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POPULATION DENSITY , BIOMASS AND SECONDARY PRODUCTION OF OCNERODRILUS OCCIDENTALIS (EISEN) FROM A TROPICAL CROPLAND AGROECOSYSTEM AT RANCHI, JHARKHAND, INDIA.

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ABSTRACT

Density, biomass, secondary production and turnover of *Ocnerodrilus occidentalis* (Eisen) was assessed in a tropical cropland agroecosystem at Ranchi, Jharkhand. The average density was 2585 m^{-2}. The density was minimum 75 ± 30.62 m^{-2} in June and maximum 7600 ±108.97 m-2 in August 2000. Average biomass was 11.32 g dry weight m^{-2}. Biomass ranged between 0.57 ± 0.33 to 30.01 ± 3.15 g dry weight m^{-2}. The secondary production in the site was 302.10 Kcal $m^{-2} yr^{-1}$ with biomass turnover value of 5.77 times yr^{-1}.

Key Words : *Ocnerodrilus occidentalis, population density, biomass, secondary production and agroecosystem.*

INTRODUCTION

Fragoso et al., (1997) stressed the need of more research to clarify the functional role of earthworm species in tropical agroecosystem since the functional significance of earthworm in soils of humid tropics have received more attention while only a few studies have been conducted in tropical agroecosystem (Dash and Patra, 1977, 1979; Bhadauria and Ramakrishna, 1989; Lavelle and Pashanasi, (1989).

Ocnerodrilus occidentalis (Eisen), a peregrine species to the Indian main land having cosmopolitan distribution has not been studied except for taxonomic details and places of collection. No information is available on the ecology of this widely distributed worm of agroecosystem. It is for the first time that an attempt has been made to know the ecophysiology of the worm *Ocnerodrilus occidentalis* collected from agro-ecosystem at Ranchi, Jharkhand, India to ascertain its functional significance in soil sub system. The present paper deals with the density, biomass and secondary production of *Ocnerodrilus occidentalis*.

MATERIALS AND METHOD

Monthly sampling and population studies were confined to agroecosystem sites in Ranchi, Jharkhand, India. The study area falls between 21°58' N - 25°19' N latitude and 83°20' E - 88°4' E longitude at a height of 629 m above mean sea level. The climate of the area is broadly divided into 3 seasons, winter extending from October to February, summer from March to mid June and rainy from mid June to September. Average air temperature data during the study period varied from a minimum of 15.30°C to a maximum of 31.9°C whereas, the relative humidity ranged from 51 to 83.5 % round the year. The total rainfall was 1319.9 mm out of which 77% fell during rainy season.

Soil physical parameters such as texture and soil moisture were analysed following Misra (1970). Soil organic carbon was analysed according to the method of Walkley and Black (1934), total N content was determined by kjeldahl method pH are conductivity were measured using a soil : double distilled water suspension in the ratio of 1:2 by pH meter and conductivity meter.

Earthworms were sampled by Monolith method and hand sorted once a month from October 1999 to September 2000 following Dash and Patra (1977), from an area of 20 x 20 x 30 cm during morning hours. Sampling was confined to first week of every month. On the basis of length and clitellar development *Ocnerodrilus occicentalis* were divided into 3 age classes (i) Juvenile (< 2cm, non-clitellate), (ii) Immature (>2cm <4cm, non-clitellate) and (iii) Adult (> 4cm, clitellate). The population of earthworm was expressed as number of individual per square metre. The population was estimated for three different depths each of 10 cm.

Preservation and analysis of worms were made according to Dash and Patra (1977) and Senapati and Dash (1980). Five replicates of freshly collected worms of each size groups were weighed separately after gut clearance and were kept in oven at 85°C for 24 hrs to obtain dry weight. Gut clearance of worms was made by keeping them 1/4 immersed in distilled water (changed every 13 hrs) in glass petri dishes for about 3-4 days.

