

BIOLOGY OF THE EPIGEIC EARTHWORMS IN TROPICAL WET AND DRY CLIMATE OF DHARWAD (KARNATAKA), INDIA

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ABSTRACT: Studies on biology of epigeic earthworms is very much necessary for the selection of suitable earthworm species in effective organic waste management through vermiculture and vermicomposting process for the production of quality and quantity worm biomass (vermiprotein) and vermicompost (biofertilizer). Hence, the present study was undertaken to study the biology of different epigeic earthworm species such as *Eudrilus eugeniae* (EE), *Eisenia fetida* (EF) and *Perionyx excavatus* (PE) cultured in cattle manure at tropical wet and dry climate of Dharwad district, Karnataka state, India. The results of the present study revealed that the incubation period or the time of emergence of juveniles from the cocoon was less (16.33 ± 0.53 days) in *Perionyx excavatus* as compared to *Eudrilus eugeniae* (22.33 ± 0.73 days) and *Eisenia fetida* (24.33 ± 0.88 days). The percent hatching of cocoon was more in *E. eugeniae* (86.66 ± 6.66) followed by *E. fetida* (73.33 ± 5.33) and *P. excavatus* (66.66 ± 4.66), whereas number of hatchling/cocoon was more in *Eisenia fetida* (2.66 ± 0.33) followed by *Eudrilus eugeniae* (2.33 ± 0.28) and less in *Perionyx excavatus* (1.33 ± 0.23). The mean weight of juvenile (mg) at the time of hatching was more in EE (7.90 ± 0.20) followed by EF (7.00 ± 0.57) and less in PE (5.70 ± 0.35). The attainment of sexual maturity was observed early during 6th -9th week in EF and PE, but it was late in EE during 7th -10th week and commencement of cocoon production was noticed soon after one or two week of maturity i.e. from 8th week onwards. It was continuous and multimodal in nature with slight decline in the growth rate after maturity and cocoon production in all three epigeic earthworm species (EE, EF and PE). The various life activities such as incubation period and number of hatchling, maturity were more in EF as that of EE and PE, whereas percent hatching and juvenile weight were more in EE followed by EF and PE. Therefore, the success of vermiculture and vermicomposting process for the production of quality and quantity worm biomass (vermiprotein) and vermicompost (biofertilizer) is mainly depends on the biology or life cycle of the epigeic earthworms. type of organic waste materials used and it also depends on the prevailing abiotic factors.

KEYWORDS: Biology, Epigeic earthworms; *E. eugeniae*, *E. fetida*, *P. excavatus*, Cattle manure, Tropical climate and Dharwad district.

INTRODUCTION

Vermicomposting is nothing but bio-oxidation cum biodegradation and stabilization of organic waste materials involving joint action of earthworms and microorganisms²³. Studies revealed that epigeic earthworms seems to be well known and suitable organisms for such kinds of bioprocessing. The involvement of earthworms in vermicomposting process

decreases the time of stabilization of organic wastes and produces an organic pool with energy reserves as vermicompost³⁷. It is because of their natural ability to colonize organic wastes, high consumption rate, digestion and assimilation of organic matter, tolerance to a wide range of environmental factors, short life span, high reproductive capability, endurance and tolerance of handling situation in vermicomposting process. The biology and ecology of

earthworms in organic waste management are controlled by several biotic and abiotic factors such as temperature, moisture, pH, feed substrate and its palatability, particle size, earthworm density, fecundity and gut microorganisms etc, which directly or indirectly influence the potentials of vermicomposting process¹³. There are several epigeic earthworm species e.g. *Eisenia fetida*, *Eisenia andrei*, *Eudrilus eugeniae*, *Perionyx excavatus* have been identified throughout the world as potential candidates for managing variety of organic waste resources.

