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Performance of Earthworm (*Lumbricus rubellus*) During Different Transportation Durations

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ABSTRACT

Earthworms (*Lumbricus rubellus*) are one of the soil organisms with a protein content of approximately 76%, providing significant benefits to human life. It is necessary to transport livestock/animals from their place of origin to the destination for processing or further cultivation in order to maximize the utilize of earthworms. During transportation, various challenges are encountered, leading to a decline in the performance of earthworms. The aimed of this research was to study the influence of different transportation durations on the performance of earthworms. A Completely Randomized Design (CRD) was employed with three different transportation duration treatments and three replications. Further analysis would be conducted using Duncan's multiple-range test if the results differred significantly. Variables observed in this study included the conditions of the media pH, media temperature and humidity, environmental temperature, and humidity, weight loss and earthworm mortality. The results indicated that transportation duration significantly differs (P<0.05) in affecteding the weight loss and mortality earthworms. The 3-hour transportation treatment resulted in the highest weight loss (82.33 g, equivalent to 55.63%) and mortality (411.87 g, equivalent to 91.07%).

Keywords: Earthworm, *Lumbricus rubellus,* performance, transportation

ABSTRAK

Cacing tanah (*Lumbricus rubellus*) merupakan salah satu makhluk hidup biota tanah yang memiliki kandungan protein sekitar 76% yang memiliki manfaat cukup banyak bagi kehidupan manusia. Untuk dapat dimanfaatkan secara maksimal perlu untuk memasok ternak/hewan dari tempat asal ke tempat tujuan untuk pengolahan atau budidaya lanjutan. Pada saat mentransportasikan banyak ditemukan kendala yang menyebabkan menurunnya performa cacing tanah. Penelitian ini bertujuan mempelajari pengaruh perbedaan durasi transportasi terhadap performa cacing tanah. Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan 3 perlakuan durasi pengangkutan yang berbeda dengan 3 ulangan, jika hasil yang diperoleh berbeda maka dianalisis lanjut dengan uji lanjut Duncan. Peubah yang diamati dalam penelitian ini meliputi kondisi pH media, suhu dan kelembapan media, suhu dan kelembapan lingkungan), penyusutan bobot badan cacing tanah dan mortalitas cacing tanah. Hasil penelitian menunjukkan bahwa durasi pengangkutan berbeda nyata (P<0.05) terhadap susut bobot dan mortalitas cacing tanah. Perlakuan durasi transportasi 3 jam mengakibatkan susut bobot tertinggi (82.33 g setara 55.63%) dan kematian tertinggi (411.87 g setara 91.07%).

Kata kunci: Cacing tanah, *Lumbricus rubellus*, performa, transportasi

INTRODUCTION

Earthworms (*Lumbricus rubellus*) are invertebrate animals commonly found in Indonesia. They are cultivated as bird and fish feed and used in various combinations for medicinal purposes, traditional herbal remedies, and cosmetics (Warsa *et al.* 2000). According to Rusmini *et al*. (2016), earthworms have a very high protein content of approximately 76%, surpassing mammalian meat (65%) or fish (50%), mealworms (45-50%) (Nata 2017), crickets 58.3% (Wang 2005), maggots 30-45% (Azir *et al*. 2017), silkworms 54.9% (Dewi and Setiohadi 2010), and crickets 23-65% (Nuraeni and Anggraeni 2020). Earthworms also contain other components such as fat (7-10%), ash (8-10%), and energy (900-4100 calories/gram) (Ernawati *et al*. 2017). Earthworms thrive in a moist environment rich in organic materials for easy digestion and protection from direct sunlight. Optimal environmental conditions for earthworms included a temperature range of 23-30 °C, humidity of 40-50%, and pH of 6.8-7.2 (Mubarak and Zalizar 2003). Environmental changes for earthworms can be influenced by media type, media conditions (temperature, humidity, and pH), and transportation. According to Kosman and Subowo (2010), environmental changes, such as soil conditions (soil pH, temperature, and humidity) and weight loss, can be affecteded by transportation, influencing the sensitivity of earthworms.