Secondary production is defined as the amount of tissue substance produced (change in body weight (g) over a period of time (say one year) irrespective of whether it has survived to the end of that period or not (Cragg, 1961; Macfadyen, 1967). According to Golley (1961), production can be written as $\Delta P = B + E$, where ΔB represents the change in biomass (growth + reproduction) and E stands for elimination (loss) i.e., the biomass of individuals that have died or been killed. Changes in number of worms show loss or gain of weight. Growth and mortality were thus calculated from the gain and loss of number and biomass of earthworms (Dash and Patra, 1977). Since cocoon production by worm was not examined, the secondary production has been calculated taking growth and the loss of tissue due to mortality into consideration. Biomass turnover value was calculated from the ratio of secondary production to average biomass (Senapati and Dash, 1981).

Statistical analysis of the data was done according to Snedecor and Cochran (1979). Two way analysis of variance (ANOVA) was done to determine significant differences between sites and between months.

OBSERVATION

The physico chemical parameters of soil of the study site are presented in Table 1. Total organic carbon, total nitrogen and specific conductance were higher in upper horizon compared to lower horizons. pH of the soil was slightly acidic (pH- 6.04, 10 cm deep). Texturally the surface soil is sandly loam whereas the underlying soil are loam to clay loam.

The dynamics of population density of *Ocnerodrilus occidentalis* is shown in Fig-1. The average monthly earthworm population in agroecosystem of Ranchi during 1999-2000 was 2585 m^{-2}. The total worm density ranged from 75 $\pm$30.62 m^{-2} to 7600 $\pm$ 108.97 m^{-2} obtained in the months of June and August 2000 respectively. Worm density constituted 5-39 % of juveniles, 48-100% immatures and 10-31 % of adult worms. This shows that the adults formed the smallest component of total population indicating slow transformation.

Worm density showed significant positive correlation with rainfall, humidity and soil moisture (Table 2) showing their impact on population. A two way ANOVA relating to total population density shows that the mean value does not differ significantly at different sites ($F = 2.218$; df = 4.44) (Table 3) however a significant difference in population density at different months ($F = 940.29$; df = 11, 44; $p< 0.001$) (Table 3) was observed.

The earthworms on the basis of size class have been grouped under three age groups viz. juvenile, immature and mature. Many authors have examined the ratio of immature: mature individuals of earthworm population, where both juvenile and immatures have been kept together. The immature and mature ratio in earthworm population of agroecosystem of Jharkhand ranged from 2.200 (May 2000) to 8.949 (March 2000) showing the outnumbering of the adult population by non-adult population (Table 4). Among the three age groups the immatures were always higher than both juvenile and adult indicating the slow transformation of immature. This observation gives an idea of fast early growth followed by a slower growth pattern after hatching and before becoming adult.

The biomass dynamics of *Ocnerodrilus occidentalis* is shown in Fig 2. The average monthly biomass (g dry weight m^{-2}) was 11.32. The total worm biomass in the study site ranged from 0.57 $\pm$ 0.33 to 30.01 $\pm$ 3.15 g dry weight m^{-2}. The minima and maxima of biomass were observed in the months of June and September 2000 respectively. Worm biomass constituted 0.69-9 % of juvenile, 60-100% of immatures and 7-34% of adult worms.

Worms biomass also showed significant positive correlation with rainfall, humidity and soil moisture (Table 2). A two way ANOVA of total biomass shows that the mean value of worm biomass differ significantly among different months ($F = 342.27$; df = 11,44; $p < 0.001$) (Table 3). There was no significant difference (Table 3) in worm biomass among different site ($F = 0.369$; df = 4,44).

Secondary production (g dry weight m^{-2} yr^{-1}) of *Ocnerodrilus occidentalis* was 65.39 (Table 4). The calorific value (1 g dry earthworm tissue = 4.62 kcal; Golley, 1961) of secondary production was 302.10 kcal m^{-2} yr^{-1}. The contribution of tissue growth increment and of tissue lost due to mortality was 58.22% and 41.78% respectively. Population biomass turnover ratio of secondary production to average monthly biomass was observed to be 5.77 times yr^{-1}.

