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STUDIES ON THE LIFE CYCLE OF THE EARTHWORM, *EUDRILUS EUGENIAE* DURING DIFFERENT SEASONS

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ABSTRACT : The commercial production of vermicomposting and worm biomass is mainly depends upon the potentiality of the earthworm used and the environmental factors prevailing in different seasons. The present study was undertaken to know the influence of seasonal environmental factors on the basic life (incubation period, hatching, no. of hatchling/ cocoon, worm biomass, growth rate, maturity, mating time and cocoon rate) activities of the epigeic earthworm, *E. eugeniae* cultured on cattle manure in arid region of Karnataka. Results revealed that the incubation period was more in summer (21.33 days) followed by winter (18.33 days) and monsoon (17.66 days), whereas the % hatching and No. of hatchling/cocoon were more in monsoon (82% & 1.76) followed by winter (79.66% &1.49) and least in summer (64% & 1.37), respectively. Similarly biomass (mg) and growth (rate mg/d/gm) were more in monsoon (621±0.88 & 1204±2.33) followed by winter (591±0.88 & 905±1.45) and least in summer (552±1.45 & 801±3.16) season. The sexual maturity was early in monsoon (27.33 days) followed by winter (29 days) and it was delayed in summer (34.66 days). The mating period and cocoon rate were 2 days & 1.45 in monsoon, 2.66 days & 1.45 in winter and 3.33 days & 0.81 worm/week in summer seasons. From the above results, it can be concluded that the basic life activities of this earthworm were much influenced by different seasons. The environmental factors prevailing in the monsoon and winter seasons were found to be more congenial for culturing the earthworm, *E. eugeniae*. The seasonal environmental factors not only influenced the life activities, but they also indirectly affect the production of quality and quantity vermicompost and worm biomass in vermicomposting process.

Key words : Life cycle, Epigeic earthworm- *Eudrilus eugeniae*, seasons.

INTRODUCTION

Abiotic factors such as temperature, percent relative humidity (% RH) and type of organic waste foods etc. are the important factors influencing survival and growth of earthworms (Qiao *et al*, 2003; Hou *et al*, 2005). The commercial production of both vermicompost and worm biomass is mainly depends on the potentiality of the earthworms used in this technology (Kale *et al*, 1982; Haimi and Huhta, 1986). Edwards (1988) noticed optimum growth of *E. fetida* in different animal and vegetable wastes at 25-30°C temperature and 75-80% moisture content. According to Edwards (1998) the type, quality and quantity of organic wastes were also much influenced on the reproductive capabilities of many earthworm species (Graff, 1981; Reinecke and Viljoen 1990; Gunadi *et al*, 2003).

Much of the research work related to different life activities or the biology of the earthworms were carried out at controlled laboratory conditions (Pulikeshi *et al*, 2008). But the basic life activities or the biology of earthworms in uncontrolled laboratory conditions during different seasons was probably not yet carried out. Hence, the present study was undertaken to known the influence of different seasonal environmental factors on basic life activities (incubation period, percent hatching, number of hatchlings/cocoon, worm biomass, growth rate, maturity, mating time and cocoon production) of the epigeic earthworm, *E. eugeniae* cultured on cattle manure during monsoon, winter and summer seasons in arid region of Karnataka.

MATERIALS AND METHODS

Selection and maintenance of earthworm stock culture

In the present investigation, the epigeic earthworm, *E. eugeniae* was selected as a experimental animal model to study the basic life activities or biology of this worm during different seasons. Worms were brought from University of Agricultural Sciences (UAS), Dharwad and were stock cultured in stabilized cattle manure for further experiments.

Incubation period and hatching

Five fresh cocoons of *E. eugeniae* were isolated from stock culture and kept it in a culture box containing cattle manure in triplicate. Incubation period, percent hatching

and number of hatchlings were all noticed during different seasons (monsoon, winter and summer).

