Trans. Zool. Soc. East. India, 7(2) : 33-41 , 2003

POPULATION BIOLOGY AND REPRODUCTION STRATEGY OF OCNERODRILUS *OCCIDENTALIS* (OLIGOCHAETA : OCNERODRILIDAE) FROM TROPICAL AGROECOSYSTEM AT RANCHI, JHARKHAND, INDIA.

M. P. Sinha, R. Srivastava, M. Kumar, D. K. Gupta and N. S. Sen

Department of Zoology, Ranchi University, Ranchi-834 008 (Jharkhand) India.

Abstract

The present paper deals with the population biology and reproductive strategy of a peregrine earthworm *Ocnerodrilus occidentalis* (Eisen) from a tropical agro agroecosystem of Jharkhand near Ranchi town. The average monthly worm population of 2585 m^{-2} was observed while the peak population of 7600 m^{-2} was found. A considerable variation in density of worm at different depth was recorded. **ANOVA** relating to population density of earthworm at different sites indicates that mean values does not differ significantly at different sites at 5% and 1% level. However, there was a significant difference in population density value of different months at 5% and 1% level. Soil moisture is significantly correlated with total earthworm number ($r = 0.895$, $p < 0.001$). The rate of reproduction of *O. occidentalis* reached a peak of 3.191 indicating single reproductive peak in a year.

Introduction

Earthworms are widely distributed throughout the world and their population contributes about eight percent of the total biomass of the soil organisms. There is a great paucity of information on the biology of tropical earthworms (Dash 1978; Lavelle 1978). A comprehensive programme for understanding the environmental regulation of life cycle strategy in tropical earthworms has been taken up in different agroecosystems. Dash and Patra (1977), Senapati *et al* (1979) Dash and Senapati (1980) Sahu and Senapati (1986) have reported the activity of earthworms in low land upland and plain pasture ecosystems of Orissa but till date earthworms of Jharkhand have not been studied. The importance and functional significance of earthworm in the soils of the humid tropics have received more attention in the last few years (Lee, 1983; Lavelle, 1988; Lavelle et al., 1992, 1994). Most of this research has been carried out at the level of communities in natural savannas (Lavelle, 1978, 1983), pastures (Dash and Patra, 1977, 1979; Senapati, 1980; Lavelle *et al*., 1980) and tropical forests (Mishra, 1980; Nemeth and Herrera, 1982; Fragoso and Lavelle, 1987, 1992), while only a few studies have been conducted in agroecosystems (Cook *et al*., 1980; Bhadauria and Ramakrishna, 1989; Lavelle and Pashansai, 1989). This underlines the need of study on earthworms of agroecosystems in tropics.

Despite the high diversity of tropical earthworms, only a small number of species have been intensively studied in relation to soil processes, e.g. *Millsonia anomala* (Lavelle, 1978; Blanchart, 1992; Martin and Lavelle, 1992). As another example, no more than ten species (e.g. *Polypheretima elongata, Amynthas spp.*) of he Asiatic complex of pheretimoid earthworm genera (formerly named *Pheretima*) comprising more than 700 species (Easton, 1987) have been the subject of soil fertility studies (Gould *et al*., 1987). Clearly more research is needed to clarify the relationship between earthworm species diversity and the function of the ecosystem (Fragoso *et al*., 1997).

The present investigation intends to know about the earthworms of Jharkhand. The present paper deals with the population biology and reproductive strategy of *Ocnerodrilus occidentalis* in tropical agroecosystem at Ranchi, Jharkhand, India.

Study site and climate

Earthworms were collected from different sites of agroecosystem in and around Ranchi, located between 25° 15' N latitude and 83° 20' E longitude at a height of 666 m above mean sea level (MSL). The climate is broadly divided into three seasons. Winter (October-February) Summer (March-mid June) and rainy (mid June-September). Average air temperature data during the study period varied from a minimum of 15.30°C to a maximum of 31.9°C. Relative humidity of the study area ranged from 51 to 83.5% around the year. The total rainfall was 1319.9 mm out of which 77% fell during rainy season.

