10. COMPARATIVE STUDY ON THE BIOLOGY OF *EUDRILUS EUGENIAE* (KINBERG) AND *EISENIA FETIDA* (SAVIGNY) UNDER LABORATORY CONDITIONS

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Introduction

Many species on our planet, such as bacteria, fungi, protozoa, nematodes, live in soil. The diversity of these animals is necessary to sustain key functions of the agro-ecosystem. Earthworms have been long recognized to have the capability of converting poor soil into rich soil. The accumulation of solid wastes is an uphill task, the management of which can be done by enhancing the scope of vermitechnology. Earthworms can be cultured and later put to various uses, i.e., to improve soil fertility, to convert organic waste into manure, to produce protein-rich food for livestock, drug and vitamin source as natural detoxicant, and a bait for fish (Ghosh 2004).

For these purposes, the most commonly cultured species of earthworm worldwide is *Eisenia fetida*, also known as the Tiger or Brandling worm (Haimi 1990). Other suitable species include *Lumbricus rubelles*, *Eudrilus eugeniae* and *Perionyx excavatus* (Edwards 1995). *Eudrilus eugeniae* is used extensively for bio-composting in the tropics, especially Africa and Asia, and is capable of bioconversion of large quantities of organic waste (Sinha *et al.* 2002).

Before recommending the use of any species on a commercial level, it is imperative that the reproductive biology and the growth of the species be worked out. The present study was designed to compare the life cycle of *Eudrilus eugeniae* with the reference species *Eisenia fetida*, under laboratory conditions using farm yard manure as a substrate.

To study the reproduction and growth of *Eisenia fetida* and *Eudrilus eugeniae*, five non-clitellated hatchlings of both species, weighing 500-550 mg were observed. Each was introduced separately in rectangular plastic containers (18.5 x 13.5 cm) containing 200 gm of farm yard manure (FYM). These were placed in triplicate at room temperature and continually monitored for mortality, sexual maturity and cocoon production. The moisture content of substrate was maintained at about 80%. Duration of life cycle, incubation time (in days) for cocoons to hatch and the number of hatchlings from one cocoon were the reproductive parameters recorded (Table 1). The mean values were calculated from the triplicate sets. The substrate in the container was turned out, earthworms were separated by hand, after which they were examined for clitellum development. They were weighed after drying on tissue paper. All earthworms and substrate were then returned to the respective containers. No additional feed was added at any stage during the study period. Cocoon production was recorded weekly. After the earthworms laid cocoons, the cocoons were separated from each dish by hand. Freshly laid cocoons were kept separately in Petri dishes (8.6 x 8.6 cm) with substrate and observed every three days to record hatching. The cocoons were kept in the same substrate in which their parents had grown as followed by Dominguez *et al.* (2001). These cocoons were further used for studying different life stages of *E. fetida* and *E. eugeniae*. Mean number of hatchlings were recorded in each plate.

Results

Growth rate – The mean weight of five earthworms of *Eudrilus eugeniae* was 7.489 ±0.07 gm, which was significantly ($P<0.05$) higher than mean weight of 3.926 ±0.04 gm attained by *Eisenia fetida*. The maximum weight (worm^{-1}) gain of *E. eugeniae* was 141 mg per week as against 56 mg per week for *E. fetida* (Fig. 1). The growth rate has been a good comparative index to compare the growth of different earthworm species as indicated by Edwards *et al.* (1998). Maximum weight gain of about 60 mg per week in case of *E. fetida*, comparable to the present observations, has