The transportation of livestock or animals is carried out to supply them from their place of origin to the destination for consumption or further cultivation. Transportation can be done using land, sea, or air routes and modes. The transportation conditions in Indonesia have not fully adhered to animal welfare standards (Gopar *et al.* 2020). It is expected that livestock will be transported using inadequate transportation modes that do not consider the welfare of the animals. Often, animals are transported without considering the appropriate carrying capacity and its effects on the animals (Gopar *et al*. 2020). Livestock transportation, whether short or long distances, affected the condition of the animals before transportation, during the journey, and when the animals are unloaded from the mode of transport (Trisiana *et al*. 2021). The three main factors in the transportation process that affected the condition of the animals were physiological stress, thermal stress, and physical condition stress of the animals (Fisher *et al*. 2009). Stress during the transportation process can result in weight loss (Lendrawati *et al*. 2019).

The longer the journey or transportation, the greater the weight loss in livestock/animals (Ginting 2006). Socheh *et al*. (2020) reported that weight loss occured during transportation (in cattle) because the cattle were stressed due to fatigue and are not provided with feed or water. The different positions of livestock (in goats and sheep) during transportation affected weight loss in the animals. Livestock experiences much pressure during transportation, leading to weight loss (Lendrawati *et al.* 2019). Weight loss often occurs during transportation. According to Swallow *et al.* (2005), the transportation of laboratory animals such as mice, can includeds significantly stress that impacts the well-being and research quality of the animals. Therefore, this research was conducted to study the effects of different durations of transportation on the weight loss of earthworms, earthworm mortality, and the conditions of soil media (soil pH, soil temperature, and humidity), as well as environmental conditions (temperature and humidity) during the transportation process.

MATERIAL AND METHODS

Material

The tools used in this research included ground transportation mode (motorcycle), the container for transporting earthworms (size of 2 L plastic containers with perforated lids), digital scale (precision 0.01 g), digital pH meter (precision 0.01), digital thermohygrometer (precision 0.1), a watch, and writing tools. The materials used in this research were 4.5 kg of earthworms (*Lumbricus rubellus*) and 4.5 kg of beef cattle manure that has decomposed for 7 days as a media for earthworms.

Methods

Preparation of Equipment and Materials. The first step is to prepare the equipment and materials for the research. The prepared equipment includeds a motorcycle, 2 L plastic containers with perforated lids (media for transporting earthworms), a digital scale, a pH meter, a digital thermohygrometer, a watch, and writing tools. The prepared materials were 4.5 kg of earthworms and 4.5 kg of 4.5 kg of beef cattle manure that has decomposed for 7 days as a media for earthworms, placed in 9 plastic containers (2 L each) with perforated lids. Each container contains 500 g of earthworms and 500 g of dried beef cattle manure (Gultom 2022).

Transportation of Earthworms. Earthworms are transported using a motorcycle. The transportation of earthworms with three different duration treatments was carried out round trip, commencing and concluding at the Laboratorium Lapangan Blok C, Bagian Non Ruminansia dan Satwa Harapan (NRSH). The first treatment involves transportation for one hour (P1), the second treatment for two hours (P2), and the third treatment for three hours (P3). Transportation involved carrying three plastic containers at a time for each treatment. The first treatment (P1) begins at 11:30 AM and ends at noon, from Laboratorium Lapangan Blok C to Jalan Sholeh Iskandar. The second treatment (P2) starts at 11:30 AM and ends at 12:30 PM, traveling from Laboratorium Lapangan Blok C to Jalan Mawar Raya, Parung. The third treatment (P3) starts at 11:30 AM and ends at 1:00 PM, covering the route from Laboratorium Lapangan Blok C to Jalan Ciputat Raya, South Jakarta. Transportation involves carrying three containers at a time for each treatment. Transportation is conducted during critical hours, between 11:00 AM and 2:00 PM, as the weather is quite hot, and traffic conditions are dense due to vehicle activities. The earthworms' condition is observed during transportation. The transportation route for earthworms can be seen in Figure 1 and illustration of the transportation process in Figure 2.

