Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

| ISSN: 0972-6268 | Vol. 12 | No. 1 | pp. 179-182 | 2013 |
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Original Research Paper

# Biomass and Secondary Production of Earthworm *Drawida willsi* (Michaelsen) from a Tropical Agroecosystem in Ranchi, Jharkhand

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**Nat. Env. & Poll. Tech.**
Website: www.neptjournal.com

*Received:* 15-10-2012
*Accepted:* 30-11-2012

**Key Words:**
*Drawida willsi*
Secondary production
Agroecosystem

## ABSTRACT

Biomass variation, secondary production and turn-over of the earthworm *Drawida willsi* (Michaelsen) was assessed from a tropical agroecosystem site at Ranchi for 18 months. The total biomass ranged between 0.88 ± 0.33 and 29.55 ± 3.15 g dry weight $m^{-2}$. Secondary production of 53.37 g dry weight $m^{-2}$ $yr^{-1}$ was obtained which in terms of calorific value amounts to 246.57 kcal $m^{-2}$ $yr^{-1}$. Biomass turnover value was 4.99.

## INTRODUCTION

Earthworms represent a major group in the soil fauna, and seasonal factors play an important role in explaining changes in size and biomass of their population (Edwards & Bohlen 2004). Earthworms are known as good friends of farmers from the time of Aristotle, (White 1770, Darwin 1881). Earthworms are both, the soil managers and decomposers. In tropical ecosystems, although the earthworms dominate the soil invertebrate biomass (>80%), they were not studied in detail until Bhal (1925).

*Drawida willsi* (length 55-60 mm, diameter 2.5 mm) an endemic species inhabits soils with high organic matter content (>10g%). It is abundant in crop fields, compost pits and drains. The present paper deals with the biomass, secondary production and turnover of the earthworm from an agroecosystem site at Ranchi.

## MATERIALS AND METHODS

Earthworms were sampled by monolith method following Dash & Patra (1977) and hand sorted twice a month during the study period from November 2009 to April 2011 from an area of 20 × 20 × 20 cm during morning hours.

On the basis of length and clitellar development earthworms were divided into three age classes. They are (i) juvenile (< 2 cm, non clitellate), (ii) immature (≥ 2 < 4cm, non clitellate) and (iii) mature (≥ 4cm, clitellate). Preservation and analysis of earthworms were made according to Dash & Patra (1977) and Senapati & Dash (1980). Five replicates of freshly collected worms of each size groups were weighed separately after gut clearance and kept in oven at 85°C for 24 hrs to obtain dry weight. Gut clearance of worms was made by keeping them ¼ immersed in distilled water (changed every 12 hrs) in glass Petri dish for 3-4 days.

Secondary production is defined as the amount of tissue substance produced (change in body weight Δb) and reproduction (Δg) over a period of time (say one year) irrespective of whether it has survived to the end of that period or not (Cragg 1961, 1969, Macfadyen 1967). According to Golley (1961) production can be written as $P = \Delta B + E$, 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 earthworms show loss or gain of weight. Growth and mortality were, thus, calculated from the gain and loss of number and biomass of earthworms following Dash & Patra (1977). Since cocoon production by earthworms was not examined, the secondary production has been calculated taking growth and the loss of tissue due to mortality into consideration.

## RESULTS

Total biomass (g dry weight $m^{-2}$ ± SD) and biomass of different age groups of *Drawida willsi* at the study site are given in Table 1. The total biomass in the site during the study period ranged between 0.88 ± 0.33 and 29.55 ± 3.15 g dry weight $m^{-2}$ obtained in the months of April 2010 and August 2010 respectively. The average monthly earthworm biomass (g dry weight $m^{-2}$) during the study period was 8.21.

