



## Biodynamics of epigeic earthworms *Perionyx ceylanensis* and *Lampito mauritii* during recycling of poultry droppings amended with sugar industrial by product

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### Abstract

A comparative study was conducted among indigenous earthworms *Perionyx ceylanensis* and *Lampito mauritii* to evaluate the suitability for vermicomposting of poultry industry wastes poultry droppings amended with sugar industrial by product press mud for large scale vermicompost production. Therefore, a comparative study was conducted among *P. ceylanensis* and *L. mauritii* for the assessment of their efficiency in vermicomposting of poultry droppings. Vermicomposting of poultry droppings (PD) amended with press mud (PM) takes 90 days of time, resulted in significance difference between the two species in their growth and reproduction performance. Different vermitreatments of both worms having different proportions of PD and PM were established and monitored growth and fecundity of the earthworms for 90 days. Result revealed that maximum worm biomass gain was observed in control, i.e., 100% PM and the lowest in 20% PM+ 80% PD feed mixture. Correspondingly, cocoon numbers and hatchlings production was significantly more in all the vermitreatments except in vermitreatments having more than 50% PD for both worms. Hence, from this study it was concluded that higher percentage of PD in different vermitreatments significantly affected the growth and reproduction of both species of worms.

**Keywords:** earthworms, vermicomposting, reproduction, poultry droppings, press mud

### Introduction

In India, poultry droppings generated from poultry industry in huge quantity creates problem for safe disposal due to the presence of a large number of soil contaminants, such as organic compounds, heavy metals, and pathogens. Collection and transportation of poultry droppings out of the affected areas may decrease the negative environmental effects related to its land application (Beohar and Srivastava, 2011) <sup>[1]</sup>. On the other hand, too much and direct land application of these wastes can lead to surface water runoff of plant nutrients, which in turn can cause eutrophication of water reservoirs (Atiyeh *et al.*, 2000; Meharaj and Manivannan, 2015) <sup>[2, 3]</sup>.

Sugarcane industry generates huge quantity of residue after the sugarcane juice has been clarified commonly known as press mud. There is a chief disposal problem for the sugar industry waste press mud although it is fairly rich in plant nutrients; it finds small use as agricultural fertilizer. The primary reason for this is the insoluble and imbalanced nature of the nutrient content in it. However, it generates heat (65°C), foul odor and takes long time for usual decomposition. Indiscriminate disposal of these wastes on agricultural fields induces soil and plant toxicity and creates depressive effects on the metabolism of soil microorganisms by drastically modifying physico-chemical and biological environments of soil (Manivannan *et al.*, 2004) <sup>[4]</sup>. Hence, there is an important need for ecologically as well as economically sustainable technologies which support possible recovery of recyclable constituents from these two wastes as it is rich in nutrients and has higher organic matter content.

Industrial wastes that are wealthy in organic matter and free

from toxic substances or ions could be suitable substrates for vermicomposting (Khwaitrakpam and Bhargava, 2009) <sup>[5]</sup>. In years numerous researches have been conducted on the potential use of different earthworms in nutrient recovery from agro industrial wastes. It has been well established that epigeic earthworms can speed up the waste degradation process to a significant level with production of a better quality of vermicompost as compared with those prepared through natural composting methods (Anbalagan *et al.*, 2012) <sup>[6]</sup>. Many organic wastes have been converted into vermicompost by different species of earthworms include industrial sludge (Yadav and Garg, 2009) <sup>[7]</sup>; cattle dung (Kaushik and Garg, 2003) <sup>[8]</sup>; horse waste (Sangwan *et al.*, 2009) <sup>[9]</sup>; wood waste (Kumar *et al.*, 2010) <sup>[10]</sup>; sago industry solid (Subramaniyan *et al.*, 2010) <sup>[11]</sup>; filter mud (Manivannan *et al.*, 2004) <sup>[4]</sup>; water hyacinth (Gupta *et al.*, 2007) <sup>[12]</sup>; paper waste (Gajalakshmi, 2002) <sup>[13]</sup>, etc. From the bibliographic review, it is evident that there is paucity of data on vermicomposting of poultry droppings using local earthworms which is available in huge quantities. Authors have observed that farmers are unwilling to apply it directly on field due to its odor, transportation cost and fear that its application may lead to pH variation, crust formation and pollution problem. As a result, the vermicomposting of poultry droppings using local earthworms is, a waste is renewed into value supplementary product and it controls a pollutant that is a consequence of increasing poultry industrialization. This work reports the feasibility of vermicomposting technology of poultry industry waste amended with press mud using the native earthworm species.