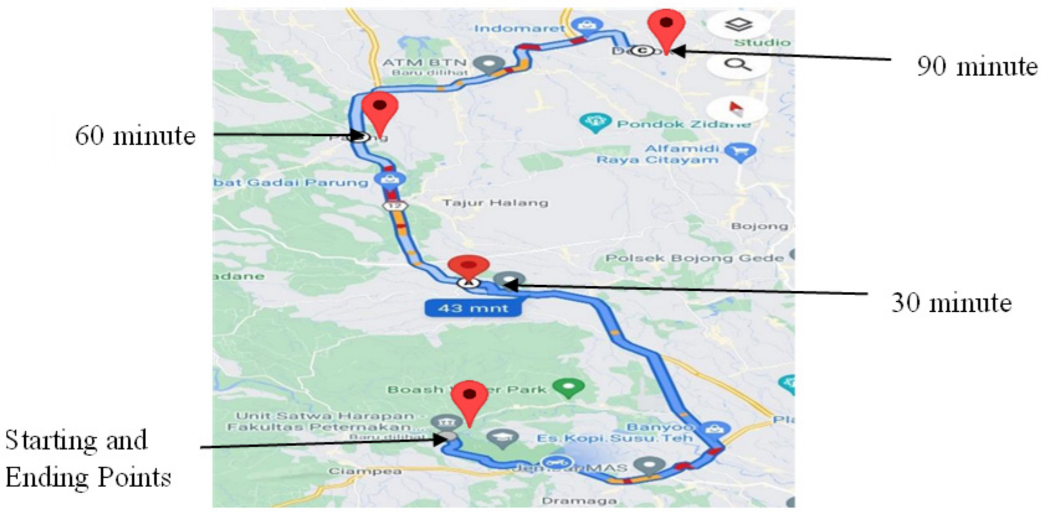

Figure 1. Route of Transportation

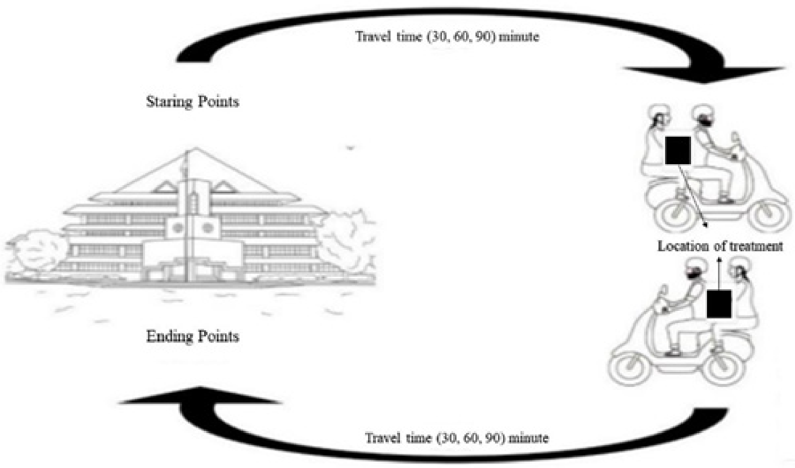

Figure 2. Illustration of the transportation process

Data collection. The observed variables in this study included environmental temperature (°C) and humidity (%), soil temperature (°C) and soil humidity (%), soil pH, weight loss of earthworms (g and %), and mortality of earthworms (g and %).

1. **Weight of Earthworms (Gultom 2022).**
   Earthworms are weighed for their initial weight (before transportation) and final weight (after reaching the destination) using a digital scale to calculate the weight loss of earthworms during transportation.
2. **Mortality (Gultom 2022)**
   The earthworm population is counted at the initial (before transportation) and final (after reaching the destination) stages to calculate the mortality of earthworms during the transportation process.
3. **Soil pH (Gultom 2022)**
   Soil pH measurements are conducted for all treatment durations (1 hour, 2 hours, and 3 hours) using a pH meter at the beginning, middle, and end of the transportation process.
4. **Temperature and Humidity (Media and Environment) (Gultom 2022)**
   Temperature and humidity (both in the media and the environment) are measured for all treatments using a thermohygrometer at the process's beginning, middle, and end.

