Journal of Academia Vol. 12, Issue 2 (2024) 240 – 247

THE COMPARISON OF *Onthophagus* sp. (COLEOPTERA: SCARABAEIDAE) DEVELOPMENT IN FOREST AND RUBBER PLANTATION IN NEGERI SEMBILAN

Nurul Syakirah binti Nor Affendi[1], Nur Farah Atikah binti Anuar[1], Nur Hasyimah binti Ramli[1,2]*

[1]*School of Biological Sciences, Faculty of Applied Sciences*
Universiti Teknologi MARA (UiTM), Cawangan Negeri Sembilan, Kampus Kuala Pilah, 72000 Kuala Pilah, Negeri Sembilan, Malaysia
[2]ECONATREA, School of Biological Sciences, Faculty of Applied Sciences, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Kuala Pilah, 72000 Kuala Pilah, Negeri Sembilan, Malaysia

**Corresponding author: nurhasyimah@uitm.edu.my*

Abstract

Dung beetles are a valuable taxon to research disturbance due to their superiority as bioindicators of habitat quality and environmental change. They also have a significant impact on basic ecological processes such soil aeration, decomposition, nutrient recycling, secondary seed distribution, and suppression of vertebrate parasites. Although there is a growing body of knowledge regarding how species react to disturbances, studies on development seldom consider. This study aimed to determine and compare the development of *Onthophagus* sp. at UiTM Cawangan Negeri Sembilan forest (UiTM forest) and rubber plantation Kg. Beting, Negeri Sembilan. A total of 10 baited pitfall traps were installed systematically and left overnight for four days per sampling session, over a period of two weeks. Subsequently, the trapped samples were collected, preserved, and identified. Morphometric measurement was conducted on head width (mm) and body length (mm) and the development calculation refers to the formula: head width/ body length. The research findings indicated that *O. breviconus* demonstrated the greatest developmental rate range (0.0556mm) within the UiTM forest, whereas *O. proletarius* showcased the highest developmental rate range (0.1328mm) within the forest environment. Conversely, the *O. batesi* displayed the lowest rates range (0.0138mm) in UiTM forest while O. *patenensis* (0.0033mm) showed the lowest developmental rate range in rubber plantation. A higher development rate signifies faster growth and maturation compared to other individuals or species within the population. These findings provide valuable data for further *Onthophagus* sp. studies and serves as a guideline for future research and conservation efforts in Malaysia.

Keywords: *Onthophagus* sp., pitfall trap, development, forest, rubber plantations

Article History:- Received: 11 September 2024; Revised: 12 September 2024; Accepted: 17 September 2024; Published: 31 October 2024

Introduction

Dung beetles are an important bioindicator species in an ecosystem (Zakaria et al., 2022). Dung beetles are worldwide, and distributed on every continent except Antarctica, and can live in various habitats, ranging from deserts to forests (Vieira et al., 2022). According to Audino et al. (2017), dung beetles (Coleoptera: Scarabaeinae) are frequently employed as markers of environmental alterations brought on by edge effects, habitat fragmentation, post-logging treatments, and restoration initiatives. Dung beetle diversity was affected by habitat type, and forest cores and forest edges had higher diversity than pastures. Besides, each habitat type was characterized by a distinct dung beetle assemblage, with pastures showing the highest heterogeneity in the dung beetle assemblage (Salomão et al., 2023). Other than that, more species of dung beetles can be found in landscapes with higher levels of forest cover than in those with lower canopy cover. In both tropical and subtropical locations, the composition of dung beetle species has been demonstrated to be influenced by edge density and forest-plantation transitions (Souza et al., 2020). Higher edge density landscapes may see a decline in dweller beetle species (i.e., species that stay within the resource deposits) (Souza et al., 2020), whereas richness and abundance of tunnelers (i.e., species that dig tunnels directly beneath or close to the food resource) may increase in forests on clay soils (Salomão et al., 2022). Prior research has indicated that environmental factors, including temperature, humidity, soil texture, canopy openness, and landscape context, play significant role in determining the assemblages and abundance of dung beetles (Vieira et al., 2022). However, no relationship was discerned between percentage of soil organic matter and diversity indices (r=0.348), evenness (r=-0.289), and richness (r= 0.972) of dung beetles was reported by Zakaria et al., (2022).

