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Growth and reproduction of *Pontoscolex corethrurus* in the mineral soils of different age groups of rubber (*Hevea brasiliensis*) plantations under laboratory conditions

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ABSTRACT

Clitellate specimens of Pontoscolex corethrurus were used to study their growth and reproduction in the soils of different age groups of rubber plantations. Pontoscolex corethrurus was selected for the present study because of the following factors: (i) It had high biomass and density values in rubber plantations. (ii) Recognized to be widely tolerant to environmental factors. (iii) Possesses continuous breeding strategy with high fecundity and high hatching success of cocoons. Peak of biomass of Pontoscolex corethrurus appeared on the 30th day both in unutilized land soil (790mg) and 14yr old Hevea soil (680mg), while the biomass peaks in 20yr old (680mg) and 25yr old (730mg) Hevea soils appeared 15 days later i.e. on the 45th day. Rate of growth of the earthworms was significantly higher ($p < 0.05$) in the unutilized land soil (13mg worm^{-1}day^{-1}), compared to that in 14yr old(9mg worm^{-1}day^{-1}), 20yr old (6mg worm^{-1}day^{-1}) and 25yr old (7mg worm^{-1} day^{-1}) Hevea soils. The general growth rate of the studied worm in different substrate followed the order: Unutilized land soil > 14yr old Hevea soil > 25yr old Hevea soil > 20yr old Hevea soil. Total number of cocoon produced by Pontoscolex corethrurus within 60 days in the soils of different age groups of Hevea plantations and unutilized land differed. It was highest in the 14yr old Hevea plantation (44 cocoons) and lowest in the unutilized land soil (24 cocoons) at the end of experiment. Among the different substrates, highest and lowest rate of reproduction of Pontoscolex corethrurus were recorded in the 20yr old Hevea soil (0.51 cocoon worm^{-1}week^{-1}) and unutilized land soil (0.28cocoonworm^{-1}day^{-1}) respectively. The rate of fecundity in different substrates maintained the following order: 20yr old Hevea soil > 25yr old Hevea soil > 14yr old Hevea soil > Unutilized land soil.
Hatching success (%) of the cocoons in different substrates was as follows:
25yr old Hevea soil > 14yr old Hevea soil > 20yr old Hevea soil > Unutilized land soil
Steady increase in growth and production of cocoons in Pontoscolex corethrurus in mineral soils without any food additives indicates that this worm is exclusively geophagous or endogeic type of earthworm.

Key words: Rubber plantation, mineral soil, *Pontoscolex corethrurus*, growth, reproduction

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INTRODUCTION

In tropical and sub-tropical areas, tree plantations are becoming an increasingly common land use system. Plantations are being established for different reasons including shift in timber production from native forests to plantations, restoration of degraded lands, catalysts of forest succession and also as buffer zones for biodiversity conservations [1]. Raise in forest plantation is the most widely adopted method to recover fragile ecology of forest. Thus, in Tripura, rubber plantation was introduced in 1963 by the Forest Department to check soil degradation due to slash and burn agriculture practiced by the local tribal people and also as a part of their rehabilitation programme.

Rubber tree (*Hevea brasiliensis*, Family: Euphorbiaceae), a source of natural rubber, is a native of Amazon rain forest. Being a deciduous plant with very fast growth rate, it shows maximum litter fall during February – March with annual litter addition to plantation floor amounting to 7 tons ha^{-1} [2]. The litter is not generally removed but persists on plantation floor through a large part of the year and shows very slow rate of decomposition due to high lignin and polyphenol contents.

Earthworms belonging to the class Oligochaeta under the phylum Annelida, are found in the soils of forest, grassland, pasture, agricultural lands and also in the organic wastes. Since earthworms represent a major fraction (> 80%) of the soil invertebrate biomass [3], they are involved in the process of soil formation and maintenance of soil fertility, ecosystem function and production. Due to their peculiar mode of feeding, burrowing and casting activities, they make the soil fertile and support the above ground vegetation. With their soft and unprotected bodies which remain in full contact of the soil, they are considered as ideal bio-indicator of soil.

Despite various contributions made by a good number of earthworm scientists in vermitechnology [4, 5, 6, 7], earthworm taxonomy [8], distribution, diversity, ecology and role of earthworms in various habitats viz. deciduous forests, tropical rain forests, plain grasslands etc [9, 10], growth and reproduction in litter feeding earthworms [11, 12, 13, 14, 15], scientific literature is almost lacking on distribution, diversity, ecology and population dynamics of tropical earthworms in different age groups of monoculture and exotic plantations like rubber. Besides these, reports are scanty [16, 17] on biology of geophagous earthworms. Reports which are available on growth and reproduction in geophagous earthworms comprised of effect of food additive on growth and reproduction of earthworm [17]. As the soil dwelling or endogeic earthworms exclusively feed on mineral soil it is interesting to know the growth and reproduction of endogeic species of earthworms in soils (without food additive) under laboratory conditions.

