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Pontoscolex corethrurus (Müller, 1857), Linking Earthworm and Soil Mineral Content

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Abstract

Pontoscolex corethrurus is an exotic earthworm and they often occur in degraded habitat. Exotic earthworms usually have a eurytopic characteristic to overcome the environmental pressure to enhance their survivability. This mechanism is predicted to include the control of soil mineral level, which is ingested by the earthworms. Here, we tested whether soil mineral contents, i.e.: phosphorous, calcium, magnesium, potassium, and sodium, in Bungku Village, Jambi, influenced mineral content in *P. corethrurus*' body and gut. Those soil mineral contents do not influence *P. corethrurus*' except for calcium. We suggested that the presence of calciferous glands is responsible to maintain Ca content in the body and gut of *P. corethrurus*.

Keywords: adaptation; calciferous gland; calcium; eurytopic.

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1. Introduction

Pontoscolex corethrurus is an exotic earthworm [1-3] and they often occur in degraded habitat [4-5], where the stenotopic earthworms are not capable to live. They are predicted to originate from South America [6-7] and have been introduced worldwide along rubber plantation [8].

Exotic earthworms usually have a eurytopic characteristic to overcome the environmental pressure to enhance their survivability [2-3, 9]. This mechanism is predicted to include the control of soil mineral content, which is ingested by the earthworms. It is shown by some earthworms (*Lumbricus rubellus*, *Lumbricus castaneus*, and *Lumbricus terrestris*), which have more active calcium secretion glands, are more tolerant to metal [10].

Here, we tested whether soil mineral contents, i.e.: phosphorous, calcium, magnesium, potassium, and sodium, in Bungku Village, Jambi, influenced mineral content in *P. corethrurus*' body and gut. Those minerals are crucial in energy metabolism, nervous system, and homeostasis [11]. We will show that only soil calcium content affected the calcium content in *P. corethrurus*' body and gut.

2. Method

2.1. Study Sites

Pontoscolex corethrurus were extracted from Bungku Village, Batanghari Regency, Jambi (1^o15'-2^o20' south latitude – 120^o30'-104^o30' east longitude) on November 2012. Sampling areas included four habitat types: oil palm plantation, rubber plantation, rubber jungle, and secondary forest. Those areas were having 25.5^oC annual temperature and 2700 mm cumulative precipitation [12].

2.2. Pontoscolex corethrurus extraction

Digging and hand-sorting was conducted to extract the earthworms. *P. corethrurus* was identified following description established by [13]. Twenty five plots of 30 x 30 cm in size and 30 cm depth were placed randomly in each habitat type. These plots were replicated three times, making total of 75 plots in each habitat type. The extracted earthworms were cleaned and fixated in 70% ethanol.

2.3. Soil parameters

Soil samples were taken by using compositing method in each habitat type with three replications. Five hundred grams of soil samples were taken into Laboratory of Department of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agricultural University. They were air dried prior to analyzing P, Ca, Mg, K, and Na content. Phosphor was analyzed by using HCl 25% solution. Meanwhile, Ca, Mg, K, and Na were analyzed by using neutral 1 M NH_4OAc [14].

2.4. **Pontoscolex corethrurus** *mineral content*

In order to assess the mineral content in *P. corethrurus*' body and gut, the extracted *P. corethrurus* from each habitat type were grinded using porcelain mortar. Starch soluble powder was added to make the final weight of ten grams of pasta and the result was corrected by dilution factor. Each mineral (P, Ca, Mg, K, and Na) was analyzed based on two grams pasta using atomic absorption spectroscopy method [15] at Center for Agro Based Industry (CABI), Bogor.

2.5. Data analysis

Soil mineral contents were taken into the same unit (mg/kg). Ca, Mg, K, and Na values were multiplied by 200, 120, 390, and 230, respectively. Subsequently, the data were transformed logarithmic naturally to convert into similar scale. Kruskal Wallis test was conducted to compare the soil and *P. corethrurus*' mineral in each habitat type. Shapiro's test showed that the data followed normal distribution. Hence, linear mixed effect model, which was fitted by maximizing the restricted log-likelihood, was used to assess the influence of mineral content in soil to *P. corethrurus*' using 'nlme' [16] package in R.3.0.0 [17]. *P. corethrurus* mineral content was set as response and soil mineral content was set as predictor. Random intercept was set and the data were grouped by habitat type.

3. Result

All of the sampling areas only consisted of *P. corethrurus* (Fig. 1). The amount of extracted *P. corethrurus* in oil palm plantation, rubber plantation, rubber jungle, and forest were 250, 217, 248, and 225 individuals, respectively. *P. corethrurus* were dissected and they occurred to have calciferous glands (Fig. 2).