Table 1: Total Biomass (g dry weight $m^{-2} \pm$ SD) and biomass of different age groups of *Drawida willsi*.

| | Juvenile | Immature | Mature | Total |
|---|---|---|---|---|
| Nov 09 | 0 | 8.75±1.02 | 2.25±0.83 | 11.00±0.66 |
| Dec 09 | 0 | 4.39±0.89 | 0 | 4.39±1.02 |
| Jan 10 | 0 | 3.82±0.91 | 1.42±0.72 | 5.24±0.72 |
| Feb 10 | 0 | 4.83±1.00 | 0 | 4.83±0.76 |
| Mar 10 | 0 | 3.82±0.59 | 0 | 3.82±0.99 |
| Apr 10 | 0 | 0.88±0.33 | 0 | 0.88±0.33 |
| May 10 | 0 | 0 | 0 | 0 |
| Jun 10 | 0 | 1.60±0.83 | 0 | 1.60±0.33 |
| Jul 10 | 1.95±0.56 | 15.19±1.66 | 3.69±0.34 | 20.83±1.05 |
| Aug 10 | 2.71±0.24 | 18.24±1.68 | 8.60±0.67 | 29.55±3.15 |
| Sep 10 | 2.41±0.33 | 15.01±1.42 | 10.21±1.70 | 27.63±1.08 |
| Oct 10 | 0.83±0.22 | 9.09±1.14 | 8.51±1.14 | 18.43±1.66 |
| Nov 10 | 0.45±0.02 | 5.25±0.65 | 1.89±0.72 | 7.59±0.67 |
| Dec 10 | 0 | 3.42±0.62 | 0 | 3.42±0.57 |
| Jan 11 | 0 | 1.92±0.69 | 0 | 1.92±0.56 |
| Feb 11 | 0 | 3.20±0.56 | 0 | 3.20±0.57 |
| Mar 11 | 0 | 2.50±0.44 | 0.95±0.28 | 3.45±0.42 |
| Apr 11 | 0 | 0 | 0 | 0 |

The mean value of earthworm biomass differ significantly among different months ($F = 701.36$; df = 17, 68; $p < 0.001$) (Table 2), while, there was no significant difference in worm biomass at different sites ($F = 2.158$; df = 4,68) (Table 2) when the total biomass values were analysed by a two-way ANOVA. The total earthworm biomass consisted of 4.50-9.36% by juveniles, 49.32-100% by immatures and 17.71-46.17% by mature worms during the study period (Fig. 1).

Correlation of earthworm biomass with different environmental parameters is given in Table 3 which reflected a significant positive correlation with rainfall ($r = 0.611$, $p < 0.01$) and relative humidity ($r = 0.771$, $p < 0.001$). In the present study earthworm biomass (Y) was significantly correlated with soil moisture content (X) ($r = 0.922$, $p < 0.001$) and these two parameters were related by the equation $Y = 1.66x-13.12$ (Fig. 2) whereas, a positive correlation was obtained between biomass of earthworm and soil temperature ($r = 0.131$) and these two parameters were related by the equation $Y = 2.99 + 0.242x$ (Fig. 3).

Table 4 shows the biomass change and different components of secondary production. The net increase in earthworm tissue over one year was 30.40 g dry weight $m^{-2}$ and the elimination figured to 22.97g dry weight $m^{-2}$. The

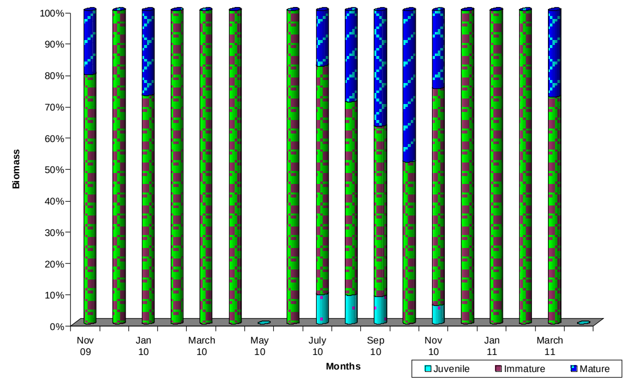


Fig. 1: percentage contribution of different age groups to the total Biomass of *D.willsi.*

total production amounted to 53.37g dry weight $m^{-2}$ $yr^{-1}$. The contribution of tissue growth increment was 56.96% and of tissue lost due to mortality was 43.04% to the earthworm secondary production. The secondary production in terms of calorific value was 246.57 kcal $m^{-2}$ $yr^{-1}$. Biomass and elimination turnover value was 4.99 and 2.15 respectively (Table 4).