Among the 27 different species of earthworms found in the *Hevea* plantations of Tripura [18, 19, 20], *Pontoscolex corethrurus* was selected for the present study because of the following factors:
(i) It had high biomass and density values in rubber plantations [18].
(ii) Recognized to be widely tolerant to environmental factors [21].
(iii) Possesses potential for management of tropical soil [22].
(iv) Continuous breeding strategy with high fecundity and high hatching success of cocoon (character like ‘r’ selected species) [23].

MATERIALS AND METHODS

Clitellate specimens of *Pontoscolex corethrurus* (Müller) were used to study their growth and reproduction in the soils of different age groups of *Hevea* plantations and also in soils of an adjacent unutilized land.

The earthworms used were of almost similar biomass (360-390 mg fresh weight) and ages and were collected during July 2009 from mature rubber plantations of Taranagar area of Mohanpur Block, Tripura by conventional digging and hand sorting method. The earthworms were acclimatized under laboratory conditions for two weeks.

In spite of its abundance under rubber plantations, preliminary experiments showed that *Pontoscolex corethrurus* was unable to grow and reproduce well when raised in soil- rubber leaf litter mixtures under laboratory conditions. So, in the present experiment, mineral soils of rubber plantations were used as substrates to study their impact on growth and reproduction of the worm. Also, while carrying out field study, density of *P. corethrurus* was found to be much higher in 14yr old, 20yr old and 25yr old *Hevea* plantations compared to the other age groups of rubber plantations that were studied. Hence, soil from the 14yr old, 20yr old and 25yr old rubber plantations were used as food substrate in the present experiment. Top-soils (0-5 cm depth) containing almost decomposed residues of *Hevea* leaves and rootlets from *Hevea* plantations of different ages (14yr old, 20yr old and 25yr old) and also from an adjoining unutilized land were brought to the laboratory and air-dried for seven days. When completely dry, the soil was hand grinded and sieved through a metal sieve of 2mm pore size. The soil was steam-sterilized to remove any micro organisms present. Soil (dry weight 1500gm) was then introduced in plastic boxes (17cm x 12.5cm x 8.5cm) with lids. Perforations (70 in number) were made in the sides and lid of each box for better aeration. Water was added to each box to bring the moisture level up to 30%. Lowe and Butt [24] suggested maintenance of 25% - 30% moisture for soil dwelling earthworms like *Pontoscolex corethrurus*. The boxes were kept undisturbed for ten days after which two healthy clitellate worms were added to each of the twenty boxes [five replicates for each age group of *Hevea* plantation (experimental) and unutilized land (control)].

The boxes were kept in BOD (Remi, India) at a temperature of 26±2˚C (average temperature of *Hevea* plantation floor) for two months (24.8.2009 to 23.10.2009). Moisture level was maintained at 30% by hand spraying on every alternate day. As no food additive like (rubber leaf litter, cow dung etc) was mixed with the mineral soil during the study, the experiment was terminated on the 60th day, after a decrease in the body weight of the worms was noticed in all the treatments.

The live weight of the worms (with full gut content) and their cocoon production were measured biweekly by hand sorting of the culture media. To determine the hatching success, cocoons were incubated in Petri dishes containing either one of the substrates viz. unutilized land soil, 14yr old *Hevea* soil, 20yr old *Hevea* soil and 25yr old *Hevea* soil. The rate of biomass production (mg $worm^{-1}day^{-1}$) and reproduction (cocoon $worm^{-1}week^{-1}$) were calculated using the following formulae:

$$1.\ \text{Rate of growth} = \frac{\text{Maximum worm weight - Initial worm weight}}{\text{No. of days to attain maximum weight}}$$

$$2.\ \text{Rate of reproduction} = \frac{\text{No. of juveniles}}{\text{No. of adults at '0' day x Total no. of days to attain juvenile population}} \times 7$$

Physico-chemical analysis of the diet

The pH, organic carbon, potassium, calcium, phosphate and nitrogen content of the soils of different age groups of *Hevea* plantations and the adjoining unutilized land which was used as food substrate in this experiment was done following standard methods. The soil texture was also determined by using soil hydrometer.

Statistical analysis

One way ANOVA was done to determine significant differences between biomass increase (rate of growth) and number of cocoons produced by each adult (reproductive rate) per week in the four different treatments. Student's t test was performed to determine the maximum number of days allowing significant increase in biomass in the same substrate (compared to the initial day).

