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Productivity of Earthworms (*Pheretima sp.*) with the Combination of Cow Dung and Flour of Green Mussel Shell Flour as Cultivation Media

Produktifitas Cacing Tanah Pheretima sp. dengan Kombinasi Kotoran Sapi dan Tepung Cangkang Kerang Hijau Sebagai Media Budidaya

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ABSTRACT

Composting and mixing organic and inorganic materials are among the abilities of earthworms. The survival of earthworms is influenced by several environmental factors, including media temperature, media pH, media moisture, media texture, and media nutrient content. Shellfish shells are underutilized waste that is increasing in quantity as more people consume food from the sea. This study aims to analyze the productivity of earthworms (*Pheretima sp.)* using a combination of cow dung and green shellfish shells as a cultivation media. The study uses a Completely Randomized Design (CRD) method with four treatments and three replications, and the obtained results are analyzed using the Tukey test. The observed parameters are temperature, moisture, pH, total body weight, population, cocoon count, and media depletion. The results of the study show a significant (P<0.05) on the use of green shellfish shells in all measured parameters. The treatment P1 increase the body weight of earthworms (*Pheretima sp.*) by 33.3 grams and resulted in a media loss 262.67 grams. The use of green mussel shell flour at a concentration of ≥ 10% can increase the productivity of soil worms.

Keywords: Cow dung, green mussel shell, *Pheretima sp.,* productivity

ABSTRAK

Mendekomposisi dan mengaduk material organik dan anorganik merupakan salah satu kemampuan dari cacing tanah. Keberlangsungan kehidupan cacing tanah dipengaruhi oleh beberapa faktor lingkungan yakni suhu media, pH media, kelembaban media, tekstur media, dan kandungan nutrien media. Cangkang kerang merupakan limbah yang pemanfaatannya masih kurang dan jumlahnya semakin banyak seiring dengan banyaknya masyarakat mengkonsumsi makanan yang berasal dari laut. Penelitian ini bertujuan untuk menganalisis produktivitas cacing tanah jenis (*Pheretima sp.)* dengan kombinasi kotoran sapi dan cangkang kerang hijau sebagai media budidaya. Penelitian ini menggunakan metode Rancangan Acak Lengkap (RAL) dengan empat perlakuan dan tiga ulangan, hasil yang diperoleh dianalisis dengan uji Tukey. Parameter yang diamati adalah suhu, kelembaban, pH, bobot badan total, populasi, jumlah kokon, dan penyusutan media. Hasil penelitian menunjukkan pengaruh nyata (P<0.05) terhadap penggunaan cangkang kerang hijau pada semua parameter yang diukur. Perlakuan P1 meningkatkan bobot badan cacing tanah (*Pheretima sp.*) 33.3 gram dan susut media 262.67 gram. Penggunaan tepung cangkang kerang hijau ≥ 10% dapat meningkatkan produktivitas cacing tanah.

Kata Kunci: cangkang kerang hijau, kotoran sapi, *Pheretima sp.,* produktivitas

INTRODUCTION

Earthworms are low-level animals that do not have a backbone and have many benefits, such as being waste decomposers, livestock feed ingredients, medicinal resources, and cosmetics (Ratnawati *et al*. 2019). The commonly cultivated earthworm species in Indonesia belong to the families *Megascolicidae* and *Lumbricidae*, including *Lumbricus, Eisenia, Pheretima, Perionyx, Diplocardi,* and *Lidrillus* (Sosek 2015). The *Pheretima sp.* earthworm species is a type of earthworm that exhibits good adaptation to cultivation media. *Pheretima sp.* earthworms have a wide tolerance to environmental conditions, as they can thrive and reproduce well in both organic and inorganic land conditions (Jayanthi *et al.* 2014). *Pheretima sp*. earthworms are larger in size compared to *Lumbricus rubellus* worms. *Pheretima sp*. earthworms have a length of approximately 11.5-14 cm with segments ranging from 125-145 segments (Firmansyah *et al.* 2017), while *Lumbricus rubellus* worms have a length ranging from 7.9-14.5 cm with 95-120 segments (Mambrasar *et al*. 2018).

The ability of *Pheretima sp*. earthworms to decompose both organic and inorganic materials in the soil needs to be supported by adequate environmental factors. The environmental is a factor's that influence the life and growth of earthworms include soil temperature, soil pH, soil moisture, soil water content, soil texture, and types of organic matter (Edward and Lofty 1977; Kale and Karmegan 2010). The primary habitat of earthworms is well-suited as both a cultivation media and a food source in the form of animal dung. According to Brata (2009), suitable media for earthworm cultivation include animal dung such as cow, buffalo, horse, sheep, goat, and chicken dung. Sihombing (2000) states that cow dung is suitable as a cultivation media for earthworms due to its high crude protein content.