Data Analysis

This study was conducted using the Completely Randomized Design (CRD) method with three treatments: transportation of earthworms for 1 hour (P1); transportation of earthworms for 2 hours (P2); and transportation of earthworms for 3 hours (P3). Each treatment was replicated 3 times, resulting in a total of 9 experimental units. The data obtained will be analyzed using analysis of variance (ANOVA) at a 95% confidence level, followed by Duncan's test. The following mathematical model will be used:

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

Where:
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

Temperature of Environmental and Media Earthworm

The average results of environmental and media temperatures in the three treatments (1 hour, 2 hours, and 3 hours) were presented in Figure 3. Environmental temperature is the most crucial factor affecteding the productivity of earthworms (Febrita *et al*. 2015).

Environmental Temperature is the degree of heat in the air at a particular location expressed in degrees celsius (°C). The environmental temperature during the transportation of earthworms was related to the temperature of the earthworm media (Figure 3). The highest environmental and media temperatures were found in the 3-hour treatment. As the duration of transportation increases, both environmental and media temperatures also rise with averages 1-2 °C. This is because the transportation is carried out during the daytime using a motorcycle, exposing the research subjects to direct sunlight. The environmental conditions during the study are not ideal for the survival of earthworms because the environmental temperature values during the study significantly differ from the literature values. According to Palungkun (2010), the required environmental temperature for earthworms ranges from 15-25 °C, and temperatures higher than 25 °C are still suitable for the growth of earthworms if the humidity supports it.

The environment influences the temperature of the research media; when the environmental temperature is high, the media temperature also rises, and heat is absorbed by the media, causing the media temperature to rise (Susanto, 2001). The media can quickly dry out due to the high media temperature, this is supported by the research findings of Rahayuningtyas and Kuala (2016), indicating that the greater the temperature difference, the faster the heat

