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Original Research Paper

Monthly Variation in the Density of *Drawida willsi* (Michaelsen) in Relation to Some Climatic and Edaphic Factors

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ABSTRACT

Fluctuation of population density of the earthworm *Drawida willsi* (Michaelsen) in relation to some climatic and edaphic factors was assessed from a tropical cropland agroecosystem site at Ranchi for a period of eighteen months. The total density ranged between 75 ± 25.49 (April 2010) to 2115 ± 189.87 m^{-2} (August 2010). Of the various factors studied rainfall, relative humidity, soil moisture, organic carbon and nitrogen content of the soil showed a significant positive correlation with the total earthworm density. Moisture content of the soil was considered to be the most important single factor responsible for the population fluctuation of the earthworm.

INTRODUCTION

Temperature, moisture, salinity and availability of food are important parameters influencing the survivality, fecundity and distribution of the earthworms (Laverack 1963, Dash 1978). Climate of the soil, to a large extent, is dependent on the atmospheric climatic conditions. These not only have direct influence on the nature of the soil but also determine vegetational pattern as well as soil fauna. Fluctuation of such abiotic factors may often cause changes in the population density of earthworms inhabiting the soil. No ecological work is available on the population ecology of earthworm from acidic soil and hilly topography of Jharkhand State because of the paucity of information on earthworms. The present study was undertaken to study the monthly variation in population density of *Drawida willsi* in relation to some climo-edaphic factors.

MATERIALS AND METHODS

The present investigation was carried out in an agroecosystem site at Ranchi during November 2009 to April 2011. The study area falls between 2°58'-25°19' N latitude and 83°20'-88 4' E longitude at a height of 629 m above mean sea level.

Soil samples were passed through a 2mm mesh sieve before analysis. pH and conductivity were measured using a soil:double distilled water suspension in the ratio of 1:5 by using a Grid 'D' pH meter, Systronics-327 and digital conductivity meter, Systronics-304 respectively. Organic carbon was analysed according to the method of Walkley & Black (1934), total nitrogen content by microKjeldahl method, and potassium and phosphorus by Misra (1970). Soil temperature and soil moisture were recorded by soil thermometer and oven drying method respectively.

Rainfall (mm/month) relative humidity (%) and air temperature (°C) data for the study site have been collected from the Department of Agricultural Physics, Birsa Agricultural University, Kanke, Ranchi.

Earthworms were sampled and hand sorted twice a month from November 2009 to April 2011. Sampling was confined to first and third week of every month. During each sampling, 5 random samples of 20 × 20 × 20 cm each were taken from the study site during morning hours. On the basis of length and clitellar development *D. willsi* was divided into 3 age classes: (i) juvenile (< 2cm, non-clitellate), (ii) immature (> 2cm < 4cm, non-clitellate) and (iii) adult (> 4 cm, clitellate). The population was expressed as number of individuals per square meter.

RESULTS

The climate of the area is broadly divided into 3 seasons namely winter, summer and rainy. The climatological data of the study site are given in Fig. 1. The physico-chemical characteristics of soil are presented in Table 1. pH of the soil was slightly acidic (6.29). Texturally, the surface soil is sandy loam.

Five species of earthworms, i.e., *O. occidentalis* Eisen, *Glyphidrilus tuberosus* Stephenson, *Lampito mauritii*

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

	Range
Sand	47.47± 4.72
Silt	28.4 ± 1.8
Clay	24.13 ± 6.92
Organic Carbon (mg C/g)	5.43-7.78(6.44)
Total Nitrogen (mg N/g)	0.61-0.78(0.674)
Specific Conductance (mmhos/cm)	0.151-0.341(0.231)
pH	5.81-6.81(6.29)
Phosphorus (kg/hectare)	143.3-148.9(146.71)
Potassium (kg/hectare)	23.6-30.5(27.783)

Kinberg, *Drawida willsi* Michaelsen and *Drawida calebi* Gates were found in the sampling sites of the agroecosystem. Of these 5 species *D. willsi* was the dominant species having IV value greater than 90%, hence *D. willsi* was studied in detail. Monthly variation in total number of earthworms in relation to soil moisture and soil temperature is shown in Fig. 2. The total density ranged between 75 ± 25.49 and 2115 ± 189.87 m^{-2}. The average monthly worm density during the study period was 603 m^{-2}. The earthworm density was maximum (2115 ± 189.87 m^{-2}) in August 2010 whereas, a minimum of 75 ± 25.49 m^{-2} was observed in April 2010. Population turnover value was calculated to be 28.2.

A two-way ANOVA relating to total population density showed that the mean value did not differ significantly at different sites ($F = 1.291$; df = 4, 68) (Table 2). However, there was significant difference in population density in different months ($F = 554.11$; df = 17, 68; $p < 0.001$) (Table 2) of investigation.

The dynamics of population density of *D. willsi* is shown in Fig. 3. The total earthworm density was constituted by 12.07-23.85 % of juveniles, 53.21-100% of immature and 11.62-34.72% of adults.