Insect activity, survival, development, and reproduction are influenced by the habitat's temperature and moisture content. The characteristics of the ecosystem and the current weather will determine the actual temperature and moisture at a given place. Despite the high numbers of hatching beetles, the size of the beetles was bigger in the wetter and darker sites. It has been demonstrated that *Onthophagus* sp. size is positively impacted by optimal moisture (França et al., 2017). Insect size can be influenced by both moisture content and temperature, with smaller insects emerging from harsh and stressful environments. If temperature and moisture had an impact on food quality, then it could also have an indirect effect on the size of the dung beetles (Tavares et al., 2019). The morphologies of dung beetles are diverse, ranging from tiny species that develop to be less than 0.5 cm long to large species that can reach lengths of more than 6 cm. In addition, they exhibit a range of colors, including blue, green, black, and red (Edwards et al., 2017).

Understanding the development of dung beetles and their ecological roles is essential for appreciating their significance in ecosystems and for implementing effective conservation and management strategies (França et al., 2017). Their life cycle involves several stages of development, and their activities contribute to nutrient cycling, pest control, and soil health. The life cycle begins when a female dung beetle lays eggs in or near a dung pat. The number of eggs laid, and the specific behavior of the female vary among species. Upon hatching, the larvae, commonly referred to as grubs, feed on the dung (Costa et al., 2022). The dung provides them with nutrients, and the larvae undergo several molts as they grow. After completing their larval development, dung beetle larvae form pupae. During this stage, they undergo metamorphosis, transforming into adult beetles. The adult dung beetle emerges from the pupal case. The time it takes for the complete life cycle to unfold varies among species and environmental conditions (Costa et al., 2022).

The distribution and development rate of dung beetles are significantly influenced by vegetation cover, soil type, abiotic factors, and physical characteristics of forests (Davis & Sutton, 2019). Abiotic factors such as temperature and humidity play important role in dung beetles' abundance (Douan et al., 2022). To increase knowledge on the development of *Onthophagus* sp. in Negeri Sembilan, this study aims to determine and compared the development of *Onthophagus* sp. in the UiTM Cawangan Negeri Sembilan Forest (UiTM Forest) and Rubber Plantation, Kg. Beting (rubber plantation). This study shows the accelerated development rate of *Onthophagus* sp. in rubber plantations in comparison to forests, primarily because the warmer and more humid environmental conditions in rubber plantations create a more favorable environment for the beetles' growth and development as mentioned by Goh & Hashim (2019). Furthermore, the study will expand the body of knowledge in entomology, and conservation biology, providing a foundation for further research and educational purposes.

Methods

Sampling Site Determination

The sampling sites selected in this study are UiTM Cawangan Negeri Sembilan Forest (UiTM forest) and rubber plantations Kg. Beting, Negeri Sembilan (Rubber plantation). The sites were selected by classifying both as undisturbed and disturbed ecosystems, respectively as shown in Figure 1. The Geographical Positioning System (GPS) was used to determine the accurate geographical coordination; UiTM forest (2° 47' 11.94" N, 102° 16' 16.46"E) and rubber plantation (2° 46' 27.59"N, 102° 14' 43.51"E).

a) b)