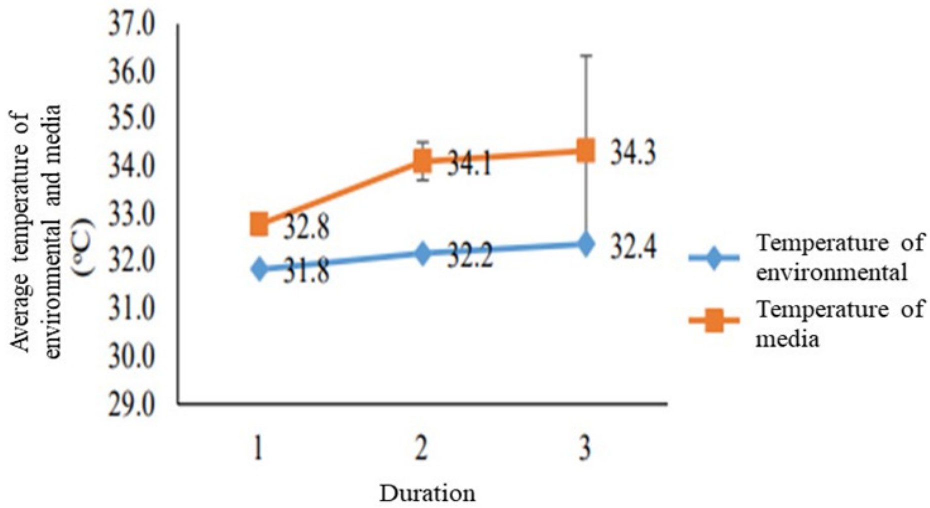

Figure 3. Average temperature of environmental and media

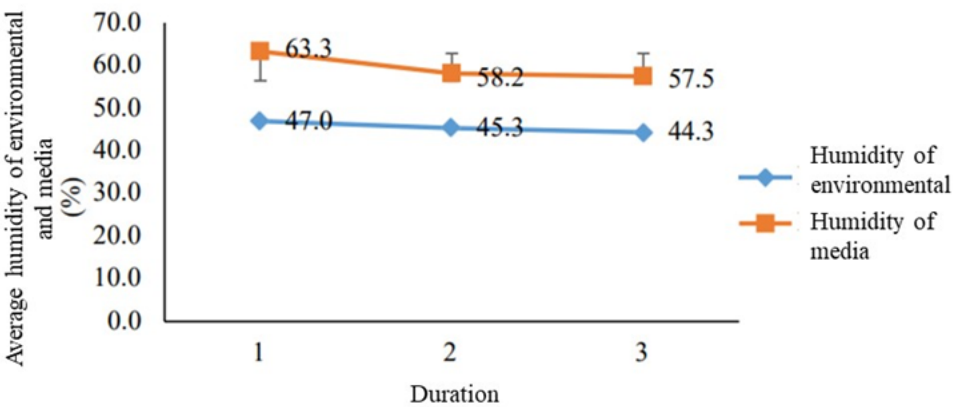

Figure 4. Average humidity of environmental and media

transfer process occurs, leading to a quicker evaporation process, and vice versa. The high temperature of the soil or media is influenced by the activities, metabolism, growth, respiration, and reproduction of earthworms (Manurung *et al*. 2014). According to Sihombing (2000), the media for earthworms generally has a temperature of 18-27 °C. Based on the research results, the environmental temperature and media temperature during the entire transportation duration are not suitable for the growth of earthworms.

Humidity of Environmental and Media Earthworm

Figure 4 displayeds the average environmental humidity and media humidity for the 1-hour, 2-hour, and 3-hour treatments. Temperature and humidity are among the factors that influence the growth of earthworms (Zulkarnain *et al.* 2019).

Environmental and media humidity decreased with the duration of the journey to averagen 44.3-63.3%. The ideal humidity for earthworms ranges from 15% to 50%, while the optimum humidity ranges from 42% to 60% (Hanafiah 2005) and approximately 75% (Saputra 2019). The humidity throughout the transportation duration is lower than in the literature, indicating that the humidity of the research media could be better. Relative humidity is inversely proportional to environmental temperature. If the air is cold, humidity will increase, and if the air is hot, humidity will decrease (Sandi *et al.* 2017). The dry season or dry conditions cause earthworms to stop eating and gather in a ball-like formation to reduce body water evaporation, and the clitellum shrinks (Djamhari 2000).

pH of Media Earthworms

The pH value of the media fluctuates during the transportation duration. In an acidic environment, which inhibits the growth of earthworms, the pH of the growing media is crucial (Palungkun 2010). According to Salamah *et al.* (2015), the CO_2 emitted by livestock can cause a decrease in blood pH, leading to acidosis, where the supply of oxygen for energy metabolism processes is reduced. The pH of the earthworm media for the 1-hour, 2-hour, and 3-hour treatments was shown in Figure 5.

Based on the pH data of the media to average 6.42-6.55, the suitability of the media for the life of earthworms indicates that it falls within a reasonable range for earthworms. According to Saputra (2019), earthworms can thrive well in a neutral or slightly alkaline pH, around 6.0-7.2. Based on this literature, the pH of the research media is ideal to support the life of earthworms. Too acidic media can cause the earthworm's cocoon to swell and burst, leading to the death of earthworms (Sihombing 2002). Earthworms can tolerate changes in the pH of their media, allowing them to inhabit it comfortably (Maulina 2019).

Weight Loss and Mortality of Earthworms

The standard performance indicators observed for earthworms are growth, weight loss, and mortality. According to Sadia *et al*. (2020), the growth of earthworms can be measured by weight gain (mg) and growth rate (mg/worm). Environmental factors influencing the growth and reproduction of earthworms included temperature, pH, soil moisture content, and the type of feed (Manurung *et al*. 2014). The performance of earthworms at different transportation durations is presented in Table 1.