For commercial vermicomposting, much of the research work have been focused on *Eisenia fetida*³⁴, *Lumbricus rubellus*²⁰ and *Dendrobaena veneta*²¹. The life cycle and population biology of *E. fetida* and *E. andrei* in different organic wastes have been investigated by several researchers^{7, 23}. Some tropical composting earthworms namely *Eudrilus eugeniae*, *Perionyx excavatus* and *Perionyx sansibaricus* are getting much attention among commercial worm growers in both tropical and sub-tropical countries. The life cycle parameters of tropical species have been investigated with respect to their environmental requirements like temperature²², pH³³, density and feed substrate⁸ and moisture content of the culture bed¹⁶. Much of the research work related to biology or life activities of the various earthworm species were carried out at controlled laboratory conditions²⁸. But, the basic aspects of life cycle or biology of

the epigeic earthworms at uncontrolled abiotic environmental factors was not witnessed much in continuous changing environmental climate in particular area. Although, cattle manure is recognized as a suitable food for earthworm culture, but other organic waste materials from agriculture and industry have also proved successful¹⁸.

Therefore, population dynamics, productivity rate and energy flow in earthworms cannot be fully understood unless we know their detailed biology or life cycle in different environmental parameters or climatic conditions. Studies on biology or life cycle of earthworms are also necessary for the selection of suitable earthworm species in effective vermiculture and vermicomposting process for the production of quality and quantity vermicompost and worm biomass. Hence, the present study was aimed to study the biology or life cycle of three epigeic earthworms, *E. eugeniae*, *E. fetida* and *P. excavatus* cultured in cattle manure at tropical wet and dry climate of Dharwad district, Karnataka state, India.

MATERIALS AND METHODS

Selection and maintenance of epigeic earthworms stock in laboratory

The epigeic earthworms, *Eudrilus eugeniae* (EE), *Eisenia fetida* (EF) and *Perionyx excavatus* (PE) were selected as experimental models to study their biology or life cycle cultured in cattle manure (CM) at tropical wet and dry climate of Dharwad

district. Worms were brought from University of Agricultural Sciences (UAS), Dharwad and were cultured, maintained in cattle manure at Department of Zoology, Karnatak University, Dharwad as a stock culture for further experimental use. The environmental temperature [Range- 22°C - 33.7°C (Mean: 27°C)] and percent humidity [Range- 40% - 87% (Mean: 63.33%)] and rainfall (864mm/annum) were recorded during the experimental period.

Incubation period and hatching

Five fresh cocoons from each of the three epigeic earthworm species such as *E. eugeniae* (EE), *E. fetida* (EF) and *P. excavatus* (PE) were isolated from freshly maintained stock culture in our department and kept it in a petriplates containing stabilized cattle manure (in triplicates). Incubation period, percent hatching, number of hatchlings/cocoon was calculated as per Chaudhuri and Bhattacharjee⁴ and Chaudhuri and Datta⁵ and mean weight of juvenile (mg) at the time of emergence was also noticed.

Maturity and cocoon production

Freshly hatched juveniles were collected from previous experiments and cultured in stabilized cattle manure (in triplicates) so as to see the sexual maturity and start of cocoon production. Weekly observations were made with respect to time taken for attainment of sexual maturity, percent maturity, mating period and commencement of cocoon production. Sufficient food (cattle manure) and moisture

content of 70-75% were maintained throughout the experimental period by adding stabilized cattle manure and sprinkling of tape water respectively.

Statistical analysis

Statistical analysis of the data i.e. significance of variance (≤ 0.05) was carried out by using ANOVA test through SPSS 16.0 programme. Post hoc significance analysis (≤ 0.05) was performed through LSD (Fisher's Least Significance Difference) test.

RESULTS AND DISCUSSION

The results of the present study such as various life activities of three epigeic earthworms (EE, EF and PE) such as incubation period, percent hatching, number of hatchling/cocoon, mean weight of juvenile at the time of hatching, time of sexual maturity, percent maturity and commencement of cocoon production along with significant F and P values were represented in the Table-1 and 2, Graph-1 and Plate-1 to 3.