RESULTS

The chemical characteristics of the soils of different age groups of rubber plantations (14yr, 20yr and 25yr) and an adjoining unutilized land that were used as substrates for *Pontoscolex corethrurus* are given in Table 5.1. Growth and reproduction of *P. corethrurus* in Hevea soils of different age groups of plantations and adjoining unutilized land are given in Table 5.2 and Table 5.3 respectively.

I. Growth

Biomass of *P. corethrurus* in all the experimental pots increased significantly ($p<0.05$) within the first 15days (Figure 5.1 and Table 5.2). Peak of biomass of *P. corethrurus* appeared on the 30th day both in unutilized land soil (790 mg) and 14yr old *Hevea* soil (680 mg), while the biomass peaks in 20yr old (680 mg) and 25yr old (730 mg) *Hevea* soil appeared 15 days later i.e on the 45th day. Although the highest biomass (680 mg) achieved was same in both 14yr old and 20yr old *Hevea* soils, the number of days to attain maximum body weight was 15 days less in case of 14yr old *Hevea* soil. Moreover while there was no significant difference ($p>0.05$) in the highest biomass values achieved by *P. corethrurus* in the 25yr old *Hevea* soil (730 mg) and in unutilized land soil (790 mg), highest biomass values of each of these studied soils was significantly higher than those of 14yr old and 20yr old *Hevea* soils (Table 5.2).

Rate of growth was significantly higher ($p<0.05$) in the unutilized land soil (13 mg $worm^{-1}day^{-1}$), compared to that in 14 yr old (9 mg $worm^{-1}day^{-1}$), 20yr old (6 mg $worm^{-1}day^{-1}$) and 25yr old (7 mg $worm^{-1}day^{-1}$) *Hevea* soils (Table 5.2).

Biomass of *P. corethrurus* declined in the unutilized land soil and 14yr old *Hevea* soil from the 45th day, while in the 20yr old and 25yr old *Hevea* soils biomass declined after the 60th day of experimentation. Although, there was no significant difference ($p>0.05$) in the rate of growth of *P. corethrurus* in 14yr old, 20yr old and 25yr old *Hevea* soils, the general growth rate of *P. corethrurus* on different substrates followed the order:

Unutilized land soil > 14yr old *Hevea* soil > 25yr old *Hevea* soil > 20yr old *Hevea* soil.

II. Reproduction

Reproduction of *P. corethrurus* in the soils of *Hevea* plantation of different age groups and unutilized land are given in Figure 5.2 and Table 5.3. In unutilized land soil, biomass peak (30th day) was followed by peak of reproduction

(45th day), but in 14yr old and 20yr old *Hevea* soils reproduction peak (15th day) appeared much earlier than the biomass peak (30th day and 45th day).

Total number of cocoons produced by *P. corethrurus* within 60 days in the soils of different age groups of *Hevea* plantations and unutilized land differed. It was highest in the 14yr old *Hevea* soil (44 cocoons) and lowest in the unutilized land soil (24 cocoons) at the end of the experiment (Table 5.4). There was a significant correlation ($p < 0.05$) between body weight of *P. corethrurus* and number of cocoons produced per worm per week {Figure 5.3(a) and Figure 5.3(b)}.

Cocoons of *P. corethrurus* appeared on first 15 days in all the experimental and control pots. Peak of cocoon production was noticed in both unutilized land soil and 25yr old *Hevea* soil on the 45th day of the experimental period, while that appeared 30 days earlier i.e on the 15th day in the 14yr old and 20yr old *Hevea* soils respectively (Figure 5.2 and Table 5.3). Cocoon production drastically declined on the 60th day in unutilized land soil, 14yr old *Hevea* soil and 25yr old *Hevea* soil. No cocoons appeared in the 20yr old *Hevea* soil on the 60th day (i.e. day of termination of the experiment).

Table 5.1 Physico-chemical characteristics of the four different experimental diets

SOIL PARAMETERS	*Hevea* PLANTATION SOILS			UNUTILISED L AND SOIL
	14yr	20yr	25yr	
Soil texture	Sandy sand 88% silt6% clay 6%	Sandy sand 90% silt 6% clay 4%	Loamy sand sand 83% silt 7% clay 10%	Sandy sand 88% silt 7% clay 6%)
pH	4.74±0.05	4.78±0.10	4.59±0.18	4.89±0.05
Organic carbon (%)	1.05±0.08	1.19±0.20	1.01±0.10	0.74±0.18
Potassium (mg/100g)	0.78±0.18	0.55±0.41	1.47±0.58	1.54±0.25
Calcium (mg/100g)	368.96±9.94	354.42±25.86	161.17±60.42	163.25±36.86
Phosphate (mg/100g)	0.812±0.13	0.89±0.17	4.39±2.22	5.62±3.06
Total Nitrogen (%)	0.009±0.007	0.008±0.002	0.013±0.006	0.017±0.005