Materials and Methods

Earthworms were sampled and hand sorted once a month from October 99 to September 2000. Sampling was confined to first week of every month. During each sampling, 5 random samples were taken from an area of 20 x 20 x 30 cm separately from study site (Dash and Senapati 1980). Earlier works of Dash and Patra (1977), Senapati *et al* (1979) and Senapati and Dash (1981, 1983) on tropical earthworms from various agroecoststems which standardised methods for sampling, collection, preservation and analysis of worms were followed. *Ocnerodrilus occidentalis* was dominant in both number and biomass (>85%) in the study sites. On the basis of length and clitellar development, *O. occdentalis* worms were divided into 3 age classes I) Juvenile (>2cm, non clitellate), ii) Immatuare (³2cm<4cm, non clitellate develop non clitellate) and iii) Adult (³4 cm, clitellate). The population of earthworm was expressed as number of individual per square metre. The population of earthworm was expressed as number of individual per square metre. The population was estimated for three different vertical depth each of 10 cm. Soil moisture (g%) content has been measured by oven drying method respectively. Rainfall (mm/month) relative humidity (%) and air temperature (°C) data for the study sites have been collected from the Department of Agricultural Physics, Birsa Agrocultural University, Kanke, Ranchi.

Statistical analysis of the data was done according to Snedecor and Cochran (1967). Two factor analysis of variance (ANOVA) was done to determine significant differences between sites and between months.

Results

Population size and structure

The dynamics of different age class density and rate of reproduction of *O. occidentalis* have been presented in Table 1. The average monthly worm population of 2585 m^{-2} was observed during 1999-2000. The peak population of 7600 m^{-2} was found during August 2000 and a minimum of 75 m^{-2} was observed in June 2000. Population turn over value was calculated to be 101. Population structure constituted 5.39% of juveniles 48-100% of immatures and 10-31% of adults during the study periods (Table 1). This shows that the adults formed the smallest component of total population indicating slow transformation of immatures and/or low mortality.

Fig 1 shows the variation in density of worms at different depths. At a depth of 0-10 cm the worm density ranged between 75 ± 30.62 to 3500 ± 218.66 m^{-2} $month^{-1}$ obtained in the months of June 2000 and July 2000 respectively. The total number of worms at a depth of 10-20 cm ranged from 100 ± 63.73 to 3700 ± 271.57 m^{-2} $month^{-1}$ in the months of May 2000 and September 2000 respectively. A zero population was observed during June 2000. At a depth of 20-30 cm the number of worms ranged between 25 ± 30.61 to 1060 ± 171.94 m^{-2} $month^{-1}$ in December 99 and September 2000 respectively. A zero population of earthworm was observed in the months of April 2000, June 2000 and July 2000.

ANOVA relating to population density of earthworm at different sites indicates that mean values does not differ significantly at different sites at 5% and 1% level (Table 2). However there was a significant difference in population density value of months at 5% and 1% level (Table 2).

Population distribution and environmental regulation

Correlation coefficient values of different environmental parameters with total *O. occidentalis* density is given in Table 3. Figure 2 shows the vertical distribution of *O. occidentalis* population in the study site.

