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LIFE ACTIVITIES OF THE EPIGEIC EARTHWORM, *EISENIA FETIDA* DURING DIFFERENT SEASONS

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Abstract : Climate has a direct influence on earthworm biology and their life cycle, while their habitats and feeding activities are indirectly related to climate. Hence, the present study was undertaken to know the influence of seasonal environmental factors on different life activities by the epigeic earthworm *E. fetida* cultured in cattle manure at uncontrolled laboratory conditions. Five fresh cocoons of *E. fetida* were isolated (in triplicates) from the stock culture and kept them in a culture box containing cattle manure. Incubation period (IP), percent hatching (PH), and number of hatchling/cocoon (NH/C), juvenile weight at the time of hatching (JWH) were all noted during three seasons (i.e. monsoon, winter, and summer). In continuation, five fresh juveniles of *E. fetida* were isolated (in triplicates) from previous experiments and cultured in a pot size of 11cm diameter and 10cm height containing a stabilized cattle manure after noting their weight in all three seasons. The stabilized food and moisture content of the cultures were maintained. Weekly observations with respect to attainment of sexual maturity (WWM), hundred percent maturity (HWMW), worm biomass at maturity (WWM) and start of cocoon production (SCPW) were made during all three seasons. The seasonal environmental factors such as temperature, %relative humidity (RH) and rainfall (RF) were noted regularly throughout the experimental period during three seasons. The results of our studies revealed that the IP, WMW, HWMW and SCPW were early in monsoon and winter seasons as compare to summer seasons. Whereas pH, NH/C and WWM were comparatively more in monsoon and winter seasons followed by summer seasons, whereas JWH was less in monsoon and winter than that of summer season. There is a significant difference among three seasons was noticed with respect to all life activities like IP, NH/C, WMW, HWMW, WWM except pH and JWH.

Based on the results, it can be concluded that the life activities of epigeic earthworms not only influenced by quality and quantity of food, density of worms but also strongly influenced by the prevailing abiotic and seasonal environmental factors such as ET, %RH, and RF for effective vermiculture and vermicomposting for organic waste management.

Keywords: Earthworm, life activities, seasonal environmental factors, *E. fetida*

I. INTRODUCTION:

Epigeic earthworms are significant ecosystem engineers in the soils and play key roles for numerous ecosystem services, such as decomposition, nutrient cycling, crop yield, etc. (Scheu, 2003; Groffman *et. al.*, 2004; Jordan *et. al.*,2004; Johnston *et. al.*, 2007; Kaneda *et. al.*, 2008). Earthworms represents a major group in the soil fauna helps in soil fertility, organic waste degradation and recycling of nutrients. As the seasonal factors play an important role in changes in the size and biomass of their populations (Edwards and Bohlen, 2004; Valckx *et. al.*, 2006; Nagumanova, 2007). In order to encourage earthworms populations naturally or artificially or by culturing them, it is very important to determine the optimal levels of temperature, moisture, humidity, food resources, etc. Variations in the life activities such as growth and reproduction of earthworms is associated with their ecological strategies (Tsukamoto and Watanabe, 1977; Reinecke and Kriel, 1981; Reinecke and Hallat, 1989; Butt, 1991).

Climate has a direct influence on earthworm life activities including their life cycle, while their habitats and feeding activities are indirectly related to climate. For example, temperature affects either earthworm metabolic activities individually or their distribution globally (Lavelle, 1983; Lavelle *et. al.*, 1989, 1999). Insufficient soil moisture at high temperatures affects earthworm populations and earthworm activities changes greatly between seasons in temperate reasons (Gerard, 1967; Phillipson *et. al.*, 1976). The main soil characteristics features that control the earthworm number and biomass are a soil organic matter (SOM), texture, pH, water holding capacity and soil temperature (Lee, 1985; Bernier and Ponge, 1994; Lavelle and Spain, 2001; Karaca *et. al.*, 2010).