In addition to the diversity of terrestrial regions, Indonesia also possesses high diversity in its aquatic regions, which brings forth numerous fisheries products and capabilities for Indonesian citizens, especially those living in coastal areas. Green mussels are one of the aquatic resource commodities with great potential in Indonesia (Sutaman *et al.* 2016). Along with the high capability of fisheries products, coastal communities face issues such as the accumulation of shell waste (Kusumaningrum *et al.* 2021). This is due to the low understanding among the residents regarding shell waste management, which poses a threat to the cleanliness and health of communities surrounding the coastal areas. Tongchan (2009) states that in Thailand, almost all fillet industry waste (shell waste) is utilized for livestock feed and handicrafts. However, the utilization for livestock feed and handicrafts is still limited. Therefore, this research aims to utilize green mussel shells as a cultivation media for earthworms as an alternative solution to enhance the value of mussel shells and reduce environmental pollution.

MATERIALS AND METHODS

Materials

The tools used include a box-shaped cultivation container with dimensions of 38 cm x 30 cm x 12 cm, gloves, a mini shovel, a spray bottle, a digital scale with a precision of 0.01 g, a digital thermohygrometer, a soil meter, tarpaulin sacks, and writing utensils. The materials used include earthworms *Pheretima sp.*, cow dung, green mussel shells, and water. A total of 50 grams of *Pheretima sp*. earthworms are prepared for each research box.

Methods

Media preparation. The test container consists of 12 plastic boxes, with the bottom of each box pierced and cleaned with water. All plastic boxes are filled with a combination of cow dung and green clamshell flour according to the treatment, with a total weight of 2 kg. The cow dung used has been dried and exposed to sunlight for 5-7 days to reduce moisture and ammonia content (Rahayu 2022). The green clamshells used are thoroughly washed, dried, and powdered with a 60-mesh size. The treatments used are as follows:
P0: 100% cow dung (control);
P1: 90% cow dung + 10% green clam shell;
P2: 80% cow dung + 20% green clam shell;
P3: 70% cow dung + 30% green clam shell;

Spreading *Pheretima sp.*. *Pheretima sp.* are spread in a container containing a combination of media weighing 50 g. The worms used are mature worms aged 2-3 months. The condition of the earthworms after spreading should be observed to ensure their compatibility with the media. Earthworms will burrow into the media if it is suitable for their growth and reproduction.

Water spraying. Water spraying is crucial to maintain the growing media and moisture necessary for survival and reproduction of earthworms. Water is administered through spraying every 3 days, with 100 ml per media.

Data collection. Weight increment, earthworm population, and cocoon count data are collected every 7 days for 28 days in each box by separating the worms from the media using the hand-sorting method. Media loss data is collected on day 28. Temperature, humidity, and pH measurements are taken from five points in each experimental container, including the four corners and the center. Temperature and humidity of the media are measured daily, while pH measurements of the media are taken every 3 days since the initial spreading of earthworms into the media.

1. Total body weight

The weight of the earthworms is measured by weighing the worms on day 0, 7, 14, 21, and 28.

$$WG = TWn - W0$$

where: WGR = Weight gain rate; TWn = Total weight on day n; W0 = Initial weight of the previous measurement

2. Population count

The population of earthworms is determined by counting the number of individuals on day 0, 7, 14, 21, and 28.

$$PC = CPn - C0$$

where: PC = Population count rate; CPn = Count of individuals on day n; C0 = Initial count of population from the previous measurement

3. Cocoon count

The count of earthworm cocoons is determined by counting the number of cocoons on day 0, 7, 14, 21, and 28.

$$CC = CCn - CN0$$

where: CCR = Cocoon count rate; NCn = Count of cocoons on day n; N0 = Initial cocoon count from the previous measurement

4. Media loss

Media loss of earthworms is calculated by weighing the media on day 0 and day 28.

$$ML = Mf - Mi$$

where: ML = Media loss; Mf = Final media weight; Mi = Initial media weight.

Data Analysis

This study was conducted using the Completely Randomized Design (CRD) method with 4 treatments: control without substitution (P0), 90% cow dung + 10% green mussel shell (P1), 80% cow dung + 20% green mussel shell (P2), and 70% cow dung + 30% green mussel shell (P3). Each treatment was replicated 3 times, resulting in a total of 12 experimental units. The data obtained will be analyzed using analysis of variance (ANOVA) at a 95% confidence level, followed by Tukey's test. The following mathematical model will be used:

$$Y_{ij} = \mu + P_{(i)} + \varepsilon_{(ij)}$$

Exp:
Yij : the observation,
μ : the overall mean,
P(i) : the effect of treatment at the *i*-th level on the variable, and
Ɛ(ij) : the experimental error of the *i*-th treatment on the *j*-th replication.