Table 1 : Age Structure and rate of reproduction of *Ocnerodrilus occidentalis*

Months	Vertical Depth (in cm)	Juvenile Worms J	Immature Worms IM	Mature Worms M	Total Worms TW	Rate of reproduction
Oct. 99	0 - 30	1330 ± 225.97	2680 ± 242.64	1225 ± 186.24	5235 ± 167.33	1.086
Nov.99	0 - 30	110 ± 57.55	740 ± 114.02	235 ± 106.95	1088 ± 202.02	0.468
Dec.99	0 - 30	50 ± 39.52	325 ± 119.89	50 ± 46.77	425 ± 123.24	1
Jan.00	0 - 30	45 ± 20.91	385 ± 65.19	115 ± 45.41	545 ± 110.96	0.391
Feb.00	0 - 30	150 ± 77.05	350 ± 82.92	125 ± 53.03	625 ± 157.12	1.2
Mar.00	0 - 30	245 ± 57.01	1015 ± 84.04	535 ± 57.55	1795 ± 161.43	0.458
Apr.00	0 - 30	50 ± 30.61	800 ± 88.38	95 ± 27.39	945 ± 105.18	0.526
May.00	0 - 30	-	330 ± 59.69	150 ± 75.00	480 ± 89.09	-
Jun.00	0 - 30	-	75 ± 30.62	-	75 ± 30.62	-
July.00	0 - 30	1100 ± 113.19	3000 ± 276.69	700 ± 86.60	4800 ± 179.41	1.571
Aug.00	0 - 30	3000 ± 140.31	3660 ± 85.88	940 ± 179.06	7600 ± 108.97	3.191
Sep.00	0 - 30	2160 ± 271.91	3705 ± 480.03	1550 ± 346.86	7415 ± 596.23	1.394

Table 2 : Value of two factor ANOVA test calculated for population of *Ocnerodrilus occidentalis* from different agro ecosystem at Ranchi

Source of variation	Sum of square	Degree of freedom	Mean square	Variance ratio F	Tabulated value F		Significant
					5%	1%	
Population							
Different Sites	383333.33	4	95833.33	2.218	2.58	3.78	Not significant
Different Month	446857365	11	40623397	940.298	2.01	2.68	Significant
Residual	1900916.67	44	43202.65	-	-	-	-

Table 3 : Correlation coefficient of different climo-edaphic Parameters with total worm number.

Parameter	Total worm number
Rainfall (total)	+ 0.677 *
Relative humidity (average)	+ 0.668 *
Air temperature (average)	+ 0.276 ***
Soil moisture (0-30) (average)	+ 0.895 **

* p<0.02 ** p<0.001 *** NS

Soil moisture is significantly correlated with total earthworm number ($r = 0.895$, $p < 0.01$). Similar relationship with worm number has been reported for relative humidity and rainfall. Significant positive correlation of worm population with soil moisture indicates the hydrophilic nature of earthworm. An average of 42, 48 and 10% of worms were stratified at 0-10, 10-20 and 20-30 cm of soil depth respectively. Dynamics of total worms (nos m^{-2} $month^{-1}$) showed unimodal form of population peaks at the agroecosystem site (Table 1).

Reproductive strategy

Table 1 provides the data on the rate of reproduction and Fig. 3 shows the life cycle of *O. occidentalis* in the agroecosystem. The rate of reproduction of *O. occidentalis* reached a peak of 3.191 in August 2000 indicating single reproductive peak. Considering the peak rate of reproduction, peak juveniles and peak population the probable duration for completion of *O. occidentalis* life cycle may be about 5-6 months in the study sites.

Discussion

Population size and structure

Population size of earthworms varies greatly and maximum density generally occurs in base rich grassland and minimum in acid soil (Petersen, 1982). While comparing earthworm densities in different world sites, types of sampling methods, climate and soil types should be considered as these have been found to influence population density. The *O. occidentalis* population is very high (7600 m^{-2} $month^{-1}$) in comparison to the previously reported values. Presence of high population density may be attributed to the rainfall that occurred throughout the study period. The population turnover value for the tropical pasture earthworms is very high in comparison to temperate pasture earthworms (Edwards and Lofty, 1972; Dash and Patra, 1977; Dash and Senapati, 1980; Mishra and Dash, 1984). The present finding is in agreement with the above reports.

Information on the structure of earthworm population are very scanty. Evans and Guild (1948), Satchell (1967), Lavelle (1978), Dash and Patra (1977), Mishra and Dash (1984) have reported that juveniles and immature occupy a large proportion of earthworm population throughout the year. In the present investigation higher proportion constituted by the juveniles and immature earthworm population throughout the year confirms the above findings.