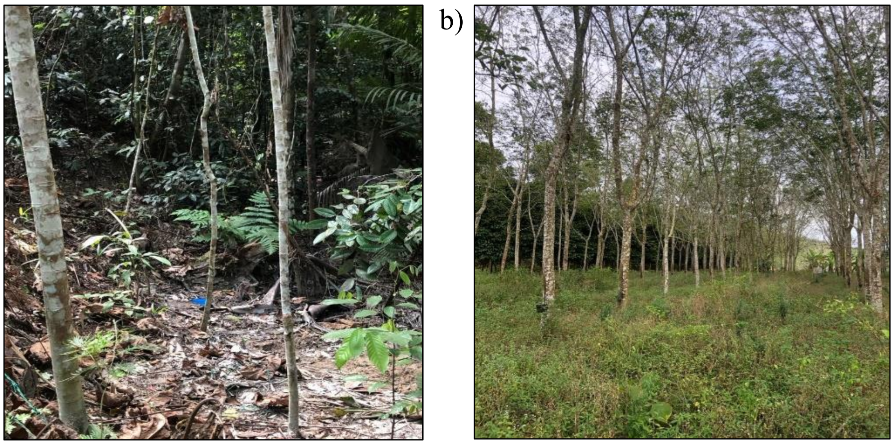

Figure 1. shows a) sampling sites at UiTM forest and b) at rubber plantation, Kg. Beting.

Sampling Activities and Samples Collection

The sampling was conducted through a modification of pitfall trap methods by Woodcock et al., (2005) as shown in Figure 2 which is the best method in trapping or collecting crawling insects such as dung beetles. Other than that, this method is easy to set up and affordable (Alves et al., 2020). Each pitfall was set up systematically within a 500m distance area. 10 holes were dug using a round head hoe and shovel and the bucket (1/2 gallon) was buried at the same level as the soil in each hole. To keep the dung beetles from escaping, ¼ volumes of soap solution were filled into the bucket. A polystyrene cup with rotten fish as bait was put inside each of the buckets to attract the *Onthophagus* sp. Rotten fish was used as bait because it was easily obtainable. The pitfall trap was left overnight for four days per sampling session, over a period of two weeks. The samples were placed in plastic containers filled with 70% alcohol for preservation, labelled and brought to the UiTM laboratory for further processing.

Figure 2. The samples collection activities by using pitfall trap method.

Isolation of Samples

The samples were put in the stackable tray and the isolation process was conducted by removing other samples of insects or organisms. The *Onthophagus* sp. were kept in a plastic container filled with 70% alcohol for preservation and labelled (date and sampling site).

Sample Identification

Onthophagus sp. were moved to a tray and divided into groups through an observation on its morphological characteristics including the head, legs, pronotum, antennae, and elytra. The process of identification is done by referring to an overview of studies on the diversity and taxonomy of beetles in Malaysia (Din et al., 2019), an identification guide to the Scarabaeinae dung beetles of Cusuco National Park, Honduras (Creedy & Mann, 2012), and Peterson field guides for beetles (White, 2007).

Morphometric Measurement and Data Record of *Onthophagus* sp.

Figure 3 shows the mean length of abdomen (in mm) and width of the head (in mm) of each individual sample was measured using Dino-Capture 2.0 software (Ibarra et al., 2021) for determination of development rate. Then, the image of each species was captured using a Stereo microscope (SZ61).

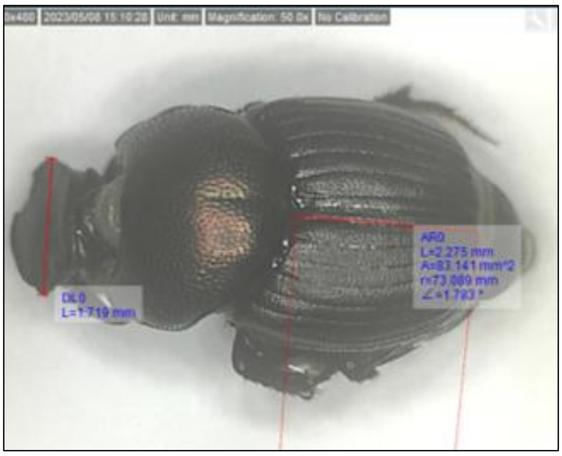

Figure 3. The morphometric measurements of dung beetles.