DISCUSSION

The values of population density of worms m^{-2} recorded during the present investigation are more than those of Sears and Evans (195), Waters (1955), Mc Coll and Lautour (1978), Reinecke and Ljungstrom (1969) and Dash and Patra (1977) (Table 5). Sahu *et al*., (1988) while working on *Dichogaster bolaui* from upland grazed pasture receiving kitchen waste reported maximum population of 8030 m^{-2} which is comparable to the density obtained in the present investigation. The biomass of *Ocnerodrilus occidentalis* in the study site is comparable with values given by Sears and Evans (1953) and Reynoldson (1966) for pasture ecosystem (Table 5). The values are more than those for tropical pastures as reported by Dash and Patra (1977), Lavelle (1978) and Senapati and Dash (1981). One of the probable reasons of higher population density of earthworm during the present study may be the intermittent rain throughout the period of investigation keeping the soil moisture suitable for the worms. Many authors like Evans and Guild (1947). Dash and Patra (1977) and Mishra and Dash (1984) have reported soil moisture to be an important regulating factor for earthworms. A significant positive correlation has been found between earthworm population density and soil moisture ($r = 0.895$, $p < 0.001$) during the study supporting the previous findings.

The other important factor affecting earthworm population density is temperature and the temperature tolerance of earthworms depends to a great extent on soil moisture (Dash and Patra, 1977). The suitable soil moisture due to rains might be the causative factor for higher population density, through decreasing the limiting impact of temperature by interaction of factor.

Earthworm population dominated by immature population as has been found during the present study is in agreement with the previous observations of van Rhee (1965, 1967) and Reinecke and Ljungstrom (1969). The ratio of immature : mature individuals ranging from 5 to 25 has been reported for *Aporrectodea caliginosa* from Holland by van Rhee (1965) while he also reported (1967) in population of *Lumbricus terrestris, L. castoneus, A. rosea* and *A. caliginosa* and the higher number of immatures. In a mixed population of *A. caliginosa* and *A.*

rosea in pastures of South Africa Reinecke and Ljungstrom (1969) found the ratio (immature : mature) varying between 0.6 to 24.0 for *A.caliginosa* and between 2 and 19 for *A. rosea*. The variation of the ratio for *Ocenerodrilus occidentalis* during the study has been between 2.200 to 8.949. The immature : mature ratio seems to be influenced by climo-edaphic factor, as for the same species *A.caliginosa* two different range of ratios have been reported from two different locations. 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 reproductive strategy.

Secondary production values of very few species of earthworm have been reported from different agroecosystem of the world (Lakhani and Satchell, 1970; Satchell, 1971; Nowak, 1975; Dash and Patra, 1977; Lavelle, 1978; Senapati and Dash, 1981 and Sahu and Senapati, 1986). The earthworm production in terms of kcal m^{-2} yr^{-1} obtained in the present values of production for tropical agroecosystems of present study and previous studies indicate that earthworms of the tropical climate are more productive in comparison to those of the temperate climate.

Biomass turnover value of earthworms are not available for many world sites (Petersen, 1982). The biomass turnover value in the present investigation was 5.77 times yr^{-1} which lies in the range of 1.2 to 7 times yr^{-1} as reported by Lavelle (1974), Dash and Patra (1977) and Senapati and Dash (1981) for tropical agroecosystem. In temperate agroecosystems however, the turnover values range from 0.5 - 1.3 times yr^{-1} (Lakhani and Satchell, 1970; Nowak, 1975; Phillipson *et al.*, 1978). The higher turnover values obtained for the study area at Ranchi indicate rapid replacement in tropical habitats in comparison to temperate habitats.