Growth and reproduction

Simultaneously, five freshly emerged juveniles were isolated and inoculated in a culture boxes containing stabilized cattle manure (in triplicate) for 16 weeks in all three seasons. Weekly observations were made with respect to worm biomass, growth rate, sexual maturity, mating period and cocoon production. The moisture content of 70-75% was maintained in all the culture boxes throughout the experimental period in all three seasons (summer, monsoon and winter).

Seasonal environmental factors

Daily room environmental temperature and percent relative humidity (% RH) were recorded in all three seasons so as to find out the co-relationship between seasonal environmental factors with various life activities of earthworm, *E. eugeniae*. The seasonal mean room temperature was 34.33°C, 26°C & 22°C and percent RH was 47%, 58% & 63.33% during summer, monsoon and winter seasons, respectively.

Statistical analysis

Statistical analysis of the data such as significance of variance and co-relation co-efficient were carried out with the help of ANOVA ($P < 0.05$ level) and Pearson's co-relation co-efficient respectively by using SPSS program (16 version).

RESULTS

Table 1 and Figs. 1-3 represents the data (Means± SE) of different seasonal environmental factors (room temperature, percent relative humidity), moisture content of the culture and other life activities of the epigeic earthworm, *E. eugeniae* during different seasons.

Incubation period and hatching

The results revealed that the incubation period was more (21.33 days) in summer followed by winter (18.33 days) and monsoon (17.66 days) seasons, whereas the percent hatching was more in monsoon (82%) followed by winter (79.66%) and it was least in summer season (64%). Similarly, the number of hatchling from each cocoon was also more in monsoon (1.76) followed by winter (1.49) and summer (1.37) seasons.

Growth and reproduction

The biomass (mg) and growth rate (mg/day/gm) were more in monsoon followed by winter and summer seasons as shown in Table 1. The mean biomass (mg) and growth rate (mg/day/gm) were 552±1.45, 621±0.88, 591±0.88 and 801±3.16, 1204±2.33, 905±1.45 in summer, monsoon and winter seasons respectively. Attainment of sexual maturity was early in monsoon (27.33 days) and winter (29.00 days) seasons and it was delayed in summer (34.66 days) season. The average mating period soon after maturity was varied during different seasons, it took 2 days in monsoon, 2.66 days in winter and 3.33 days in summer seasons. The mean cocoon production (worm/week) was equal in both monsoon and winter (1.45/worm/week) seasons, whereas it was less in summer (0.81/worm/week) season as mentioned in the Table 1.

The data of seasonal room environmental factors such as temperature and % percent relative humidity showed significant difference between seasons. Likewise, there is also a significant difference in various life activities of this earthworm between different seasons except the incubation period (Table 1). The Pearson correlation co-efficient between different seasonal room environmental

Table 1 : Comparative data of seasonal environmental factors and various life activities of the earthworm, *E. eugeniae* during different seasons with their significant values. (Mean ± SE).

S. No.	Parameters	Summer	Monsoon	Winter	F-value	P-value
A	**Seasonal environmental factors**					
1	Mean room temperature (^{0}C)	34.33 ± 0.66	26.00 ± 0.57	22.00 ± 0.57	8.45	0.027
2	Mean relative humidity (%)	47.00 ± 0.57	58.00 ± 0.57	63.33 ± 0.33	20.64	0.004
3	Moisture content (%) maintained in culture pots	70-75%	70-75%	70-75%	-	-
B	**Life activities of the earthworm, *E. eugeniae***					
4	Mean incubation period (days)	21.33 ± 0.88	18.33 ± 0.33	17.66 ± 0.33	2.72	0.15
5	Mean percent hatching (%)	64.00 ± 0.57	82 ± 1.15	79.66 ± 0.33	116.2	0.000
6	Mean number of hatchlings/cocoon	1.37 ± 0.01	1.76 ± 0.01	1.49 ± 0.01	776.18	0.000
7	Mean biomass (mg)	552 ± 1.45	621 ± 0.88	591 ± 0.88	1345.5	0.000
8	Mean growth rate (mg/day/gm)	801 ± 3.16	1204 ± 2.33	905 ± 1.45	8.852	0.025
9	Time taken for maturity (days)	34.66 ± 1.20	27.33 ± 0.66	29.00 ± 0.57	18.22	0.005
10	Mean mating period (days)	3.33 ± 0.33	2.00 ± 0.00	2.66 ± 0.33	9.00	0.024
11	Mean cocoon rate (worm/week)	0.81 ± 0.01	1.45 ± 0.01	1.45 ± 0.01	298.53	0.000

