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# Reproductive potential of the earthworm *Metaphire posthuma* (Oligochaeta) in different food substrates

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**Abstract:** Reproductive potential of *Metaphire posthuma* grown on field soil, cow manure and poultry droppings was quantified in laboratory conditions to evaluate its suitability for vermicomposting and improving soil fertility in crop fields of Kumaun region. The study revealed that copulation is not a prerequisite for production of viable cocoons. The mean growth rate was 5.4 mg worm$^{-1}$ day$^{-1}$ reaching sexual maturity on 50 day and producing 0.24 cocoons worm$^{-1}$ week$^{-1}$ (single) and 6.2 mg worm$^{-1}$ day$^{-1}$ reaching sexual maturity on 50 day and producing 0.12 cocoons worm$^{-1}$ week$^{-1}$ (batches) in field soil; 8.4 mg worm$^{-1}$ day$^{-1}$ reaching sexual maturity at 51 day and producing 0.16 cocoons worm$^{-1}$ week$^{-1}$ (single) and 7.7 mg worm$^{-1}$day$^{-1}$ reaching sexual maturity at 46 day and producing 0.09 cocoons worm$^{-1}$ week$^{-1}$ (batches) in cow manure; 7.1 mg worm$^{-1}$ day$^{-1}$ reaching sexual maturity at 64 day and producing 0.15 cocoons worm$^{-1}$ week$^{-1}$ (single) and 4.9 mg worm$^{-1}$ day$^{-1}$ reaching sexual maturity at 62 day and producing 0.12 cocoons worm$^{-1}$ week$^{-1}$ (batches) in poultry droppings. After an incubation period of 23.0 ± 1.8 day, 84% of cocoons hatched with a mean of 1.3 ± 0.3 hatchlings per cocoon. Superior growth rates were observed in earthworms raised in cow manure than field soil and poultry droppings. Earthworms raised single produced more cocoons in all three substrates than those reared in batches.

**Resumen:** El potencial reproductivo de *Metaphire posthuma* que creció en suelo del campo, estiércol de vaca y excremento de aves de corral fue cuantificado en condiciones de laboratorio para evaluar su conveniencia en la elaboración de vermicomposta e incrementar la fertilidad del suelo en campos de cultivo en la región Kumaun. El estudio reveló que la copulación no es prerrequisito para la producción de capullos viables. La tasa promedio de crecimiento fue 5.4 mg lombriz$^{-1}$ día$^{-1}$, alcanzando la madurez sexual en 50 días y produciendo 0.24 capullos lombriz$^{-1}$ semana$^{-1}$ (solitarias), y 6.2 mg lombriz$^{-1}$ día$^{-1}$, alcanzando la madurez sexual en 50 días y produciendo 0.12 capullos lombriz$^{-1}$ semana$^{-1}$ (grupos) en suelo del campo; 8.4 mg lombriz$^{-1}$ día$^{-1}$, alcanzando la madurez sexual en 51 días y produciendo 0.16 capullos lombriz$^{-1}$ semana$^{-1}$ (solitarias) y 7.7 mg lombriz$^{-1}$día$^{-1}$, alcanzando madurez sexual en 46 días y produciendo 0.09 capullos lombriz$^{-1}$ semana$^{-1}$ (grupos) en estiércol de vaca; 7.1 mg lombriz$^{-1}$ día$^{-1}$, alcanzando la madurez sexual en 64 días y produciendo 0.15 capullos lombriz$^{-1}$ semana$^{-1}$ (solitarias) y 4.9 mg lombriz$^{-1}$ día$^{-1}$, alcanzando la madurez sexual en 62 días y produciendo 0.12 capullos lombriz$^{-1}$ semana$^{-1}$ (grupos) en excremento de aves de corral. Después de un periodo de incubación de 23.0 ± 1.8 días, 84% de los capullos eclosionaron, con una media de 1.3 ± 0.3 crías por capullo. Se observaron tasas de crecimiento mayores en las lombrices criadas en estiércol de vaca que en las de suelo del campo y excremento de aves de corral. Las lombrices criadas en solitario produjeron más capullos en los tres sustratos que las criadas en grupos.