Result and Discussion

Development rate of dung beetles

Table 1 shows the development rate of *Onthophagus* sp. recorded at both UiTM forest and rubber plantation. As a result, there is no significant difference on development rate of *Onthophagus* sp.at both study sites with the p-value= 0.451 ($p>0.05$). Out of 18 species found at rubber plantations, only 6 species show higher development rate (in mm) compared to UiTM forest. However, a total of 6 species out of 21 species present at UiTM forest show higher development rate (in mm) than rubber plantation. A total of 8 species of *Onthophagus* collected at rubber plantation including *O. insicus*, O. *horii,* O. *rutilans*, O. *rudis*, O. *semifex*, O. *deflexicollis*, O. *trituber and O. leusermontis* unable to be compared with UiTM forest due to the absence of the species. Additionally, 5 species, including *O. sagittarius, O. viridicervicapra, O. waterstradti, O. recticornutus,* and *O. orientalis*, were not recorded in the UiTM forest, despite being present in the rubber plantation, making it challenging to compare their developmental rates.

Based on the table below, it shows that the development rate of *O. latreille* at both sites is the same (0.6925 mm). However, other species show different sizes in both UiTM forest and rubber plantations. The highest developmental rate range of the same species shown at UiTM forest were *O. breviconus* (0.0556 mm) followed by *O. obscurior spp.* (0.0387 mm), O. *ponticus* (0.0241 mm), *O. insularis* (0.0240 mm), O. crassicollis (0.0236 mm), O. *semipersonatus* (0.0227 mm) and *O. batesi* (0.0138 mm). While in the rubber plantation, there are several species that show a higher range development rate compared to UiTM forest. These species were *O. proletarius* (0.1328 mm), *O. verticicornis* (0.0650 mm), *O. furcatus* (0.0369 mm), *O. pacificus* (0.0289 mm), *O. patenensis* (0.0033 mm).

Table 1. Development rate of *Onthophagus* sp. at UiTM forest and rubber plantation, Kg. Beting.

Species	Number of species	Composition (%)	Forest Development rate (mm)	Rubber Development rate (mm)	Range (mm)
Onthophagus latreille	22	6.06	0.6925	0.6925	0.0000
Onthophagus batesi	25	6.89	0.6679	0.6541	0.0138
Onthophagus furcatus	81	22.31	0.6878	0.7247	-0.0369
Onthophagus pacificus	121	33.33	0.6722	0.7011	-0.0289
Onthophagus petenensis	5	1.38	0.7316	0.7349	-0.0033
Onthophagus proletarius	8	2.20	0.6271	0.7599	-0.1328
Onthophagus insicus	2	0.55	0.8296	N/A	-
Onthophagus semipersonatus	23	6.34	0.6523	0.6296	0.0227
Onthophagus sagittarius	2	0.55	N/A	0.6689	-
Onthophagus horii	2	0.55	0.6961	N/A	-
Onthophagus rutilans	5	1.38	0.6868	N/A	-
Onthophagus rudis	2	0.55	0.7903	N/A	-
Onthophagus viridicervicapra	1	0.28	N/A	0.7098	-
Onthophagus insularis	3	0.83	0.7308	0.7068	0.0240
Onthophagus ponticus	17	4.68	0.8072	0.7831	0.0241
Onthophagus waterstradti	1	0.28	N/A	0.6721	-
Onthophagus recticornutus	1	0.28	N/A	0.7640	-
Onthophagus orientalis	1	0.28	N/A	0.8438	-
Onthophagus breviconus	9	2.48	0.7126	0.7682	0.0556
Onthophagus semifex	1	0.28	0.7651	N/A	-
Onthophagus deflexicollis	4	1.10	0.5977	N/A	-
Onthophagus trituber	1	0.28	0.5658	N/A	-
Onthophagus obscurior spp.	9	2.48	0.6007	0.5620	0.0387
Onthophagus verticicornis	5	1.38	0.7295	0.7945	-0.0650
Onthophagus crassicollis	10	2.75	0.6910	0.6674	0.0236
Onthophagus leusermontis	2	0.55	0.6860	N/A	-