As stated by several researchers, the type, quality and quantity of organic wastes were much influenced on the reproductive capabilities of many earthworm species (Graff, 1981; Edwards, 1998; Gunadi *et. al.*, 2003). Abiotic factors also equally influenced the growth and survival of earthworms (Qiao *et. al.*, 2003; Hou *et. al.*, 2004). Production of quality and

quantity vermicompost and worm biomass are mainly depending on the potentiality of the earthworms (Kale *et. al.,* 1982). Usually, research work related to different life activities (biology) of the earthworms were carried out at controlled laboratory conditions (Reinecke and Hallat, 1989). The biology of the earthworms in uncontrolled laboratories conditions, in different seasonal environmental conditions need to be studied properly by using potential epigeic earthworms.

Hence, the present research was undertaken to know the influence of seasonal environmental factors on life activities such as incubation period, percent hatching, number of hatchlings / cocoons, juvenile weight, sexual maturity, worm biomass at maturity, mating time and start of cocoon production by the epigeic earthworm *E. fetida* cultured in cattle manure at uncontrolled laboratory conditions.

II. MATERIALS AND METHODS:

a. Preparation of food:

Dried cattle manure powder was used as nutritive medium for these earthworms, which is moistened with tap water so as to maintained 70-80% moisture and allowed to stabilize for about one week in a laboratory condition for initiation of microbial degradation or primary degradation.

b. Maintenance of earthworm stock culture:

To study the life activities of the epigeic earthworm, *Eisenia fetida*, cultures of these worms were maintained in a stabilized cattle manure as stock culture for further experimental studies during different seasons.

c. Experimental setup:

i. Incubation period and hatching:

Five fresh cocoons of *E. fetida* were isolated (in triplicates) from stock culture and kept them in a culture box containing cattle manure. Incubation period, percent hatching and number of hatchlings/cocoons, juvenile weight at the time of hatching were all noted during three seasons (i.e. monsoon, winter and summer).

ii. Maturity and reproduction:

In continuation, five fresh juveniles of *E. fetida* were isolated (in triplicates) from previous experiment, and cultured in a pot (size 11cm diameter and 10cm height) containing a stabilized cattle manure after noting their weight in all three seasons (monsoon, winter and summer).

The stabilized food was maintained throughout the experiment. The moisture content of the cultures was maintained about 70 to 80% by sprinkling of tap water whenever necessary. Weekly observations with respect to attainment of sexual maturity, hundred percent maturity, worm biomass at maturity and start of cocoon production were made during all three seasons.

d. Seasonal environmental factors:

The onset of each season starts from June to September (monsoon); October to January (winter); February to May (summer). The seasonal environmental factors such as temperature, % relative humidity and rainfall were noted regularly throughout the experimental period during monsoon, winter and summer seasons. The data of average environmental temperature, % relative humidity and rainfall were represented in the Table – 1.

e. Statistical analysis:

Statistical analysis of the data such as significance of variance and co-relation tests were carried out by the help of ANOVA test at $P \leq 0.05$ level and Pearson two tailed co-relation coefficient test respectively by using SPSS (16.0) software.

III. RESULTS AND DISCUSSION:

The results of the present study were represented in the Table-1, 2 & 3, Graph- 1 & 2 and Figure – 1, 2 & 3. *E. fetida* displayed a significant variation ($P \leq 0.05$) in incubation period (IP), percent hatching (PH), number of hatchling/cocoon (NH/C), juvenile weight at the time of hatching (JWH), attainment of sexual maturity week (WMW), hundred percent maturity week (HWMW), worm biomass at maturity week (WWM) and start of cocoon production week (SCPW) during three different seasons (monsoon, winter and summer).

a. Incubation period and hatching:

The results revealed that the incubation period i.e. the time taken for hatching and emergence of juveniles from the cocoon was more in summer season (24.83±0.16) followed by winter (23.66±0.33) and monsoon (23.50±0.28) seasons, whereas percent hatching & number of hatchling/cocoons was more in monsoon (80.00±0.00 & 2.30±0.05) and winter (80.00±0.00 & 2.46±0.03) followed by summer (73.33±0.66 & 1.96±0.03) season. The juvenile weight at the time of hatching was more in summer (7.00±0.11) followed by monsoon (6.50±0.28) and winter (6.06±0.23) season (Table -1 and Graph – 1&2).