Fluctuation in the density of *D. willsi* seems to involve several climo-edaphic factors. Of the various factors studied, moisture content of the soil, relative humidity, rainfall, organic carbon and total nitrogen content of the soil showed a significant positive correlation with the total earthworm density (Table 3). Significant positive correlation of earthworm population with soil moisture indicates the hydrophilic nature of the earthworm. The equations determining the relationship between the earthworm density and different climo-edaphic factors are given in (Table 3).

DISCUSSION

Population size of earthworms varies greatly in different habitats and different geographical regions. Maximum density generally occurs in base rich grassland, and minimum in acid soil (Petersen 1982). The values of the present investigation (75 - 2115 m^{-2}) are more than those of Sears & Evans (1953), Waters (1955), Barley (1959), Reinecke & Ljungstrom (1969) and Dash & Patra (1977). Sahu et al. (1988), while working on *Dichogaster bolaui* from upland grazed pasture receiving kitchen waste, reported maximum population of 8030 m^{-2}. McColl & Lautour (1978) reported

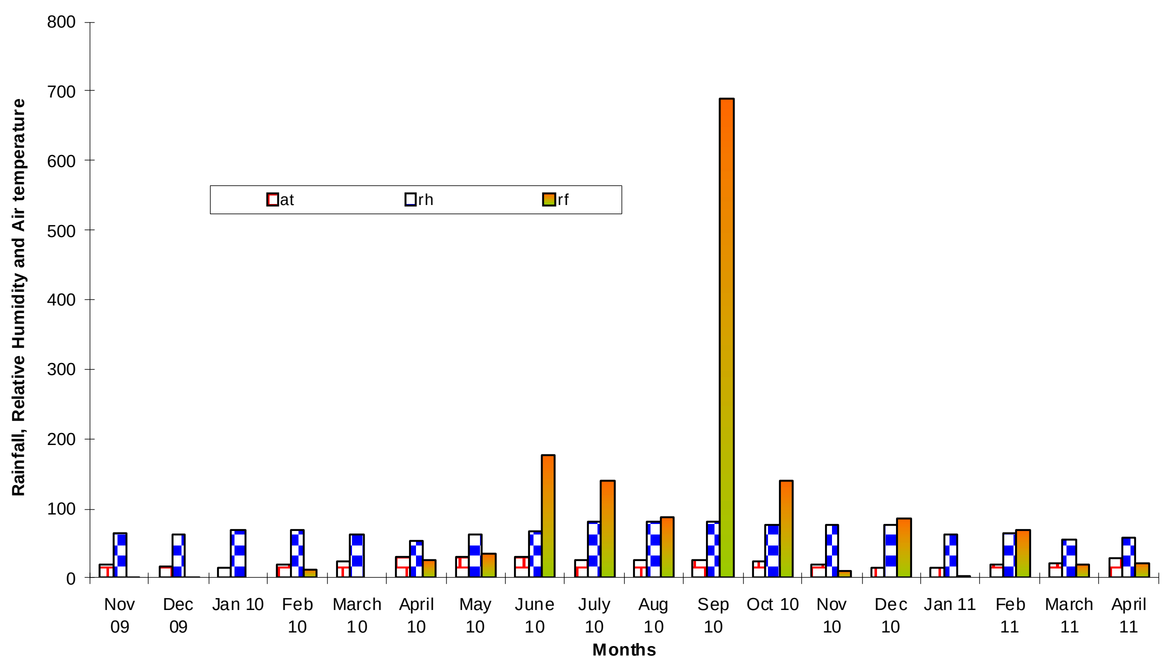

Fig. 1: Monthly variation in rainfall, relative humidity and air temperature during the study period.

Table 2: A two-way ANOVA test among population densities of different sites and different months of *Drawida willsi* during 2009-2011.

Source of variation	Sum of Square	Degree of freedom	Mean square	Variation ratio F	Significance
Different sites	21169.44	4	5292.361	1.291373	NS
Different months	38605035	17	2270884	554.1116	$p < 0.001$
Residual	278680.6	68	4098.243		