**Resumo:** O potencial reprodutivo da *Metaphire posthuma* crescendo num solo de cultura, estrume de vacas e excrementos de galinha foram quantificados em condições de laboratório

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para avaliar a sua adequação para a produção de composto de minhocas e melhoria da fertilidade do solo nos campos de cultura na região de Kumaun. O estudo revelou que a copulação não é um pré-requisito para a produção viável de casulos. A taxa média de crescimento foi de 5,4 mg vermes$^{-1}$ dia$^{-1}$ atingindo a maturidade sexual em 50 dias e produzindo 0,24 casulos de minhoca-1 semana-1 (não acasalados) e 6,2 mg de minhoca$^{-1}$ dia$^{-1}$ atingindo maturidade sexual em 50 dias e produzindo 0,12 casulos minhoca$^{-1}$ semana$^{-1}$ (batches) no solo de cultura; 8,4 mg minhoca$^{-1}$ dia$^{-1}$ atingindo maturidade sexual em 51 dias e produzindo 0,16 casulos minhoca$^{-1}$ semana$^{-1}$ (não acasaladas) e 7,7 mg minhoca$^{-1}$ dia$^{-1}$ atingindo maturidade sexual em 46 dias e produzindo 0,09 casulos minhoca$^{-1}$ semana$^{-1}$ (batches) no estrume de vacas; 7,1 mg minhoca-1 dia-1 atingindo maturidade sexual em 64 dias e produzindo 0,15 casulos minhoca-1 semana-1 (não acasaladas) e 4,9 mg minhoca-1 dia-1 atingindo maturidade sexual aos 62 dias e produzindo 0,12 casulos minhoca-1 semana-1 (batches) em excrementos de galinha. Depois de um período de incubação de 23,0 ±1,8 dias, 84% dos casulos eclodem com uma média de 1,3± 0,3 eclosões por casulo. Taxas superiores de crescimento foram observadas nas minhocas criadas no estrume de vacas do que no solo de cultura ou excrementos de galinha. As minhocas cultivadas não acasaladas produziram mais casulos nos três substartos do que quando cultivadas em batches. Earthworms raised single produced more cocoons in all three substrates than those reared in batches.

**Key words:** Earthworth, foodsubstrate, Reproductive potential.

## Introduction

In vermiculture, *Eisenia fetida* and other litter dwelling earthworm species could be easily bred than large and deep burrowing earthworms (Loehr *et al.* 1985). The application of vermiculture may be used for the production of large numbers of selected species of earthworms for land restoration (Butt *et al.* 1992). The reproductive biology of *Dendrobaena rubida* and *Lumbricus rubellus* (Elvira *et al.* 1996), *Eisenia andrei* (Dominguez & Edwards 1997), *Eisenia andrei* and *D. veneta* (Fayolle *et al.* 1997) has been studied by evaluating their suitability for vermiculture. Only a few studies have been carried out in India (Chaudhuri *et al.* 2000; Dash & Senapati 1980; Julka 1988; Kale 1998).

*Metaphire posthuma* is an endogeic species common to tarai region, which exhibit a clear preference for organic substrate (Julka 1988). There is no information on the life-cycle of *Metaphire posthuma* Vail under laboratory conditions on survival, growth rates, and the duration of cocoon production on different substrates. The aim of the present study were: (1) to examine growth and maturation rates of *M. posthuma*; (2) to measure the rates of cocoon production; and (3) to study the viability and hatching success of cocoon under different conditions. These parameters have been studied to evaluate its suitability for vermicomposting and increasing soil fertility in tarai region of Kumaun Himalaya.

## Materials and methods

Adults of *M. posthuma* were collected from Shantipuri (29$^0$ 55´ N and 79$^0$ 40´ E, altitude 233 m), and cultured in glass columns (50 x 20 cm diameter) in the laboratory at 20-25 $^o$C. The worms were kept in soil with moisture content of 25-30%. The soil used in the experiment was brought from the study site, air-dried and water content was maintained at a uniform level by regular watering. The worms were fed with air-dried cow manure and poultry droppings (5 g dry wt) every 15 days.