## Materials and Methods

### Organic waste and earthworm species

Sugar industrial waste Press mud (PM) was obtained from effluent treatment plant of E.I.D. Parry Sugar Mill India Ltd in Pugalur, Tamil Nadu, India. One week old poultry droppings (PD) were collected from Indian feeds farm Pvt. Ltd. Perumalkovilmedu village, Namakkal district, Tamil Nadu, India. Different age groups of local earthworm species *Perionyx ceylanensis* (Mich.) and *Lampito mauritii* (Kinberg) were cultured and developed outside the laboratory using partially degraded cow dung as feed material, respectively. *P. ceylanensis* (25-30 days) and *L. mauritii* (30-35 days old) were randomly selected from the stock culture maintained in the laboratory and used for this experimentation.

### Experimental setup

This experiment was carried out in laboratory using circular cement containers (10L capacity) as vermitreatments. We prepared different vermitreatments (VTP1 to VTP9 for *P. ceylanensis*; VTL1 to VTL9 for *L. mauritii*) containing selected waste mixtures of PM and increasing percentage of PD over a total amount of 5kg (Table 1). All the PD and PM quantities were used on dry weight basis and each vermitreatments was established in triplicate. The feed mixtures were turned manually every day for 10 days in order to stabilize the feed so that it becomes palatable to eat worms. After 10 days 100 species of worms (20/kg) were introduced in each vermitreatments, separately. The moisture content was maintained at 65-75% during the experiment. The vermitreatments were covered with moist jute to prevent moisture loss. The 0 day (initial) refers to the day of inoculation of earthworms to the respective vermitreatments of after stabilization (10 days).

### Growth and reproduction study

Biomass gain, cocoon and hatchlings production by *P. ceylanensis* and *L. mauritii* in each vermitreatments were recorded periodically during experimentation, respectively. The feed substrate in the vermitreatments was turned out then earthworms and cocoons were separated from the substrate by hand sorting, after which they were counted and weighed after washing with water. Then all earthworms and the substrate (but not cocoons) were returned to their respective vermitreatments. All the results reported in the text are the mean of three replicates. One-way ANOVA was used to analyze the significant differences among different vermitreatments. Tukey's *t*-test was used as a post hoc analysis to compare the means. The probability levels used for statistical significance were  $P < 0.05$  for the tests.

### Results and Discussion

The changes in earthworm growth (biomass), reproduction and mortality of all vermitreatments for *P. eylanensis* and *L. mauritii* over the vermicomposting period are illustrated in Tables 2-5. In the present study, *P. eylanensis* and *L. mauritii* showed significant difference in biomass production and reproduction potential, i.e., maximum biomass achieved at end ( $\text{mg worm}^{-1}$ ), biomass gain ( $\text{mg worm}^{-1}$ ), growth rate ( $\text{mg worm}^{-1} \text{day}^{-1}$ ), total number of cocoon, total hatchling number among different vermitreatments. Both species of worms