Table 5.2 Changes in biomass and rate of growth of *Pontoscolex corethrurus* in the different experimental diets

Substrate	Biomass (mg fresh weight)					Rate of growth (mg worm^{-1}day^{-1})
	0 days	15 days	30 days	45 days	60 days	
S_0	380.0 ± 1.0	680.0 ± 3.0	790.0* ±4.0	740.0 ± 3.0	600.0 ± 4.0	13.0^b ± 1.0
S_1	370.0 ±1.0	600.0 ± 1.0	680.0* ±1.0	670.0 ± 2.0	640 ± 4.0	9.0^a ± 1.0
S_2	370.0 ±1.0	500.0 ± 1.0	550.0 ±1.0	680.0* ± 3.0	630.0 ± 1.0	6.0^a ± 2.0
S_3	390.0 ±1.0	620.0 ± 5.0	660.0 ±4.0	730.0* ± 3.0	610.0 ± 2.0	7.0^a ± 1.0

** peak*

S_0 - unutilized land soil, S_1 - 14yr old Hevea soil, S_2 - 20yr old Hevea soil, S_3 - 25yr old Hevea soil; Values are mean ±SE; Values with same letters correspond to no significant difference ($p > 0.05$)

Table 5.3 Reproduction of *Pontoscolex corethrurus* in different experimental diets

Substrate	0 days		15 days		30 days		45 days		60 days		Rate of reproduction (cocoon worm^{-1} week^{-1})
	A	C	A	C	A	C	A	C	A	C	
S_0	2	0	2	1.2 ± 0.37	2	1.2 ± 0.37	2	1.6* ± 0.25	2	0.80±0.37	0.28^b ± 0.03
S_1	2	0	2	3.6* ± 0.51	2	1.6 ± 0.24	2	1.4 ± 0.40	2	0.20±0.20	0.40^a ± 0.04
S_2	2	0	2	4.8* ± 0.49	2	2.8 ± 0.37	2	1.4 ± 0.49	2	0	0.51^a ± 0.03
S_3	2	0	2	1.6 ± 0.51	2	1.8 ± 0.37	2	2.4* ± 0.51	2	1.40±0.40	0.42^a ± 0.06

** peak*

S_0 - unutilized land soil, S_1 - 14yr old Hevea soil, S_2 - 20yr old Hevea soil, S_3 - 25yr old Hevea soil; Values are mean ±SE; Values with same letters correspond to no significant difference ($p > 0.05$)

Among the different substrates, highest and lowest rate of reproduction of *P. corethrurus* were recorded in the 20yr old *Hevea* soil (0.51 cocoons worm^{-1}week^{-1}) and unutilized land soil (0.28 cocoons worm^{-1}week^{-1}) respectively (Table 5.3 and Table 5.4). Although there was no significant difference ($p > 0.05$) in the rate of reproduction of the studied worm among the soils of different age groups of *Hevea* plantations, *P. corethrurus* in each age group of *Hevea* plantation showed significantly higher ($p<0.05$) rate of reproduction in comparison to the unutilized land soil (Table 5.3). The rate of fecundity of *P. corethrurus* in different substrates maintained the following order:

20yr old *Hevea* soil > 25yr old *Hevea* soil > 14yr old *Hevea* soil > unutilized land soil.