Population distribution and environmental regulation

Seasonal differences in the population density could be attributed to earthworm species, soil type, climate and attitude (Guild, 1952; Murchie, 1958). Gerard

(1967), Nakamura (1968), Edwards and Lofty (1972), Dash and Patra (1977), Dash and Senapati (1980), Senapati and Dash (1981) have stressed the importance of soil moisture and temperature on earthworm. The present finding reveal that the soil moisture is the most important factor regulating the activity of tropical earthworm. A significant positive correlation between earthworm population and soil moisture content ($r = 0.895$, $P < 0.001$) during the investigation supports the previous findings of Dash and Patra (1977) and Mishra and Dash (1984).

Reproductive strategy

Reproductive strategy of a few species has been studied from both temperate and tropical habitats. Previous studies on tropical earthworms, *Drawida calebi*, *Lampito mauritii* and *Octochaetona surensis* studied by Dash and Senapati (1980) revealed a single peak and prolonged emergence pattern. The present findings are in agreement with above findings.

Fig. 1 : Density of worms at different depth.

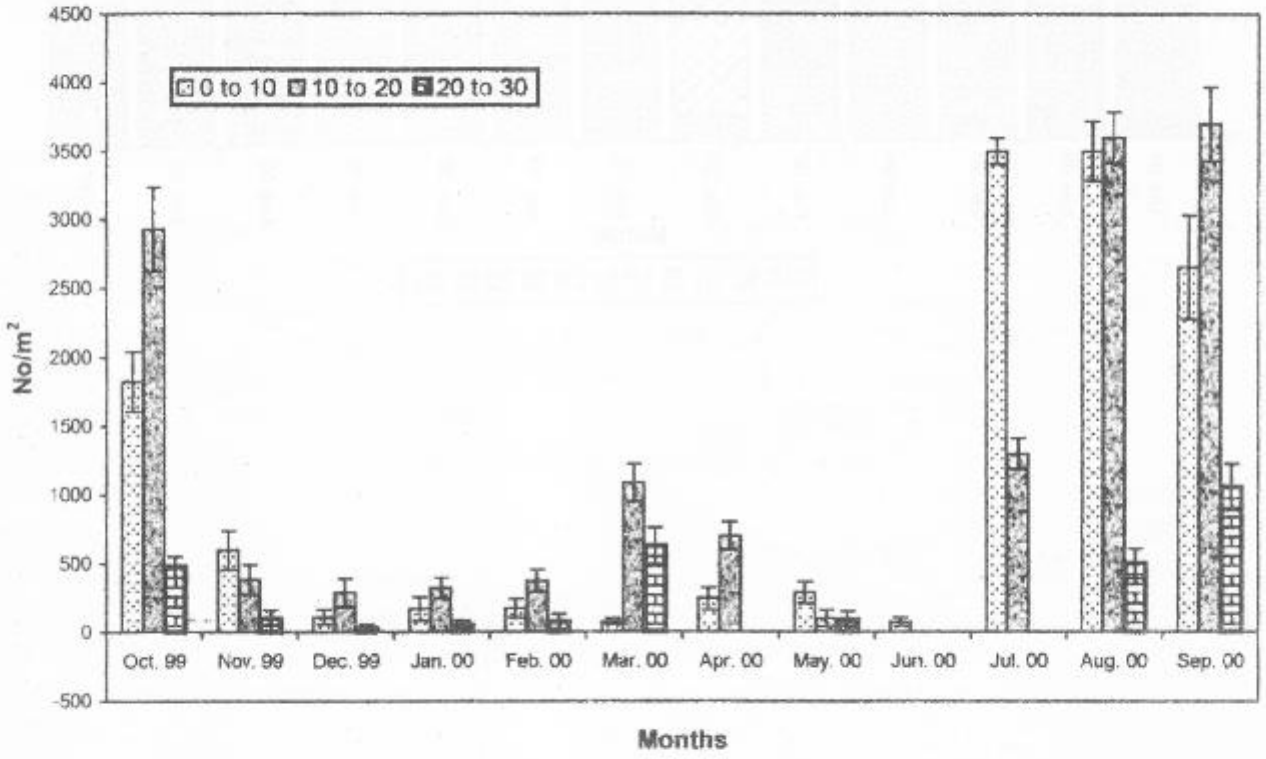


Fig. 2. Vertical distribution of *Ocnerodrilus occidentalis* at study sites during 1999-2000.