P< 0.05

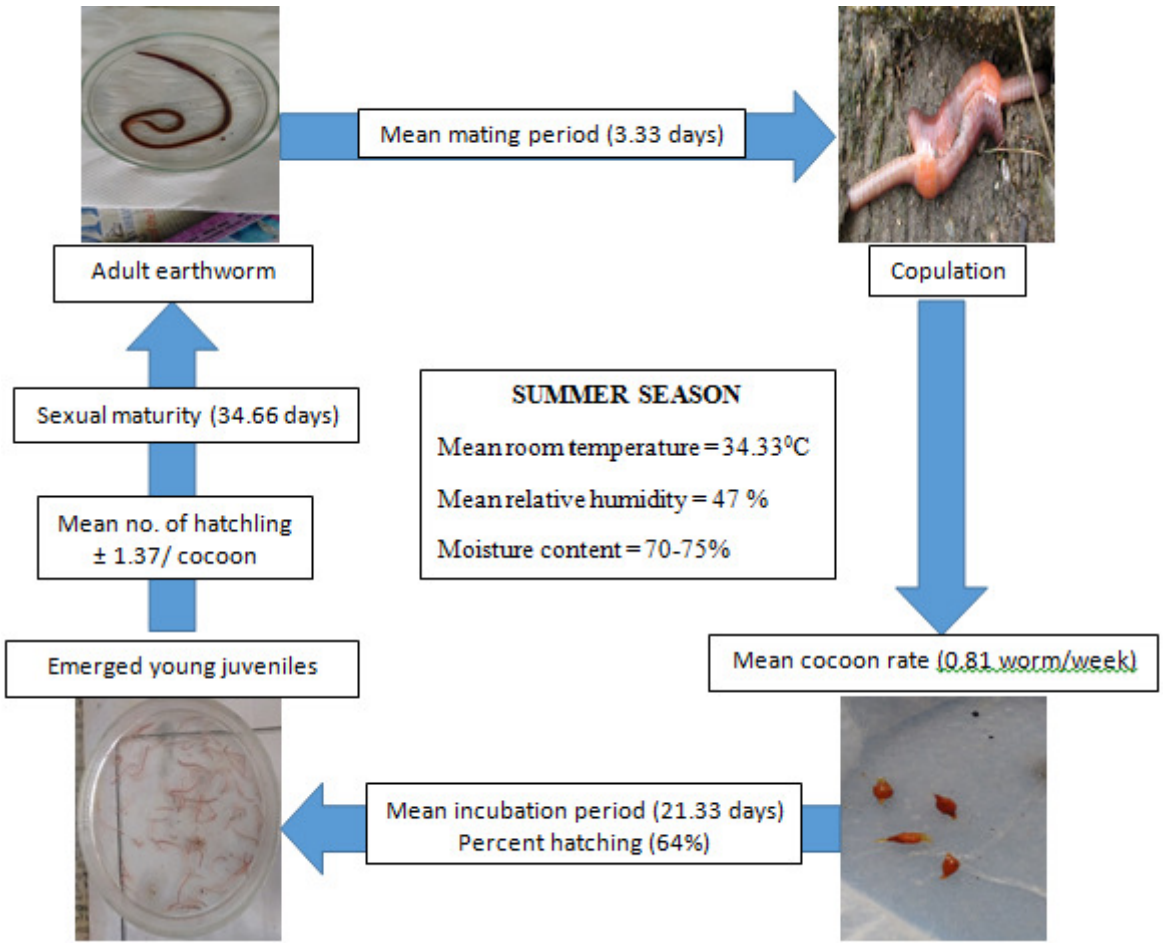

Fig. 1 : Life cycle of the earthworm, *Eudrilus eugeniae* cultured in cattle manure during summer season.

