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The effects of diet and incubating media on the production and hatchability of the earth worm *Eudrilus eugeniae* (Kinberg) cocoons

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Abstract: Effects of various diets on *Eudrilus eugeniae* (Oligochaeta) coccon production and the effects of various incubating media on hatchability of the cocoons, were studied in culture pots. The results indicated that the *Pennisetum polystachion* (Shum et Thonn) grass diet, as compared to the *Panicum maximum* (L) grass diet induced more and faster cocoon production, greater hatchability, greater number of worms per hatch, and also faster hatching out of cocoons. Hatchability and number of worms per hatch were negatively correlated to weight^{-1} cocoon (size) and varied with the stage (duration days) of vermicomposting at which the cocoons were laid. The nature of the diet on which the cocoons were laid and isolated, and (for cocoons isolated from a given diet) the type of the incubating media significantly influenced hatchability and the number of worms per hatch. Generally vermicompost material (mostly earthworm casts and little organic residues) constituted favourable incubating media which gave rise to great hatchability and hight number of worms per hatch. The number of days to hatching of cocoons was negatively correlated to the stage (duration days) at which they were laid. Cocoons laid at later vermicomposting stage hatched out faster than those laid at the earlier stage.

There are several studies of feeding biology and earthworm ecology (Maldague *et al.* 1970, Satchell *et al.* 1967). The influence of specific diets on growth has also been investigated (Hartenstein 1983, Mba 1984, Hatanaka *et al.* 1983). However, the influence of specific diets on growth of tropical earthworms is poorly known. For instance, no studies were pursued to determine the effects of food on cocoon production. In fact the influence of specific diets on the hatchability and the activities of earthworm cocoon has been entirely a neglected area of research. Yet, the success of earthworm breeding depends on the fecundity of earthworms which depends on the activities and the hatchability of the cocoons. The ecology of cocoons consequently is a vital factor in the manufacture of vermicompost (so far the best organic fertilizer) and for biomass production by earthworms. Nigeria is becoming seriously concerned about environmental pollution by the use of inorganic fertilizers and pesticides. This, coupled with lack of foreign exchange, is seriously forcing the country to seek alternative material for soil amendment and animal food materials for crop production and meat industries.

This paper reports preliminary results of a study on the influence of diet on cocoon production by *Eudrilus eugeniae* and the influence of diets and incubating media on hatchability of cocoons. This will help identify the most adequate media to enhance the manufacture of vermicopmost and earthworm biomass.

MATERIAL AND METHODS

E. eugeniae worms and cocoons were obtained from the earthworm breeding complex of the University of Nigeria Nsukka Research farm.

Experiment 1: Rate of cocoon production: Fully clitellate adult worms were isolated from soil-*Paspalum* vermicompost. Ten worms were potted in plastic containers 20 cm by 6 cm with perforated base, using 80 g of either *Penisetum*

TABLE 1

Some chemical properties of the diets and the incubator media

	Soil	*Pennisetum polystachion* fermented and aerated	*Panicum maximum*	*Gmelina* fruits	Cassava vermicompost	Gmelina & cassava vermicompost
% Clay	10					
% Silt	5					
% Sand	86					
% C	0.69	28.2	29.7	21.0	27.0	26.4
% N	0.053	0.80	1.08	1.51	1.71	1.86
% P		0.23	0.26	0.26	0.13	0.25
% Ca		0.56	0.16	0.80		
% K		0.60	0.33	2.00	1.70	1.00
% Mg		0.48		0.96		
C/N	13.02	35.5	27.5	13.9	15.8	14.2
C/P	.	122.63	116.5	80.8	207.69	104.2
p^H (H_2O)	4.7					
p (KCl)	4.0					
available						
meq/100g Mg	0.3					
meq/100g Ca	0.8					
meq/100g K	0.24					
meq/100g Na	0.10					
meq/100 g CEC	13.0					
meq (ppm) P	9.0					

polystachion or *Panicum maximum* diet. Each diet consisted of fermented, air dried and ground grass, watered to field capacity (about 20% dry matter) and incubated overnight before inoculating with worms. Pots were incubated in the dark. Moisture content was maintained by watering as needed. Cocoons were sorted out and weighed at 3 day intervals. At monthly intervals, pots were emptied, the worms sorted out, weighed and replaced with fresh food. Cocoons from each pot and at each sampling date were incubated separately in a cup containing moist soil (80% dry matter). The first hatching date, and the number of hatchlings per hatch were noted after 40 days incubation (3 pots per treatment).