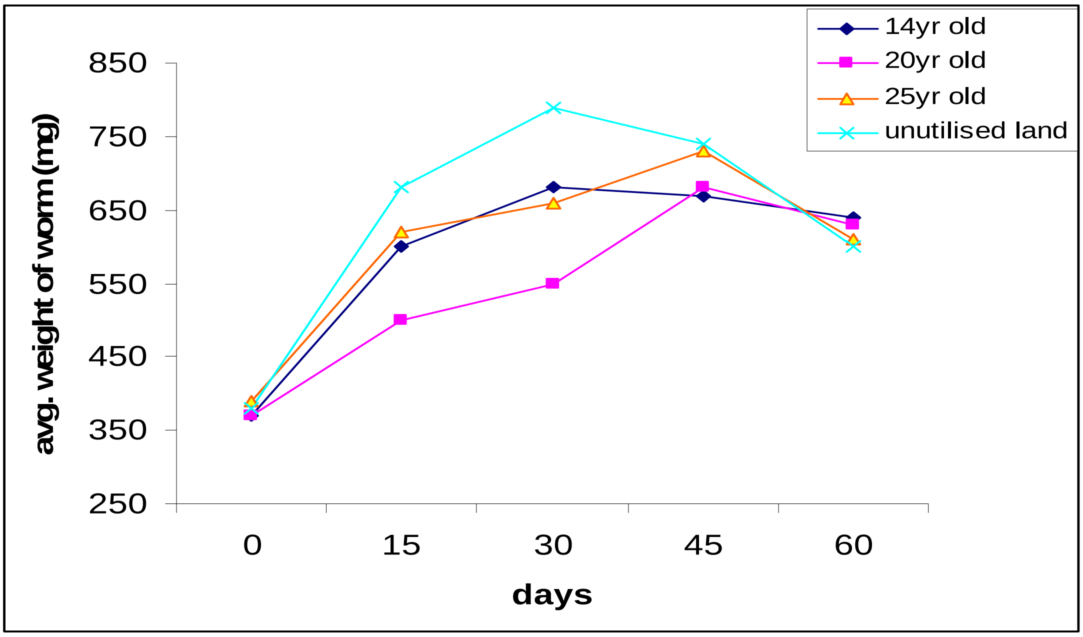

Fig 5.1 Growth of *Pontoscolex corethrurus* in *Hevea* plantation soils of different age groups and in unutilized land soil.

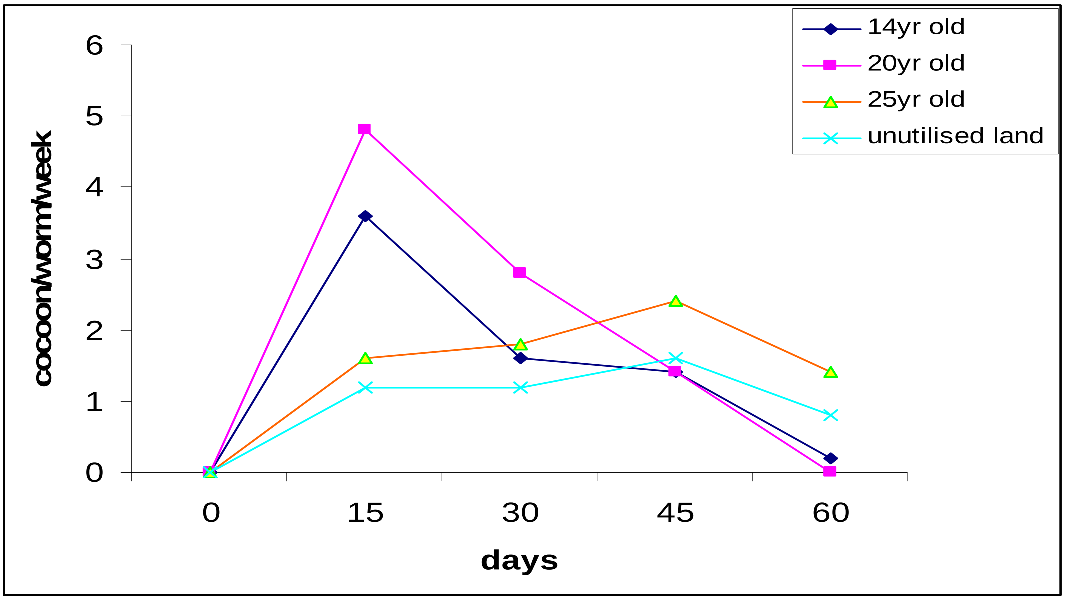

Fig 5.2 Reproduction of *Pontoscolex corethrurus* in *Hevea* plantation soils of different age groups and in unutilized land soil.

Hatching success (%), i.e. juveniles emerged per 100 cocoons, of *P. corethrurus* was similar (64%) in case of both 14yr old and 25yr old *Hevea* soils (Table 5.4). Hatching success of the studied cocoons in different substrates was as follows:

25yr old *Hevea* soil ≥ 14yr old *Hevea* soil > 20yr old *Hevea* soil > unutilized land soil.

Total number of juveniles obtained from five pots at the end of the experiment was highest in 14yr old *Hevea* soil (28 juveniles) and lowest in unutilized land soil (11 juveniles) (Table 5.4).

Table 5.4 Effect of soil from *Hevea* plantations of different age groups and adjascent unutilized land on growth and reproduction of *Pontoscolex corethrurus*

Parameters studied	14yr old *Hevea* soil	20yr old *Hevea* soil	25yr old *Hevea* soil	Unutilized land soil
Initial body weight (mg)	370.0 ± 1.0	370.0 ± 1.0	390.0 ± 1.0	380.0 ± 1.0
Highest individual body weight (mg)	$680.0^b \pm 2.0$	$680.0^b \pm 3.0$	$730.0^a \pm 3.0$	$790.0^a \pm 4.0$
Number of days to attain highest body weight	30	45	45	30
Growth rate (mg $worm^{-1} day^{-1}$)	$9.0^a \pm 1.0$	$6.0^a \pm 2.0$	$7.0^a \pm 1.0$	$13.0^b \pm 1.0$
Rate of reproduction (cocoons $worm^{-1} week^{-1}$)	$0.40^a \pm 0.04$	$0.51^a \pm 0.03$	$0.42^a \pm 0.06$	$0.28^b \pm 0.03$
Total number of cocoons obtained from 5 pairs of worms in 60 days	44	34	36	24
Total number of juveniles obtained in 60 days	28	18	23	11
Hatching success	63.64	52.94	63.89	42.31