Incubation period and hatching

The results revealed that the incubation period i.e. time taken for hatching and emergence of juvenile from the cocoon was less (16.33 ± 0.53 days) in *Perionyx excavatus* as compared to *Eudrilus eugeniae* (22.33 ± 0.73 days) and it was more in *Eisenia fetida* (24.33 ± 0.88 days). The percent hatching of cocoon was more in EE (86.66 ± 6.66) followed by EF (73.33 ± 5.33) and PE (66.66 ± 4.66), whereas, number of

Table-1: The data of the various life activities (incubation period, percent hatching, number of hatchling/cocoon, juvenile weight, sexual maturity and cocoon production) of three epigeic earthworms (EE, EF and PE) and their significant F and P values ($P \leq 0.05$). Data are in Mean \pm SE.

Sl. No.	Earthworm species and significance	Incubation period	Percent hatching	Number of Hatching / cocoon	Juvenile weight at hatching time	Maturity		Start of cocoon production (week)
						Start	100%	
1	EE	22.33 \pm 0.73	86.66 \pm 6.66	2.33 \pm 0.28	7.90 \pm 0.20	7 th	10 th	9 th
2	EF	24.33 \pm 0.88	73.33 \pm 5.33	2.66 \pm 0.33	7.00 \pm 0.57	6 th	8 th	8 th
3	PE	16.33 \pm 0.53	66.66 \pm 4.66	1.33 \pm 0.23	5.70 \pm 0.35	7 th	9 th	8 th
4	F-Value	22.286	2.333	4.333	7.254	-	-	-
5	P-Value (d \leq 0.05)	0.002	0.178	0.068	0.02	-	-	-

Table-2: The significant variations ($P \leq 0.05$) between various activities of three different epigeic earthworms (EE, EF and PE).

Sl. No.	Parameters	Incubation period			Percent hatching			Number of hatchling/cocoon			Juvenile weight			
		Earthworm species	EE	EF	PE	EE	EF	PE	EE	EF	PE	EE	EF	PE
1	Incubation period	EE	-	0.160	0.003	-	-	-	-	-	-	-	-	-
		EF	0.160	-	0.001	-	-	-	-	-	-	-	-	-
		PE	0.003	0.001	-	-	-	-	-	-	-	-	-	-
2	Percent hatching	EE	-	-	-	-	0.207	0.078	-	-	-	-	-	-
		EF	-	-	-	0.207	-	0.506	-	-	-	-	-	-
		PE	-	-	-	0.078	0.506	-	-	-	-	-	-	-
3	Number of hatchling/cocoon	EE	-	-	-	-	-	-	-	0.506	0.078	-	-	-
		EF	-	-	-	-	-	-	0.506	-	0.030	-	-	-
		PE	-	-	-	-	-	-	0.078	0.030	-	-	-	-
4	Juvenile weight	EE	-	-	-	-	-	-	-	-	-	-	0.171	0.009
		EF	-	-	-	-	-	-	-	-	-	0.171	-	0.067
		PE	-	-	-	-	-	-	-	-	-	0.009	0.067	-

hatchling/cocoon was more in *Eisenia fetida* (2.66 ± 0.33) followed by *Eudrilus eugeniae* (2.33 ± 0.28) and less in *Perionyx excavatus* (1.33 ± 0.23) and mean weight of juvenile (mg) at the time of hatching was more (7.90 ± 0.20) in EE followed by EF (7.00 ± 0.57) and less (5.70 ± 0.35) in PE (Table-1, Graph-1 and Plate-1-3).

In general, there is a significant variation was observed among incubation period and freshly emerged juvenile weight, whereas no significant difference was observed among percent hatching and number of hatchlings of all three epigeic earthworms (Table-1). But in particular, there is no significant difference was noticed in percent hatching, number of hatchlings/cocoon and freshly emerged juvenile weight except between EF and PE in number of hatchlings/cocoon and EE and PE in juvenile weight. The significant variation was noticed with respect to incubation period except between EE and EF between three epigeic earthworm species (Table-2).

