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# Detritivore Macrofauna Assemblages and Litter Accumulation in Bukit Pinang-Pinang Tropical Rainforest Area: A Comparative Study across Land Use Types

**ABSTRACT** Litter, as dead organic matter on the soil surface, is a habitat and food source for detritivores soil macroarthropods. We assessed the condition of soil ecosystems as a result of these land use changes in the Bukit Pinang-Pinang tropical rainforest area by collecting comprehensive data on the composition of detritivores soil macroarthropods and litter accumulation, together with characteristics of soil physical and chemical properties in forests, logged forest areas, mixed gardens and monoculture gardens. Sampling was purposive, with detritivores soil macroarthropods collected with pitfall traps, litter samples collected directly , disturbed soil samples collected with a composite soil drill, and intact soil samples collected with a sampling ring. Forests supported groups of detritivores soil macroarthropods that tended to have higher total abundance of individuals and species, as well as litter accumulation, compared to other land types. Land use change leads to a decrease in the presence of soil detritivores, which is influenced by decrease in litter accumulation. Reduced litter accumulation in deforested areas, mixed gardens and monoculture gardens significantly affected the total abundance of individuals and species of soil macroarthropod detritivores. In addition, soil pH, soil moisture and litter C content also significantly affected the abundance of soil macroarthropods.

**Keywords**: Soil ecosystem, land use, diversity, soil macroarthropods, rainforest

## Introduction

Soil macroarthropods play an important functional role above ground in regulating food web systems and are responsible for the provision of other ecosystem goods and services, such as the water cycle and primary productivity (Forstall-Sosa et al. 2020). Soil macroarthropods belong to a group of soil organisms that are sensitive to changes and disturbances in nature and human practices that will trigger ecosystem degradation on a larger scale (Menta and Ramelli 2020). An important role of soil macroarthropod groups in maintaining the complexity and stability of aboveground ecosystems is the decomposition of litter that falls to the soil surface. In this case, soil macroarthropod groups usually tend to nibble, shred, and reduce the volume of litter biomass from the fresh litter phase to fermented litter (Potapov et al. 2022). The soil detritivore group of soil macroarthropods that decompose this litter is considered an important group of organisms because, in addition to decomposing fresh dead leaves, they can also stimulate decomposer microflora that affect the mineralization of organic matter (David 2014).

The status of aboveground detritivore macroarthropod biodiversity locally, regionally, and even globally has shown a decline and will continue to face a crisis if awareness of maintaining ecosystem integrity and function is not improved (Hansen et al. 2021). Increasing human population and community needs pose a strong challenge to maintaining forest ecosystems and conserving soil biodiversity, especially aboveground detritivores (Geisen et al. 2019). The conversion of forest functions to agricultural areas, such as mixed or monoculture gardens, has reduced the overstorey vegetation or tree composition, leading to habitat fragmentation and reducing the abundance of aboveground litter for soil detritivores from the soil macroarthropod group (Marsandi et al. 2023).

Increasingly alarming global conditions have focused attention on the loss of plant and animal diversity (Cifuentes-Croquevielle et al. 2020). In addition, the continuing fragmentation of forests has also led to a decline in soil quality (Marsandi et al. 2024). The presence of soil macroarthropods as detrivores provides many benefits to soil ecosystems (Neher and Barbercheck 2019). Research on soil detritivore macroarthropods on the forest floor still needs more attention from the point of view of describing species composition or comparative study of communities and their integration with litter, especially in tropical rainforest areas (Goncalves et al. 2021). The response of soil detritivores to land-use change, as indicated by their abundance and diversity and their integration into litter accumulation, provides a snapshot of ecosystem conditions on the land.

Changes in land use with different litter conditions on the soil surface, leading to the presence of soil detritivores (soil macroarthropods), also vary. Not all soil macroarthropod detritivores have the same preference for fresh litter falling to the soil surface. Soil detritivores have different adaptations to litter types, which can be seen in physical structure and body size, although soil macroarthropod detritivores tend to have relatively larger body sizes and are more visible in person (Hättenschwiler & Gasser 2005). Furthermore, the composition of the soil detritivore group of the soil macroarthropod community and its integration with litter accumulation on different land types as a result of land use change have not been investigated in depth. Therefore, this study aims to compare the diversity of detritivores and litter accumulation on different land types due to land use change.