Cocoons collected from the stock culture were hatched separately in pots (15 cm diameter, 20 cm deep) using cow manure, poultry droppings with urine or straw, and field soil for growth studies. The nutritive medium was prepared by air-drying, grinding and then sieving through a 2 mm sieve.

pH of the food substrates was determined using pH meter. Organic C was determined using the wet oxidation method and N by Kjel auto Vs KTP Nitrogen analyzer (Jackson 1958; Misra 1968). Cellulose and lignin were determined by the method of Goering & Van Soest (1975).

For the growth study, new hatchlings collected from the pots were weighed individually after rinsing with distilled water, gently dried on filter paper and weighed. The hatchlings were placed in Petri dishes (15 cm diameter) single and in batches of five in each type of substrate and covered with plastic mesh (1 mm) for ventilation. Fresh cow manure, poultry droppings were added to each container every 15 days, @ 1 g dry wt for the worms kept single and 5 g dry wt for the worms kept in batches. Number of replicates for each experiment was five. The worms were weighed (with full guts) at every 15 day interval for 195 days to avoid any nutritional deficiency.

At each weighing, the worms were examined to determine the extent of maturation as indicated by clitellum development. In order to determine the onset of cocoon production, the substrate surface was examined every day under a magnifying lens as soon as the clitellate worms were observed.

The cocoons were counted and weighed. Before weighing, the cocoons were washed lightly in distilled water and most of the debris and organic particles adhering to the sticky outer layer were removed with a fine brush. The cocoons kept single were randomly divided into five batches and incubated into Petri dishes. Five media were used for incubation, fine-particle cow manure, poultry dropping, field soil, distilled water (replaced with clean water every 7 days), and moist filter paper (kept moist by adding distilled water periodically). The cocoons were observed every 24 h and hatchlings were removed daily, weighed and preserved in 70% ethanol. The hatchling success of the cocoons in different media and over the incubation period was determined together with the weight of hatchlings per cocoon.

The regression analysis was done using linear correlation coefficient (SAS 1987).

## Results and discussion

### *Food*

The composition of food given to *Metaphire posthuma* differed with respect to the amount of C, which was higher in cow manure than in field soil (Table 1). Differences in C:N ratio and pH were also observed in the food substrates.

### *Growth rate*

The mean biomass of newly hatched worms was 2.6 ± 0.2 mg (single) and 2.2 ± 0.1 mg (batches) in field soil, 2.6 ± 0.2 mg (singly) and 2.0 ± 0.1 (kept in batches) in cow manure; and 2.4 ± 0.2 mg (single) and 2.2 ± 0.3 mg (batches) in poultry droppings. The mean growth rate after the worms attained the maximum biomass was 5.4 mg $worm^{-1}$ $day^{-1}$ or 6.1 mg $g^{-1}$ $day^{-1}$, reaching a mean weight of 892 ± 41 mg $worm^{-1}$ (single) and 6.2 mg $worm^{-1}$ $day^{1}$ or 6.7 mg $g^{-1}$ $day^{-1}$, reaching a mean weight of 933 ± 27 mg $worm^{-1}$ (batches) in field soil (Fig.1a). In cow manure, the mean growth rate was 8.4 mg $worm^{-1}$ $day^{-1}$ or 7.4 mg $g^{-1}$ $day^{-1}$, reaching a mean weight of 1140 ± 93 mg $worm^{-1}$ (single) and 7.7 mg $worm^{-1}$ $day^{-1}$ or 7.4 mg $g^{-1}$ $day^{-1}$, reaching a mean weight of 1042 ± 52 mg $worm^{-1}$ (batches) (Fig. 1b). The mean growth rate was 7.1 mg $worm^{-1}$ $day^{-1}$ or 6.0 mg $g^{-1}$ $day^{-1}$, reaching a mean weight of 1170 ± 84 mg $worm^{-1}$ (single) and 4.9 mg $worm^{-1}$ $day^{-1}$ or 5.5 mg $g^{-1}$ $day^{-1}$, reaching a mean weight of 887 ± 33 mg $worm^{-1}$ (batches) in poultry droppings (Fig. 1c). The worms died after attaining the maximum biomass and also showed a decline in growth rates.