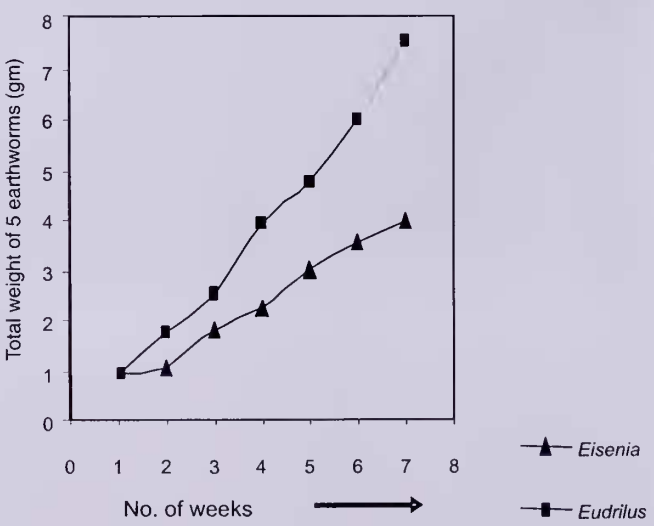

Fig. 1: Growth of *Eisenia* and *Eudrilus*

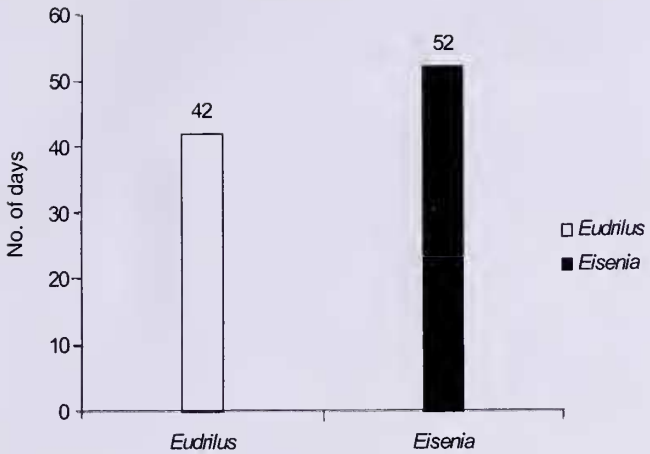

Fig. 2: Age (in days) at which worms of in FYM both species develop the clitellum. Each batch consists of five worms

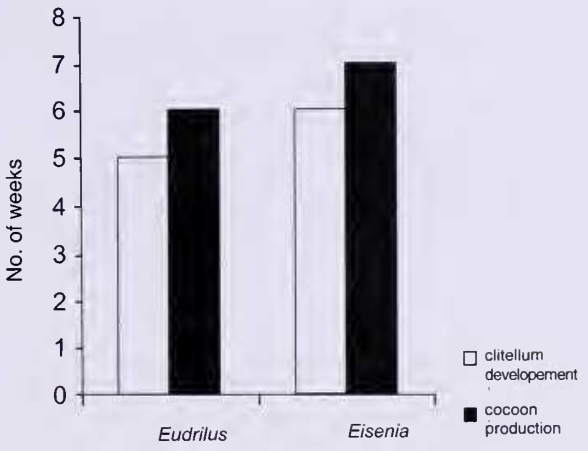

Fig. 3: Time duration of start of clitellum development and cocoon production in two species of earthworms

been reported by earlier workers (Graff 1974; Watanabe and Tsukamoto 1976). Dominguez *et al.* (2001), however, have reported a maximum weight gain per week of 280 mg, which is in contrast to the present observations. The record of increase of weight per worm per week by Reinecke *et al.* (1992) was 150 mg and comparable to our results. Chaudhari *et al.* (2004) have recorded similar comparable growth rates of 202 mg per week in *E. eugeniae* and 44 mg per week in *E. fetida* using rubber leaf litter as substrate. The results of this study corroborate the earlier findings that there is a general rule establishing a direct relationship between the growth and quality of feed material, i.e., substrate (Butt 1993; Elvira *et al.* 1997), except for local climatic differences.

Clitellum development and cocoon production – In both the epigeic species studied, clitellum development is an indication of attaining sexual maturity (Fig. 2). Clitellum developed in *E. eugeniae* in 36 days with all worms being fully clitellate by 42 days. In *E. fetida*, the first fully clitellate individual was observed after 44 days, with all the worms being fully clitellate by 52 days after hatching. Reinecke *et al.* (1992) and Dominguez *et al.* (2001) reported a duration of 35 days for attaining sexual maturity in case of *E. eugeniae* while Harteinstein *et al.* (1979) reported 42-56 days as the duration for producing cocoons in *E. fetida*. Cocoon production started after a week in both species after attaining sexual maturity. The cocoon production per worm per day for *E. fetida* was 0.47 ±0.07, and for *E. eugeniae* was 0.62 ±0.06 (Fig. 3). Cocoon production was thus higher in *E. eugeniae*. Mean cocoon production per worm per day of *E. eugeniae* was higher than 0.46 as reported by Reinecke *et al.* (1992), but lower than 1.26 as reported by Vilijoen and Reinecke (1989). Knieriemen (1985) and Dominguez *et al.* (2001) reported mean cocoon production per worm per day of 0.50 and 0.55 respectively for *E. eugeniae*. The mean cocoon production per worm per day for both species during the present investigation is shown in Fig. 4.

