Influence of Worm Density on the Growth of *Eudrilus eugeniae*

A. Vorsters, F. Demey & J. Hardouin*

Keywords : Earthworm – Density – *Eudrilus eugeniae* – Biomass – Growth – Reproduction.

Summary

The experiment shows that there is an optimal density to obtain the highest biomass when rearing hatchlings of Eudrilus eugeniae. *Higher densities induce lower individual weight gain and longer duration to sexual maturity.*

Résumé

*L'expérience montre qu'il existe, pour élever des vermisseaux d'*Eudrilus eugeniae, *une densité optimale qui aboutit à une biomasse maximale. Des densités plus élevées entraînent un gain de poids individuel plus faible et une durée prolongée pour atteindre le stade adulte.*

Introduction

It is well known that feeds for monogastrics need to contain proteins of high quality. Since several years the terrestrial *Oligachaeta* are mentioned as potential protein source for animal feed. Feeding trials have already demonstrated that one can replace fish or meat meal in chicken feed by earthworm meal. The earthworm *Eudrilus eugeniae* belongs to the class of *Oligochaeta*, family of the Eudrilidae and is indigenous in West-Africa. Time to mature varies between 49 and 68 days according to authors. Viljoen and Reinecke have found that the hatchlings became adult in 45 days and at a weight of 1.5 gram, that in average a full grown adult weighs 2.9 gram, produces 1.2 cocoons per day and 2.7 hatchlings per cocoon. Analysis in the effect of cohabitation between the hatchlings and the mature worms showed that the gain of biomass in the system stops after some time; this is also mentioned for *Eisenia fœtida*. We personally found a number of adults inferior to the number we could expect by calculation using the results of the life cycle. Viljoen and Reinecke already pointed out that "It seems evident that worm density affects both growth and reproduction, independent of the role of food availability.".

Material and Methods

The earthworm *E. eugeniae* used in the present study was obtained from the Université Nationale du Bénin, Faculté des Sciences Agronomiques (UNB/FSA). The hatchlings were produced at the laboratory of the Tropical Animal Production Unit (SPAT). From a pool of hatchlings, aging 1 to 9 days and produced by the same group of reproducers, different groups were made at random.

The substrate consisted of 1 liter of commercial garden compost and 30 grams of rabbit droppings (RD) on day DO, with a ratio volume/free area of 1000 cc/100 square cm. Every 2 weeks, and from day D28 every week, 30 grams of RD were added. The rearing substrate was placed in plastic cylindrical recipients (diameter 12 cm, height 15 cm and a free surface of 100 cm^2) put on a laboratory shelter at ± 20° C.

Twice a week, the humidity was checked and adjusted if required. Considering the problems described by Reinecke and Venter in the determination of the humidity and due to the decreasing size of the particles during the experiment, the control was based on visual and tactile sensations. The humidity, equal in all the recipients, was high but without any free water at the bottom of the containers. Twice a week the complete substrate was turned up and mixed for better aeration. The hatchlings were weighed individually with a balance METTLER BB120 (centigram accuracy) at days D25, D34, D42 and D49. Before weighing the hatchlings were washed and kept for a few seconds on absorbent paper. Four different densities were studied by placing 10, 30, 50 and 72 hatchlings in four identical recipients labelled A, B, C and D.

Results

The mean weight increased faster with the decrease in the density (Table 1). The highest biomass was obtained at a density of 30 worms per recipient (Table 2). While weighing the worms it was noticed that at day D34, all the worms in recipient A were adult while only a part of the population in recipient B. Recipient C and D did not contain a single worm with a clitellum till day D49 when the experiment was closed.

Table 1 : Changes in mean individual weight of *Eudrilus eugeniae* kept at various densities under similar conditions.

Time (days)	Mean individual weight (g) 10 worms	30 worms	50 worms	72 worms
0	0.02 ± nd	0.01 ± nd	0.01 ± nd	0.01 ± nd
7	0.11 ± nd	0.03 ± nd	0.02 ± nd	0.02 ± nd
25	0.88 ± 0.18	0.50 ± 0.14	0.23 ± 0.10	0.17 ± 0.07
34	1.4 ± 0.23	0.78 ± 0.21	0.30 ± 0.15	0.24 ± 0.10
42	1.69 ± 0.31	0.96 ± 0.22	0.44 ± 0.18	0.30 ± 0.11
49	2.04 ± 0.36	1.11 ± 0.19	0.54 ± 0.20	0.35 ± 0.13

From day 25 until the end is the difference in mean weight between the different densities very significant ($P < 0.0001$) (nd not determined).

* BEDIM Secretariat Fac., Univ. Sc. Agron., 2 Passage des Déportés, B-5030 Gembloux, Belgium.
Received on 23.07.97 and accepted for publication on 11.08.97.

Table 2 : Changes in total worm biomass of *Eudrilus eugeniae* kept at various densities under similar conditions.

Time (days)	Total worm biomass (g) 10 worms	30 worms	50 worms	72 worms
0	0.2	0.3	0.5	0.6
7	1.1	1.0	1.0	1.2
25	8.8	15.0	11.7	12.2
34	14.0	23.5	15.2	17.1
42	16.9	28.8	22.1	21.9
49	20.4	33.3	26.6	25.4

The best correlation between the average individual weight (y) and the density (x) was expressed as an exponential curve of the form y = exp(a+bx) with "a" being the intercept and "b" the slope.

Using this formula one can calculate that the optimal density xop for a maximum total biomass (x times y) is obtained when xop = -1/b. The various optimal densities at different days are given in Table 3.