The research indicated that different transportation durations significantly affected ($P<0.05$) earthworms' weight loss and mortality. The weight loss of earthworms during 1-hour (26.67%) and 2-hour (39.00%) transportation durations is not significantly different, but the 3-hour transportation duration shows a significant difference compared to the 1-hour and 2-hour durations. The 3-hour transportation duration exhibits the highest weight loss in

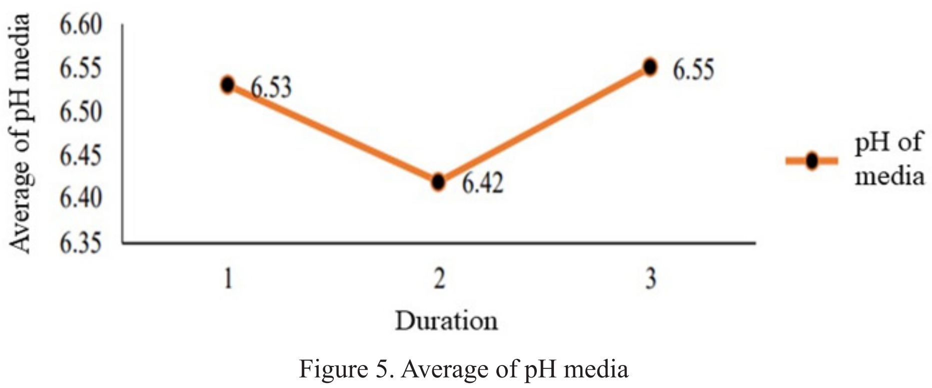

Figure 5. Average of pH media

Table 1. Average weight loss and mortality of earthworms

Variable	Duration (hours)		
	1	2	3
Weight of Earthworms (g)	26.67b±2.31	39.00b±7.81	82.33a±8.02
Weight of Earthworms (%)	18.02b±12.73	26.35b±43.05	55.63a±44.21
Mortality (g)	12.20b±3.65	28.17b±3.39	411.87a±5.65
Mortality (%)	2.70b±28.76	6.23b±26.71	91.07a±44.52

* Different letters on the same line show different real results ($P<0.05$).

grams, with a percentage of 82.33%. This can be caused by the physiological and behavioral responses of earthworms to an unsuitable environment, leading to high stress and affecteding various functions and biological systems of the earthworms. According to Swallow *et al*. (2015), prolonged stress can disrupt various functions and biological systems acquired from the livestock's environmental conditions.

The mortality of earthworms (in grams) during 1-hour (12.30 g) and 2-hour (28.17 g) transportation durations is not significantly different but significantly differs compared to the 3-hour (411.87 g) transportation duration. The highest mortality (in grams and percentage) is found during the 3-hour transportation duration. Livestock (including earthworms) experience various pressures during transportation, including environmental pressures such as inappropriate environmental temperature and media and discomfort due to road conditions (Deiss *et al.* 2009). This causes earthworms to feel uncomfortable during the transportation process. The weight of earthworms can decrease due to soil moisture, soil conditions such as pH, temperature, aeration, CO_2, soil type, and inappropriate organic material (Khairuman and Amri 2009).

The high level of mortality was caused by excessively high environmental temperatures, leading to low and media humidity. If the media humidity is too low, worms will leave the media, and when the humidity is too high, worms will enter the media, causing them to pale and die (Brata *et al.* 2017). Earthworms are highly sensitive to light or ultraviolet rays from the sun. If exposed to the sun for more than a minute, earthworms will experience dehydration, become limp, and eventually die (Pradinasari *et al.* 2017).

CONCLUSION

Different transportation durations affected the performance of earthworms (*Lumbricus rubellus*). A transportation duration of 3 hours shows the highest weight loss (82.33 g, equivalent to 55.63%) and the highest mortality (411.87 g, equivalent to 91.07%) caused by temperatures and humidity levels that are not suitable for the earthworm's living environment.

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