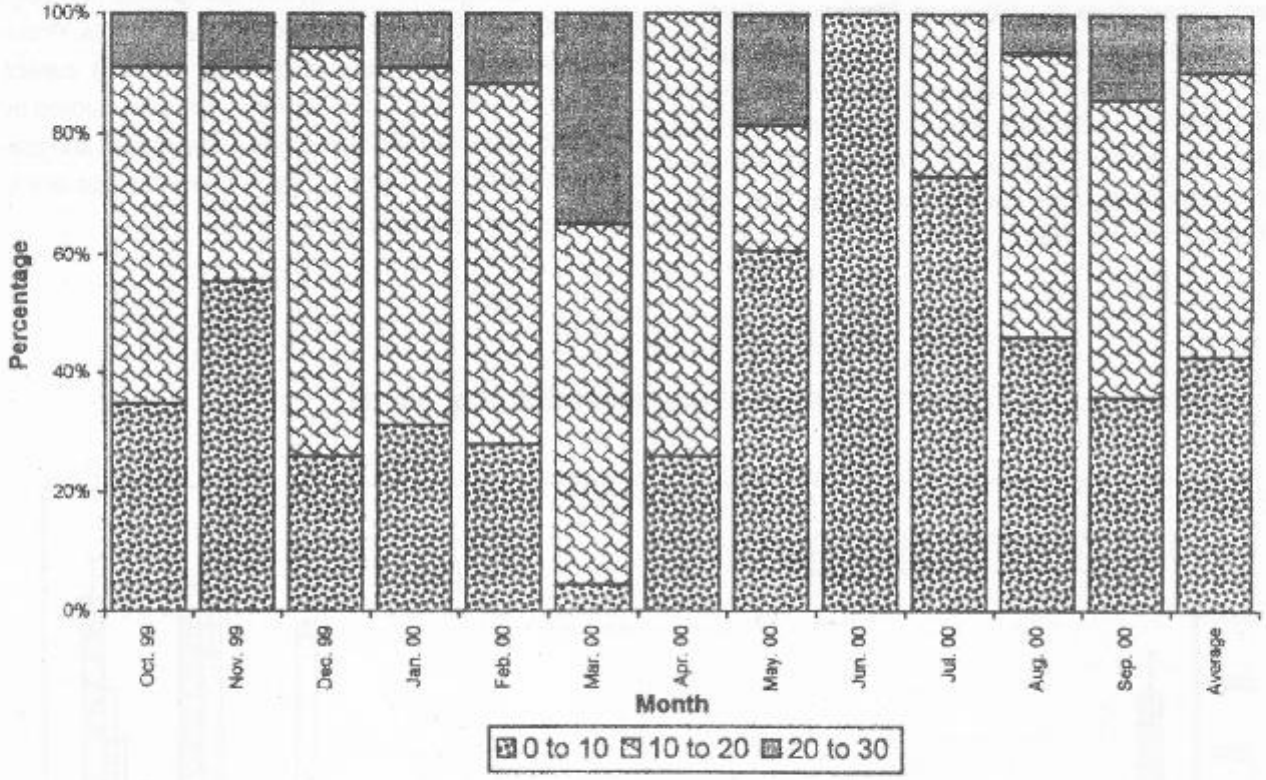
