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REPRODUCTIVE BEHAVIOUR OF *Eisenia Fetida Andrei* BOUCHÉ, 1963 (LUMBRICIDAE) AND *EUDRILUS EUGENIAE* (KINBERG, 1867) (EUDRILIDAE), IN WINTER AND SPRING, FOR COMMERCIAL PURPOSES.

(Comportamento reprodutivo de *Eisenia fetida andrei* Bouché, 1963 (Lumbricidae) e *Eudrilis eugeniae (Kinberg, 1867) (Eudrilidae), no inverno e primavera, com fins comerciais.)*

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ABSTRACT

At the Aquaculture Department of the Instituto de Pesca, Fernando Costa Park, São Paulo city, São Paulo state, Brazil, through experiments it was verified,aiming at finding new choices of alternative food for commercial frogherds, that *Eisenia fetida andrei* can be raised indoors, at room natural temperature, in cow manure, in Winter and Spring months. It was also verified that *Eudrilus eugeniae* did not tolerate the studied conditions in Winter. The production of *E. f. andrei* fell in Winter when compared with that in Spring: in Winter, from five individual resulted 15.5 and 22.5 cocoons, in average, and in Spring, from five, resulted 208.25 individuals and 11.5 cocoons, in average; in Winter, from five, resulted 2,5 individuals of *Eudrilus eugeniae* and 9,5 cocoons, in average. It was concluded that *E. F. andrei* owns the potentialities to reproduce under thrifty conditions, widening the frogfarmers' choices of food, in the Southeastern Region of Brazil, in the referred seasons. The rate of viable cocoons in *E. f. andrei* was found to be 28% and the number of individuals hatching from one cocoon was 3.5, in average.

KEY-WORDS: Earthorn, reproduction, manure, season, frogherd.

RESUMO

Na Seção de Aqüicultura do Instituto de Pesca, no Parque Fernando Costa, na cidade de São Paulo, estado de São Paulo, Brasil, através de experimento visando a descoberta de novos alimentos alternativos para plantéis comerciais de rã, foi verificado que *Eisenia fetida andrei* pode ser criada à temperatura natural, em ambiente coberto, empregando-se como substrato esterco de vaca, nos meses de inverno e primavera, na Região Sudeste do Brasil. Foi verificado que, no inverno, *Eudrilus eugeniae* não apresentou desempenho tão satisfatório quanto o da *E. f. andrei*. A produção de *Eisenia fetida andrei* foi menor no inverno, quando comparada com a da primavera: no inverno, de cinco exemplares, resultaram 15,5 indivíduos e 22,5 casulos, em média, e, na primavera, de cinco, resultaram 208,25 indivíduos e 11,5 casulos; de cinco exemplares de *Eudrilus eugeniae*, resultaram, no inverno, 2,5 indivíduos e 9,5 casulos, em média. Conclui-se que *E. f. andrei* dispõe de potencialidades para reproduzir-se, nas estações referidas, ampliando-se a possibilidade de escolha de alimentos alternativos, na ranicultura comercial da região, em que, de há muito, somente se empregam larvas de moscas, principalmente. Em *E. f. andrei*, a taxa de casulos viáveis foi de 28% e o número de indivíduos eclodidos de cada casulo foi 3,5, em média.

PALAVRAS-CHAVE: Minhoca, reprodução, esterco, estação, rã.

1. INTRODUCTION

Since the bullfrog (*Rana catesbeiana* Shaw, 1802), which is utilized in the Brazilian commercial frogfarms, does not accept inert food, any ration whatsoever, it is important to develop in these frogplants thrifty technology for the production of insects and their larvae, little fishes and crustaceans, tadpoles and earthworms, which are the animals the bullfrog naturally feeds upon (PRIDDY & CULLEY, 1971).

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The success, achieved by some frog-farmers using larvae of flies as food, has been acting as a strong incentive for the development of earthworm cultivations, mainly of *Eisenia fetida andrei* Bouché, 1963, a Lumbricidae, and *Eudrilus eugeniae* (Kinberg, 1867), an Eudrilidae, the former a subspecies of *Eisenia fetida* (Savigny, 1826), known as "manure worm", and the latter as the "African Night Crawler", both recommended by Associação Brasileira de Minhocultores (ABRAMI) for the above mentioned purpose, because they are cultivated all over the world, on account of their capacity to reproduce in captivity. It is now very difficult to know exactly the natural geographical distribution of these species, since they have been spread by man to almost every corner of the world; yet, *E. eugeniae* was first found in Africa (SIMS & GERARD, 1985) and *E. f. andrei,* as it is referred by REYNOLDS (1977), may be naturally present in Italy, and in the south of France.

