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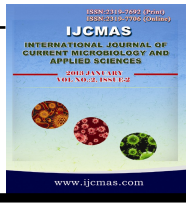

Original Research Article

Growth and reproduction of *Perionyx excavatus* in different organic wastes

M. Birundha[1], J.A. John Paul[2,*] and P. Mariappan[1]

[1]Department of Zoology, Raja Serfoji Government College,
Thanjavur–613 005, Tamil Nadu, India.
[2]DST-PURSE Scheme, Faculty of Agriculture, Annamalai University,
Chidambaram – 608 002. Tamil Nadu. India.

***Corresponding author:** *jajpaul@gmail.com*

Keywords

Cocoon production; growth curve; life cycle; *Perionyx excavates;* Vermiculture.

A B S T R A C T

Earthworm as one of the best means of abating organic pollution and also to minimize indiscriminate use of inorganic fertilizers. Earthworms have important functions by virtue of their feeding and general behavioral activities like burrowing, digesting, excreting with microorganisms and supporting further decomposition of biodegradable matters. The growth and reproduction efficiency of locally available earthworm species, *Perionyx excavatus* was assessed in various biodegradable organic wastes powder such as leaf litter (LL), straw waste (SW), coirpith (CP) and pressmud (PM) which was mixed with cowdung powder at 1:3 ratio (W/W). Maximum growth rate of 4.81±0.47 and 4.30±0.38 mg/worm/day was observed on the 90th day in PM and LL respectively. The mean age of clitellum development was 30.63, 31.44, 31.44 and 33.00 days for PM, LL, SW and CP respectively. The rate of cocoon production was 0.79 cocoons/worm/day in pressmud. Cocoons of *P.excavatus* that were produced in PM, LL, SW and CP had a hatching success of 67.27, 65.38, 54.00 and 48.05 % respectively. Among the four substrates LL was preferred by this earthworm followed by PM.

Introduction

Earthworms have been successfully used in the vermistabilization of urban, industrial and agricultural wastes in order to produce organic fertilizers and obtain protein for animal feed. Although many species could be used for these ends, given their nutritional requirements and reproductive biology, only *Perionyx excavatus* and *Lampito mauritii* are widely used. The most effective use of earthworms in organic waste management requires a detailed understanding of the biology of all potentially useful species (Edwards and Bohlen, 1996). *P.excavatus* is an earthworm found commonly over a large area of tropical Asia (Gates, 1972). This is an epigeic species, which lives in organic wastes, and high moisture contents and adequate amounts of suitable organic materials are required for populations to become fully established and for them to process organic waste efficiently.

In order to encourage earthworm populations it is important to determine optimal levels of their food resources. The manure from mammalian herbivores is a highly nutritious food source for many species of earthworms (Lee, 1985). Works related to the exploitation of indigenous earthworms for waste management is scanty in India. Thorough research may help in selecting suitable indigenous vermicomposting species for different Indian regions with distinct climates.

The endogeic earthworms have a long growth phase and low reproductive rate whereas the epigeic earthworms have a long growth phase and low reproductive rate whereas the epigeic earthworms have short growth phase and high rate of reproduction. This type of variation in the growth and reproduction in earthworms is associated with their ecological strategies. Earthworms are one of the best means of abating organic pollution and also to minimize indiscriminate use of inorganic fertilizers. Although moisture requirements and moisture preferences of earthworms are considered to the physicochemical properties of different organic wastes indicate that these preferences can vary among substrates. Kale and Bano (1994) also showed that the earthworms preferring nitrogen rich diet grow faster and produce more cocoons than those feeding on mineralised soil. Even litter feeding worms show an order of preference for certain leafy matter (Kale and Krishnamoorthy, 1981).

The knowledge on the biology, food habits and habitat selections of worms are important factors for encouraging culturing of worms for degradation of animal waste, plant residues and wastes from the food processing units. Biomass production of worms on one hand helps to enhance process of waste degradation and on the other hand residue free worms can be used as an alternate source of protein for poultry birds and fish (Kale, 1993). Hence, the present study is carried out to find the influence of some organic wastes on the growth and reproduction of *P.excavatus* over a period of 100 days.

Materials and Methods

Collection and identification of earthworms

The earthworms were obtained from the Department of Biology, Gandhigram Rural Institute, Gandhigram, in live condition along with some humus in plastic containers. The earthworms were mass multiplied using cowdung as the medium.

Mass culture of earthworms

Earthworms were cultured in mass culture tanks containing cowdung medium. From the mass culture tanks, fifty healthy adult worms of uniform size were sorted out and transferred to plastic containers of 45cmx30cmx15cm size filled 2/3 with cowdung holding 70-80 percent moisture content.