According to growth curves for each food (Fig. 1a-c), growth rates were superior in cow manure and field soil than on poultry droppings. Final mean biomass was also greater in worms raised single than those reared in batches in cow manure and poultry droppings was lower in field soil. The availability of food was never a limiting factor in

**Table 1.** Selected chemical attributes of food substrates provided to *Metaphire posthuma* in the present study.

| Chemical attributes | Substrates | | |
|---|---|---|---|
| | Field soil | Cow manure | Poultry droppings |
| pH | 0.8 | 8.5 | 8.8 |
| Lignin (%) | – | 15.2 | 13.2 |
| Ligno-celluslose (%) | – | 3.9 | 5.2 |
| Ash (%) | – | 0.89 | 1.3 |
| Total C (%) | 1.42 | 20.3 | – |
| N (%) | 0.073 | 0.23 | – |
| C:N | 19.5 | 88.3 | – |

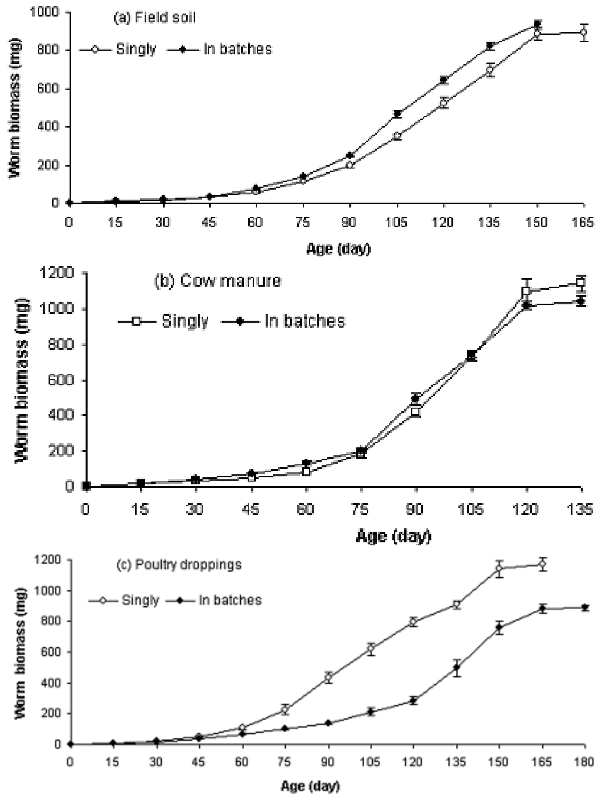


**Fig 1.** Changes in biomass of *Metaphire posthuma* raised single and in batches in field soil (a), cow manure (b) and poultry droppings (c). Bars represent ±SE.

the present study. Significant differences were observed in growth rates on each food substrates ($r = 0.937$, $P < 0.01$ raised single and $r = 0.832$, $P < 0.01$ raised in batches in field soil; $r = 0.911$, $P < 0.01$ single and $r = 0.932$, $P < 0.01$ batches in cow manure, and $r = 0.965$, $P < 0.01$ single and $r = 0.918$, $P < 0.01$ batches in poultry droppings). Kale *et al.* (1982), in case of *Perionyx excavatus* and Dominguez & Edwards (1997), in *Eisenia andrei*, have also reported slower growth rates in worms reared in batches than those reared single.

Growth rates of *M. posthuma* were lower in comparison to the findings of Hartenstein & Hartenstein (1981) for *Eisenia fetida* fed on wet activated sludge (14 mg worm$^{-1}$ day$^{-1}$); for immature *E. andrei* in batch culture (4.5 mg worm$^{-1}$ day$^{-1}$, Cluzeau *et al.* 1992); for *E. fetida* fed on cattle manure (7 mg worm$^{-1}$ day$^{-1}$, Reinecke *et al.* 1992); for *Lumbricus rubellus* fed on cow manure (8.0 mg worm$^{-1}$ day$^{-1}$, Elvira *et al.* 1996), for *E. andrei* fed on four fresh green waste (7.2 mg worm$^{-1}$ day$^{-1}$, Frederickson *et al.* 1997); for *Dendrobaena veneta* fed on horse manure (14.1 mg worm$^{-1}$ day$^{-1}$) and fed on paper sludge (21.3 mg worm$^{-1}$ day$^{-1}$) (Fayolle *et al.* 1997); for *Metaphire houletti* fed on different food substrates (2.9 to 4.1 mg worm$^{-1}$ day$^{-1}$, Kaushal *et al.* 1999).