Experiment 2: hatchability of cocoons isolated from various vermicompost materials on moist soil: Cocoons from the following vermicompost origin were sorted out (1) Star grass (*Cynodon dactylon*), (2) *Penisetum polystachion,* (3) *Panicum max.* + *Gmelina arborea* fruits (*Gmelina*), (5) *P. polystachion* + *Gmeli-*

TABLE 2

Rate of cocoon production by Eudrilus eugeniae *as influenced by the stage of (duration days) vermıcomposting.* Panicum *max. diet and* Penisetum polystachion *diet.*

Stage of vermicomposting (duration days)	Diet *Panicum* production rate:	*Penisetum* cocoons $^{-1}$ week $^{-2}$ worms
	In the first month	
(life weight of parent worms)	1.50-2.09 g	1.16-1.21 g
	#	#
4	0 +0	1.8 ± 0.4
7	1.8 ± 0.5	5.6 ± 1.0
10	2.2 ± 0.7	6.1 ± 1.5
14	4.9 ± 1.2	5.3 ± 0.4
18	7.3 ± 1.5	7.3 ± 1.0
22	3.9 ± 0.9	3.9 ± 1.0
31	1.5 ± 0.6	3.1 ± 0.9
	In the following months (average of 2 months)	
4	2.5 ± 0.7	3.5 ± 1.2
7	4.9 ± 0.5	7.2 ± 0.6
10	16.3 ± 3.0	16.1 ± 4.1
14	18.0 ± 3.4	26.6 ± 3.5
18	9.2 ± 4.0	12.5 ± 2.4
25	7.0 ± 2.0	10.4 ± 3.4
31	1.2 ± 0.7	1.3 ± 0.4
(Life weight of parent worms)	2.09-3.40 g	1.21-2.90g

\# Standard deviation.

na, (6) cassava peels + *Gmelina* (7) cassava peel vermicompost consisting mostly of earthworm casts and little organic residues. Normal cocoons (evaluated by sıght) were weighed and potted in batches of 10 in plastic cups containing moist soil (3 cups were prepared for each compost material).

Experiment 3: hatchability of cocoons in various incubating media: Batches of 10 normal cocoons isolated from *Gmelina* + cassava peels vermicompost were weighed and potted in cups containing 5g of each of the following in duplicate: (1) nylon tissue soaked in water, (2) cassava peel vermicompost, (3) *Gmelina* + cassava peel vermicompost (cassava), (4) fermented and airdried *Seteria* (sp) grass, (5) fermented and airdried *Paspalum* sp. grass, (6) field vermicompost (mostly *Panicum maximum* + *Andropogon* sp. + *Centrosema* sp.). All materials were moistened to 30% dry matter with tap water and incubated in the dark for 40 days.