N/A=Not Applicable; - = Not Comparable; Range= the difference between the highest and lowest value from a set of data

The highest development rate of 3 species of *Onthophagus* in the rubber plantation compared to UiTM forest due to the warmer and more humid conditions, which are more favorable for the development of these beetles. According to Tavares et al. (2019), the presence of food and water in rubber plantations led to *Onthophagus* sp. developing at a mean rate that was much greater in this site than in forests. The study also discovered that *Onthophagus* sp. had much bigger average body sizes in rubber plantations than in forests. This implies that the better environmental circumstances found in rubber plantations are also favorable for growth. Based on the observation, this area is also visited by herds of cattle released by the villagers for food graze purposes. At the same time, dung from those animals makes the area very suitable as a habitat for *Onthophagus* sp. According to Filgueiras et al (2011), dung beetles are significant ecosystem builders that are essential to the breakdown of dung and the recycling of nutrients (Filgueiras et al., 2011). Contrary to this study, Abebe et al. (2018) claim that dung beetles encounter several difficulties in disturbed areas, including a reduction in the amount of dung available, greater competition from other insects, and exposure to pesticides. Their growth rates are hence frequently slower in disturbed areas than in undisturbed places.

Morphometric measurements can be used to identify different individuals to study and to understand the ecology of dung beetles. It can be measured by determining the total mean of body length and head width of *Onthophagus* sp. beetles (Abdullah & Azmir, 2021). This method can relate to the development of dung beetles in several ways such as larger dung beetles tend to develop more slowly than smaller dung beetles. This is because larger dung beetles have more cells to develop, which requires more time and energy. The size of the head can also be a predictor of development rate. Dung beetles with larger heads tend to have larger brains, which may allow them to learn more quickly and develop more complex behaviors. Other than that, dung beetles with a more streamlined shape tend to develop more quickly than dung beetles with a bulkier shape. This is because streamlined dung beetles are more efficient at moving through the environment, which allows them to find food and mates more quickly (Sousa et al., 2019).

The beetles may be able to complete their life cycle more quickly in this ecosystem given the rubber plantation's higher rate of expansion. This may work to the beetles' advantage since they would be less likely to be eaten by predators or pass away from other reasons before they could reproduce (Sousa et al., 2019). After becoming adults, *Onthophagus* sp. frequently procreates. They may be able to enter the reproductive stage early if they finish their life cycle more quickly in the rubber plantation. They have a wider opportunity to mate and have young as a result, boosting their likelihood of successful reproduction (Edwards et al., 2017).

Onthophagus iniscus (0.53%), *O. orientalis* (0.26%), and *O. rudis* (0.53%) were the three most frequently found large species, however other frequently encountered large species (> 0.8mm) were also detected with a lower abundance than small species (10mm). Body size is a significant biological characteristic that can be used to assess the effects of forest disturbance on various species. Larger organisms are more sensitive to disturbance than smaller ones. This is because larger creatures need more energy to thrive due to their slower metabolism (Sousa et al.,2019). They are therefore more susceptible to being impacted by environmental changes, such as the elimination of food supplies or the deterioration of their habitat. According to a study by Edwards et al., (2017), because logging had devastated the dung beetles' habitat and food supply, their body size was much smaller in areas that had recently been disturbed. Contrary to Sousa et al. (2019), this study recorded the presence of *O. insicus* in UiTM forest, however, *O. orientalis* was collected at rubber plantations only.

Large dung beetles were more successful in removing and decomposing manure from pastures than small dung beetles. This suggests that larger dung beetles are more important for the decomposition of organic materials in pastures than smaller dung beetles (Sousa et al., 2019). Due to lower amounts of dung being generated by the mammals to feed larger dung beetles, smaller dung beetles have been found in greater numbers in more damaged forests (Costa et al., 2022). Thus, a disturbed habitat may appear with high diversity, but give smaller body sized dung beetles, such as *O. batesi*, *O. semipersonatus* and *O. crassicollis* in rubber habitat.