Table 2 : The Pearson's correlation co-efficient between seasonal environmental factors with various life activities of the earthworm, *E. eugeniae* during different seasons.

S. No.	Life activities of the earthworm	Summer		Monsoon		Winter	
		RT	RH	RT	RH	RT	RH
1	Incubation period (in days)	0.75	0.32	0.86	0.86	-0.86	0.50
2	Percent hatching	0.86	-0.50	0.50	-0.50	0.00	-1.0
3	No. of hatchlings/cocoon	-0.86	-0.50	-0.63	0.66	-0.80	0.48
4	Mean biomass (mg)	-0.86	-1.00	0.00	0.00	0.86	0.86
5	Mean growth rate (mg/day/gm)	-0.11	-0.59	-0.32	-0.32	0.65	-0.75
6	Sexual maturity period (days)	0.50	0.00	-0.37	-0.37	0.59	-0.80
7	Mating period (days)	0.27	0.72	-0.86s	0.86	-0.50	-0.86
8	Cocoon rate (worm/week)	0.50	0.86	1.00	1.00	1.00	-1.00

factors (Temperature and % RH) and with various life activities of this earthworm was mentioned in the Table-2. The data revealed that except with few parameters, the room temperature was almost negatively co-related and % RH was positively co-related with various life activities of the earthworm, *E. eugeniae* during different seasons.

DISCUSSION

In the present study, seasonal environmental factors prevailing during different seasons were much influenced on various life activities (such as incubation period, percent hatching, number of hatchling, biomass, growth rate, time taken for sexual maturity, mating period and cocoon production) of the earthworm, *Eudrilus eugeniae*.

Incubation period and hatching

The incubation period, % hatching and number of hatchling/cocoon were slightly varied with different seasons. The time taken for hatching (incubation period) was more (21.33 days) in summer than that of monsoon (18.33 days) and winter (17.66 days), whereas % hatching and number of hatchling were comparatively more in