The population biomass turnover for Ranchi site is 5.77 times the average biomass and is slightly less than the value reported by Lamotte *et at.*, (1974) for *Millsonia anomala*. The production at Ranchi is minimum value for the species *Ocnerodrilus occidentalis* because the weight loss due to cocoon deposition by adults has not been calculated.

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Table - 1 : Physico-chemical characteristics of soil (average values in parentheses) .

	0-10 cm	10-20 cm	20-30 cm	Average
Texture g%				
Sand	52.6±5.2	46.5±3.1	43.3±3.6	47.47±4.72
Silt	29.9±3.2	28.9±1.6	26.4±1.9	28.4±1.8
Clay	17.5±2.0	23.6±1.7	31.3±1.8	24.13±6.92
Organic Carbon (mg C g^{-1})	6.82-10.52 (8.434)	5.12-7.12 (6.031)	5.35-7.29 (6.352)	5.79-8.31 (6.938)
Total Nitrogen (mg N g^{-1})	0.56-0.8 (0.689)	0.34-0.53 (0.472)	0.43-0.6 (0.519)	0.43-0.63 (0.56)
Specific Conductance (m Mhos cm^{-1})	0.238-0.512 (0.356)	0.147-0.363 (0.227)	0.067-0.148 (0.111)	0.151-0.341 (0.231)
pH	5.5-6.5 (6.04)	5.5-6.63 (6.17)	6.3-6.98 (6.585)	5.83-6.67 (6.27)

Table - 2 : Correlation coefficient of different parameters with total worm density and biomass.

Parameter	Total worm number	Total worm biomass
Rainfall (total)	+ 0.677*	+ 0.682*
Relative humidity (average)	+ 0.668*	+ 0.609**
Air temperature (average)	+ 0.276^{NS}	+ 0.287^{NS}
Soil moisture (0-30) (average)	+ 0.895***	+ 0.904***

* $p< 0.02$ ** $p < 0.05$ *** $p< 0.001$

Table - 3: Values of two way ANOVA test calculated for population and biomass of *Ocnerodrilus occidentalis* from agroecosystem site at Ranchi.

Source of variation	Sum of square	Degree of freedom	Mean square	Variance ratio F	Significant
Population					
Different sites	383333.33	4	95833.33	2.218	Not significant
Different month	446857364.6	11	40623397	940.29	p < 0.001
Residual	1900916.667	44	43202.65		
Biomass					
Different sites	2.47486	4	0.618716	0.369	Not significant
Different month	6301.3495	11	572.85	342.27	p < 0.001
Residual	73.64208	44	1.673684		

Table – 4: The non adult – adult ratio (NA/A) total biomass, secondary production and biomass turnover value of *Ocnerodrilus occidentalis*.

Months	NA/A	Total Biomass (g dry weight m^{-2})	Sec. Production	
			ΔB	E
Oct. 1999	3.273	19.26 ± 2.26	-	-
Nov. 1999	3.617	6.02 ± 0.69	-	13.24
Dec. 1999	7.500	2.36 ± 0.40	-	3.66
Jan. 2000	3.609	3.07 ± 0.52	0.71	-
Feb. 2000	4.000	3.34 ± 1.02	0.27	-
Mar. 2000	2.355	10.99 ± 0.66	7.65	-
Apr. 2000	8.949	7.23 ± 0.84	-	3.76
May 2000	2.200	2.84 ±0.64	-	4.39
Jun. 2000	0.000	0.57 ±0.64	-	2.27
Jul. 2000	5.857	21.42 ± 0.96	20.85	-
Aug. 2000	7.085	28.69 ±1.08	7.27	-
Sep. 2000	3.784	30.01 ± 3.15	1.32	-

Secondary Production (P) = ΔB + E

Where

Δ B = Change in biomass (G + R)

E = Elimination (loss i.e. the biomass of individuals that have died or been killed).