Collection and preparation of organic substrates

The growth and reproduction studies were carried out in various organic wastes such as leaf litter (LL), straw waste (SW), coirpith (CP) and pressmud (PM). The organic substrates were selected based on the survey of their availability in huge quantities. All the organic waste substrates were chopped into small pieces and allowed for shade dry. To study the effect of various organic substrates on the growth and reproduction of earthworms, 1:3 ratio of each organic wastes and cowdung powder (sieved powder with

particle size of 1000-500 µm) were mixed. These substrates were maintained with a moisture content of 70 to 80 percent and allowed to stabilize for four days in a rearing chamber.

Growth studies

The containers used for the study measured 12 cm dia x 9 cm height and were fitted with perforated lids. Initially 50 gram of the medium was kept in each container. As suggested by Hallatt *et al.* (1990), the work was started with many replications and, afterwards, restricted to minimum numbers (six replication) in order to get accurate results for statistical authentication. For the growth study, the hatchlings were gathered from small containers in which cocoons had been placed to hatch. the biomass of each hatchling was measured. Fifteen numbers of *P.excavatus* hatchlings were introduced to the experimental containers with different substrates which were kept in a rearing chamber at 27±1ºC with relative humidity of 80-85 percent. After 15 days, fresh medium was added to every container. This was repeated every ten days till the termination of the experiment. While adding the fresh medium some of the older substrates were removed and weighed. This was done to maintain the original volume of the medium in each container.

The biomass of *P.excavatus* was determined every ten days up to the end of the study. The growth rate of the worms was calculated as per the formula of Mazantseva (1982) as given below:

$$\text{Growth rate (mg/worm/day)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = Initial weight of the worms
W_2 = Final weight of the worms
t_1 = Age of the worms at the start of the experiment (in days)
t_2 = Age of the worms at the end of the experiment (in days)

Reproduction of earthworms

A batch of six replicates was separately kept for hatchlings in different organic substrates for *P.excavatus,* for studying the reproduction parameters. The worms cultured in various organic substrates were closely watched for the development of clitellum after 15 days of the introduction of the worms until all the worms developed clitellum. After the formation of clitellum the substrates were searched for cocoons for every five days and the number of cocoons produced was recorded for each experimental setup till the termination of the study.

Incubation of cocoons

The cocoons recovered from the vermibeds produced by *P.excavatus* were separately kept in small containers with their respective composts. From the total cocoons recovered, a batch of 50 cocoons was randomly selected. The cocoons were individually kept in small plastic containers of 2.5 cm dia x 2.5 cm height carrying one gram of respective composts and observed for the emergence of hatchlings. The number of hatchlings that emerged from each cocoon and the total number of cocoons that hatched were also recorded separately for each substrate. The percentage of hatching success was calculated as follows:

$$\text{Percentage of hatching success} = \frac{\text{Number of cocoons hatched}}{\text{Number of cocoons incubated}} \times 100$$

Food preference study

The food preference of *P.excavatus* was determined based on the percentage of utilized substrates removed from the different vermibeds.

$$\text{Percentage of food utilization} = \frac{A - B}{A} \times 100$$

Where,

A = Total weigh of organic substrate in the vermibed

B = Weight of utilized material

Results and Discussion

The growth rate of *P.excavatus* at various organic wastes over a period of 100 days is given in Table 1. During the first week, the growth was slow, after that, the rate of growth steadily increased and it reached its maximum during the 80th day. Comparatively very least growth rate was observed in coirpith and cowdung mixture. Maximum growth rate of 4.81 and 4.30 mg/worm/day was observed on the 90th day in PM and LL respectively. Maximum growth rate of 3.20 and 2.30 mg/worm/day was observed on the 80th day in the SW and CP respectively. In the entire substrates slight gradual decline was observed after 90th day. During the whole period of observation, a mean growth rate of 3.43, 3.13, 2.15 and 1.40 mg/worm/day was recorded for the worms cultured in PM, LL, SW and CP respectively. Reinecke and Hallatt (1989) reported a growth rate of *P.excavatus* as 3.48 mg over the first 30 days at 25ºC in cattle solids, but, in this study similar growth rate was observed on 50th day in PM and LL.

The growth curve for *P.excavatus* in various organic substrates is drawn using the biomass as a marker against the number of days of study (Fig. 1). The initial biomass of the hatchlings subjected to this study was 2.05±0.18 mg/worm. The steady biomass increase was observed all over the study period, from the initial stage up to 80th day, after that the biomass increases was less. The maximum of biomass obtained while the termination of the experiment was in the order of 237.58±19.11, 213.90±17.35, 181.43±13.61 and 148.78±11.23 mg for PM, LL, SW and CP respectively. A highly significant positive correlation at 0.1% was observed between the age and the biomass of the worms.