There is a significant variation was noticed in incubation period, number of hatchlings/cocoons among all three seasons, whereas statistically no significant difference was observed with respect to percent hatching and juvenile weight at the time of hatching (Table – 1).

b. Maturity and cocoon production:

The sexual maturity was early in monsoon (6.00±0.00 week) and winter (6.33±0.33 week) season than that of summer (7.00±0.11 week) season. Hundred percent sexual maturity was also observed in the early weeks during monsoon and winter seasons (7.33±0.33week) than that of summer season (8.66±0.33 week). The mean worm biomass at maturity was more during winter (205.00±2.88) and monsoon (192.67±3.92) seasons followed by summer (185.33±2.88) season. The start of cocoon production was also early during monsoon and winter (7.33±0.33 & 7.66±0.33) seasons as compared to summer (8.66 ±0.33) season (Table-1 & Graph-1&2).

There is a significant variation was witnessed with respect to worm maturity, 100% worm maturity at weeks and worm weight at maturity period except with respect to start of cocoon production week by the earthworm, *Eisenia fetida* among three seasons (Table – 1).

Significant difference was also noticed between various life activities (WMW, HWMW & WWM) of *Eisenia fetida* in different seasons except between monsoon & winter in WMW & HWMW & between monsoon & summer with respect to WWM (Table-2). Significant variation was also noticed between various life activities like IP, NH/C except between monsoon & winter in IP (Table-2)

IV. DISCUSSION:

Environmental factors such as ET, %RH & RF affects various life activities of E. fetida in our studies. Reinecke *et. al*., (1992) reported a mean incubation period of 17.80 days and 15.30 days incubated at 25˚Cand at 25-37˚C respectively for cocoons of *Perionyx excavatus*. Further, it is also noticed that temperature higher than 25˚C decreased the mean incubation period of earthworm species *Perionyx excavatus*, *Eudrilus eugeniae* and *Eisenia fetida*. Watanabe and Tsukamoto (1976), who stated that the temperature above the optimum level for growth has decreased the incubation period. The IP was comparatively more in our studies from 23 to 24 days at uncontrolled environmental conditions in different seasons. Venter and Reineke (1988) have reported more number of hatchlings at about 2-2.5 / cocoon at constant temperature and percent relative humidity. The data of No. of hatchling (1.96-2.46) in our studies correlates with above studies. According to Holmstrup *et. al.*, (1991) the threshold temperature for hatching should be regarded as an adaptation to the particular habitat conditions in which the species lives. Increase in the incubation period along with increase in the number of hatching/cocoons of *Lampito mauritii.*

Edwards (1988) reported that time taken for development of cocoons for temperate epigeic earthworms was 32-73 days in *Eisenia fetida*, 40-126 days in *Dendrobaena veneta* and for tropical epigeic worms was 13-27 days in *Eudrilus eugeniae* and 16-21 days in *Perionyx excavatus.* According to Senapati and Sahu (1993) incubation period, in general ranges from 3 to 30 weeks in temperate earthworms and 1 to 8 weeks in tropical earthworms.

Cocoon production (number/adult/year) varies with different species and prevailing environmental conditions (Evans and Guild, 1948; Satchell, 1967). Cocoon production and time for hatching of cocoons vary with earthworm species, population density, age structure and external factors like soil temperature, moisture and energy content of the available food (Lee, 1985; Edwards and Bohlen, 1996).

The sexual maturity was seen early in monsoon and winter seasons as compared to summer season may be because of optimum range of seasonal environmental factors (such as environmental temperature, % Relative humidity and rain fall) in the early two seasons than that of summer seasons. The early maturity was also witnessed by Venter and Reinecke (1988) but worms cultured at constant temperature and % RH. Dominguez *et. al.*, (2001) have also noticed the shortest period (i.e.7-8 weeks) for attainment of sexual maturity by the *E. fetida*. Dominguez (2004) have mentioned that the growth and reproduction of *E. eugeniae* was affected much by several factors such as food quality, moisture, temperature and population density a laboratory conditions.