P = 38.07 + 27.32

P = 65.39 g dry weight m^{-2} yr^{-1}

$$\text{Biomass turnover} = \frac{65.39}{11.32} = 5.77 \text{ times } yr^{-1}$$

Table – 5: Population density (No m^{-2}) and biomass (g fresh weight m^{-2}) of earthworms in various world agroecosystems.

Habitat	Location	Extraction Method	Population density	Biomass	References
Savana					
Tropical Savannas	Ivory Coast	H & WS	230	49	Lavelle (1974)
Low laying wet Savana	Lamto (Ivory coast), Africa	H	180-340	39.57	Lavelle (1977)
Shrub Savana	Lamto (Ivory coast), Africa	H	400	-	Lavelle (1978)
Organic waste deposit sites					
Pasture receiving Kitchen waste	Jyoti Vihar, Orissa, India	H & WS	0 - 8038	0-66.2	Sahu & Senapati (1986)
Dung deposit site	Sambalpur, Orissa, India	H & WS	0-12617	0-51.4	Sahu *et. al.*, (1988)
Straw thatched roof drain site	Ladukhai, Orissa, India	H	800	-	Julka & Senapati (1987)
Garbage Site	Ranchi, Jharkhand, India	H	375-10050	58.25 – 1647.08	Sinha and Srivastava, (2001)
Grasslands					
Sown Pasture	New Zealand	H	208 – 775 740– 1235 690-2020	60-241 146-303 305 (Mean)	Sears & Evans (1953) Waters (1955) McColl & Lautour (1978)
Old Pasture	Wales	H	646	149	Reynoldson (1966)
Pasture (lowland protected)	Berhampur, Orissa, India	H	64-800	6-60	Dash & Patra (1977)
Cropland agroecosystem	Ranchi, Jharkhand, India	H	75-7600	2.85 - 149.96	Present study

H = Hand sorting, WS = Wet sieving

Fig. 2: Instantaneous growth rate (IG) in terms of dry wt m⁻² of *Perionyx sansibaricus* during period of investigation.

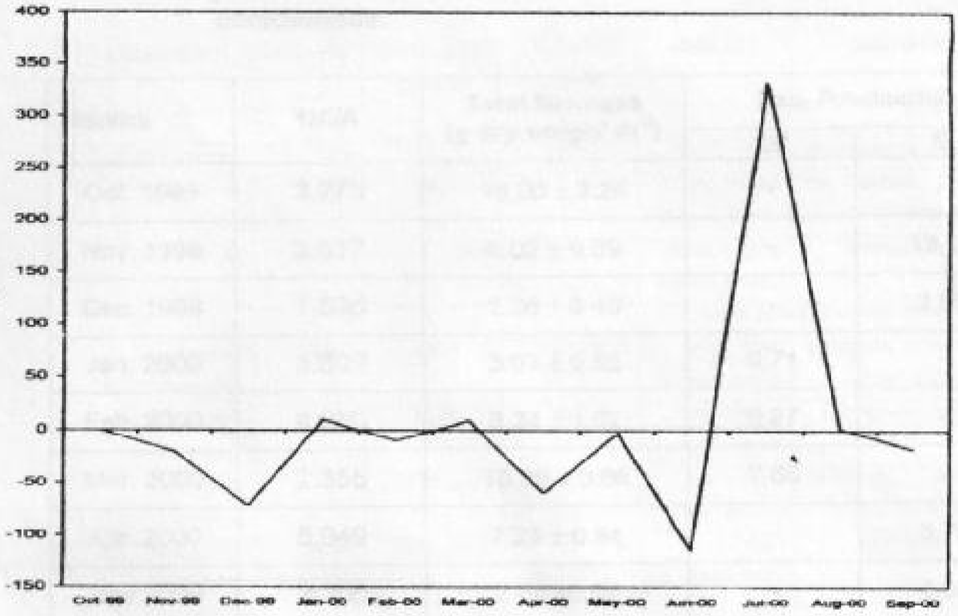

Fig.1: Variation of total biomass of *Perionyx sansibaricus* at different depth.