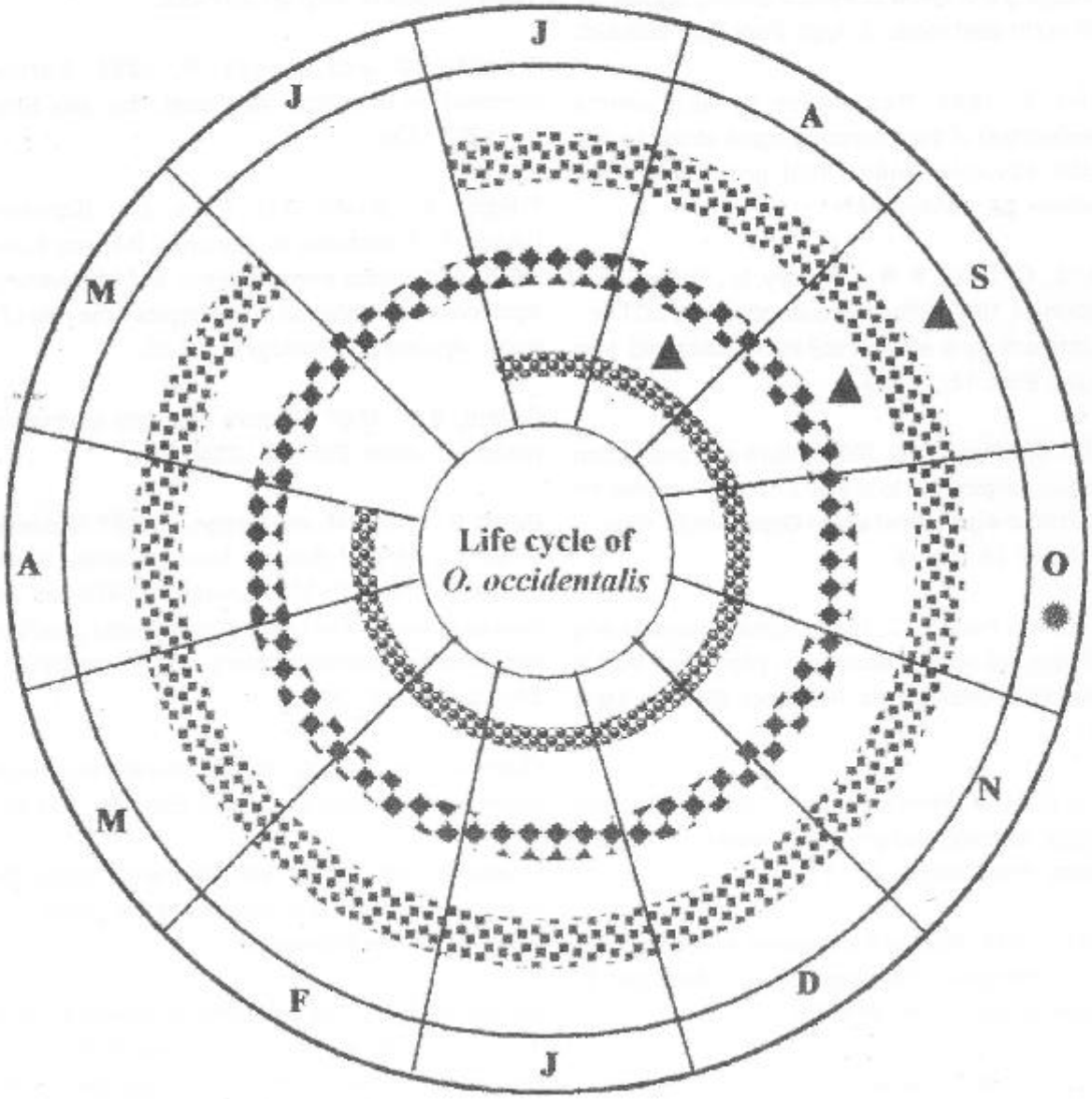