### *Maturation*

The first indication of clitellum development appeared of 50th day after hatching in worms reared single and in batches in field soil and 100 % worms became clitellate by 66th day. In cow manure, clitellum appeared on 46th day reared in batches and 51st day reared single and 100 % worms became clitellate on 62 (batches) to 64 day (single). Clitellum was recorded as on 46th day (single) or 49th day (batches) in poultry droppings, with all worms becoming clitellate on 60th (single) to 67th (batches) day (Fig. 2). When three substrates are considered together, maturation of all worms was completed between 46 to 67 days (Fig. 2). Worms reared single and in batches did not differ much to attain sexual maturity in field soil but they did differ in cow manure and poultry droppings. Neuhauser *et al.* (1979) reported that food availability and population density determined sexual maturation in earthworms. Worms raised single and those raised in batches did not differ much with respect to the time taken to reach maturity (Fig. 2).

### *Cocoon production*

Worms kept single in the three food substrates produced cocoons, which hatched successfully. The clitellum of the worm becomes swollen before the formation of the cocoon. The cocoons of *M.*

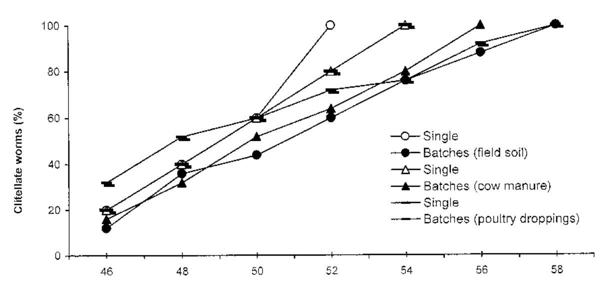


**Fig 2.** Percentage clitellated individuals of *Metaphire posthuma* raised single and in batches in field soil, cow manure and poultry droppings at different ages.

**Table 2.** Cocoon production of *Metaphire posthuma* kept single and in batches in field soil, cow manure and poultry droppings.

| Age of worms (day) | Single | | | | | In batches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Worm biomass (mg) | Total cocoons (no.) | Mean no. of cocoons week$^{-1}$ | Cocoon biomass (mg) | Mass of hatchlings (mg) | Worm biomass (mg) | Total cocoons (no.) | Mean no. of cocoons week-1 | Cocoon biomass (mg) | Mass of hatchlings (mg) |
| Field soil | | | | | | | | | | |
| 120 | – | – | – | – | – | 643 ± 39 | 2 | 0.03 | 52 | 4 |
| 135 | – | – | – | – | – | 820 ± 44 | 9 | 0.17 | 240 | 20 |
| 150 | 887 ± 86 | 3 | 0.28 | 81 | 14 | 933 ± 27 | 12 | 0.22 | 312 | 24 |
| 165 | 892 ± 41 | 2 | 0.19 | 64 | 21 | 909 ± 24 | 2 | 0.04 | 52 | 5 |
| Cow manure | | | | | | | | | | |
| 90 | – | – | – | – | – | 490 ± 67 | 1 | 0.02 | 30 | 2 |
| 105 | – | – | – | – | – | 743 ± 32 | 7 | 0.13 | 182 | 20 |
| 120 | 1096 ± 145 | 3 | 0.28 | 84 | 9 | 1018 ± 35 | 12 | 0.22 | 292 | 34 |
| 135 | 1140 ± 93 | 2 | 0.19 | 54 | 6 | 1042 ± 52 | 4 | 0.08 | 105 | 11 |
| 150 | 986 ± 51 | 1 | 0.09 | 28 | 2 | 643 ± 32 | 1 | 0.02 | 24 | 3 |
| 165 | 723 ± 28 | 1 | 0.09 | 30 | 2 | – | – | – | – | – |
| Poultry droppings | | | | | | | | | | |
| 105 | 620 ± 78 | 1 | 0.09 | 29 | 2 | – | – | – | – | – |
| 120 | 795 ± 51 | – | – | – | – | 285 ± 52 | 1 | 0.02 | 29 | 1 |
| 135 | 909 ± 30 | 1 | 0.09 | 25 | 2.0 | 495 ± 108 | 7 | 0.13 | 197 | 18 |
| 150 | 1140 ± 104 | 3 | 0.28 | 88 | 17.0 | 757 ± 87 | 12 | 0.22 | 283 | 33 |
| 165 | 1170 ± 84 | – | – | – | – | 887 ± 33 | 5 | 0.09 | 143 | 17 |

