hauser, Tübingen, Germany, pp 112—127.
Loehr RC, Neuhauser EF, Malecki R (1985) Factors affecting the vermi stabilization process. Temperature, moisture content and polyculture. Water Res 19 : 1311—1317.
Madge DS (1969) Field and laboratory studies on the activities of two species of tropical earthworms. Pedobiologia 9 : 184—214.
Monroy F, Aira M, Velando A (2006) Seasonal population dynamics of *Eisenia fetida* in the field. C. R. Biologies 329 : 912—915.
Neuhauser EF, Loehr RC, Malecki MR (1988) The potential of earthworms for managing sewage sludge. In : Edwards CA, Neuhauser EF (eds). Earthworms in Waste and Environmental Management. SPB Academic Publishing BV, The Hague, pp 9—20.
Reinecke AJ, Viljoen SA, Saayman RJ (1992) The suitability of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* (Oligochaeta) for vermicomposting in Southern Africa in terms of their temperature requirements. Soil Biol Biochem 24 : 1295—1307.
Rodriguez C, Canetti ME, Reines M, Sierra A (1986) Lifecycle of *Eudrilus eugeniae* (Oligochaeta : Eudrilidae) at 30^0C. Poeyana. Instituto de Zoologia. Academia de Ciencias de Cuba 326 : 1—13.
Stearns SC (1992) The Evolution of Life Histories, Oxford University Press, Oxford.
Stephenson J (1930) The Oligochaeta. Oxford Univ Press, London, pp 977.
Suthar Surendra (2006) Nutrient changes and biodynamics of epigeic earthworm *Perionyx excavatus* during recycling of some agriculture wastes. Bioresour Technol. 98 : 1608—1614.
Vasanthi K, Senthilkumar M, Chairman K, Ranjit Singh AJA (2013) Influence of temperature on growth and reproduction of earthworm *Eudrilus eugeniae*. Int J Curr Microbiol App Sci 2 (7) : 202—220.
Venter JM, Reinecke AJ (1988) The life cycle of the compost worm *Eisenia foetida* (Oligochaeta). South Afr J Zool 23 : 161—165.
Viljoen SA, Reinecke AR (1992) The temperature requirements of the epigeic earthworm species *Eudrilus eugeniae* (Oligochaeta). A laboratory study. Soil Biol Biochem 24 : 1345—1350.