Incubation period and number of hatchlings from one cocoon – The mean incubation period for *E. eugeniae* was 17 ±0.82 days and 21 ±2.5 days for *E. fetida*. Reinecke *et al.* (1992) recorded incubation period of 15 days for *E. eugeniae* and 19 days for *E. fetida*. Dominguez *et al.* (2001) reported incubation period of 14 days in *E. eugeniae*. The present study reveals that, the hatchlings of *E. eugeniae* from a single cocoon ranged between one and three. Only few cocoons produced four hatchlings (Fig. 4). Vilijoen and Reinecke (1989) reported that cocoons of *E. eugeniae* can produce up to five hatchlings. The maximum number of hatchlings observed in the present study from a cocoon was

Table 1: Reproductive parameters of *Eisenia fetida* and *Eudrilus eugeniae*

S.No.	Reproductive parameters	*Eisenia fetida*	*Eudrilus eugeniae*
1.	Duration of life cycle (days)	70 ±1.24[b]	58 ±0.82[a]
2.	Cocoon production (worm^{-1}day^{-1})	0.47 ±0.07[b]	0.62 ±0.06[a]
3.	Incubation period (days)	21 ±2.5[b]	17 ±0.82[a]
4.	No. of hatchlings from one cocoon	1-5	1-3
5.	Mean number of hatchlings	3.3 ±0.94[a]	2.66 ±0.44[a]

a,b: Significant difference-t-test ($p<0.05$)
Values are mean ±SD (Triplicate set)

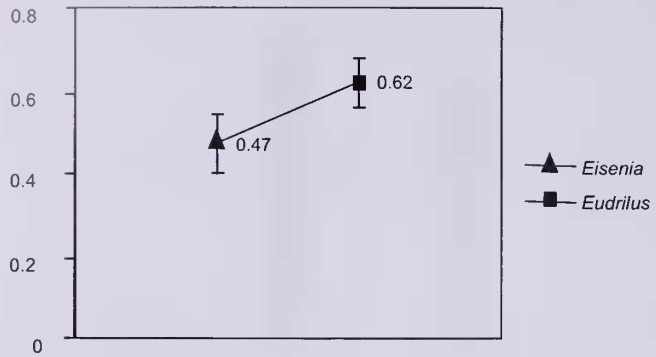

Fig.4: Mean cocoon production per worm per day in two species

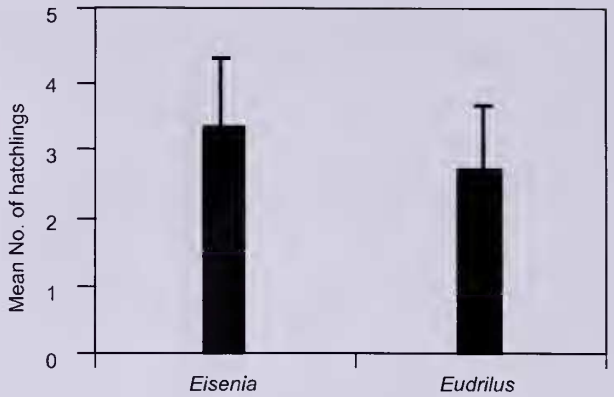

Fig. 5: Mean Number of hatchlings per cocoon in both species

up to five in *E. fetida*, which is higher than in *E. eugeniae* (Fig. 5). Evans and Guild (1948) observed 1-4 hatchlings from one cocoon in *E. fetida* while Dhiman and Battish (2005) observed emergence of two hatchlings from cocoon of *E. fetida*.

Life cycle – Life cycle duration was 58 days for *E. eugeniae* while it was 70 days for *E. fetida*, as the incubation period for *E. eugeniae* was shorter. Reinecke *et al.* (1992) observed life cycle duration of 60 and 70 days for *E. eugeniae* and *E. fetida* respectively. The present results follow a trend similar to earlier findings in different laboratories of the world. However, in direct contrast are the observations of Tripathi and Bhardwaj (2004) who have reported up to 120 days for *E. fetida* to complete its life cycle. It is probably due to the ambient climatic conditions (hot and dry in Rajasthan) where the experiment was conducted.

Conclusion

Both *Eisenia fetida* and *Eudrilus eugeniae* can survive in organic matter in the absence of soil and can be used for the conversion of organic wastes into compost. *E. eugeniae* has a shorter life cycle (58 days), higher cocoon production (0.62), shorter incubation period (17 days) than *E. fetida*. Though, *E. eugeniae* has less mean number of hatchlings from single cocoon it is well-compensated by the growth rate of 141 mg per week. The findings indicate that *E. eugeniae* has a higher reproduction potential than *E. fetida* and in favourable conditions is a faster growing earthworm.