showed maximum and minimum mean individual biomass achieved at the end in vermitreatments, respectively. However, *L. mauritii* showed significantly higher individual weight in PM ( $1240 \pm 72.37 \text{mg}$ ) followed by VLT2, VLT3, VLT4, VLT5, VLT6, VLT7, VLT8 and VLT9 and *P. eylanensis* showed significantly higher individual weight in VPT1 ( $959 \pm 35.21 \text{mg}$ ), followed by VPT2, VPT3, VPT4, VPT5, VPT6, VPT7, VPT8 and VPT9 during the experimentation (Table 2). On the other hand, biomass gain ( $\text{mg worm}^{-1}$ ) and maximum growth rate ( $\text{mg worm}^{-1} \text{day}^{-1}$ ) of *L. mauritii* and *P. eylanensis* in CD vermitreatments was higher than other vermitreatments studied. The order of biomass gain among vermitreatments was: VPT1 > VPT2 > VPT3 > VPT4 > VPT5 > VPT6 > VPT7 > VPT8 and VPT9 in *P. eylanensis* and VLT2 > VLT3 > VLT4 > VLT5 > VLT6 > VLT7 > VLT8 and VLT9 in *L. mauritii* during the experimentation (Table 2&3). However difference among PM alone and PM mixed with PD up to 50% in vermitreatments for *P. eylanensis* and *L. mauritii* in respect to maximum biomass achieved ( $\text{mg worm}^{-1}$ ), biomass gain ( $\text{mg worm}^{-1}$ ) and growth rate ( $\text{mg worm}^{-1} \text{day}^{-1}$ ) were not statistically significant ( $p < 0.05$ ).

In the present study, maximum biomass for both worms in the vermitreatments may be due to the more palatability and acceptability of feed by earthworms and the minimum biomass in the vermitreatments with higher proportion of PD (more than 50%) was possibly due to the presence of some growth-retarding material in it. The results from the present work, in the context of vary in individual weight of worms with the stocking density corroborates with the findings of other researchers (Monroy, 2006; Nedegwa and Thompson, 2005) [14, 15]. It is suggested that reduce in individual weight of worms at high stocking densities may be due to the exhaustion of foods below maintenance level in the vermitreatments towards the end of experiment. The growth rate ( $\text{mg biomass gained/worm/day}$ ) has been considered a good comparative index to compare the growth of earthworms in different feeds (Tamizhazhagan *et al.*, 2016) [16]. Hence, the difference in growth rate among different vermitreatments in the present study seems to be closely related to feed quality and combinations.

The cocoon production by *P. eylanensis* and *L. mauritii* in different vermitreatments is given in table 4. The total cocoon numbers varied among vermitreatments and maximum and minimum cocoons obtained at the end were in VPT1 and VPT9 in *P. eylanensis* vermitreatments and VLT1 and VLT9 for *L. mauritii*, respectively. Cocoon production ( $\text{worm}^{-1}$ ) and reproduction rate ( $\text{cocoon worm}^{-1} \text{day}^{-1}$ ) varied significantly among different vermitreatments ( $p < 0.05$ ). Statistically, the difference between VTP1 to VTP5 in *P. eylanensis* and VTL1 to VTL5 in *L. mauritii* for number of cocoon production was not significant (Table 4). The maximum number of hatchling was produced in VPT1 to VPT5 in *P. eylanensis* vermitreatments and VLT1 and VLT5 for *L. mauritii*, respectively. However, VTP1 to VTP5 in *P. eylanensis* and VTL1 to VTL5 in *L. mauritii* vermitreatments did not show a statistically significant difference for reproduction rate (Table 4). The results suggested that higher proportions of PD with PM were not suitable for cocoon production. It may be concluded that production of cocoons in the feed mixtures

could be related to the biochemical quality of the feed, which was one of the important factors and in addition to the biochemical properties of waste, the microbial biomass and decomposition activities during vermicomposting are also important in determining the cocoon production (Manivannan *et al.*, 2004) [4]. Srijayam and Manivannan (2017) [17] concluded that chemical nature and humus composition of feeding stock may be of a primary importance for rearing of earthworm or organic waste resources. So, the difference in cocoon production could be due to variation in quality of the substrate. *P.eylanensis* and *L. mauritii* showed a statistically different pattern of worm mortality among different vermitreatments (Table 5). However, difference among VTP1 to VTP5 in *P. eylanensis* and VTL1 to VTL5 in *L. mauritii* vermitreatments in respect to total worm mortality was not statistically significant ( $p < 0.01$ ) for both species of worms. The growth and survival of earthworms in feed mixtures is drastically influenced by the chemical environment and ambient climatic variability. The food consumption rate in earthworms during initial critical period (period of acclimatization of earthworms in waste system) also determines the survival rate of earthworms. The C:N ratio of initial feedstuff may also be a limiting factor the feed consumption rate in earthworms (Campitelli and Ceppi, 2008) [18] and consequently affects earthworm survival during