From the perusal of the reports of REYNOLDS (1977), TOMLIN (1981a, 1981b e 1981c), SHIELDS (1982), KNAEPPER (1984) and SIMS & GERARD (1985), and the personal observations of the authors of this paper, one may infer that, in the process of adapting these species to a new climatic condition, with a specific annual variation of temperature, it is advisable, first of all, to verify their multiplication potentialities, when reared indoors, all year round, without any air-conditioning system, in little boxes containing cow manure, inasmuch as they are quite demanding as far as temperature is concerned and its control may be too expensive to invalidate any commercial approach.

This research has been planned to comply experimentally with the above mentioned advice, for the months of Winter and Spring, aiming at the Southeast-brazilian frogfarmers' necessities of food for their frogherds, especially in this period of the year, when the flies tend to diminish or even disappear completely in this part of Brazil.

2. MATERIALS AND METHODS

The experiment was divided into three parts, running, the first one, from June 23rd., 1987, through September 29th., 1987; the second, from September 29th., 1987, through January 4th., 1988; and the third part simultaneously to the second, from September 29th., 1987, through November 11th., 1987. It was carried out at the Aquaculture Department of the Instituto de Pesca, in São Paulo City, São Paulo State, Brazil.

Both in the first and in the second part, translucent white plastic boxes, measuring 28cm long x 14 cm wide x 10 cm high were employed, containing each 0.5 kg of cow manure, dried up under the sun, no longer attracting flies, totally scentless. In the third part, 25 plastic cups, containing each about 2.5 cc. of cow manure in the same conditions as above referred. The boxes and cups were always kept in a shaded corner of a non-airconditioned room.

The room temperature was daily recorded at 10 a. m. About 50 cc. and 2 cc. of regular tap water was weekly sprinkled into each box and cup, respectively.

The animals employed in these experiments are directly descendants from those brought from Ravenna, Italy, by Mr. Lino Morganti, in the beginning of this decade, to the "O Sítio da Kokó" farm, Via Marechal Rondon, 118.5 km, Itu, São Paulo State and were graciously offered to the authors of this paper by Mrs. Sílvia Esteves Torre and Mr. Tharsis Palhares.

FIRST PART

In order to compare the reproductive capacity of *E. f. andrei* with that of *E. eugeniae,* in Winter (approximated time period, as one can see above), through the resulting number of individuals, cocoons and biomass, eight boxes were employed, containing 4 of them, each, 5 adult exemplaries of *E. f. andrei* and 4 of them,

each, 5 adult exemplaries of *E. eugeniae*, picked up at random, from the earthworm rearing beds of the Institute. In all, 20 individuals of each species were employed; individual average weight 0.5 g for *E. f. andrei* and 1.7 g for *E. eugeniae*.

The statistical design employed was that of a totally randomised experiment with two treatments and four replicates. The data were submitted to an analysis of variance, followed by an "F" test (SNEDECOR & COCHRAN, 1971).

SECOND PART

In order to compare the reproductive capacity of *E. f. andrei*, in Winter, with that in Spring (time periods not precisely circumscribed), through the same variables as referred in the FIRST PART, 4 plastic boxes were set up for this species, in the beginning of Spring, in similar conditions to those reported for Winter. In the comparison, it was employed the same statistical design, being the two treatments in this instance, Winter and Spring.

THIRD PART

To assess in *E. f. andrei* both the rate of viable cocoons and the average number of individuals hatched per one of them, 25 cups as above described were employed, each one containing just one cocoon, picked up at random, from those resulted in the FIRST PART. The duration of this experiment was 28 days, according with some previous observations of the authors of this work and with the duration observed for the kin species *E. fetida* (Savigny, 1826), which is reported to be about a month (KNAEPPER, 1984).

3. RESULTS AND DISCUSSION

In Winter, *E. f. andrei* showed the best performance: from 5 resulted, in average, 2.5 individuals of *E. eugeniae* and 15.5 of *E. f. andrei* (TABLE 1).

TABLE 1
Number of individuals in the replicates of each treatment, in Winter.

E. eugeniae	*E. f. andrei*
2	17
3	16
2	15
3	15
Total 10	63
Mean 2.5	15.75

The results of the analysis of variance (TABLE 2) show that the difference is significant at 1% probability level.

TABLE 2
Analysis of variance of the number of individuals of *E. eugeniae* and E. f. andrei, in Winter.