ACKNOWLEDGEMENTS

We thank the Professor and Head, Department of Zoology, Punjab Agricultural University for providing the necessary facilities for conducting research and the Punjab Agricultural University for providing financial assistance in the form of Merit Fellowship to Zinia during the entire course of this study.

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11. *CORTIELLA CAESPITOSA* SHAN & SHEH (APIACEAE) — A NEW ENTRANT TO INDIA

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The genus *Cortiella* Norman was established by Norman (in *J. Bot.* 75: 94. 1937) with the single species *Cortiella hookeri* (C.B. Clarke) Norman based on *Cortia hookeri* C.B. Clarke, distributed in the Sikkim Himalaya, India. The genus *Cortiella* was segregated from *Cortia* DC., mainly based on the characters of rays and the morphology of fruits. Another species, *Cortiella caespitosa* Shan & Sheh (in *Acta Phytotax. Sin.* 18: 376. 1980) has been described from Xizang area of Tibet (China) and considered as endemic to China (Menglan and Watson 2005). Watson added a third species *C. cortioides* (Norman) Watson (in Edinburgh *J. Bot.* 53: 130. 1996) based on *Selinum cortioides* Norman. Presently, all the three species are known to occur in the Eastern Himalayas from Nepal, India (Sikkim), Bhutan to China (Tibet). Mukherjee and Constance (1993) in their revision of the Family Umbelliferae (Apiaceae) of India had maintained two species, *Cortiella hookeri* (C.B. Clarke) Norman and *C. cortioides* (Norman) Watson (as *Selinum cortioides* Norman).

During the floristic studies of Sikkim Himalayas I came across a few gatherings of *Cortiella* in the herbaria of Botanical Survey of India, Sikkim Himalayan Circle, Gangtok, Sikkim (BSHC), and Central National Herbarium (CAL), which had been collected from the Sikkim Himalaya, and identified as *Cortiella hookeri*. The small caespitose habit along with uni- to sub-bipinnate leaves and collar-like expanded pedicel tip clearly revealed that all these specimens are truly *Cortiella caespitosa* Shan & Sheh, but not *C. hookeri* as identified earlier. Further, the identity of the specimens was also confirmed by comparison with the protologue and the other literature as Flora of China (Menglan and Watson 2005). Thus, its presence is a new record for India from the Sikkim Himalaya.

A detailed description along with illustrations and a key to the species of *Cortiella* are presented in order to facilitate its identity.

KEY TO THE SPECIES OF *CORTIELLA* NORMAN

1. Plant smaller, less than 5 cm diam.; leaves 1- (2-) pinnate; pedicels dilated at tip, collar-like ..... *C. caespitosa*
— Plants larger, more than 7 cm diam.; leaves 2- (3-) pinnate; pedicels never dilated at tip 2
2. Ultimate leaf segments longer, more than 4 mm; wings on fruits convoluted ..... *C. cortioides*
— Ultimate leaf segments smaller, less than 4 mm; wings on fruits not convoluted ..... *C. hookeri*

Cortiella caespitosa R.H. Shan & M.L. Sheh, Acta Phytotax. Sin. 18: 376. 1980; Menglan & Watson, Fl. China 14:154.2005 (Fig. 1).

Stemless, caespitose, perennial herb, 3.5-5.0 cm in diam. *Leaves* few, rosulate, oblong in outline, 1.5-2.5 cm long, uni- to sub-bipinnate; leaflets to 5 mm long; ultimate segments obovate-elliptic or linear, *c.* 2x1 mm, simple or 2- (3-) lobed, thick, glabrous; petioles sheathing at base, sparsely puberulous. *Inflorescence* a compound umbel; umbellule several (*c.* 10), crowded, unequal to equal, 0.5-1.5 cm long, glabrous, *c.* 10-flowered; bracteoles simple, linear-oblong (-elliptic), *c.* 3-4x0.5-1 mm, puberulous along margin. *Flowers* bluish-green, white- or purple-tinged; pedicels 2-5 mm long, dilated above, glabrous; receptacle annular; petals subequal, obovate-elliptic, *c.* 1.5x0.8 mm, apex strongly inflexed, apiculate; midvein thinly winged, purplish; stamens subequal, *c.* 2 mm long; filaments 1.2-1.5 mm long, often with a constriction towards apex, vein lateral; ovary oblongoid-obovoid, *c.* 1.5x1 mm, winged; wings unequal, thin; styles