vermicomposting. Some worm mortalities were observed during the vermicomposting experiment. Mortality was higher in those vermitreatments which had higher PD concentrations and it may be concluded that pre-composting is essential to avoid the earthworm mortality (Kaushik and Garg, 2003) [8]. Hence, the vermitreatments containing more than 50% PD with press mud was unable to support growth and reproductive success of both worms. It was inferred that the higher percentage of PD in the feed mixture significantly affected cocoon and hatchlings production.

**Table 1:** Description and composition of waste mixtures in different vermitreatments

Vermittreatments	Composition of feed substrate	
	PD (%)	PM (%)
VTP1 & VTL1 (control)	-	100
VTP2 & VTL2	10	90
VTP3 & VTL3	20	80
VTP4 & VTL4	30	70
VTP5 & VTL5	40	60
VTP6 & VTL6	50	50
VTP7 & VTL7	60	40
VTP8 & VTL8	70	30
VTP9 & VTL9	80	20

VTP1 to VTP9 for *P. ceylanensis*; VTL1 to VTL9 for *L. mauritii*

**Table 2:** Mean initial and maximum biomass of *P. ceylanensis* and *L. mauritii* during vermicomposting of PD amended with PM in different vermitreatments.

Vermittreatments	Mean initial biomass worm <sup>-1</sup> (mg)		Maximum biomass achieved Worm <sup>-1</sup> after 90 days	
	<i>P. ceylanensis</i>	<i>L. mauritii</i>	<i>P. ceylanensis</i>	<i>L. mauritii</i>
VTP1 & VTL1	155±22.5	195±13.1	959±35.21 <sup>ef</sup>	1240 ± 72.37 <sup>e</sup>
VTP2 & VTL2	157±19.2	195±14.8	942±52.15 <sup>e</sup>	1193 ± 67.18 <sup>d</sup>
VTP3 & VTL3	156±21.8	194±12.9	923±46.23 <sup>e</sup>	1138±52.15 <sup>cd</sup>
VTP4 & VTL4	156 ±19.6	194±20.1	876±57.24 <sup>de</sup>	1120±79.21 <sup>cd</sup>
VTP5 & VTL5	154±12.5	193±18.5	862±29.31 <sup>d</sup>	1004±95.15 <sup>c</sup>
VTP6 & VTL6	157±11.3	195±17.2	845±27.38 <sup>d</sup>	936±53.24 <sup>b</sup>
VTP7 & VTL7	155±17.6	193±30.4	789±46.29 <sup>c</sup>	915±49.23 <sup>b</sup>
VTP8 & VTL8	153±14.2	194±11.2	425±29.41 <sup>b</sup>	619±66.29 <sup>a</sup>
VTP9 & VTL9	154±11.8	194±19.2	307±19.24 <sup>a</sup>	606±68.17 <sup>a</sup>

VTP1 to VTP9 for *P. ceylanensis*; VTL1 to VTL9 for *L. mauritii*; All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Tukey’s t- test,  $p < 0.05$ ., ND - Not Deducted.

**Table 3:** Biomass production by *P. ceylanensis* and *L. mauritii* during vermicomposting of PD amended with PM in different vermitreatments.