Table 3 : Correlation y = exp(a+bx) between mean individual weight (y) and density (x) of *E. eugeniae* at different days of the experiment and the calculated optimal densities.

Day	Intercept a	Slope b	Optimal density Xop = -1/b
25	0.0514	- 0.0267	37
34	0.5922	- 0.0303	33
42	0.7816	- 0.0286	35
49	0.9639	- 0.0291	34

Discussion

The density of the hatchlings had an influence on the evolution of their individual weight. For young adults of the species *Eisenia fœtida* Viljoen and Reinecke (13) found also that growth was influenced by the denstiy of the earthworms. The range of densities tested allowed to determine the optimal density for rearing *E. eugeniae* in the given condition. After 34 days the same treatment gave 23.5 g/dm2 fresh worm biomass with a density of 30 hatchlings/dm2, but only 70% of this production was observed with 72 hatchlings/dm2 and 60% with 10 hatchlings/dm2. The 4 groups show a linear growth and the fluctuation of the xop at day 25-34-42-49 (Table 3) is very small. This could indicate that food availability (g RD/g worm) is not the only determining factor of growth. The food availability is changing significantly during the experiment without changing the linearity of the growth nor the optimal densities.

Besides an influence on growth, it was noticed that sexual maturity is reached later at higher densities. At a density of 10 worms/dm2 the adolescence period is comparable with that found by Viljoen and Reinecke (12). It was also observed that at a density of more than 50/dm2 not a single worm was adult after 49 days. This effect was neither studied by Neuhauser, Hartenstein and Kaplan (5) nor by Viljoen and Reinecke (13) on *E. fœtida.*

Conclusion

This experiment shows the relative value of many research findings on the biological life cycle on earthworms, as the conditions used to rear earthworms play a large role on the results. This study shows also the existence of an optimal density to produce a maximal biomass from hatchlings of same age and reared in same conditions. Consequently vermiculturists should not only pay attention to temperature and food availability but also to control the worm population if they want to produce high amounts of worm biomass. As *Eudrilus eugeniae* has the capacity to produce many offsprings in a short period, the density becomes quickly too high, which has a negative influence on the total biomass production and on the number of adults. A high production requires harvesting the worms and their transposition in more favourable conditions.

SAMENVATTING

Het experiment toont aan dat er een optimale densiteit bestaat om een maximale biomassa te bekomen voor het kweken van *Eudrilus eugeniae* wormen. Hogere densiteiten veroorzaken een lagere individuele gewichtstoename en een langere periode om het volwassen stadium te bereiken.

Literature

1. Barcelo, P.M., 1988. Production and utilization of earthworms as feeds for broilers in the Philippines. Tropicultura **6** : 21-24.
2. Bouché, M., 1984. Les vers de terre. La recherche 156 : 796-804.
3. Guerrero, R.D. 1983. The culture and use of *Perionyx excavatus* as a protein resource in the Philippines. In : Satchell, J.E. ed. Earthworm ecology, from Darwin to Vermiculture Chapman & Hall. London, pp. 309-313.
4. Hartenstein, R., 1981. Production and Earthworms as a Potentially Economical Source of Protein. Biotechnology and Bioengineering **13** : 1797-1811
5. Neuhauser, E.F., Kaplan, D.L. & Hartenstein, R., 1979. Life history of the earthworm *Eudrilus eugeniae.* Rev. Ecol. Biol. Soc. **16** : 525-534.
6. Ngeukam, 1990. Production et utilisation des vers de terre comme source de protéines animales dans l'alimentation des poulets de chair en finition. Mémoire d'Ingénieur Agronome. Centre Universitaire de Dschang.
7. Reinecke, A.J. & Venter, J.M., 1985. The influence of moisture on the growth and reproduction of the compost worm *Eisenia fœtida (Oligochaeta).* Rev. Ecol. Biol. Soc. **16** : 525-534.
8. Reinecke, A.J., Hayes, J.P. & Cilliers, S.C., 1991. Protein quality of three species of earthworms, S. Afr. J. Anim. Sci. **21** : 99-103.
9. Rodriguez, C., Canetti, M.E., Reines, M. & Sierra, A., 1986. Life-Cycle of *Eudrilus eugeniae* (*Oligochaeta* : *Eudrilidae*) at 30° Celsius. Poeyana. Inst. Zool. Cienc. Cuba 326 : 1-13.
10. Schultz, E. & Graff. O., 1977. Zur bewertung von regenwurmmehl aus *Eisenia foetida* (Savigny 1826) als eiweissfuttermittel. Landbauforschung Völkenrode **27** : 216-218.
11. Ulep, L.J.L. & Lopez, L., 1982. The production, processing and evaluation of the nutritive value of the earthworm *Perionyx excavatus* as feed for broilers. Ph. D. thesis University of the Philippines.
12. Viljoen, S.A. & Reinecke, A.J., 1989. Life cycle of the African nightcrawler. *Eudrilus eugeniae (Olgochaeta).* South Africa Journal of Zoology **24** : 27-32.
13. Viljoen, S.A. & Reinecke, A.J., 1990. Moisture preferences, growth and reproduction of the African nightcrawler, *Eudrilus eugeniae (Oligochaeta).* South Africa Journal Zoology **25** : 155-160.

* A. Vorsters, Belgian, Agronomist (VUB), M. Sc. (ITM), Int. Product Specialist Innogenetics.

** F. Demey, Belgian, Agronomist (KUL), Ph. D. (ITM), First Assistant ITM.

*** J. Hardouin, Belgian, Agronomist (FUSAGx), Dr. in Vet. Med. (Cureghem), Emeritus Professor (ITM).