Same letter (a,a) correspond to no significant difference (p > 0.05)

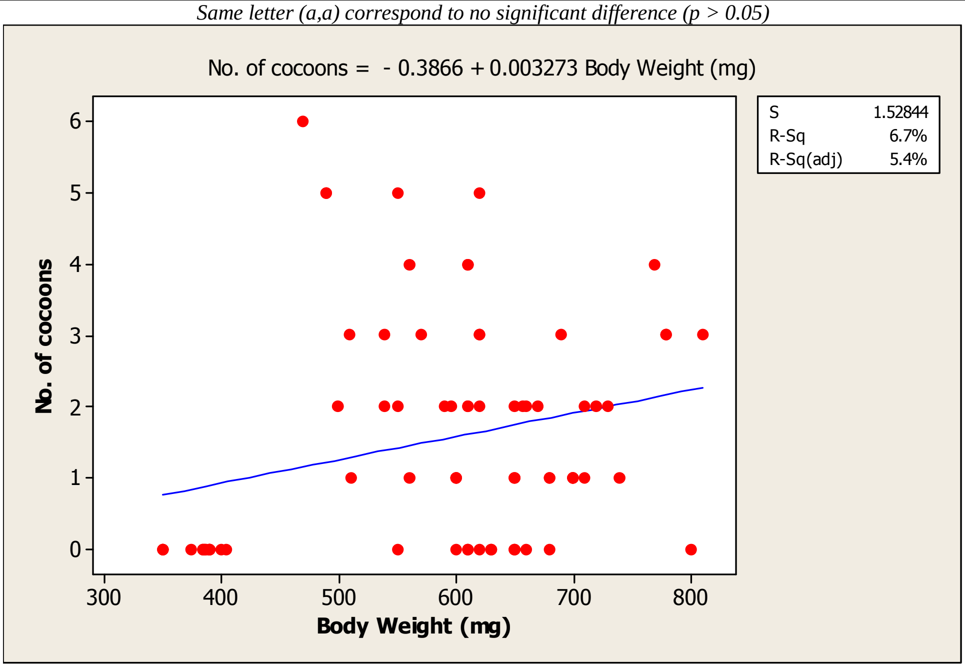

Fig 5.3 (a): Relationship (p=0.02) between mean body weight (mg) of *Pontoscolex corethrurus* and number of cocoons found in pots with soil from different age groups of *Hevea* plantation.

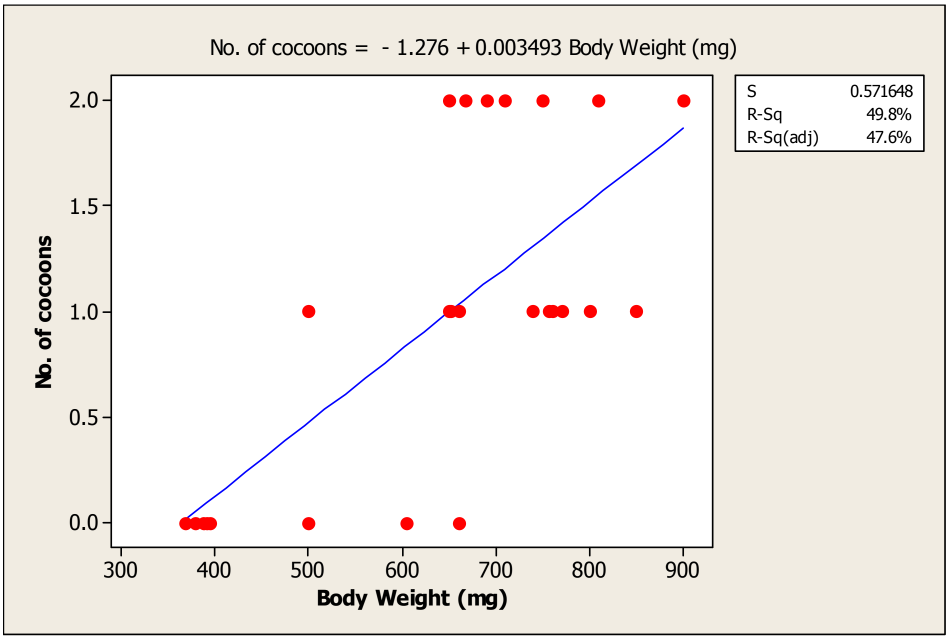

Fig 5.3 (b): Relationship (p=0.00) between mean body weight (mg) of *Pontoscolex corethrurus* and number of cocoons found in pots with soil from unutilized land.