*posthuma* have on oval shape. There are two sticky fibrous spines at both ends of the cocoon to which organic particles can adhere. The cocoons are soft and light yellowish directly after their formation. They harden rapidly and the colour changes to reddish brown due to blood vessels of pre-emergent hatchling developing immediately before hatching. The cocoons become transparent so that embryos and young worms can be seen through the wall. The mean length of the cocoons produced by worms raised in field soil was 3.4 ± 0.1 mm (range 2.5-4.0 mm; n = 30) and the mean diameter 2.5 ± 0.9 mm (range 1.5-3.5 mm; n = 30).

Data on the cocoon production of *Metaphire posthuma* are presented in Table 2. With regard to reproduction rate, *M. posthuma* kept in batches began cocoon production earlier (after 120 day) than those kept single (after 150 day) in field soil. In cow manure, cocoon production started after 90 day (batches) and after 120 day when single. In poultry droppings, it began after 105 day (single) and after 120 day (batches). In field soil, mean cocoon production rate when kept single was 0.235 ± 0.005 (peaking between 150 and 165 day) and in batches 0.117 ± 0.047 cocoons per mature worm per week (peaking between 120 and 165 day) (Table 2). In cow manure, 0.163 ± 0.046 cocoons per mature worm per week were recorded (peaking between 120 and 165 day, single) and 0.094 ± 0.039 cocoons per mature worm per week (peaking between 90 and 150 day, in batches) (Table 2). Poultry droppings showed 0.153 ± 0.063 cocoons per mature worm per week (peaking between 105 and 150 day, single) and 0.117 ± 0.043 cocoons per mature worm per week (peaking between 120 and 160 day, in batches) (Table 2). Cocoon production stopped as the worms aged and died. Cocoon mass relationship with the mass of the parent adult was non-significant in all three substrates separately and also when all substrates considered together.

Mating does not seem to be prerequisite for cocoon production in *M. posthuma* since worms kept single and in batches in different food substrates produced cocoons which hatched successfully. Evans & Guild (1948) found that cocoon produced by unmated sexually mature specimens of the genera *Allolobophora*, *Dendrobaena* and *Octalasion* did hatch, while

**Table 3.** Number of hatchling per cocoon and hatchling success of cocoon of *Metaphire posthuma*.

| Medium | No. of cocoons used | No. of cocoons and % of total number of cocoons that hatched | | | | | | | | | | No. of cocoons hatched | Hatching success % | No. of hatchlings | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 hatchling | | 2 hatchlings | | 3 hatchlings | | 5 hatchlings | | 10 hatchlings | | | | By total cocoons | By cocoons hatched |
| | | No. | % | No. | % | No. | % | No. | % | No. | % | | | | |
| Cow manure | 10 | 7 | 70 | 3 | 30 | – | – | – | – | – | – | 10 | 100 | 1.3 ± 0.2 | 1.3 ± 0.2 |
| Poultry waste | 10 | 5 | 50 | 3 | 30 | 1 | 10 | 1 | 10 | – | – | 10 | 100 | 1.9 ± 0.4 | 1.9 ± 0.4 |
| Moist soil | 10 | 7 | 78 | 1 | 11 | – | – | – | – | 1 | 11 | 9 | 90 | 1.9 ± 0.9 | 2.1 ± 1.0 |
| Wet cotton | 10 | 6 | 100 | – | – | – | – | – | – | – | – | 6 | 60 | 0.6 ± 0.0 | 1.0 ± 0.0 |
| Distilled water | 10 | 7 | 100 | – | – | – | – | – | – | – | – | 7 | 70 | 0.7 ± 0.0 | 1.0 ± 0.0 |
| Total | 50 | 32 | 76 | 7 | 16 | 1 | 2 | 1 | 1 | 1 | 2 | 42 | 84 | 1.3 ± 0.3 | 1.5 ± 0.2 |

cocoons produced by unmated specimens of the genera *Lumbricus* and *Eisenia fetida* did not hatch. *Eudrilus evgeniae* produced cocoons even through copulation had not taken place, but these cocoons never hatched (Viljoen & Reinecke 1989).