## Methods

### *Study Area*

The research was conducted in the Bukit Pinang-Pinang area, Ulu Gadut, Padang City, West Sumatra, which is part of the upper watershed of Padang City. This area is classified as a tropical rainforest, part of the Bukit Barisan series, which has a dense tree composition with high litter abundance. The area is located approximately 17 km from Padang City at coordinates 0°55' SL and 100°30' EL. The area, located at an altitude of about 650 m above sea level, with an average temperature of 27°C and humidity in the range of 73–80%, is no longer a dense forest but has been used or converted by local communities into various types of land use, including land that is still in the form of former tree felling, mixed garden areas planted with different types of fruits (mangosteen (*Garcinia mangostana* L.), cacao (*Theobroma cacao* L.), sawo (*Manilkara zapota* (L.) P. Royen), durian (*Durio zibethinus* L.), banana (*Musa acuminata* Colla), cinnamon (*Cinnamomum burmani* (Nees & T.Nees) Blume), water guava (*Syzygium aqueum* (Burm.f.) Alston), duku (*Lansium domesticum* Corrêa), and coffee (*Coffea canephora* Pierre ex A.Froehner), and monoculture garden areas planted with cocoa fruit (Fig. 1).

[Here the Fig 1]

### *Methodology*

Tools and materials used in this study include sample ring, soil drill, clear plastic cup, sterofoam disc, straight wooden stick, rectangular plot of 50 x 50 cm, litter plastic, 100 cc pvot tube, sample plastic, tweezers, small brush, petri dish, olympus microscope, identification book, laptop, propyl glycol, 70% alcohol, and 96% alcohol, and laboratory materials in the analysis of physical and chemical properties of soil and litter. Soil macroarthropods were collected with pitfall traps in the field, while litter was collected with a 50 x 50 cm rectangular plot in the area where pitfall traps were installed. Soil samples were taken after litter collection (on the litter-free ground surface). Disturbed soil was sampled using a soil auger, while intact soil was sampled using a sampling ring. The sampling of disturbed soil was composite.

The sampling points were determined by purposive sampling, where the research plots were determined based on the slope of the land, namely at the top, middle, and bottom of each land type in the Bukit Pinang-Pinang area (forest, logged forest area, mixed garden, and monoculture garden) with a size of 40 x 40 m each. In addition, four sampling points were randomly selected in each plot until there were four points in each plot and 12 trap installation points in one land type. Thus, the total number of traps installed was 48. The study was conducted with four replications each month for four months.

Soil macroarthropods were identified using various sources, including the book Identification of Soil Insects (Triplehorn and Jhonson 2005), The Insects of Australia (Farrow 2016), Bug Guide (BugGuide.net), and other relevant literature studies, to ultimately not only identify the composition of soil macroarthropods but also the functional groups of soil macroarthropods in the soil detritivore group. Litter accumulation is calculated from the shrinkage of the litter weight or the remaining dry weight of the litter collected in the field. The total number of individuals and species of soil detritivore were counted under a microscope using a handheld counter, recorded in a logbook and plotted graphically. Diversity of soil detritivore was calculated using the Shannon-Weener index, dominance using the Simpson index and evenness using the Pielou index (Maguran 2004). In addition, the frequency of occurrence, relative density and detritivore importance index were also calculated (Fachrul 2012). Data on litter accumulation and soil physical and chemical properties were analysed by ANOVA, then continued with the Tukey test using IBM SPSS-23. Furthermore, to analyse the effect of soil physical and chemical properties and litter accumulation on the total number of individuals and species of soil detritivore, T-test was performed for the effect of each element and F-test for the effect simultaneously. The coefficient of determination is also determined to show the extent to which the contribution of the independent variables in the regression model is able to explain the variation in the dependent variable. In addition, the correlations showing the relationship between abundance and diversity of soil detritivore species with litter accumulation and soil physical and chemical properties was also presented graphically using Statistical Product and Service Solutions IBM SPSS-23.

## Result

### *Abundance of soil macroarthropods as soil detritivores*

The results showed that 11 families, 4 orders, and 2 classes of soil macroarthropods belonging to the soil detritivore group were found in the Bukit Pinang-Pinang area, Padang, Indonesia. The family groups of soil detritivore macroarthropods and their percentage abundance are shown in Figure 2.