Percentage of clitellated individuals of *P.excavatus* in various substrates is given in Table 2. The appearance of clitellum is started after 24th day at 25ºC and continued up to the 36th day. The growth and clitellum development was 28 days for *P.excavatus* (Hallatt *et al.,* 1990). The cumulative cocoon production of *P.excavatus* cultured in various organic substrates until the age of 100 days is shown in Fig. 2. *P.excavatus* started producing cocoons at the age of 28 days in all the substrates. The cumulative cocoon production was increased with the increase in the age for all the four substrates. Maximum number of 183 cocoons was observed at the termination of the experiment in PM. The cocoon production was also affected by the food source. CP supports the least growth and reproduction of the earthworm species.

Maximum individual biomass achieved by *P.excavatus* in various organic substrates is shown in Table. 3. The maximum biomass was observed in PM i.e., 251.89±15.33mg. Several earthworm species have been identified as detritus feeders that can be reared in large numbers on organic waste materials. Loehr *et al.* (1984) used sewage

Table. 1 Growth rate of *P.excavatus* at various organic wastes over a period of 100 days

Worm Age (days)	Growth rate (mg/worm/day)			
	Leaf litter	Straw waste	Coirpith	Pressmud
10	0.95±0.05	0.73±0.04	0.26±0.01	1.09±0.09
20	1.93±0.12	0.90±0.07	0.35±0.03	1.98±0.15
30	2.35±0.16	1.41±0.11	0.74±0.05	2.43±0.18
40	2.91±0.23	1.86±0.14	0.98±0.07	2.99±0.25
50	3.40±0.25	2.13±0.19	1.46±0.13	3.52±0.27
60	3.82±0.32	2.48±0.25	1.57±0.13	3.95±0.29
70	3.91±0.34	2.82±0.21	2.08±0.19	4.25±0.38
80	4.12±0.35	3.20±0.29	2.30±0.17	4.57±0.33
90	4.30±0.38	3.04±0.26	2.15±0.19	4.81±0.47
100	3.65±0.31	2.88±0.27	2.06±0.18	4.73±0.44

Table. 2 Percentage of clitellated individuals of *P.excavatus* in various organic substrates

Incubation Time (days)	Percentage of clitellate			
	Leaf litter	Straw waste	Coirpith	Pressmud
25	2.5	2.5	0	0
27	22.5	17.5	5.0	5.0
28	40.0	32.5	20.0	27.5
29	62.5	55.0	32.5	50.0
31	75.0	67.5	57.5	67.5
33	87.5	80.0	75.0	82.5
35	92.5	87.5	82.5	90.0
37	97.5	92.5	90.0	95.0
38	100	100	97.5	100
39	-	-	100	-

Fig. 1 Growth curves for *P.excavatus* in various organic wastes over a period of 100 days

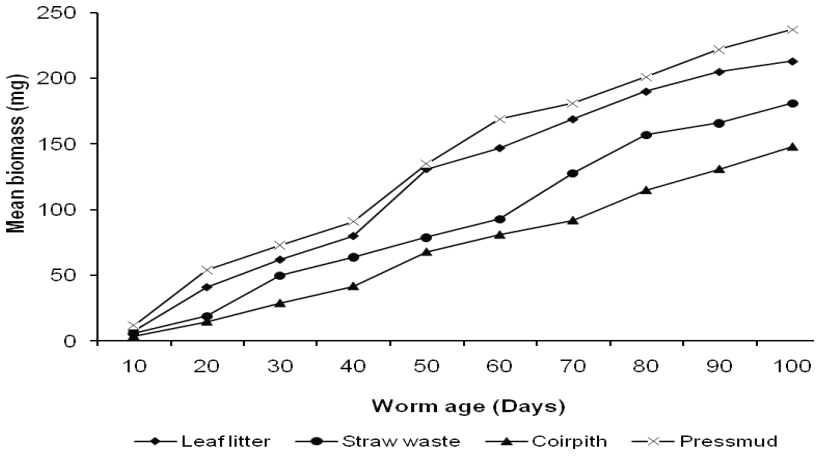

Fig. 2 The cumulative cocoon production of *P.excavatus* in various organic substrates until the age of 100 days