RESULTS AND DISCUSSION

Cultivation Media Conditions for *Pheretima sp*.

Worm productivity is greatly influenced by and dependent on the cultivation media, which serves as both a living media and a food source. According to Munir (2020), earthworms are highly sensitive to foreign stimuli due to their mucous glands, which function to aid respiration, lubricate the body, and facilitate movement in the soil (Ciptanto and Paramita 2011). Media conditions, including pH, temperature, humidity, and feed type, are important factors in enhancing the growth and reproduction of earthworms (Manurung *et al.* 2014). The following data presents the conditions of the earthworm cultivation media, including temperature, humidity, and pH in Table 1.

The research results indicate that the average temperature range of the media is between 27.37-27.48 ℃, and the average relative humidity falls within the range of 77.38-78.29%. Based on these findings, the cultivation media is suitable for earthworm cultivation, in line with Sihombing (2000) statement that media for earthworms generally have a temperature range of 21-29 ℃ and humidity of 50-80%. In addition to suitable temperature and humidity, the acidity level (pH) of the media also significantly affects the survival of the worms. According to Rahayu *et al.* (2021), the life of earthworms is influenced by abiotic factors such as temperature, humidity, and soil pH.

Based on the analysis results, the pH media shows a significant (P<0.05) among the four treatments, ranging from 6.42 to 6.59 on average. This indicates that the pH of the soil worm cultivation media tends to be neutral and still within the optimal pH range for the growth and reproduction. The optimal pH for cultivation media falls within the range of 5-7.2 (Brata 2009). Media that is too acidic or alkaline can affect the growth of earthworms. According to Sihombing (2000), excessively acidic media can cause the rupture of earthworm's clitellum, while overly alkaline media can cause the worms to escape or die as they find it difficult to burrow into the media.

The Total Body Weight of *Pheretima sp*.

Weight gain of the earthworm *Pheretima sp*. is one of the important productivity factors in cultivation. Body weight data collection is conducted every week. The weight gain data of *Pheretima sp*. earthworms during cultivation is presented in Table 2.

Based on the research results and advanced statistical analysis, there were significant differences (P<0.05) observed among each treatment. The mean weight gain in treatment P1 was greater than that in treatments P0, P2, and P3. Treatment P1 had an average weight gain of 33.29 grams at the end of the cultivation period. This is believed to be due to the sufficient supply of earthworm's nutritional needs, particularly protein, and the texture of the media being suitable for the desired conditions of the worms. According to Nur *et al*. (2016), a good earthworm feed should contain 9%-15% protein and adequate moisture. Sihombing (2000)

Table 1. Average temperature, relative humidity (RH), and pH.

Treatment	Temperature (°C) ± SD	Relative Humidity ± SD (%)	pH ± SD
P0	27.48±1.65	78.29±8.22	6.59±0.11a
P1	27.48±1.74	77.63±7.93	6.55±0.05a
P2	27.37±1.52	77.42±7.64	6.42±0.07b
P3	27.48±1.42	77.38±7.08	6.43±0.04b

Different letters in the same column show different real results (P<0.05)

Table 2. Average of total body weight, population of earthworms, number of cocoons, and media loss during the study.

Variable	Treatment ± SD			
	P0	P1	P2	P3
WG (grams)	6.86±4.18b	33.29±0.66a	4.60±3.68b	-28.73±2.18c
PC (tail)	180.67±100.66a	44.00±26.18b	0.33±4.46bc	-13.00±3.44c
CC (grain)	25.92±39.44	33.00±27.12	26.33±25.03	0.42±0.70
ML (grams)	254.67±27.06a	262.67±15.14a	189.33±34.49b	137.00±31.58b

WG = Total body weight rate; PC = Population count rate; CC = Cocoon count rate; ML = Media loss. Different letters on the same line show different real results (P<0.05).

added that a high content of crude fiber plays a role in maintaining moisture in the cultivation media.

Treatment P3 experienced a decrease from the first week, with the weight of the worms at the end of the study being 21.27 grams. This is believed to be due to the condition of the media, which contains green mussel flour with a particle size of 60 mesh, causing a decrease in the worms' food absorption capacity. In addition to the reduced feeding capacity, the media with a high amount of green mussel shell flour has a sandy texture and a high ash content. According to Safitri (2010), the condition (texture) and availability of nutrients in the media significantly affect the body weight of soil worms. Edwards and Lofty (1977) stated that soil with a high sand content is generally disliked by earthworms because it has coarse particles that are unable to retain sufficient water for the worms' needs.