Vermittreatments	Biomass gained worm <sup>-1</sup> (mg) after 90 days		Growth rate worm <sup>-1</sup> day <sup>-1</sup> (mg) after 90 days	
	<i>P. ceylanensis</i>	<i>L. mauritii</i>	<i>P. ceylanensis</i>	<i>L. mauritii</i>
VTP1 & VTL1	804±10.71	1054±25.18	8.9±0.11	11.7±0.27
VTP2 & VTL2	785±32.95	998±52.38	8.7±0.35	11.1±0.58
VTP3 & VTL3	767±24.43	944±39.25	8.5±0.26	10.4±0.41
VTP4 & VTL4	720±37.64	926±59.11	8.0±0.39	10.2±0.64
VTP5 & VTL5	698±16.81	801±76.5	7.7±0.19	8.9±0.82
VTP6 & VTL6	688±16.80	741±36.04	7.6±0.19	8.2±0.41
VTP7 & VTL7	634±28.69	722±18.83	7.0±0.30	8.0±0.20
VTP8 & VTL8	272±15.21	425±55.09	3.0±0.17	4.7±0.60
VTP9 & VTL9	153±7.44	412±48.97	1.7±0.08	4.5±0.53

VTP1 to VTP9 for *P. ceylanensis*; VTL1 to VTL9 for *L. mauritii*; All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Turkey’s t- test,  $p < 0.05$ ., ND - Not Deducted.

**Table 4:** Reproduction rate of *P. ceylanensis* and *L. mauritii* during vermicomposting of PD amended with PM in different vermitreatments.

Vermittreatments	Total no. of cocoons obtained at the end of experiment		Total no. of hatchlings obtained at the end of experiment	
	<i>P. ceylanensis</i>	<i>L. mauritii</i>	<i>P. ceylanensis</i>	<i>L. mauritii</i>
VTP1 & VTL1	324±15.2	218±18.7	122±15.3	75±6.9
VTP2 & VTL2	315±12.7	178±13.5	120±12.5	71±8.1
VTP3 & VTL3	254±10.8	171±15.7	98±8.9	67±5.8
VTP4 & VTL4	245±11.2	162±12.6	90±8.7	65±4.6
VTP5 & VTL5	240±16.7	160±8.9	87±6.5	59±2.3
VTP6 & VTL6	124±8.6	58±4.2	21±1.5	08±0.5
VTP7 & VTL7	29±2.1	32±5.8	05±0.5	03±0.1
VTP8 & VTL8	12±1.5	18±1.7	ND	02±0.1
VTP9 & VTL9	ND	ND	ND	ND

VTP1 to VTP9 for *P. ceylanensis*; VTL1 to VTL9 for *L. mauritii*; All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Tukey's t- test, p < 0.05., ND - Not Deducted.

**Table 5:** The mortality (%) of *P. ceylanensis* and *L. mauritii* during vermicomposting

Vermittreatments	<i>P. ceylanensis</i>	<i>L. mauritii</i>
VTP1 & VTL1	1.4 ± 0	1.2±0
VTP2 & VTL2	5.8±0.5	3.7±0.4
VTP3 & VTL3	7.9±0.8	5.4±0.5
VTP4 & VTL4	20.5±1.8	18.4±3.4
VTP5 & VTL5	31.3±3.5	22.9±2.6
VTP6 & VTL6	50.9±7.2	45.9±6.4
VTP7 & VTL7	53.0±5.1	58.4±8.7
VTP8 & VTL8	72.9±9.8	67.5±5.9
VTP9 & VTL9	95.7 ± 10.5	89.2±805

VTP1 to VTP9 for *P. ceylanensis*; VTL1 to VTL9 for *L. mauritii*; All values are reported as mean ± standard deviation between three replicates

## Conclusion

The information presented in this work provides a basis for the vermicomposting of poultry dropping amended with press mud. In this study, PD amended with PM with *P. ceylanensis* and *L. mauritii* has been examined for its suitability for growth and reproduction of earthworms for large scale vermicomposting. Mixing of PM as bulking agent in PD creates suitable microcosms for the earthworms. The growth rate and cocoon production by the both worms was having an inverse relationship with the percentage of PD in the feed mixture. The net weight gain by the earthworms was significantly lower in feed mixtures having higher PD content. Hence, our results established that if PD is mixed 50% with PM then vermicomposting can be an alternate technology for earth worm biomass and PD management. Among the two species, *P. ceylanensis* reveal better performance than *L. mauritii*.