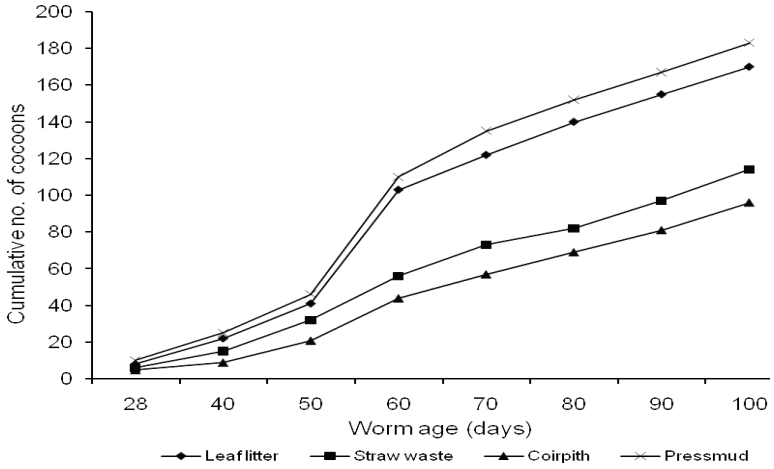

Table. 3 Vermiculture potential of *P.excavatus* in various organic substrates

Substrates	Maximum individual biomass	Mean no of cocoons	Hatching success (%)	Percentage of number of hatchlings/cocoon			Mean no. of hatchlings/ coocon	% of food utilized
				1	2	3		
Leaf litter	225.85±12.66	0.64	65.38	56	8	1	1.15	96.5±6.33
Straw waste	195.52±9.33	0.31	54.00	49	5	0	1.09	87.5±5.00
Coirpith	157.33±7.00	0.25	48.05	44	4	0	1.08	69.0±3.66
Pressmud	251.89±15.33	0.79	67.24	55	10	2	1.21	91.0±5.66

Table. 4 Various aspects of the biology of *P.excavatus* in Pressmud

Sl.no	Parameters	*P.excavatus*
1	Duration of life cycle (days)	±48
2	Growth rate (mg/worm/day)	3.43
3	Appearance of clitellum (days)	±25
4	Commencement of cocoon production (days)	±28
5	Rate of cocoon production (cocoon/worm/day)	0.82
6	Incubation period (days)	±19
7	Hatching success in compost (%)	67.27
8	Mean number of hatchlings/cocoon	1.21
9	Number of hatchlings produced from one cocoon	1-3

sludge as food source and reported that *P.excavatus* reached its maximum biomass after approximately 100 days. Their observation falls in line with these results. The average rate of cocoon production was high in PM (0.79 cocoon/worm/day). The mean number of cocoons produced per worm per day of 0.82 at 25ºC in the cattle solids (Edwards *et al.,* 1998). The important difference between rates of cocoon production in the organic substrates must be related to the quality of the waste, which was one of the factors determining the time taken to reach sexual maturation and for the onset of reproduction (Neuhauser *et al.,* 1979; Edwards, 1998). Knieriemen (1985) reported a mean of 0.33 cocoons per worm per day at 27ºC. Cocoons of *P.excavatus* that were produced in PM, LL, SW and CP had a hatching success of 67.24, 65.38, 54.00 and 48.05 % respectively. Kale *et al.* (1982) and Loehr *et al.* (1984) determined figures of 67 and 50 % respectively. Reinecke *et al.* (1992) observed the hatching success of 72 % in cattle dung at 25ºC for *P.excavatus.*

The percentages of cocoon delivering specific numbers of hatchlings at various organic substrates are also given in Table 3. An average of 44 to 56 % of cocoons produced one hatchling, 4 to 10 % produced two hatchlings and 1 to 2 % produced three hatchlings. Mean number of hatchlings per cocoon in various organic substrates was 1.08 to 1.21 hatchlings per cocoon. Reinecke *et al.* (1992) also observed similar type of hatching success and mean number of hatchlings per cocoon. After the termination of experiment, the food utilized by the earthworm was calculated to find out the food preference. Among the four substrates LL is preferred by these earthworms followed by PM.

The life cycle of *P.excavatus* is given in Table 4. Total duration of the life cycle of *P.excavatus* was ±48 days. The incubation period of cocoons of *P.excavatus* was ±19 days. The majority of the cocoons hatched only one hatchling. Bhattacharjee and Chaudhuri (1998) reported that high rate of cocoon production coupled with short incubation period in *P.excavatus* are indicative of their potential for utilization in vermiculture based biotechnology. Abbott (1980) reported that when the indigenous earthworm, *P.excavatus,* was introduced in a mixed culture along with the exotic earthworm *E.eugeniae,* the population of *P.excavatus* was gradually replaced, and it indicates the competition among the earthworm species, probably for food. The advantages of using native worms are many and notable among them is that they preserve the native diversity of the earthworms.

Conclusion

Based on the observations of the growth rate, worm biomass, formation of clitellum, cocoon production, the mean number of cocoons/worm/day, food preference study, hatchling success and mean number of hatchlings/cocoon of four different organic substrates, it is concluded that *P.excavatus* is efficient for the vermiculture in various organic wastes like LL, SW, CP and PM.

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