[Here the Fig 2]

Figure 2 shows that the Blaberidae group from the order Blattodea and Leiodidae from the order Coleoptera are the soil detritivore groups with the highest percentage of abundance compared to other arthropods in the Bukit Pinang-Pinang tropical rainforest area, namely 16.67%. Meanwhile, other Coleoptera orders, namely Clambidae and Platyarthridae from the order Isopoda, have the lowest abundance, with an abundance value of 2.08%. Although they belong to the same order, Coleoptera, the soil detritivores Leiodidae and Clambidae have different abundances on the soil surface. Another example is the order Isopoda, which shows the percentage of abundance of its family groups that tend to vary, namely Platyarthridae 2.08%, Porcellionidae 4.17%, and Armadillidiidae 12.50%. This was also the case for the order Blattodea itself, which had a variable percentage of family abundance, namely Blattidae (12.50%), Blaberidae (16.67%), and Cryptocercidae (6.25%). In the order Psocodea, only one family type was found in the rainforest area of Buki Pinang-Pinang, namely Liposcelididae, with a percentage abundance of 4.17%. Furthermore, the number of detritivore individuals and species based on different land types in the Bukit Pinang-Pinang tropical rainforest area is shown in Figure 3.

[Here the Fig. 3]

Changes in forest land use in logged forest areas (LFA), mixed farms (MG) and monoculture farms planted with cocoa/*Theobroma cacao* (Mo) showed a tendency to decrease the abundance of detritivores (Fig. 3). The total number of detritivore individuals and species decreased significantly when the natural habitat (F) was converted to LFA land and further decreased when it became MG and Mo land types.

***Frequency of presence, relative density, and importance index of soil detritivores***

[Here the Tab. 1]

Table 1 shows that detritivores of soil macroarthropodsare more often found in forests as their habitat; this can be seen from the frequency of presence, relative density, and importance index. The highest relative frequency of the presence of soil macroarthropod detritivores was found in Leiodidae from the Coleoptera order group in Mo and Porcellionidae from the Isopoda group in MG land, which was 39.68%. Furthermore, the highest relative density value was found in the Blattidae and Blaberidae groups of the Blattodea order, namely 4.85% in the forest. The highest importance value index was found in Porcellionidae, found in MG and Leiodidae, found in Mo, with both values being 41,3%.

***Diversity index of detritivores soil macroarthropods***

Table 2 shows the diversity, evenness, and dominance indices of soil macroarthropod detritivores in different soil types in the Bukit Pinang-Pinang Padang tropical rainforest area, Indonesia.

[Here the Tab. 2]

In general, the detritivore diversity index value was found in the low category, with a value of 0.639–1.377. The highest diversity index value of macroarthropods included in the detritivore category in the Bukit Pinang-Pinang tropical rainforest area was found in land type F, with a value of 1.377 ± 0.105. The change from land type F to LFA reduced the detritivore diversity index to 0.963 ± 0.106. Furthermore, the land use in Pinang-Pinang Hill for land type MG further reduced the detritivore diversity index value to 0.685 ± 0.075, and finally, land type Mo has the lowest detritivore diversity index compared to other land types in the tropical rainforest area of Pinang-Pinang Hill, which is 0.639 ± 0.083. This is in line with the value of the index of evenness and dominance of detritivore, which is highest on land F, namely 0.574 ± 0.084 and 0.054 ± 0.006, while the value of the index of evenness and dominance is lowest on land Mo, with a value of 0.266 ± 0.075 and 0.014 ± 0.002.

***Litter accumulation and soil physical and chemical properties***

The estimated values of litter accumulation and characteristics of soil physical and chemical properties in different soil types in the Bukit Pinang-Pinang area are shown in Table 3.

[Here the Tab. 3]



Table 3 shows that the highest estimated value of litter accumulation was found on soil type F with 19.11 tons/ha. This value has a considerable distance from other land use types, namely LFA (4.97 tons/ha), MG (5.24 tons/ha), and Mo (9.57 tons/ha). In addition, the estimated values of litter C accumulation and SMC showed the same value tends, with the highest value found in the F land type, namely litter C 50.10% and SMC 0.37 gr/gr, while the lowest value with a significant difference was found in the monoculture land type, namely litter C 47.64% and SMC 0.24 gr/gr. In contrast, soil pH and N values in the Mo land type showed the highest values of pH 5.78, soil N 0.56%, and litter N 1.29% compared to other land types, especially in F and LFA, which were significantly different with 4.85 and 5.00 for pH, 0.44% and 0.34% for soil N, and 1.22% and 1.02% for litter N, respectively. Then, the MG land type had a higher soil C value of 7.32% compared to the other land types, while the LFA land type had the lowest soil C value of 5.83%. Soil physical properties in terms of soil BD had the highest value in the LFA land type with 0.79 gr/cm$^3$, which was significantly different from the other land types where Mo had the lowest BD value with 0.66 gr/cm$^3$.