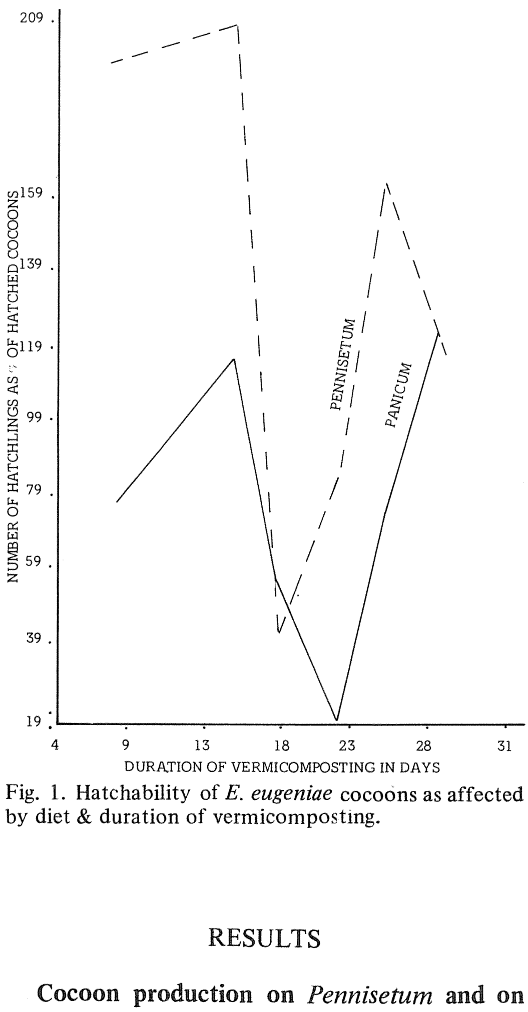

Fig. 1. Hatchability of *E. eugeniae* cocoons as affected by diet & duration of vermicomposting.

RESULTS

Cocoon production on *Pennisetum* and on *Panicum*: Rate of production and total number of cocoons (produced per 100g of dried diet) depended on the type of diet and on the stage (duration days) of vermicomposting (Table 2). Cocoon production started 5 ± 1 days earlier on *Pennisetum* than on the *Panicum* diet (total cocoons, means 128.7 ± 8.7 or 139% on *Pennisetum* and 9.1 ± 21.1 or 100% on *Panicum*). The rate of production on both diets varied with the stage of vermicomposting. On each diet and in the 1st month the rate increased to a peak in the 3rd week, then decreased during the 4th week. At early vermicomposting production rate was significantly greater on the *Pennisetum* diet. The maximum production rate was 7.3 cocoons worms^{-2} week^{-1} in each diet. However, the mean rate was 4.4 ± 0.2 or 137.5% on *Pennisetum* (3.3 ± 0.6 or 100% on *Panicum*). The rate was significantly ($P < 0.01$) greater on *Pennisetum*. The general pattern was, for the subsequent months, similar in both diets. However, the rate increased with mean live weight worm^{-1} (Table 2).

Activities of cocoons isolated from *Pennisetum* and *Panicum* diets: Hatchability and the number of days to hatching depend on the type of diet and on the stage of vermicomposting at which the cocoons were laid (Fig. 1). Cocoons in *Pennisetum* hatched significantly ($p<0.01$) faster, for instance 15±3 days relative to 19±4 for those of *Panicum* diet. On each diet the number of days to hatching was significantly and negatively correlated with the stage of vermicomposting at which the cocoons were laid. On *Panicum* diet $r=-0.9787$, $n=10$, $p<0.001$; on *Pennisetum*, $r=-0.9603$, $n=10$, $p<0.001$. For instance, cocoons laid after 6 days of vermicomposting on *Pennisetum* took 19±1 days of incubation to hatch (25±2 days on *Panicum*). Cocoons laid after 21 days on *Pennisetum* took 15±3 days (21±2 on *Panicum*). Cocoons laid at earlier vermicompostings stage took longer incubation periods, while those laid later hatched out faster.

Cocoon size: Size or average weight^{-1} cocoon depended on the type of diet. The largest size was observed on the *Panicum* diet, the least on *Gmelina* + *Panicum* and cassava diets. Interactions among diet components significantly influence cocoon size. On cassava the size was 14.9 mg. There was a large size (19.0 mg) on cassava peel + *Gmelina* and a very small size (14.0 mg) on *Gmelina* + *Panicum* diet as opposed to the largest size (22.2 mg) recorded on *Panicum* diet. For a particular diet, cocoon size was also influenced by the stage of vermicomposting at which the cocoons were laid. For instance on *Pennisetum* and on *Panicum* (Fig. 1), size increased to a peak during the 3rd and the 4th weeks. Size varied more irregularly on *Pennisetum* diet.