The incubation period, percent hatching and number of hatchling/cocoon were slightly varied between three epigeic earthworm species (EE, EF and PE). The incubation period and number of hatchlings were comparatively more in EF and EE followed by PE, but the percent hatching was more in EE followed by EF and PE (Table-1). These variations in the above life activities among different epigeic earthworms in our study may be due to intrinsic property of each earthworm species with respect to feeding, growth, size and

their reproductive potentiality. The data of life activities in the present study varies with the data of other researchers^{25,35} with respect to either same species or with different species, this may be due to uncontrolled laboratory environmental conditions or fluctuation in the abiotic factors such as temperature and humidity²⁹. Type and quality of food material provided to them in our study compared to others^{11,30}.

Reinecke *et al.*³¹ have reported less incubation period at constant abiotic factors and also witnessed low percent hatchability at higher temperature. Venter and Reinecke³⁵ have also reported more number of hatchling about 2.0-2.5/cocoon in *E. fetida* at constant temperature and % RH. The reports of Kaushal *et al.*¹⁹ with respect to mean incubation period i.e. 30 ± 2.5 days for *D. nepalensis*, 35 ± 5.20 days for *M. houlletii*, and 18.70 ± 1.8 days for *P. excavatus*, which was very much similar to 28.7 days incubation period for *D. nepalensis* and 36.5 days for *D. rubida* as reported by Elvira *et al.*¹⁰, while for *D. veneta*, it was 43–90 days as per Fayolle *et al.*¹².

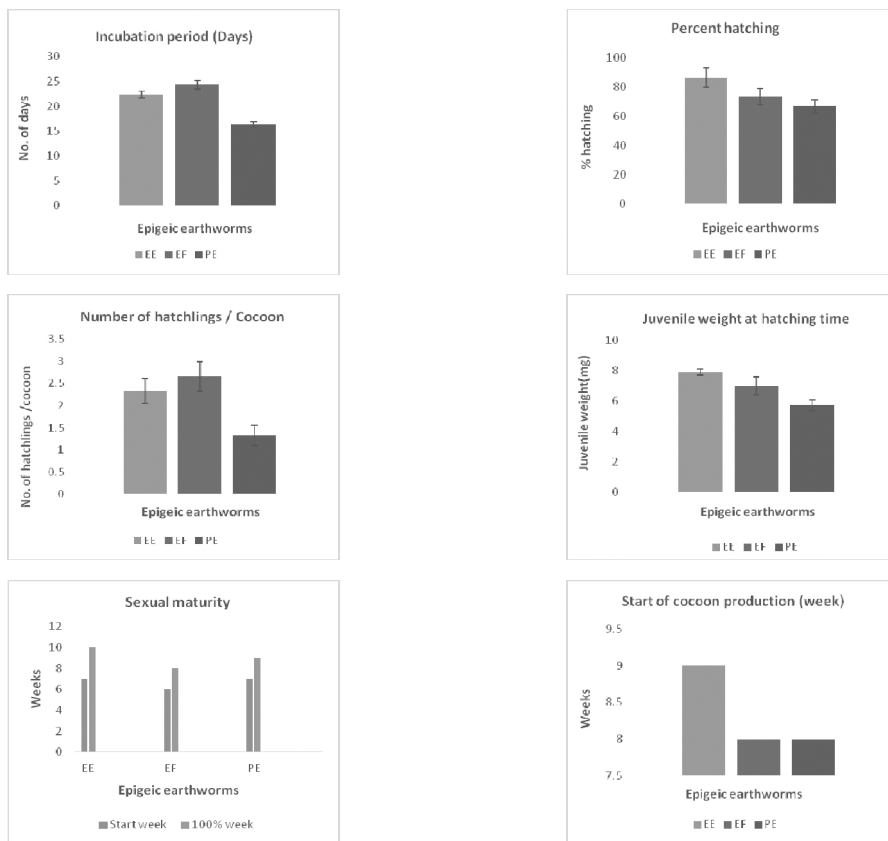
The percent hatchability of different earthworm species cultured in various organic wastes showed wide fluctuations. Similarly, number of hatchling also varied with different earthworms like 2.7 in *E. foetida* cultured in cattle manure³⁵, 2.2 in *E. eugeniae* cultured in cattle manure³⁶, *E. eugeniae* and *L. mauritii* with 2.63 and 3.15 in press mud cake and *P. excavatus* with 2.45 in cow dung and *P. excavatus* with 1.37 in kitchen wastes³. Giraddi *et al.*¹⁴, who have

reported that better hatching success of cocoons that indicate the cocoon viability. The data of the above researchers was in accordance with our data obtained in the present study.