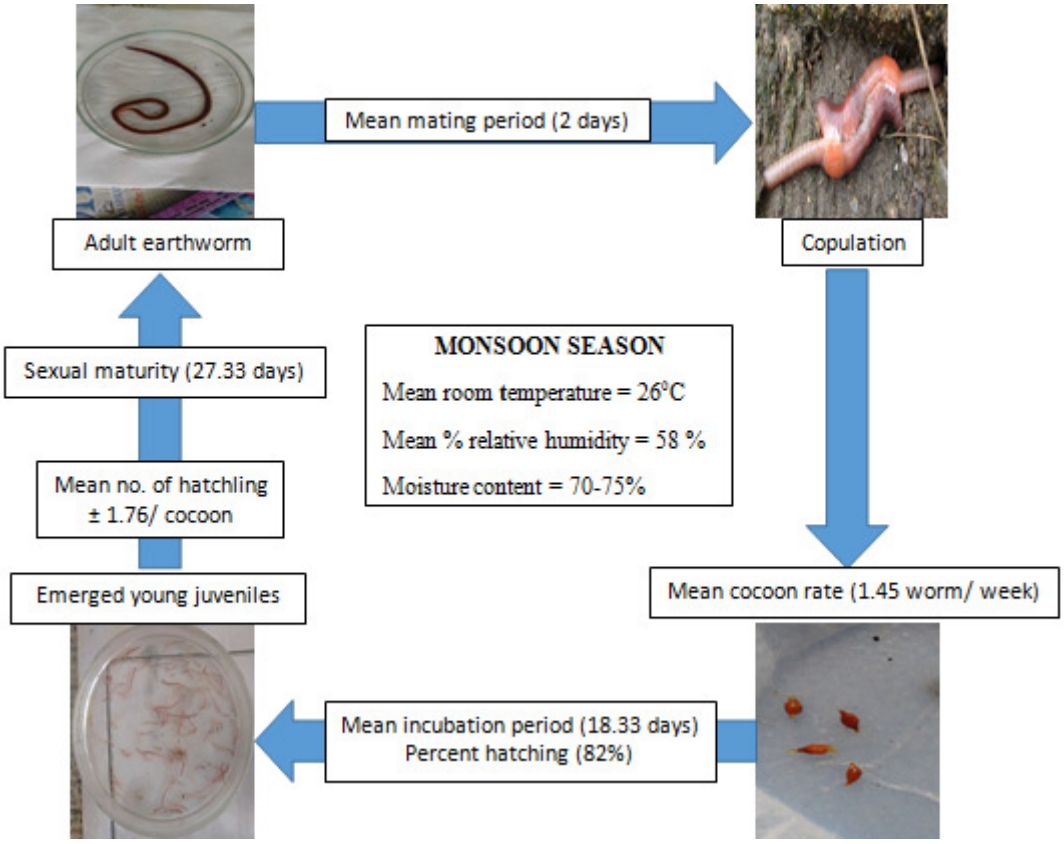

Fig. 2 : Life cycle of the earthworm, *Eudrilus eugeniae* cultured in cattle manure during monsoon season.

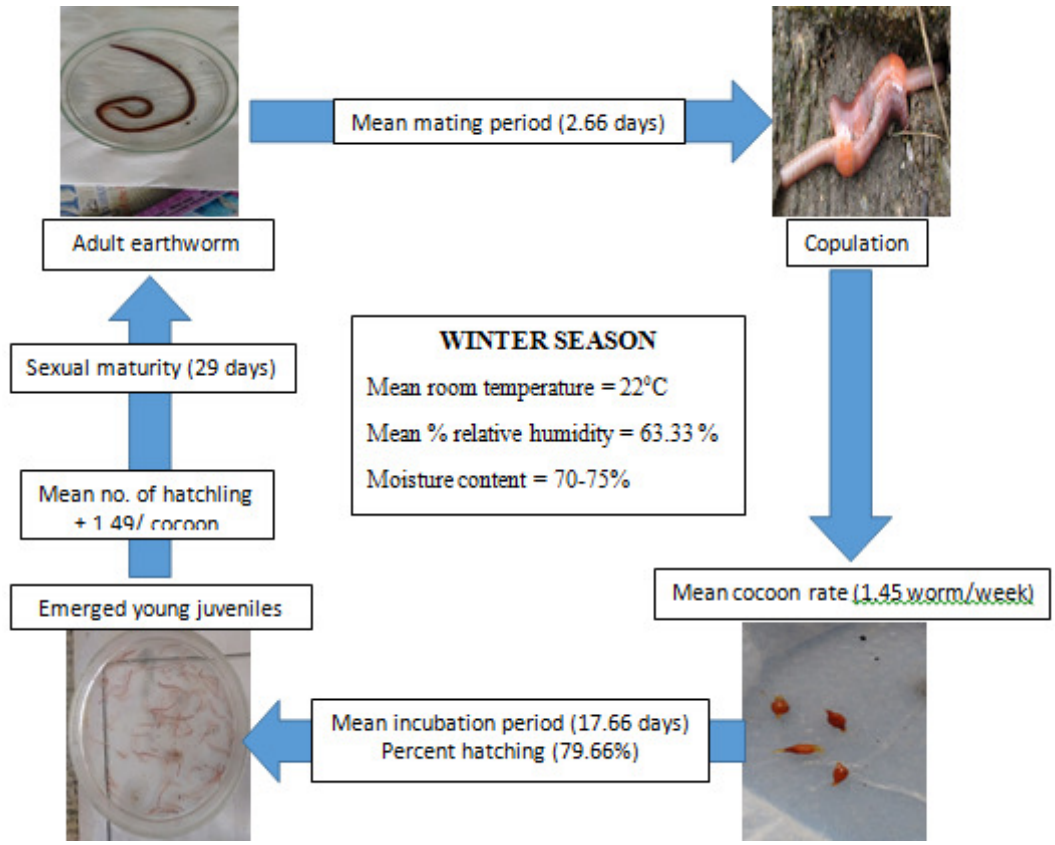

Fig. 3 : Life cycle of the earthworm, *Eudrilus eugeniae* cultured in cattle manure during winter season.