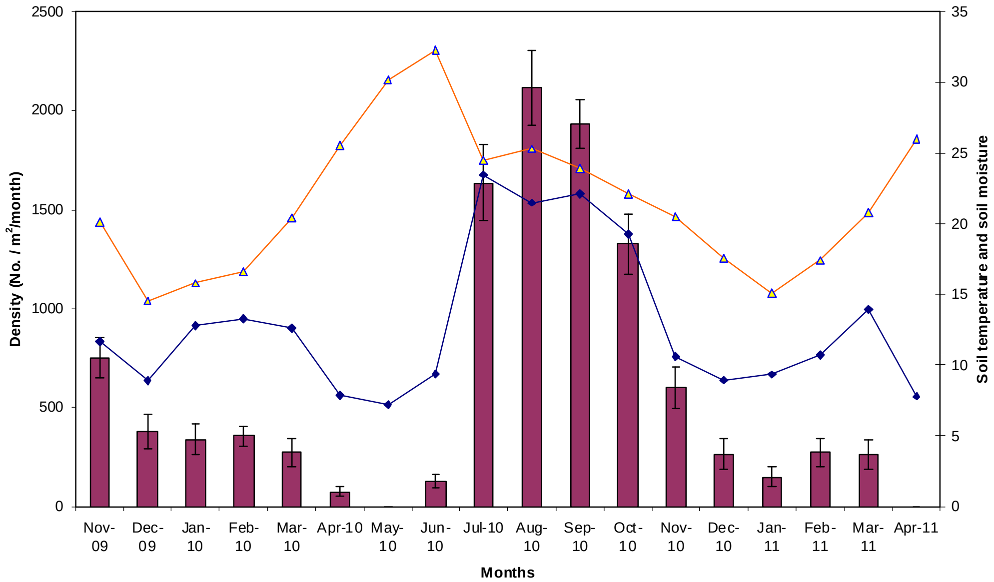

Fig. 2: Monthly variation in density (No./m^2/month ± SD) of *D. willsi* with respect to soil moisure and soil temperature.

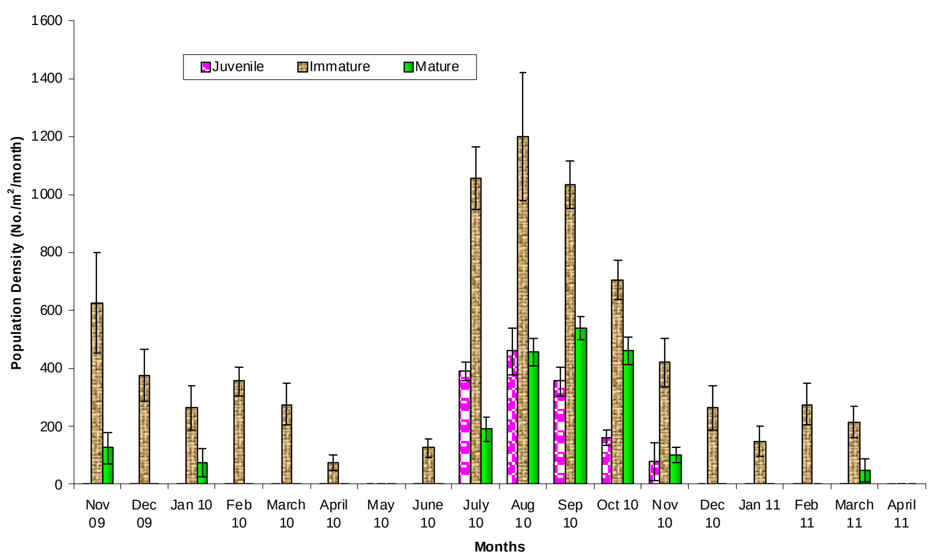

Fig. 3: Variation in population density (No./m^2/month ± SD) of different age groups of *D. willsi.*

Table 3: Correlation coefficient and equation determining the relationship between the earthworm density with different climo-edaphic factors.

Environmental Factor	Population density	Equation
Rainfall (total)	0.596*	Y=393.22+2.49x
Relative humidity (average)	0.780**	Y=59.08x-3405.53
Air temperature (average)	0.168***	Y=168.07+19.70x
Soil moisture	0.929**	Y=119.76x-935.87
Soil temperature	0.128***	Y=237.32+16.94x
Organic carbon	0.759**	Y=913.25x-5278
Total nitrogen	0.781**	Y=8243.42x-4953.01

*p < 0.01; **p < 0.001; ***NS

density of worms in sown pasture of New Zealand in the range of 690-2020 m^{-2} which is comparable to the density obtained in the present investigation (2115 m^{-2}).

Information on the age structure of earthworm population is very less. In the present investigation juveniles and immatures occupied a large proportion of earthworm population throughout the study period, which is in conformity with the findings of Evans & Guild (1948), Satchell (1967), Lavelle (1978), Dash & Patra (1977) and Mishra & Dash (1984).

Seasonal differences in the population density could be attributed to the earthworm species, soil type, climate and altitude (Guild 1952, Murchie 1958). Gerard (1967), Nakamura (1968), Edwards & Lofty (1972), Dash & Senapati (1980), Senapati & Dash (1981) and Dash & Patra (1977) have stressed the importance of soil moisture and temperature on earthworm. Dash & Patra (1977) reported significant positive correlation of moisture with number of earthworms (r = 0.67, n = 16).

In the present study soil moisture showed a significant positive correlation (r = 0.929, p < 0.001) with the number of earthworms indicating the importance of moisture for growth and survival of earthworm population. The other important factor affecting population density is temperature, and the temperature tolerance of earthworms depends to a great extent on soil moisture (Dash & Patra 1977). The soil moisture due to rain might be the causative factor for higher population density, through decreasing the limiting impact of temperature by interaction of factors. The present findings are in conformity with the findings of (Dash & Patra 1977).

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