Maturity and cocoon production

The data revealed that the attainment of sexual maturity starts from 6th -7th week onwards in all three epigeic earthworms, but 100% maturity was noticed at 8th week

in EF and 9th week in PE, whereas at 10th week in EE (Table-1, Graph-1). Similarly, commencement of cocoon production was noticed in all three epigeic earthworms (EE, EF and PE) from 8th week onwards soon after one-two week of their maturity (Table-1, Graph-1). There is as such no drastic difference in maturity and start of cocoon production was observed between different earthworm species (Table-1).



Graph-1: Data of incubation period, per cent hatching, number of hatchlings/cocoon, weight of freshly emerged juvenile, sexual maturity and commencement of cocoon production with respect to *Eudrilus eugeniae* (EE), *Eisenia fetida* (EF) and *Perionyx excavatus* (PE) epigeic earthworms cultured in cattle manure at tropical dry and wet climate of Dharwad.

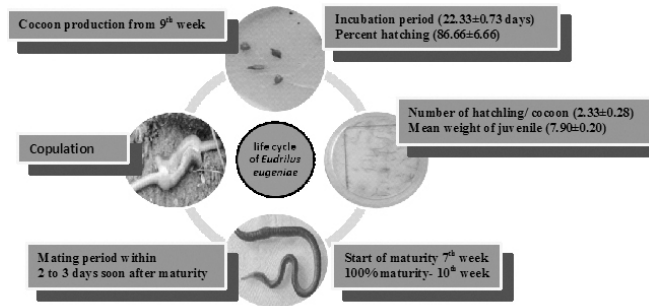


Plate-1: Biology of the epigeic earthworm, *Eudrilus eugeniae* (EE) cultured in cattle manure.

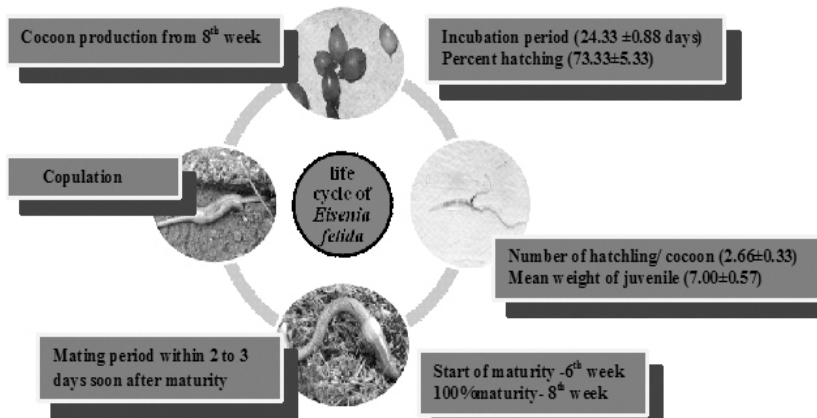


Plate-2: Biology of the epigeic earthworm, *Eisenia fetida* (EF) cultured in cattle manure.