## References

1. Beohar PA, Srivastava R K. Poultry waste management through vermicomposting employing exotic and indigenous species of earthworms. J of Soil Sci. 2011; 1(1):04-11.
2. Atiyeh RM, Dominguez J, Subler S, Edwards CA. Changes in biochemical properties of cow manure during processing by earthworms (*Eisenia andrei*) and the effects on seedling growth. Pedobiol. 2000; 44:709-724.
3. Meharaj I, Manivannan S. Influence of poultry waste amended with different organic food sources on growth and reproduction performance of indigenous earthworms *Lampito mauritii* (Kinberg) and *Perionyx excavates* (Perrier). European J of Exp. Biol. 2015; 5(6):1-6.
4. Manivannan S, Ramamoorthy P, Parthasarathi K, Ranganathan LS. Effect of sugar industrial wastes on the growth and reproduction of earthworms. J Exp. Zool. India. 2004; 7:29-37.
5. Khwairakpam M, Bhargava R. Bioconversion of filter mud using vermicomposting employing two exotic and one local earthworm species. Bioresour Technol. 2009; 100:5846-5852.
6. Anbalagan M, Manivannan S, Arul Prakasm B. Influence of Earthworm *Lampito mauritii* (Kinberg) and Organic Additives for Efficient Vermicomposting of Fly Ash. Ad in App Science Res. 2012; 3(5):3025-3031.
7. Yadav A, Garg VK. Recycling of organic wastes by employing *Eisenia fetida*. J Hazard Mat. 2009; 168:262-268.
8. Kaushik P, Garg VK. Vermicomposting of mixed solid textile mill sludge and cow dung with the epigeic earthworm *Eisenia foetida*. Bioresour Technol. 2003; 90:311-316.
9. Sangwan P, Kaushik CP, Garg VK. Vermiconversion of industrial sludge for recycling the nutrients. Waste Manage Res. 2010; 28:71-75.
10. Kumar R, Verma D, Singh BL, Kumar U, Shweta. Composting of sugar-cane waste by-products through treatment with microorganisms and subsequent vermicomposting. Bioresour. Technology. 2010; 101:6707-6711.
11. Subramanian S, Sivarajan M, Saravanapriya S. Chemical changes during vermicomposting of sago industry solid wastes. J Hazard. Mat. 2010; 179:318-322.
12. Gupta R, Mutiyar PK, Rawat NK, Saini MS, Garg VK. Development of a water hyacinth based vermireactor using an epigeic earthworm *E. fetida*. Biores. Technol. 2007; 98:2605-2610.
13. Gajalakshmi S, Ramasamy EV, Abbasi SA. Vermicomposting of paper waste with the anecic earthworm *Lampito mauritii* Kinberg. Indian J Chem. Technol. 2002; 9:306-311.

14. Monroy F, Aira M, Dominguez J, Velando A. CR. Seasonal population dynamics of *Eisenia fetida* (Savigny, 1826) (Oligochaeta, Lumbricidae) in the field. *Biology*. 2006; 329(11):912-915.
15. Nedegwa PM, Thompson SA. Effect of C and N ratio on vermicomposting in the treatment and bioconversion of biosolids. *Bioresour Technol*. 2000; 76:7-12.
16. Tamizhazhagan V, Pugazhendy K, Sakthidasan V, Revathi K, Baranitharan M. Investigation of microbial count in the soil and earthworm gut (*Eudrilus Eugeniae*). *Innovare Journal of Agri Sci*. 2016; 4(3):7-9.
17. Sri Jayam M, Manivannan S. Effect of earthworms activity on humus composition during biological stabilization of coffee pulp amended with pressmud. *Int J of Biol. Res*. 2017; 2(4):137-14.
18. Campitelli P, Ceppi S. Chemical, physical and biological compost and vermicompost characterization: A chemometric study. *Chemom. Intell. Lab. Syst*. 2008; 90:64-71.