Source	D.F.	Sum squ.	Mean squ.	F
Treat.	1	351.125	351.125	561.800**
Remain.	6	3.750	0.625	
Total	7	354.875		

Coef. of variation: 8.66%

In Winter, from 5 individuals resulted, in average, 9.5 cocoons for *E. eugeniae* and 22.5 for *E. f. andrei* (TABLE 3).

TABLE 3
Number of cocoons in the replicates of each treatment, in Winter.

E. eugeniae	*E. f. andrei*
9	23
10	22
10	24
9	21
Total 38	90
Mean 9.5	22.5

The result of the analysis of variance (TABLE 4) shows that the difference is significant at 1% probability level.

TABLE 4
Analysis of variance of the number of cocoons of *E. eugeniae* and *E. f. andrei*, in Winter.

Source	D.F.	Sum Squ.	Mean Squ.	F
Treat.	1	338.0	338.0	338.0**
Remain.	6	6.0	1.0	
Total	7	344.0		

Coef. of variation: 6.25%

In Winter, from 5 individuals resulted, in average, 4.1 g of biomass for *E. eugeniae* and 5.9 g for *E. f. andrei* (TABLE 5), being the individual average weight for *E. eugeniae* 1.65 g and 0.37 g for *E. f. andrei*.

TABLE 5
Biomass (in grams) in the replicates of each treatment, in Winter.

E. eugeniae	*E. f. andrei*
3.2	6.0
5.0	6.4
3,4	5.6
4,9	5.8
Total 16.5	23.8
Mean 4.1	5.9

The results of the analysis of variance (TABLE 6) show that the difference is significant at 5% probability level.

TABLE 6
Analysis of variance of biomass of *E. eugeniae* and *E. f. andrei*, in Winter.

Source	D.F.	Sum Squ.	Mean Squ.	F
Treat.	1	6.6612	6.6612	12.9000*
Remain.	6	3.0975	0.5163	
Total	7	9.7587		

Coef. of variation: 14.26%

The air temperatures recorded in the FIRST PART of the experiment are on TABLE 7.

TABLE 7
Temperatures recorded in Winter (Centigrade degrees).

Time period	Mean temp.	Max.	Min.	S.Dev.
Jun. 23,87 - Jul. 23,87	18.8	23	15	3.1
Jul. 24,87 - Aug. 23,87	18.2	24	14	3.3
Aug. 24,87 - Sep. 29,87	18.6	23	15	1.6

S. Dev.: Standard deviation.

SECOND PART

In Spring, from 5 resulted, in average, 208.25 individuals of *E. f. andrei* (TABLE 8).

TABLE 8
Number of individuals in the replicates of each treatment, Spring and Winter.

Winter	Spring
17	206
16	208
15	217
15	202
Total 63	833
Mean 15.75	208.25

The results of the analysis of variance show that the difference is significant at 1% probability level (TABLE 9).

TABLE 9
Analysis of variance of the number of individuals of *E. f. andrei*, in Winter and Spring.

Source	D.F.	Sum squ.	Mean squ.	F
Treat.	1	74,112.5	74,112.5	3,600.00*
Remain.	6	123.5	20.5	
Total	7	74,230.0		

Coef. of variation: 14.26%

In Spring, from 5 individuals resulted, in average, 11.5 cocoons of *E. f. andrei*.

TABLE 10
Number of cocoons in the replicates of each treatment, Winter and Spring.

Winter	Spring
22	12
22	12
24	11
21	11
Total 90	46
Mean 22.5	11.5

The results of the analysis of variance show that the difference is significant at 1% probability level (TABLE 11).

TABLE 11
Analysis of variance of the number of cocoons of *E. f. andrei*, in Winter and Spring.

Source	D.F.	Sum squ.	Mean squ.	F
Treat.	1	242.0	242.0	242.00**
Remain.	6	6.0	1.0	
Total	7	248.0		

Coef. of variation: 5.88%

In Spring, from 5 individuals resulted, in average, 55.41 g of biomass of *E. f. andrei* (TABLE 12). The individual average weight was 0.0658 g.

TABLE 12
Biomass (in grams), in the replicates of each treatment, of *E. f. andrei*, in Winter and Spring.

Winter	Spring
6.0	14.8
6.4	12.8
5.6	15.2
5.8	12.6
Total 23.0	55.41
Mean 5.7	13.71

The results of the analysis of variance (TABLE 13) show that the difference is significant at 1% probability level.

TABLE 13
Analysis of variance of the biomass of *E. f. andrei*, in Winter and Spring.