Hatchability of cocoons and the number of worms per hatch: On moist soil hatchability and the number of worms per hatch depended on the type of diet and on the stage of vermicomposting at which the cocoons were laid. Figs. 1 and 2 indicated these relationships, showing also that hatchability and number of worms per hatch decreased with the increase in cocoon size. A highly significant negative correlation r = ⁻0.601, n = 19, $p < 0.02$, was established between cocoon size and hatchability and number of worms per hatch. For example, hatchability and number of worms per hatch were greatest for cocoons isolated from cassava, and *Gmelina* + *Panicum* diets whose cocoon size (14.9 and 14.0 mg) respectively were the least, while hatchability and the number of worms per hatch were the least for cocoons isolated from *Gmelina* + *Pennisetum* and *Panicum* diets whose cocoon sizes (19.7 and 22.2 mg, respectively) were the greatest, indicating and inverse relationship (table 3).

Effects of the incubator media on cocoon hatchability: Hatchability and the number of cocoons per hatch were greatly influenced by the nature of the incubator media, (Table 4). In general vermicompost materials favoured hatchability and the number of worms per hatch (Table 4). It is noteworthy that *Setaria* and *Paspalum* grass incubator media gave "O" hatchability. Hatchability and the number of worms per hatch were significantly greatest on the cassava peel vermicompost medium, followed by water saturated nylon gauze, field vermicompost, cassava *Gmelina* vermicompost, and moist soil, in that order.

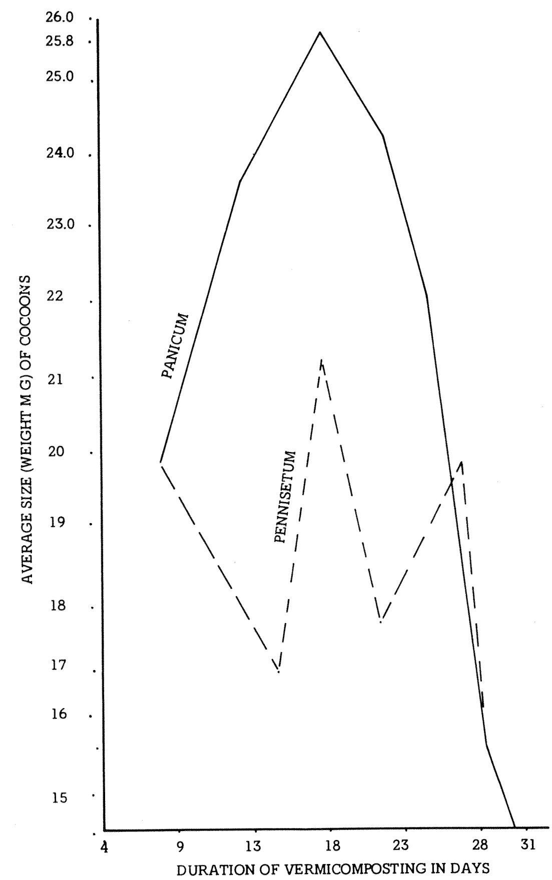

Fig. 2. Size (mean wt.) of *E. eugeniae* cacoons as affected by diet & duration of vermicomposting.

DISCUSSION

The type and the quality of diet influenced fecundity of *E eugeniae* through its influence on the rate of cocoon production, rate of hatching and the number of worms per hatch. Hatchability was zero on unvermicomposted grasses *Seteria* and *Paspalum.* A negative correlation existed between the days to hatching and the stage of vermicomposting (duration days) at which the cocoons were laid. These findings and the fact that hatchability and the number of worms per hatch were greater on vermicompost materials indicate that by vermicomposting the grasses the hatchability of cocoons was favoured and accelerated (Table 4). The type of diet and the stage of vermicomposting influence the cocoon size. The chemical properties of the diet (Table 1) could not account fully for the influence, especially since interactions among diet components also played an important role in this regard. The *Panicum* diet for instance, induced larger size (22.2 mg) compared to the small size 14.0 mg observed on *Panicum* + *Gmelina* diet (Table 3). Both *Panicum* and *Gmelina* are apparently rich in nutrient elements, although it is possible that the differences in compositon may have a bearing on their individual effects on cocoon size. The total number of cocoons per unit mass of dry matter differed with the nature of diet. The *Panicum* diet produced 39.5% less number of cocoons relative to *Pennisetum.* This difference was reflected also on the total biomass of the cocoons even though *Panicum* cocoons were on the average greater in size (Table 3). Per 100 g diet, *Panicum* cocoons biomass totalled 2022.4 mg (100%) compared to 2405.6 (119.4%) for *Pennisetum* cocoons. However, *Panicum* diet induced greater increase ($P < 0.05$) in the parent worms live weight during vermicomposting (Table 2). Snider (1970) also observed several rates of egg production on different diets fed to *Ony-*