***Soil detritivore and litter accumulation***

The presence of soil detritivores is influenced by of litter accumulation on the soil surface. The relationship between total detritivores, individuals, and species and litter accumulation is shown in Figure 4.

[Here the Fig. 4]

Figure 4 shows the correlation of total soil detritivore individuals and species with estimated litter accumulation tested by bivariate correlation analysis. The results showed that total soil detritivore individuals had a significant relationship with estimated litter accumulation with a Pearson correlation significance value (sig. (2-tailed)) 0.000 and Pearson correlation value 0.543**, which means that the level of correlation is in the medium category. Furthermore, the total species of soil detritivore with the estimated litter accumulation also showed a significant relationship, with the Pearson correlation significance value (sig. (2-tailed)) being 0.000 and the Pearson correlation value being 0.624**, which means that in this case the level of correlation is in the medium category. The diagonal line in Figure 4 shows the correlation of total individual and soil detritivore species with estimated litter accumulation in the Bukit Pinang-Pinang tropical rainforest area. In addition, the relationship between total individuals and species with estimated litter accumulation was also examined using multiple regression, which can be seen in Table 4.

Table 4 shows the multiple regression of the effect of litter accumulation and characteristics of soil physical and chemical properties on total individuals and species of detritivore, both simultaneously through the F-test and individually through the t-test. The results showed that each independent variable of soil chemical properties, pH and CSo, has a significant influence on total individuals and total species of soil detritivore. pH and Cso regression values on total individuals of soil detritivore are -3.364 and -2.227, which show a negative direction at p value of $< 0.05$. While Nso has a regression value of 0.580 with a positive direction on detritivore individuals. However, at the same time, total detritivore individuals were significantly influenced by soil chemical properties, with a regression value of 5.979, at p value of $< 0.05$ and coefficient of determination of 29%.

[Here the Tab. 4]

[Here the Fig. 5]

Total detritivore species were also significantly influenced by each independent variable of soil chemical properties, pH and Cso. Through the t-test, the influence values are -2.583 and -2.223 (negative direction), at p value of < 0.05. While Nso, through the t-test, did not show a significant effect on the total detritivore species, the t-test value shown is 0.347 with a positive direction. At the same time, the soil chemical properties had a significant effect on the total number of detritivore species, as indicated by the t-test value of 4.405 (positive direction) at p value of < 0.05. Furthermore, the coefficient of determination of the simultaneous effect of soil chemical properties on total detritivore species showed a value of 23.1%.

Table 4 also shows the effect of soil physical properties consisting of BD and SMC on the total individuals and species of detritivore in the Bukit Pinang-Pinang area. BD and SMC did not show a significant effect on the total individuals and total species of soil detritivore. The results of the t-test, BD, and SMC values are 1.417 and 1.541 (positive direction), respectively. At the same time, the F-test value also showed an insignificant effect between soil physical properties and total detritivore individuals, with a value of 1.972. In this case, the coefficient of determination of soil physical properties on total detritivore individuals is 8.1%. The values 1.585 and 1.592 are the results of the t-test of the effect of BD and SMC on the total detritivore species. At the same time, these independent variables did not show a significant effect (F test) with a value of 2.270 (positive direction). The coefficient of determination of the effect of soil physical properties on total detritivore species is 5.1%.



Litter accumulation and nutrients consisting of LAE, LNC, and LCC showed different effects on total individuals and total detritivore species. LAE and LCC showed a significant effect on total detritivore individuals and species. In its effect on total detritivore individuals, the t-test value shown is LAE 3.791 at at p value of < 0.05 and LCC 2.688 at p value of < 0.05. Meanwhile, LNC showed an insignificant effect on total individuals with a t-test value of -0.553. Simultaneously, litter accumulation and nutrient content (N and C) showed a significant effect on total detritivore individuals with an F-test value of 7.914 at p value of < 0.05, and the coefficient of determination of the effect of litter accumulation and nutrients on total soil detritivore individuals was 35%. Furthermore, LAE and LCC also had a significant effect on soil detritivore, whereas LNC had no significant effect. The t-test values for LAE and LCC were 3.403