Source	D.F.	S. Squ.	M. Squ.	F
Treat.	1	124.899	124.899	131.127**
Remain.	6	5.715	0.952	
Total	7	130.6141		

Coef. of variation: 9.85%

The recorded temperature in the SECOND PART are on TABLE 14.

TABLE 14
Temperature recorded in Spring
(in Centigrade degrees)

Time period	Mean	Max.	Min.	Stand. Devi
Oct. 30,87 - Nov. 29,87	22.52	25	20	1.5
Nov. 30,87 - Dec. 29,87	26.32	30	23	1.9
Dec. 30,87 - Jan. 04,88	26.30	30	23	1.7

THIRD PART

From the 25 cocoons, 7 hatched, revealing an average 28% viability rate, for the studied conditions. And from the 7 hatched cocoons, resulted 25 new individuals (TABLE 15), i.e., in average, 3.5 individuals per cocoon.

TABLE 15
Number of individuals hatched from each of the 7 viable cocoons of *E. f. andrei*.

Replicates	1	2	3	4	5	6	7
Number of individuals	3	3	4	2	5	4	4

Some critics may arise on the validity of the tests on TABLES 6 and 9 as to the number of replicates. Yet, it is believed that the coeficients of variation are not sufficiently high to give in to this kind of apprehension.

According with TOMLIN (1981b), corroborated by SIMS & GERARD (1985), the optimum temperature for raising *E. eugeniae* "seems to be about 24ºC, but it can tolerate temperatures from 20–26ºC; growth and development rates will be a function of temperatures and feedings. This species will not tolerate cold temperatures (less than 15ºC) and growth and reproductive rates will drop dramatically below 20ºC". The data on TABLE 7 show that the average winter temperatures was about 18ºC, varying from 14ºC to 24ºC, at 10 a.m., which might explain the poor performance of this species.

E. f. andrei did well in Winter and Spring months, being interesting to observe that the number of individuals increased from Winter towards Spring, showing that this season favours the laying of cocoons and the hatching of them.

TOMLIN (1981b), about *E. fetida* (Savigny, 1826), affirms: "Under optimum conditions cultures of manure worms can double or triple in numbers (but not weight), in 50-60 days". The results on TABLE 8, dealing with number of individuals, show that the culture about doubled in Winter, and, in Spring, was around 40 times bigger. In terms of biomass, TABLE 12, it increased about 6.5 times, in Winter, but only about doubled in Spring, showing that, as it is implicit in TOMLIN (1981b), when the number of individuals grows, there is a concomitant diminution of their weight. This author suggests that this handicap might be avoided, in *E. fetida* (Savigny, 1826), if the optimum conditions (ventilation, food, space and temperature, mostly) could be maintained by a proper management.

As to the number of individuals hatched per cocoon, TABLE 15 shows that it varied from 2 to 5, what somehow agrees with KNAEPPER (1984), who in *E. fetida* (Savigny, 1826), refers 2 to 8 individuals, at 19ºC. In future experiments, the authors intend to verify the number of individuals hatching per cocoons, from those laid in the other seasons of the year.

As to the substractum employed, it seems to contain all that is basically necessary for *E. f. andrei* to grow and reproduce. Yet, it is hoped that, adding some extra materials to the cow manure substractum, the production of individuals will considerably increase, as it is observed in its related species *Eisenia fetida* (Savigny, 1826) (KNAEPPER, 1984). In future experiments, new substracta will be tested.

Eudrilus eugeniae was not tested in Spring months for technical reasons only. But, in future experiments, it is intended to test its reproductive behaviour in all seasons of the year.

If this work does not effectively help to solve the problem of feeding a commercial frogherd it does act as an incentive towards finding alternative food to be used in this important activity.

4. CONCLUSIONS

1 - In the Southeastern Region of Brazil, in the months of Winter and Spring, using cow manure as substractum, in a sheltered ambient, the frogmarmers, at natural temperature, can rear the species *Eisenia fetida andrei*, an earthworm, to be used as an alternative food for their frogherds.

2 - The species *Eudrilus eugeniae* did not thrive in Winter under the above referred conditions, but laid cocoons, showing that the reproduction did not disappear completely.

3 - The production of *E. f. andrei* increased about 13 times from Winter towards Spring: in Winter, from 5 individuals resulted 15.5, plus 22.5 cocoons, in average, while in Spring, from 5 resulted 208.25 individuals, plus 11.5 cocoons. However, the biomass increased one time only.

4 - The rate of viable Winter cocoons, in *E. f. andrei*, was 28%. And the number of individual hatching, in average, per cocoon was found to be 3.5.

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