Conclusion

The finding of the study indicates that it is evident that several species show a higher development rate in the forest environment compared to the rubber plantation. This is particularly notable for *O. batesi*, *O. semipersonatus*, *O. insularis, O. ponticus, O. berviconus, O. obscurior spp. and O. crassicollis* among others. Conversely, in some instances, the rubber environment appears to support a slower development rate, as observed with *O. furcatus, O. pacificus, O. petenensis, O. proleterius,* and *O. verticicornis*. The UiTM forest's warmer and more humid conditions are conducive to the development of some species, while the rubber plantation may be more favorable for others. This emphasizes the ecological adaptability and specificity of these beetles to their respective habitats and highlights the importance of considering habitat factors when studying their life cycles. Recommendation for this study, researchers can establish a long-term monitoring program to track the population dynamics, development, and diversity of *Onthophagus* sp. in both habitats. This will provide valuable data on temporal trends and fluctuations, helping to identify potential impacts and assess the effectiveness of conservation measures. Next, researchers can use other abiotic factors such as soil type, rainfall, or sunlight to get a better understanding of the factors that affect the abundance and diversity of dung beetles in rubber and forest habitats.

Acknowledgement/Funding

Authors would like to acknowledge Universiti Teknologi MARA Cawangan Negeri Sembilan for providing facilities and equipment for conducting this research activity.

Author Contribution

NS Nor Affendi and NFA Anuar executed the field research, NS Nor Afendi and NH Ramli conceived the idea and NH Ramli supervised the work.

Conflict of Interest

Author declares no conflict of interest.

References

Abdullah, N. H., & Azmir, I. A. (2021). A pictorial key for the identification of beetle (Order: Coleoptera) and diversity study in selected area within pelangai forest reserve, Negeri Sembilan, Malaysia. *Biodiversitas*, *22*(2), 947–955.

Abebe A., Teketay, D., & Mehlhorn, R. (2018). Abundance and diversity of dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae) in relation to abiotic factors in the Bale Mountains, Ethiopia. *Journal of Threatened Taxa*, *10*(11), 21084–21092.

Alves, V. M., Giehl, E. L. H., Lovato, P. E., Vaz-de-Mello, F. Z., Agudelo, M. B., & Hernández, M. I. M. (2020). Dung beetles and the conservation of diversity in an agricultural landscape with maize fields and Atlantic Forest remnants. *Acta Oecologica*, *107*, 103598.

Audino, L. D., Murphy, S. J., Zambaldi, L., Louzada, J., & Comita, L. S. (2017). Drivers of Community Assembly in tropical forest restoration sites: Role of local environment, landscape, and space. *Ecological Applications*, *27*(6), 1731–1745.

Costa, M. K., França, F. M., Brocardo, C. R., & Fadini, R. F. (2022). Edge effects from exotic tree plantations and environmental context drive dung beetle assemblages within Amazonian undisturbed forests. *Forest Ecology and Management*, *520*, 120277.

Creedy, T. J., & Mann, D. J. (2011). Identification guide to the Scarabaeinae dung beetles of Cusuco National Park, Honduras. *Operation Wallacea, Conservation research through academic partnership, Lincolnshire, United Kingdom*, *1*, 12–50.

Davis, A.L.V., & Sutton, S.L. (2019). Habitat variables as predictors of dung beetle diversity in a tropical dry forest. *Journal of Insect Conservation*, *23*(1), 21–30.

Din, A. M. M., Halim, W. M. A., Ahmad, S. Z. S., & Yaakop, S. (2019). Dung beetles (Coleoptera: Scarabaeidae) composition to three different ecosystem functions: A study case in Malaysia. *Tropical Life Sciences Research*, *30*(3), 69–82.

Douan, B. G., Doh, F., Danon, A. S. D., Beugre, N. I., Touré, D. S., Guinagui, N. B., & Doumbia, M. (2022). Efficiency of four types of beetles traps in rubber plantation in the Southern of Côte d'Ivoire. *International Journal of Biological and Chemical Sciences*, *15*(6), 2426–2437.