With regards to reproduction rate, *M. posthuma* commences cocoon production later than *Perionyx excavatus* (Kale *et al.* 1982), *Eisenia fetida* (Venter & Reinecke 1988), *Dendrobaena rubida* (Elvira *et al.* 1996), *E. andrei* (Fayolle *et al.* 1997). The overall mean cocoon production rate of *M. posthuma* recorded in the present study was much lower than those reported for *Eisenia fetida* (0.5 cocoons worm$^{-1}$ day$^{-1}$, Venter & Reinecke 1988), *Endrilus eugeniae* (1.4 cocoons worm$^{-1}$ day$^{-1}$, Hallatt *et al.* 1990), *Eisenia andrei* (0.26 cocoons worm$^{-1}$ day$^{-1}$, Cluzeau *et al.* 1992; 0.225 cocoons worm$^{-1}$ day$^{-1}$, Frederickson *et al.* 1997), *Dendrobaena rubida* (0.21 cocoons worm$^{-1}$ day$^{-1}$, Elvira *et al.* 1996), and *Dendrobaena veneta* (0.74 cocoons worm$^{-1}$ day$^{-1}$, Fayolle *et al.* 1997), but was higher than for *Metaphire houletti* (0.016 to 0.028 cocoons worm$^{-1}$ day$^{-1}$, Kaushal *et al.* 1999).

### *Hatchling success of cocoons and fecundity*

The hatchling success varied according to the different media used, the highest being in cow manure and poultry waste, 100% each, and the lowest in wet cotton, 60%. An average of 84% was obtained when all five media were combined together. The infertile cocoons turned black due to fungal infestation before 4-6 days of incubation. This might have influenced the hatch record. A hatching success of 60-100% per cocoons recorded in the present study falls in the range of reported values for other species. Loehr *et al.* (1985) obtained 73% hatching success for *Eudrilus eugeniae* in aerobically maintained sludge. Hartenstein & Hartenstein (1981) and Venter & Reinecke (1988) reported that 33-88% of the cocoons of *Eisenia fetida* hatched, giving between 1.6 and 3.6 juvenile worms per fertile cocoon. van Gestel *et al.* (1992) reported that on average 91-96% of the cocoons of *E. anderi* incubated in artificial soil were fertile, giving 2.6-2.8 juvenile worms/fertile cocoon. Viljien & Reinecke (1989) reported 2.77 hatchlings per cocoon for *Eudrilus eugeniae*, and Elvira *et al.* (1996) reported 1.67 hatchlings per cocoon for *Dendrobaena rubida*.

Mean incubation period of cocoons kept in field soil was 23.0 ± 1.8 day; 27.5 ± 1.1 day in wet cotton and 30.3 ± 0.4 day in distilled water. The mean incubation period of 23 to 30 days recorded at a room temperature of 20-25 $^{0}$C for *M. posthuma* is similar to the reported 24-30 day for *Drawida nepalensis* (Kaushal & Bisht 1992; Kaushal *et al.* 1995), 36.5 day for *Dendrobaena rubida* (Elvira *et al.* 1996), 43-90 day for *Dendrobaena veneta* (Fayolle *et al.* 1997), and 31.9 day for *Metaphire houletti* (Kaushal *et al.* 1999). On average, 1.5 ± 0.23 hatchlings emerged per cocoon for all substrates from 42 cocoons of *M. posthuma* (Table 3).

Overall, the present study indicates that cow manure and poultry dropping are preferred to field soil as a source of food for *Metaphire posthuma*, as evident by faster growth rates of earthworms raised in cow manure (raised single) than those raised in field soil (raised single), although no significant differences were observed in cocoon production in different substrates. The potential use of *M. posthuma* as a waste decomposer and for plant growth depends, among other factors, on its growth and reproductive rates. Although this species has a lower growth rate and produces fewer cocoons and hatchlings per cocoon than other vermicomposting species, it has a much shorter life cycle and can produce without mating, hence, *M. posthuma* could offer greater advantage under certain conditions. These results also indicate that application of organic manure may be of vital importance in the development of sustainable population of *M. posthuma* in the agricultural fields to influence soil fertility and crop production.

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