DISCUSSION

Steady increase in growth of *P. corethrurus* up to 45 days in 20yr old and 25yr old *Hevea* soils and up to 30 days in 14yr old *Hevea* soil and unutilized land soil indicate that mineral soils without having any food additives supported the growth of *P. corethrurus*. This indicates that *P. corethrurus* is exclusively geophagous or endogeic type of earthworm. High assimilation capacity due to it's micro flora – associated mutualistic digestive system [25] is probably responsible for steady growth of *P. corethrurus* in mineral soils. Most of the workers have done growth experiments on soil dwelling earthworms using organic additives [16, 17, 22, 24, 26, 27]. Highest biomass value (790 mg) and highest growth rate (13 mg $worm^{-1}day^{-1}$) of *P. corethrurus* in the unutilized land soil than those of rubber plantation soils of different age groups indicate that qualitatively and nutritionally soils of unutilized land are much superior to *Hevea* soils because of comparatively higher content of total nitrogen. It is probable that phenolic compounds (which decrease palatability) present in the rubber leaf litter [20] had their residual effects on plantation soils still after decomposition. According to Lee [28] palatability is correlated positively with nitrogen and negatively with polyphenolic contents. No significant difference in the growth rate of *P. corethrurus* among *Hevea* soils of different age groups indicate that nutritional quality of these substrates are not of much difference.

Earlier appearance of biomass peak (i.e on the 30^{th} day) in 14yr old *Hevea* soil compared to 20yr old and 25yr old *Hevea* soils (both on 45^{th} day) was probably related to palatability linked with litter chemistry. Interestingly, high biomass values of earthworms linked to low contents of polyphenol, flavonoids and lignin and high contents of sugar in 14yr old *Hevea* leaf litter compared to those of 20yr old and 25yr old *Hevea* leaf litter has recently been reported by Chaudhuri *et al.* [20].

Lower growth rate (7 mg $worm^{-1}day^{-1}$) with higher biomass value (730 mg) of *P. corethrurus* in 25yr old *Hevea* soil compared to those of 14yr old *Hevea* soil (growth rate 9mg $worm^{-1}day^{-1}$ and biomass 680 mg) was due to the fact that total number of days to achieve maximum biomass peak in 14yr old *Hevea* soil was 15 days less than that of 25yr old *Hevea* soil. The growth rate of *P. corethrurus* in the present study (6.0 to 13.0 mg $worm^{-1}day^{-1}$) was higher than that of *P. corethrurus* fed on tropical artificial soil plus manure (0.5 – 0.8 mg $worm^{-1}day^{-1}$) [29], *Perionyx ceylalensis* fed on cow dung (1.79 mg $worm^{-1}day^{-1}$) [15], *Metaphire posthuma* (5.4 mg $worm^{-1}day^{-1}$) [30], *Drawida nepalensis* fed on pine litter (6.0mg $worm^{-1}$ day^{-1}) [26], for *Metaphire houlleti* fed on different substrates (2.2 – 4.1 mg $worm^{-1}day^{-1}$) [31], for *Perionyx excavatus* fed on rubber leaf litter (5.04 mg $worm^{-1}day^{-1}$) [12], for *Perionyx excavatus* fed on cow dung mixed with bamboo leaf litter (4.02 mg $worm^{-1}day^{-1}$) and cow dung mixed with paddy straw (4.75 mg $worm^{-1}day^{-1}$) [11], for *Drawida assamensis* (3.55 mg $worm^{-1}day^{-1}$) and *Drawida papillifer papillifer* (4.44 mg $worm^{-1}$ day^{-1}) fed on soil with rubber leaf litter mixed with cow dung [17] but comparable to *Lumbricus rubellus* fed on cow manure (8.0 mg $worm^{-1}day^{-1}$) [32], *Perionyx sansibaricus* (8 mg $worm^{-1}day^{-1}$) and *Perionyx excavatus* (6.5 mg $worm^{-1}day^{-1}$) fed on cow manure [33], *Eutyphoeus comillahnus* (8.51 mg $worm^{-1}day^{-1}$), *P. corethrurus* (8.37 mg $worm^{-1}day^{-1}$) and *M. houlleti* (12.42 mg $worm^{-1}day^{-1}$) raised in soil with food additives [17]. Very high growth rate viz.13.6 mg $worm^{-1}day^{-1}$ [22] and 21.14 mg $worm^{-1}day^{-1}$ [34] of *P. corethrurus* raised in mineral soils mixed with saw dust as food additive has been reported. In fact, difference in growth rate of earthworms as reported by different authors depends upon the species studied, it's age and nutritional quality of the food substrates.