monsoon and winter than that of summer season. The early incubation period, more % hatching, and number of hatchling in monsoon and winter season may be due to congenial and optimum range of room environmental factors (Temperature and % RH) prevailing in monsoon (26°C & 58%) and winter (22°C& 63.33%) seasons than that of summer (34.33°C & 47%) season. Venter and Reinecke (1988) have reported more number of hatchling (2-2.5/cocoon) at constant temperature and % relative humidity in their studies. Reinecke *et al* (1992) have reported less incubation period at constant abiotic factors and they also observed low percent hatchability at higher temperature.

Growth and reproduction

The biomass and growth rate of this worm was more during initial weeks of their development upto maturity then it was stagnant and declined towards subsequent weeks up to 16th week in all three seasons. Similar observations were also made by Graff (1981) and Loehr *et al* (1984) regarding decline in growth rate of worm soon after maturity and commencement of cocoon production. Suthar (2007) have studied growth performance in the earthworm *E. eugeniae* cultured on kitchen waste and he observed maximum biomass of 982mg/worm on 9th week at constant temperature (25°C). In our studies, biomass and growth rate of worms were comparatively more in monsoon and winter seasons than that of summer season, this may be due to optimum room environmental conditions favoured better growth and development in monsoon and winter seasons. The optimum room environmental conditions (25-30°C and 50-60% RH) for this worm was reported by Shagoti *et al* (2001). The sexual maturity and cocoon production were early in both monsoon and winter seasons as compared to summer season, this may be again attributed to optimum and congenial room environmental factors prevailing in monsoon and winter seasons than that of summer season. The early maturity and cocoon production by the worms were also witnessed by Venter and Reinecke (1988) cultured at constant temperature and % RH. Dominguez *et al* (2001) have also observed early (7-8 week) sexual maturity and cocoon production by *E. eugeniae.* The pattern of cocoon production is continuous and multimodal in nature throughout the experiment during all three seasons but the cocoon rate was comparatively less in summer than that of winter and monsoon seasons. Many researchers were also noticed continuous and multimodal type of cocoon production by various earthworm species (Neuhausur *et al*, 1980; Pulikeshi and Amoji, 2003; Jasikha, 2014). The cocoon production was comparatively less here with that of other researchers like Venter and Reinecke (1988) may be due to uncontrolled room environmental conditions in our studies as they have cultured worms at constant room temperature (25^0C) throughout the experiment. Domínguez (2004) have also expressed the influence of several factors such as food quality, moisture, temperature and population density on growth and reproduction of the earthworms. Pulikeshi and Vijaykumar (2015) have also reported monsoon season was extraordinarily congenial for the culture of *P. excavatus* than that of winter and summer seasons.

Hence, the prevailing room environmental conditions play a very important role for proper growth and reproduction of earthworms in effective vermiculture and vermicomposting process so as to produce quality and quantity worm biomass and vermicompost.

CONCLUSION

From the above results, it could be concluded that the various life activities of the earthworm, *E. eugeniae* were influenced by seasonal environmental factors (such as temperature and % RH) during different seasons. The monsoon and winter seasons were more favourable and congenial for culturing epigeic earthworm, *E. eugeniae* than that of summer season. The prevailing seasonal environmental factors not only influence various life activities of the earthworms but they also indirectly affect the production of quality and quantity vermicompost and worm biomass in vermicomposting process.

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