Fig. -3 : Life cycle of *Ocnerodrilus occidentalis*



A = Adult
B = Immature
C = Juvenile
D = Peak number
E = Month

References

Bhadauria, T. and Ramakrishna, P.S. 1989. Earthworm population dynamics and contribution to nutrient cycling during cropping and fallow phases of shifting agriculture (jhum) in north east India. *J. Appl. Ecol.* **26** : 505-520.

Blanchart, E. 1992. Restoration by earthworms (Megascolecidae) of the macroaggregate structure of a distructed savanna under field conditions. *Soil Biol.Biochem.* **24** : 1587-1594.

Cook. A. G., Critchley, B. R., Critchley, U., Perfect, T. J. and Yeadon, R. 1980. Effects of cultivation and DDT on earthworms activity in a forest soil in the subhumid trop ics, *J. Appl. Ecol.* **17** : 21-29.

Dash, M.C. and Patra, U.C. 1979. Worm cast production and nitrogen contribution to soil by a tropical earthworm population from a grassland site in Orissa, India. *Rev. Ecol. Biol. Sol.* **16** : 79-83.

Dash, M.C. and Patra, U.C. 1977. Density, biomass and energy budget of tropical earthworm population from a grassland site in Orissa, India. *Rev. Ecol. Biol. Sol.* **14(3)** : 461-471.

Dash, M.C. and Senapati, B.K., 1980. Cocoon morphology, hatching and emergence pattern in tropical earthworms. *Pedobiologia*, **20** : 316-324.

Dash, M.C., 1978. Role of Earthworms in decomposer system. In : *Glimpses of Ecology* (Eds.) J. Singh and B. Gopal. Inter. Science Publ. 399-406.

Easton, E.G. 1987. Forests and the distribution of Perichaetinae earthworms. In : *On Earthworms. Selected Symposia and Monographs U.Z.I. 2,* A.M. Bonvicini and P. Omodeo (Eds). Mucchi, Modena, Italy, pp. 265-280.

Edwards, C.A. and Lofty, J.R., 1972. *Biology of earth worms.* Chapman and Hall, London.

Evans, A.C. and Guild, W.J. Mc. L. 1948. Studies on the relationship between earthworms and soil fertility. V. Field populations. *Ann. Appl. Biol.* **35** : 485-493.

Fragoso, C. and Lavelle, P. 1987. The earthworm community of a Mexican tropical rain forest (Chajul, Chipas) In : *On Earthworms. Selected Symposia and Monographs U.Z.I.,* 2 A.M. Bonvicini and P. Omodeo (Eds), Mucchi, Modena, Italy. pp. 281-295.

Fragoso, C. and Levelle, P. 1992. Earthworm communities of tropical rain forest. *Soil. Biol Biochem.* **24** : 1397-1408.

Fragoso, C., Brown, G.G., Patro, J.C., Blanchart, E., Lavelle, P., Pashanasi, B., Senapati, B.K. and Kumar, T. 1997. Agricultural intensification, soil biodiversity and agroecosystem function in the tropics : the role of earth worm. *Applied Soil Ecology* **6** : 17-35.

Gerard, B.M. 1967. Factors affecting earthworms in pasture. *J. Anim. Ecol.* **36** : 235-252.

Gould, E., Andau, M. and Easton, E. 1987. Observations of earthworms in Sepilok forest, Sabah, Malaysia. *Biotropica.* **19** : 370-372. Lavelle, P. 1978 Les vers de terre de la savanna de Lamto (Cote d Ivoire): peuplements, populations et functions dans L. ecosystems; Publ. Lab. Zool. E.N. S. **12** : 301.

Guild, W.J. Mc.L., 1952. Variation in earthworm numbers within field populations. *J. Anim. Ecol.* **21** : 169-181.

Lavelle, P. 1980. The soil Macrofauna of Tropical Savana II. Earthworms. In : *Ecosystems of the world. Tropical Savana.* Elsevier Publication.

Lavelle, P. 1983. The soil fauna of tropical savannas II. The Earthworms, In : *Tropical Savannas.* F. Bourliere, (Ed.) Elsevier Scientific Publ. Co., Amsterdam. 485-504.

Lavelle, P. 1988. Earthworm activities and the soil sys tem. *Biol. Fertil. Soils.* **6**: 237-251.

Lavelle, P. 1984. Faunal activities and soil processes : adaptive strategies that determine ecosystems function. In : *Transactions of the 15th World Congress of Soil Sci ence.* J J. D. Etchevers (Ed), Volume 1: Inaugural and State of the Art Conferences. ISSS, Acapulco, Mexico, pp. 189-220.