There is strong positive correlation between environmental temperature and IP (+0.922), JWH (+0.980), WMW (+0.816), HWMW (+0.959), SCPW (+0.864) observed whereas negative correlation was noticed with respect to PH (-0.959), NH/C (-1.000), WWM (-0.931). A moderate positive correlation was also observed between % relative humidity and PH (+0.549) and JWH (-0.094), NH/C (+0.259) and strong negative correlation was noticed with respect to IP (-0.638), WMW (-0.790), HWMW (-0.549), WWM (-0.080), SCPW (0.732). There is a moderate positive correlation between RF and PH (+0.473), NH/C (+0.174) and negative correlation was noticed between RF and IP (-0.568), JWH (-0.006), MWM (-0.733), HWMW (-0.473), WWM (-0.893) and SCPW (-0.670) during all three seasons (Table-3).

Table - 1: The data of various life activities of the epigeic earthworm, *E. fetida* & *environmental factors* during different seasons (monsoon, winter and summer)

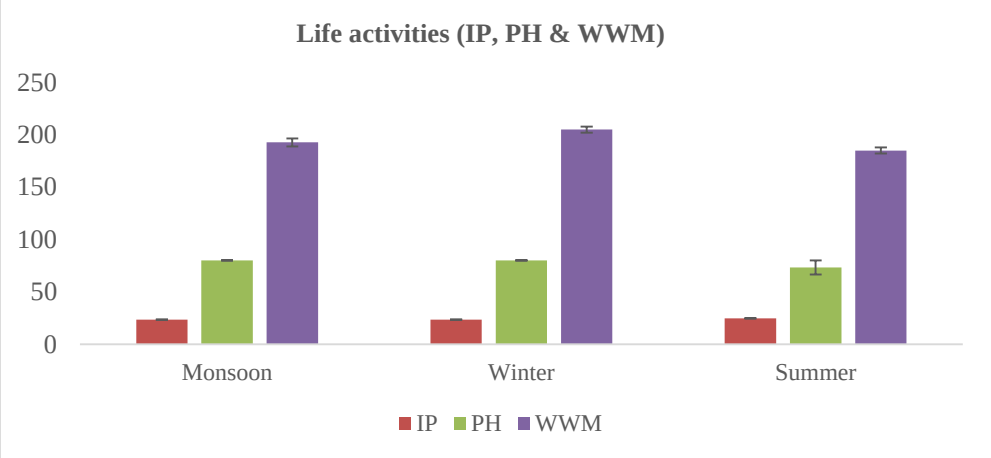
Sl. No.	Seasons ➡ Life activity Parameters ⬇	Monsoon season	Winter season	Summer season	F- value	P- value
1	IP	23.50±0.28	23.66±0.33	24.83±0.16	7.125	0.026
2	PH	80.00±0.00	80.00±0.00	73.33±6.66	1.000	0.422
3	NH/Cocoon	2.30±0.05	2.46±0.03	1.96±0.03	35.000	0.000
4	JWH	6.50±0.28	6.06±0.23	7.00±0.11	4.331	0.069
5	WMW	6.00±0.00	6.33±0.33	7.00±0.00	7.000	0.027
6	HWMW	7.33±0.33	7.33±0.33	8.66±0.33	5.333	0.047
7	WWM	192.67±3.92	205.00±2.88	185.00±2.88	9.512	0.014
8	SCPW	7.33±0.33	7.66±0.33	8.66±0.33	4.333	0.068
9	ET (Range)	20.50 to 27.00˚C	16.50 to 28.75˚C	19.25 to 33.75˚C	---	----
10	% RH (Percentage)	87.75 %	69.50 %	68.25 %	---	----
11	RF (Average)	167.50mm	22.50mm	27.50mm	----	----

Table - 2: Significant variations (P≤0.05 level) between various life activities of the epigeic earthworm, *Eisenia fetida* during different seasons.