## DISCUSSION

Sears & Evans (1953) estimated the biomass of earthworms to be 60-241g live wt $m^{-2}$ in sown pastures of New Zealand. Waters (1955) estimated the biomass of lumbricids from New Zealand to be 146-303 g live wt $m^{-2}$ whereas 205 g live wt $m^{-2}$ was the mean biomass recorded by McLoll & Lautour (1978) in sown pastures of New Zealand. The biomass of earthworm in sown pastures of South Australia was 62-78g live wt $m^{-2}$ (Barley 1959).

Dash & Patra (1977) estimated the biomass of Megascolecids and Ocnerodrilids in natural grassland of India to be of the order of 6-60g live wt $m^{-2}$. The biomass obtained in the present investigation is more than the values reported by Dash & Patra (1977), Mishra & Dash (1984), Sahu & Senapati (1996) and Mishra & Sahoo (1997) but lies in the range of 60-241g live wt $m^{-2}$ obtained by Sears & Evans (1953) for lumbricid population and 51-152g live wt $m^{-2}$ estimated by Barley (1959) in pasture from Australia.

The secondary production data are not available from many world sites. Secondary production in many species varies significantly seasonally and with climatic extremes.

Table 2: A two way ANOVA test among biomass at 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 | 5.40246 | 4 | 1.350615 | 2.158356 | NS |
| Different months | 7461.028 | 17 | 438.884 | 701.3606 | p < 0.001 |
| Residual | 42.55174 | 68 | 0.625761 | | |