Lavelle, P. and Pashanasi, B., 1989. Soil macrofauna and land management in Peruvian Amazonia (Yurimaguas, Loreto). *Pedobiologia*. **33** : 283-291.

Lavelle, P., 1978. Ivoire Les Ver de teree de la savanna de Lamto (Cote d Ivoire) : peuplements, populations et func tions dans 1 ecosysteme; *Publ. Lab. Zool.* E.N.S. 12 : 301.

Lavelle, P., Blanchart, E., Martin, A., Spain, A. and Martin, S. 1992. Impact of soil fauna on the properties of soil in the humid tropics. In : *Myths and Science of Soils of the Tropics*, R. Lal and P.A. S'anchez (Eds), Special publication No. 29 SSSA, Wisconsin, pp 157-185.

Lee, K.E. 1983. Earthworms of tropical region. Some aspects of their ecology and relationships with soils, In : *Earthworm Ecology : From Darwin to Vermiculture*. J.E. Satchell (Ed), Chapman and Hall, London, pp. 449-466.

Martin, A. and Levelle, P. 1982. Effect of soil organic matter quality on its assimilaton by *Millsonia anomala* A tropical geophagous earthworm. *Soil Biol. Biochem.* **24** : 1535-1538.

Mishra, P.C., 1980. Ecophysiological studies on tropical earthworm (Density, biomass, feeding biology, metabo lism, digestive enzymes and their role in soil). Ph.D. the sis submitted to Sambalpur University, Orissa, India. pp. 109.

Mishra, P.C., and Dash, M.C., 1984. Population dynamics and respiratory metabolism of earthworm popu lation in a sub tropical dry woodland of western Orissa, India. *Trop. Ecol.* 25(1) : 103-116.

Murchie, W. R. 1958. Biology of the Oligochaete Eisenia rosea (Savigny) in an upland forest soil of Southern Michi gan. *Am. Mid. Nat.* 66(1) : 113-131.

Nakamura, Y., 1968. Studies on the ecology of terrestrial Oligochaetae. 1. Seasonal variation in the population den sity of earthworms in alluvial soil grassland in Sapporo. *Jap. J. Appl. Ento Zool.* 3 : 89-95.

Nemeth, A. and Herrera, R. 1982. Earthworm populations in a Venezuelan tropical rain forest. *Pedobiologia*. **23** : 437-443.

Petersen, H., 1982. Structure and size of soil animal population. *Oikos*. **39** : 306-329.

Sahu, S.K. and Senapati, B.K., 1986. Population den sity, dynamics, reproductive biology and secondary pro duction of *Dichogaster bolaui* (Michaelsen); In : *Verms and Vermicomposting* (Eds) M.C. Dash, B.K. Senapati and P.C. Mishra (Burla : Five Star Press) pp 29-46.

Satchell, J.E., 1967. Lumbricidae. In : *Soil Biology*, (Eds) A. Burgess and F. Raw, Academic Press, London and N.Y.

Senapati, B.K. 1980. Aspects of Ecophysiologial studies on tropical Earthworms (Distribution, Population dynamics, Production, energetics and their role in the decomposition process) Ph.D. Thesis submitted to Sambalpur University, Orissa, India. pp. 154.

Senapati, B.K. and Dash M.C., 1981. Effect of grazing on the element of Production in vegetation and Oligochaete component of a tropical pasture. *Rev. Ecol. Biol. Soil.* 18(4) : 487-505.

Senapati, B.K., Dash, H.K. and Dash, M.C., 1979. Sea sonal dynamics and emergence pattern of a tropical earth worm, *Drawida calebi* (oligochaeta) *Int. J. Invertbr. Repord.* 1 : 271-277.

Senapati, B.K., Dash, M.C., 1983. Energetics of earth worm population in tropical pastures from India. *Proc. Ind. Acad. Sci.* (Ani. Sci.) 92 : 315-322.

Snedecor G.W., Cochran W.G., 1967. *Statistical methods*. Iowa State University Press, Ames.