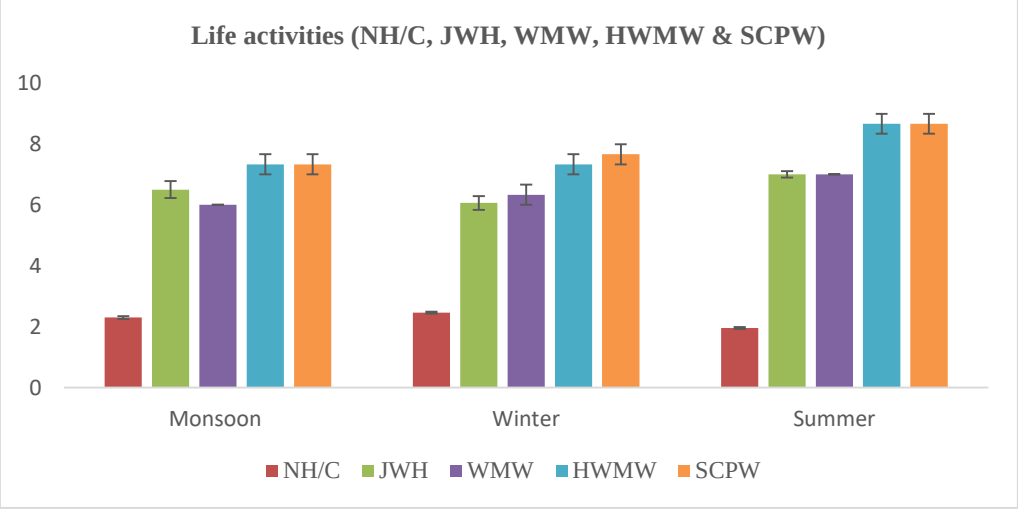
Sl. No.	Life activity Parameters		IP			NH/C			WMW			HWMW			WWM		
		Seasons	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer
1	IP	Monsoon	--	**0.68**	0.01												
		Winter	--	--	0.02												
		Summer	--	--	--												
2	NH/C	Monsoon				--	0.03	0.00									
		Winter				--	--	0.00									
		Summer				--	--	--									
3	WMW	Monsoon							--	**0.26**	0.01						
		Winter							--	--	0.05						
		Summer							--	--	--						
4	HWMW	Monsoon										--	**1.00**	0.03			
		Winter										--	--	0.03			
		Summer										--	--	--			
5	WWM	Monsoon													--	0.03	**0.14**
		Winter													--	--	0.00
		Summer													--	--	--

Table-3: Co-relation co-efficient between various life activities of the epigeic earthworm, *E. fetida* and seasonal environmental factors (Temperature (ET), %relative humidity(%RH) and rainfall (RF) during all three seasons (Monsoon, Winter &Summer).

Sl. No.	Life activity ⇒ Parameters ⇓ Environmental Factors	IP	PH	NH / cocoon	JWH	MWM	HWMW	WWM	SCPW
	Environmental temperature (ET)	+0.922	-0.959	-1.000	+0.980	+0.816	+0.959	-0.931	+0.864
	%Relative humidity (%RH)	-0.638	+0.549	+0.259	-0.094	-0.790	-0.549	-0.080	-0.732
	Rainfall (RF)	-0.568	+0.473	+0.174	-0.006	-0.733	-0.473	-0.893	-0.670



Graph-1: various life activities such as IP, PH & WWM of the epigeic earthworm, *Eisenia fetida* cultured in cattle manure during different seasons (monsoon, winter and summer).



Graph 2: various life activities such as NH/C, JWH, WMW, HWMW & SCPW of the epigeic earthworm, *Eisenia fetida* cultured in cattle manure during different seasons (monsoon, winter and summer).

V. SUMMARY AND CONCLUSION:

In the present research, the various life activities of *Eisenia fetida* such as IP, JWH, WMW, HWMW and SCPW were early in monsoon and winter seasons as compared to summer seasons. Whereas PH, NH/C and WWM were comparatively more

in monsoon and winter seasons followed by summer seasons, whereas JWH was less in monsoon and winter than that of summer season.

There is a significant difference among three seasons was noticed with respect to all life activities like IP, NH/C, WMW, HWMW, WWM except PH, JWH and SCPW.

There is a strong positive correlation between various life activities and environmental temperature and more negative correlation with % RH and RF in all three seasons during our studies.

Based on the results of the present research, it can be concluded that the life activities of epigeic earthworms not only influenced by quality and quantity of food, density of worms but it also strongly influenced by the prevailing abiotic and seasonal environmental factors such as ET, % RH and RF for effective vermiculture and vermicomposting for organic waste management.

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