TABLE 3

Dietary effect on average weight cocoon^{-1} and on hatchability of cocoons of Eudrilus eugeniae *incubated on moist soil.*

Diet	Weight cocoon^{-1} mg	Hatchability in moist soil number of hatchlings x 100% / number of cocoons % (Standard dev.)
	#	
Panicum max.	^{a}22.2 ± 3.3	^{b}88.6 ± 57.0
Penisetum polystachion	^{d}18.7 ± 2.0	^{d}139.2 ± 63.0
Cassava Peel	^{c}14.9 ± 1.6	^{f}193.3 ± 0.6
Cassava Peel & *Gmelina*	^{db}19.0 ± 0.7	^{c}125.0 ± 7.1
Gmelina & *Panicum*	^{c}14.0 ± 1.0	^{e}156.7 ± 5.8
Gmelina & star-grass	^{d}17.7 ± 1.1	^{c}116.7 ± 20.8
Gmelina & *Pen. polystach.*	^{b}19.7 ± 0.6	^{a}56.7 ± 30.5

* Similar values with different letter/s are significantly different; similar values with the same letter are not significantly different.

TABLE 4

Effect of incubator media on the hatchability and number of worms per hatch of Eudrilus eugeniae *cocoons*

Incubator medium	Weight cocoon^{-1} (mg)	Hatchability & number worms per hatch Number of hatchlings % / Number of cocoons
Moist soil	19.0 ± 1.4 *	^{e**}125.0 ± 7.1
Setaria grass (fermented & aerated)	19.0 ± 0.0	^{f}0.0 ± 0.0
Water saturated nylon gauze	19.5 ± 0.7	^{c}250.0 ± 0.0
Cassava + *Gmelina* vermicompost	19.0 ± 0.0	^{bde}150.0 ± 150.0
Cassava vermicompost	18.5 ± 0.7	^{a}275.0 ± 2.5
Field compost	19.0 ± 0.0	^{b}240.0 ± 0.0
Paspalum grass (fermented & aerated)	19.5 ± 0.5	^{f}0.0

* standard deviation

** similar values with different letter are significantly different; similar values with the same letter are not significantly different.

\# cassava = cassava peels.

chiurus justi (Collembola). The rate on *Pennisetum* diet was greater even though the *Panicum* diet was richer in nutrients (Table 1). The rate increased to a peak during early vermicomposting and fell later. This pattern was repeated on both diets following introduction of fresh diet. The initial low rate could have resulted because the diet needed to be rendered favourable to cocoons through the activities of the worms, during vermicomposting. The later reduction in rate at later vermicomposting could have resulted from the exhaustion of the diet. Hatchability was 100% on moist soil, for cocoons isolated from the cassava + *Gmelina* vermicompost, while the number of worms per hatch was only 1.25, compared to 100% hatchability and 2.30 worms per hatch of vermicompost incubator media (Table 4). A maximum of 2.80 worms per hatch was produced on cassava peel vermicompost. A mean of 2.60 worms per hatch with 78.5% hatchability was reported for *Eisenia fetida* by Vail (1974). Hatchability for *E. eugeniae* on water saturated nylon gauze was 100%.

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RESUMEN

Se estudió el efecto de varias dietas y medios de incubación en la producción y viabilidad de los capullos de la lombriz terrestre *Eudrilus eugeniae.* Se comparó dos zacates, *Pennisetum polystachion* y *Panicum maximum.* El primero favoreció más la formación de capullos y su viabilidad, al igual que el medio compuesto por exubias y residuos orgánicos ("vermicompost").

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