Fig. 2: Regression between soil moisture and Biomass of *D. willsi.*

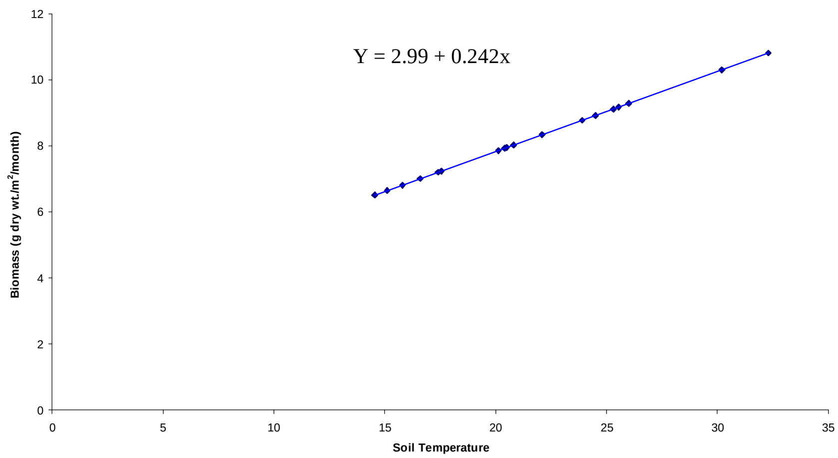


Fig. 3: Regression between soil temperature and Biomass of *D. willsi.*

Lakhani & Satchell (1970) and Satchell (1971) reported some 56.02 kcal $m^{-2}$ $yr^{-1}$ for *Lumbricus terrestris* population in Europe. Lavelle (1977) reported production of 16.80 kcal $m^{-2}$ $yr^{-1}$ for *Millsonia anomala* earthworm in Lamto Savanna, Ivory coast. Nowak (1975) reported production of *A. caliginosa* to be 58.02 kcal $m^{-2}$ $yr^{-1}$ and 12.03 kcal $m^{-2}$ $yr^{-1}$ from a partly protected and grazed pasture respectively. Dash & Patra (1977) reported secondary production value of 162 kcal $m^{-2}$ $yr^{-1}$ from a protective low land from India. Senapati & Dash (1981) reported 122.05 kcal $m^{-2}$ $yr^{-1}$ and 144.06 kcal $m^{-2}$ $yr^{-1}$ of secondary production by earthworms in tropical protected pasture and grazed pasture respectively from India. Mishra & Dash (1984) reported 66.06 kcal $m^{-2}$ $yr^{-1}$ of secondary production of earthworm population in a subtropical dry woodland of western Orissa, India. Sahu & Senapati (1996) reported a secondary production of 277 kJ $m^{-2}$ $yr^{-1}$ and 151 kJ $m^{-2}$ $yr^{-1}$ from a pasture and dung deposit sites respectively. Mishra & Sahoo (1997) reported the secondary production values for *Lampito mauritii* to be 140.37 kcal $m^{-2}$ $yr^{-1}$ and 207.01 kcal $m^{-2}$ $yr^{-1}$ in control and 50% waste water irrigated plot respectively. However, the secondary production value obtained in the present investigation was 246.57 kcal $m^{-2}$ $yr^{-1}$, which is much higher than the previous reports. This may be probably due to both the presence of earthworm population in high number and also throughout the study period. Secondary production values in the present report indicate that earthworms of the tropical climate are more productive in comparison with those of the temperate climate.

Data on biomass turnover value of earthworms are not available from many world sites (Petersen 1982). Lavelle (1977) reported that P/B ratio in Oligochaeta population in Lamto Savanna varied from 1.2 to 2.6. Nowak (1975) reported P/B ratio of 0.9 and 1.3 in temperate regions in a partly protected and grazed pasture respectively. Lavelle (1974), Dash & Patra (1977) and Senapati & Dash (1981) have re-

Table 3: Correlation coefficient of different parameters with total worm biomass.

| Environmental Factor | Biomass |
|---|---|
| Rainfall (total) | 0.611* |
| Relative humidity (average) | 0.771** |
| Air temperature (average) | 0.165*** |
| Soil moisture | 0.922** |
| Soil temperature | 0.131*** |

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

Table 4: Total biomass, secondary production and biomass turnover value of *Drawida willsi*.

| Months | Total Biomass (g dry wt $m^{-2}$) | Secondary Production $\Delta$ B | E |
|---|---|---|---|
| Nov 09 | 11.00±0.66 | - | - |
| Dec 09 | 4.39±1.02 | | 6.61 |
| Jan 10 | 5.24±0.72 | 0.85 | |
| Feb 10 | 4.83±0.76 | | 0.41 |
| Mar 10 | 3.82±0.99 | | 1.01 |
| Apr 10 | 0.88±0.33 | | 2.94 |
| May 10 | 0 | | 0.88 |
| Jun 10 | 1.60±0.33 | 1.6 | |
| Jul 10 | 20.83±1.05 | 19.23 | |
| Aug 10 | 29.55±3.15 | 8.72 | |
| Sep 10 | 27.63±1.08 | | 1.92 |
| Oct 10 | 18.43±1.66 | | 9.20 |
| | | 30.40 | 22.97 |

Secondary production (P) = $\Delta$ B + E

Where,

$\Delta$ B = Change in Biomass (G + R)

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

P = 30.40 + 22.97

P = 53.37 g dry weight $m^{-2}$ $yr^{-1}$

$$\text{Biomass turnover} = \frac{53.37}{10.68} = 4.99 \text{ times yr}^{-1}$$

$$\text{Elimination turnover} = \frac{22.97}{10.68} = 2.15 \text{ times yr}^{-1}$$

ported that the biomass turnover values range from 1.2 to 7.0 times $yr^{-1}$. In the present study the biomass turnover value was 4.99, which is in conformity with the above mentioned values. The higher turnover values (4.99) obtained in this study indicate rapid replacement in tropical habitats in comparison to temperate habitats.

## ACKNOWLEDGEMENT

One of the author (RS) is grateful to UGC (ERO) for providing financial support .

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