Figure 1: *Pontoscolex corethrurus* from Bungku Village, Jambi. Scale bar = 10 mm

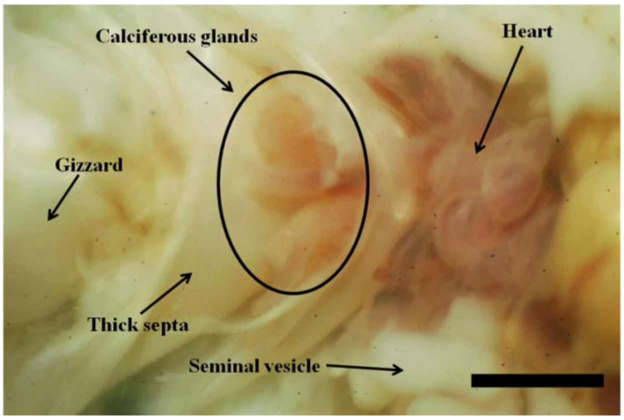

Figure 2: Calciferous glands (in circle) of *P. corethrurus*. Scale bar = 1 mm

The value of *P. corethrurus* and soil mineral content do not show any tendency in certain system. Calcium is the highest *P. corethrurus* mineral content and phosphorous is the highest soil mineral content (Table 1). Those soil mineral do not influence *P. corethrurus* mineral content except for calcium (Table 2). The increasing of soil calcium caused the decreasing of *P. corethrurus* calcium content.

Table 1: Mineral content in *P. corethrurus* and soil in four habitat types. The values are presented in minimum-maximum. Values with the same letter in a column are not significantly different (p-value < 0.05)

Habitat type	*P. corethrurus* mineral (ppm)					Soil mineral (ppm)				
	P	Ca	Mg	K	Na	P	Ca	Mg	K	Na
Oil palm plantation	687.22-777.86^{b}	718.82-961.72^{ab}	85.33-102.28^{ab}	133.04-193.27^{a}	242.67-409.39^{a}	96.20-99.70^{a}	1.66-2.42^{a}	0.44-0.78^{b}	0.12-0.17^{a}	0.29-0.41^{b}
Rubber plantation	720.24-753.07^{ab}	559.76-904.71^{b}	63.61-92.98^{b}	101.34-131.05^{b}	327.51-555.10^{a}	91.10-99.70^{a}	1.36-10.89^{a}	0.28-0.61^{bc}	0.15-0.17^{a}	0.24-0.39^{b}
Rubber jungle	793.91-840.00^{a}	952.77-1797.00^{a}	95.94-117.00^{ab}	136.01-150.00^{ab}	152.00-418.33^{a}	77.3-87.6^{b}	0.52-0.88^{b}	0.27-0.34^{c}	0.10-0.12^{b}	0.17-0.21^{c}
Forest	725.15-863.22^{ab}	649.83-1328.35^{ab}	74.13-142.10^{a}	107.96-199.38^{a}	183.89-473.16^{a}	88.3-97.9^{a}	1.02-2.17^{ab}	0.92-0.96^{a}	0.13-0.15^{ab}	0.43-0.46^{a}

Table 2: Linear mixed effect model explains the influence of soil mineral to *P. corethrurus*' mineral content

Mineral	Slope	Standard error	DF	P-value
P	-0.457	0.249	7	0.109
Ca	-0.252	0.105	7	0.047
Mg	0.031	0.172	7	0.862
K	0.082	0.482	7	0.870
Na	0.281	0.427	7	0.531

4. Discussion

Adaptation mechanism to maintain the mineral content in the body and gut is implemented in *P. corethrurus*, which is also has eurytopic characteristic. It is shown in the decreasing of Ca in *P. corethrurus* if the soil has a high Ca content. Ca acts as neurotransmitter [11] and is involved in metal elimination through cholorogogen tissue [10]. However, deficiency or excess of Ca may harm the earthworms.

We suggested that the presence of calciferous glands is responsible to maintain Ca content in the body and gut of *P. corethrurus*, as shown in this study. It also has been demonstrated that *Lumbricus rubellus*, which has the calciferous glands, has a constant Ca content in their body wall [18]. The glands are elaboration of the oesophageal wall provided with blood supply [19], and contain secretory cells producing calcium carbonate [20]. Those glands are hypothesized to act as pH buffer the blood and ingested plant material, respiratory function, mineralization [21], and have also been revealed to provide CO_2 regulation mechanism in earthworm tissue [20].

The inverse impact of soil Ca with the *P. corethrurus* Ca content indicates that the content of soil Ca in Bungku is too high for this earthworm. We predicted that *P. corethrurus* will also be able to preserve the constant Ca level in their body and gut if they are put in soil with low Ca. Hence, we concluded that *P. corethrurus* may be physiologically adapted to soil with various Ca concentration.

5. Conclusion and recommendation

Pontoscolex corethrurus is able to maintain its Ca content due to the presence of calciferous glands. The further detail of calciferous glands function and mechanism should be investigated. Due to the lacking of data comparison from similar study, we recommend conducting the research of the other earthworm species with calciferous glands.

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