Edwards, F. A., Finan, J., Graham, L. K., Larsen, T. H., Wilcove, D. S., Hsu, W. W., Chey, V., & Hamer, K. C. (2017). The impact of logging roads on dung beetle assemblages in a tropical rainforest reserve. *Biological Conservation*, *205*, 85–92.

Filgueiras, B. K., Iannuzzi, L., & Leal, I. R. (2011). Habitat fragmentation alters the structure of dung beetle communities in the Atlantic Forest. *Biological Conservation*, *144*(1), 362–369.

França, F. M., Frazão, F. S., Korasaki, V., Louzada, J., & Barlow, J. (2017). Identifying thresholds of logging intensity on dung beetle communities to improve the sustainable management of Amazonian tropical forests. *Biological Conservation*, *216*, 115–122.

Goh, T. G., & Hashim, R. (2019). Conservation of dung beetles (Scarabaeidae: Scarabaeinae) in Peninsular Malaysia. *Journal of Wildlife and Parks, 34*, 81–93.

Ibarra, J. T., Caviedes, J., Altamirano, T. A., Urra, R., Barreau, A., & Santana, F. (2021). Social-ecological filters drive the functional diversity of beetles in homegardens of campesinos and migrants in the southern Andes. *Scientific reports*, *11*(1), 12462.

Salomão, R. P., Lopera-Toro, A., Pulido-Herrera, L. A., & Arias-Buriticá, J. A. (2023). Habitat type affects the diversity of dung beetle (Coleoptera: Scarabaeidae) assemblages in a Neotropical mountainous region of Colombia. *International Journal of Tropical Insect Science*, *43*(3), 793–803.

Salomão, R. P., Pires, D. de, Baccaro, F. B., Schietti, J., Vaz-de-Mello, F. Z., Lima, A. P., & Magnusson, W. E. (2022). Water table level and soil texture are important drivers of dung beetle diversity in Amazonian lowland forests. *Applied Soil Ecology, 170*, 104260.

Sousa, W. O., Sousa, L. E., Da Silva, F. R. J., Da Graça Santos, W. I., & Aranda, R. (2019). Composition and structure of the frugivorous butterfly community (Lepidoptera: Nymphalidae) at the Serra Azul State Park (PESA), Mato Grosso, Brazil. *Zoologia (Curitiba)*, *36*, 1–10.

Souza, T. B., França, F. M., Barlow, J., Dodonov, P., Santos, J. S., Faria, D., & Baumgarten, J. E. (2020). The relative influence of different landscape attributes on dung beetle communities in the Brazilian Atlantic Forest. *Ecological Indicators*, *117*, 106534.

Tavares, A., Beiroz, W., Fialho, A., Frazão, F., Macedo, R., Louzada, J., & Audino, L. (2019). Eucalyptus plantations as hybrid ecosystems: Implications for species conservation in the Brazilian Atlantic Forest. *Forest Ecology and Management*, *433*, 131–139.

Vieira, L., Sobral-Souza, T., Spector, S., Vaz-de-Mello, F. Z., Costa, C. M., & Louzada, J. (2022). Synergistic effects of climate and human-induced landscape changes on the spatial distribution of an endangered dung beetle. *Journal of Insect Conservation*, *26*(2), 315–326.

White, R. E. (2007). Peterson field guides for beetles. Houghton Mifflin.

Woodcock, B. A. (2005). Pitfall trapping in ecological studies. *Insect sampling in forest ecosystems*, 37–57.

Zakaria, S. S., Zaidi, N., & Ramli, N. H. (2022). Diversity and abundance of *Onthophagus* sp. (Coleoptera: Scarabaeidae) in Kg. Beting's oil palm plantation and UiTM Cawangan Negeri Sembilan Forest, Malaysia. *Journal Serangga*, *27*(3), 172–186.