The cocoon production rate is influenced by the amount and quality of food supply. While unutilized land soil was a much better medium for growth of *P. corethrurus* than the *Hevea* soils of different age groups of plantations, in the former, rate of reproduction was significantly lower than that in each age group of *Hevea* soil. This indicates that a better growth supporting medium may not be a better medium for reproduction. Chaudhuri and Bhattacharjee [11] also reported a very low rate of reproduction in spite of a high biomass production for the composting worm *Perionyx excavatus* cultured in kitchen waste mixture. Unlike in *Hevea* soils of different age groups, appearance of biomass peak (30^{th} day) much earlier than the peak of reproduction in unutilized land soil is indicative of the fact that here earthworm begins their reproduction after attainment of a certain biomass. Comparatively early peak (on the 15^{th} day) of cocoon production in *P. corethrurus* with low initial ('0' day) body weight in the 14yr old and 20yr old *Hevea* soils might be interpreted as evidence for differential partitioning of resource between body tissue growth and production of reproductive tissue [28]. Sharp decline of both growth and reproduction of *P. corethrurus* after 45 days was due to exhaustion of resource in the different substrates. Significantly higher ($p < 0.05$) rate of reproduction of *P corethrurus* in *Hevea* plantation soils of different age groups than that in the unutilized land soil is probably due to much higher level of organic carbon in those substrates. Similarly no significant difference in the rate of reproduction of *P. corethrurus* among the soils of different age groups of rubber plantations was due to similar level of organic carbon in those substrates because individual fecundity depends upon the input of organic matter to the soil. In fact differential rate of growth and reproduction of the studied worm in different substrates depend not only on the energy content of the available food but also on biomass and age structure of the individuals [28].

Considering that *P. corethrurus* is a continuous breeder with 91% hatching success and 1 hatchling / cocoon [23], a reproductive rate ranging from 20 – 26 cocoons adult^{-1} year^{-1} (converting the values of 0.40 – 0.51 cocoon worm^{-1} week^{-1}) falls within the range of 13.0 – 99.0 cocoons adult^{-1} year^{-1} [22, 25]. A fecundity rate of 118 cocoons adult^{-1} year^{-1} for *P. corethrurus* cultured in pasture soil was reported by Chaudhuri and Bhattacharjee [11]. Such dramatic fluctuations in the rate of cocoon production in *P. corethrurus* may be liked with occurrence of their polymorphic varieties [35] with difference in genetic make-up. Fecundity of *P. corethrurus* in the present study is higher than the other Glossoscolecid earthworm, *Glossodrilus* sp. under field conditions (9.9 cocoons adult^{-1} year^{-1}) of Colombia [36], endogeic earthworm, *Aporrectodea caliginosa* fed on soil with meadow fescue leaves (12 cocoons adult^{-1} year^{-1}) [37], *Metaphire posthuma* fed on field soil and cow manure (0.16 cocoons worm^{-1} week^{-1}) [30], *Polypheretima elongata* fed on soil (23 cocoons adult^{-1} year^{-1}), *Eutyphoeus gammiei* (1 cocoons adult^{-1} year^{-1}) [11], *Drawida papillifer papillifer* (11.5 cocoons adult^{-1} year^{-1}), *Drawida assamensis* (10.8 cocoons adult^{-1} year^{-1}), *Metaphire houlleti* (16.8 cocoons adult^{-1} year^{-1}) and *Eutyphoeus comillahnus* (2.2 cocoons adult^{-1} year^{-1}) [23] but lower than *Drawida nepalensis* (29 cocoons adult^{-1} year^{-1}) [11], *P. corethrurus* (98 cocoons adult^{-1} year^{-1}), *Dichogaster affinis* (46.5 cocoons adult^{-1} year^{-1}) and *Octochaetona beatrix* (40 cocoons adult^{-1} year^{-1}) fed on soil and cow dung [23]. In the present study, the hatching success varied in the soils of different age groups of soils and unutilized land soil. Bisht *et al.* [30] also reported variations in hatching success according to different media used. Cocoons of *Metaphire houlleti* had hatching success 100% in cow manure, 90% in moist soil, 70% in distilled water and 60% in wet cotton. Hatching success (53% - 64%) in the rubber plantation soils is much lower than the 85% hatching success [11] and 91% hatching success [23]. Low rate of hatching success of *Pontoscolex* cocoons in the present study may be linked with the quality of the substrate used.

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