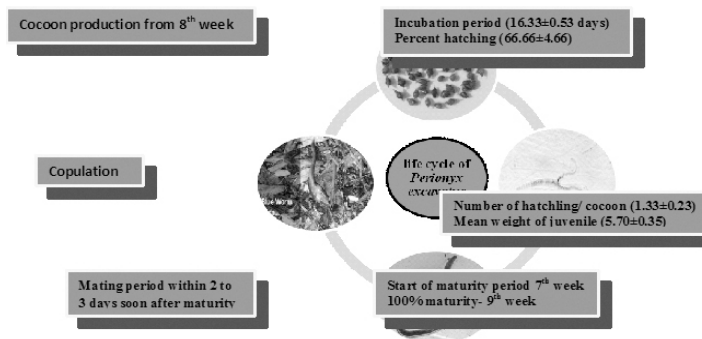


Plate-3: Biology of the epigeic earthworm, *Perionyx excavatus* (PE) cultured in cattle manure.

The attainment of sexual maturity was observed early by 6-8th week in EF and 7-9th week in PE, but it was late by 7-10th week in EE. Commencement of cocoon production was noticed from 8-9th week onwards in all three earthworm species (EE, EF and PE) with continuous and multimodal in nature soon after one or two weeks of their maturity up to the end of the experiment.

Edwards and Bohlen⁹ and Monroy *et al.*²⁴ have reported rapid pre-reproductive phase of growth followed by a steady phase of progressive biomass and reduction in growth rate was noticed once sexual maturity was attained. Jesikha and Lekeshmanaswamy¹⁷ have witnessed reduction in worms weight soon after sexual maturity and cocoon production may be because of earthworms have utilized whole energy for reproduction that is for mating, laying eggs and cocoon formation. Reinecke *et al.*³¹ reported a maximum weight gain for *E. eugeniae* of 150 mg/week at 25°C. Hait and Tare¹⁵ reported that temperature influences a lot on the biology of the earthworm by modifying their metabolic activities.

The early maturity and cocoon production was also reported by Venter and Reinecke³⁵ in epigeic earthworms but, cultured at constant temperature and percent relative humidity (RH). Many researchers^{2,27} have reported continuous and multimodal type of cocoon production by various epigeic earthworms. Pulikeshi and Amoji²⁷, Domínguez⁶ have also reported that growth

and reproduction of *E. eugeniae* was affected by several factors such as food quality, moisture, temperature and population density under laboratory conditions. Shalabi³² have reported the average standard time taken to reach sexual maturity for *E. fetida* was about 70 days and Venter and Reinecke³⁵, who have recorded 60 days in *E. fetida* to reach sexual maturity. The time of sexual maturity mentioned in the above reports was more than that of our study (49 days). The development of clitellum in *Eudrilus eugeniae* appeared during 39, 31 and 27 days cultured in soil, cattle dung and press mud cake respectively as reported by Parthsarathi²⁶, the maturity time was less than as that of our study in all three species (EE, EF and PE).

Thus, the results of the present study shown that all the life activities such as incubation period, percent hatching, number of hatchling/cocoon, attainment of sexual maturity, and commencement of cocoon production were more in EF and EE followed by PE cultured in cattle manure. Therefore, the success of vermiculture and vermicomposting is mainly depends on the biology or life activities of a particular earthworm species used and also depends on the prevailing environmental conditions i.e. whether controlled or uncontrolled abiotic factors matters in the composting process.

SUMMARY AND CONCLUSION

From the above results, it can be

concluded that the various life activities of the epigeic earthworms, *E. eugeniae* (EE), *E. fetida* (EF) and *P. excavatus* (PE) differs even though they are cultured in the same food, cattle manure at uncontrolled abiotic environmental conditions. The various life activities such as incubation period, percent hatching, number of hatchling/cocoon, weight of freshly emerged juveniles, attainment of sexual maturity and commencement of cocoon production were more in EF and EE followed by PE.

Therefore, the success of vermiculture and vermicomposting is primarily depends on the biology or life activities of a particular earthworm species and type of organic waste used as feed materials. It also depends on prevailing environmental conditions that means whether cultured under controlled or uncontrolled conditions. Hence, all three epigeic earthworm species (*Eudrilus eugeniae*, *Eisenia fetida* and *Perionyx excavatus*) used in this study are suitable for either in vermiculture or in vermicomposting technology for the production of worm biomass and vermicompost that can be used as vermiprotein and valuable biofertilizer respectively.

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