The Population of *Pheretima sp*.

One of the productivity factors that can be observed in earthworm cultivation is population growth. Based on the research data (Table 2), treatment P0 showed a significant (P<0.05) compared to other three treatments. The highest population growth was found in treatment P0, with an average of 180.67 worms. This is because the media in treatment P0 had a finer and looser texture. According to Putra *et al*. (2018), a media with good looseness facilitates the entry of oxygen into the media, allowing the worms to engage in normal production activities.

In treatment P3, with a mixture of 30% green mussel shell flour, there was a significant decline. This is suspected to be due to the relatively high ash content and the texture of the media, which is less fine and slightly sandy, resulting in reduced food absorption capacity and disrupted reproduction of the earthworms. Hartono *et al*. (2021) stated that factors such as moisture, feed, and media texture can affect the mortality rate of earthworms, with higher levels resulting in increased mortality. Manurung *et al*. (2014) also stated that a decrease in nutritional content from the previous day can lead to a decrease in productivity in earthworms.

The total cocoons of *Pheretima sp*.

Cocoons in earthworms are eggs that result from the mating process of earthworms. The cocoons containing the eggs move towards the mouth and exit the body of the earthworm (Wirosoedarno *et al.* 2019). Based on the data analysis in Table 2, it is shown that the average production of earthworm cocoons did not differ significantly (P>0.05). The highest average cocoon production was observed in treatment P1 with 33.00±27.12 cocoons, while the lowest average production was found in treatment P3, which was only 0.42±0.70 cocoons. Although treatment P1 had the highest average cocoon production of 33.00 (P>0.05), it was not accompanied by an increase in population in treatment P1. As seen in Table 2, the new population growth occurred in the 4th week, indicating that cocoons take about 7-21 days to hatch. Sihombing (2000) stated that cocoons produced by earthworms will hatch after 7-21 days.

In treatment P3, there was a very minimal cocoon production. This is suspected to be due to the drier and slightly sandy texture of the media in treatment P3, which makes it difficult for the worms to absorb nutrients, resulting in a significantly low average cocoon production of only 0.42±0.70 cocoons. This is also related to the decrease in population and weight of Pheretima sp. earthworms observed in treatment P3. Pangestika *et al.* (2016) stated that the availability of nutritional content in the media and its feed is a supporting factor in the growth and cocoon production of earthworms.

Media Loss of *Pheretima sp*.

Media loss refers to the reduction or difference in weight between the initial weight of the cultivation media and the final weight after being decomposed by earthworms. Based on the research results (Table 2), the percentage of green mussel shell flour had a significant effect (P<0.05) on the shrinkage of the Pheretima sp. earthworm cultivation media. The highest shrinkage occurred in treatment P1, while the lowest shrinkage occurred in treatment P3. This is suspected to be due to the type and texture of the media used in the earthworm cultivation. Hanafiah *et al*. (2010) suggested that the use of cow dung as the media for earthworms is preferred compared to other livestock dungs. Sembiring (2019) mentioned that the structure of the media, pH of the media, and organic matter content in the media influence the consumption of earthworms. Rahayu (2022) stated that earthworms do not prefer a sandy media for their cultivation.

In treatments using 100% cow dung (P0) and 90% cow dung + 10% green mussel shell flour (P1), there was higher shrinkage due to the media having a finer texture compared to treatments with more than 10% green mussel shell flour added. This is in line with the statement by Sofyan (2007), which suggests that a finer particle size of the media can increase the consumption of earthworms. The consumption of Pheretima sp. earthworms is directly proportional to the weight gain observed, as shown in Table 2. According to

Liberty *et al*. (2019), earthworm consumption in the media is used to increase their body weight.

Treatment P1 experienced the highest weight loss of the media, amounting to 262.67 grams. This shrinkage is caused by the fact that the living media of the earthworms also serves as a food source for them. In accordance with the statement, treatment P1, which has a composition of 90% cow dung + 10% green mussel shell flour, experienced a greater decrease compared to treatment P0, which has a composition of 100% cow dung, with a decrease of 8 grams. This aligns with the opinion of Putra *et al*. (2018) who stated that pure cow dung without other additives is less preferred by earthworms, as it can become denser and hinder their movement.

CONCLUSION

The combination of cow dung with green mussel shell flour has an influence on the productivity of Pheretima sp. earthworms in terms of total body weight and the amount of media loss. The use of green mussel shell flour at a concentration of ≥ 10% can increase the productivity of soil worms.

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