with p value of $< 0.05$ for LAE and 2.407 with p value of $< 0.05$ for LCC. In contrast, LNC showed no significant effect, with a value of -0.970 at a significance level of 0.337. For the simultaneous effect, litter accumulation and nutrients showed a significant effect on total soil detritivore species with a value of 6.450 at p value of $<$ 0.05. The coefficient of determination shows that the percentage effect of litter accumulation and nutrients on total detritivore species is 30.5%. Furthermore, the distribution of research data on the characteristics of soil physical and chemical properties, litter accumulation, and nutrients to the total number of individuals and species of soil detritivores shows a normal distribution, as shown in Figure 5, marked by the centered distribution of research data points following the diagonal line. The data points closely follow the diagonal line indicating that the residuals are close to a normal distribution, so the regression model shown in Figure 5 has met the assumption of residual normality.

**Discussion**

Bukit Pinang-Pinang, which is representative of tropical rainforest areas in West Sumatra, has high biodiversity (Kubota et al. 2000). Land use change in this tropical rainforest area has resulted in the loss of forest biodiversity (Marsandi et al. 2024), including soil macroarthropod groups as detritivores. As a result of the interpretation of the research data, it is known that in the Bukit Pinang-Pinang area, which has been converted into logged forest area, mixed gardens and monoculture gardens, including forest as its natural habitat, 11 families of soil macroarthropods were found, dominated by Blaberidae and Leiodidae with the highest percentage of individuals. The layer of litter, dead wood, tree roots and under grass (lower stands) in the soil surface layer provides good microclimatic conditions for Blaberidae and Leiodidae (Lunde et al. 2022). In addition to good browsing ability and environmental adaptation to the aboveground litter layer, Blaberidae and Leiodidae prefer and feed on litter and decaying wood (Kocot-Zalewska and Lis 2023), the hind gut of Blaberidae is dominated by bacteria capable of activating cellulase and xylanase activity (Schwarz et al. 2023).

Forests that have been converted to logged forest areas, mixed gardens and monoculture gardens reduced the abundance of aboveground litter. This, in turn, reduces the abundance of individuals and species of soil detritivores that aid in decomposition and ecosystem functioning (Fig. 3) (Singh et al. 2019, Marsandi et al. 2023). Although some soil detritivores are able to survive in altered habitat conditions, most others show an inability to adapt to changing environmental conditions that differ from their original habitat (De Smedt et al. 2018). Thus, logged forest areas, mixed farms, and monocultures that have a different vegetation and litter composition than their natural habitat will contribute little to the consumption of fermented litter to increase the surface area available for bacterial and fungal activity. Each soil detritivor has specificities related to the object of litter decomposition, so the slow rate of litter decomposition can also be caused by the reduction or disappearance of native detritivores in the habitat (Joly et al. 2020). The decreasing abundance of soil detritivores is characterised by a decreasing frequency of presence and density of each soil detritivore. Although many groups of soil detritivores were found in the forest, some species were not found in the forest but in mixed or monoculture gardens, although in small numbers. As a result, the availability of soil detritivores, becomes more limited, threatening the balance of the soil ecosystem (Marsandi et al. 2019, Damayanti et al. 2023). The presence of soil detritivores plays an important role in disturbed habitats. Data in Table 1 show that mixed gardens (MG) and monoculture gardens (Mo) had higher Importance Index (INP) compared to other land types, such as forest (F) and logged forest area (LFA). Although many soil detritivore groups are not found in mixed and monoculture gardens, their presence in anthropogenic lands is still considered important as they play a role in litter decomposition and nutrient cycling. In this regard, groups of soil detritivore families that can be found in a wide range of habitat types (generalist groups) such as Leiodidae and Dryophthoridae (Tab. 1), show wider adaptability by being found in various land types, while families such as Cryptocercidae and Platyarthridae (Tab.1) are only found in natural forests, indicating their specialist nature. These two groups (generalists and specialists) serve as references and benchmarks as bioindicators of soil health (Taradipha et al. 2019). The presence or absence of certain detritivore groups can provide valuable information on the extent of anthropogenic disturbance and its impact on soil ecosystems (Spiller et al. 2018).

An optimal habitat for soil detritivores is one that is able to support their activities and survival, both in terms of resource availability and environmental conditions. The soil surface, as the place where litter falls, plays a crucial role in providing carrying capacity for soil detritivores. Soil physical and chemical characteristics, such as texture, moisture, pH, and organic matter content, contribute significantly to the abundance and diversity of soil detritivores. Soils with high organic matter content tend to favor decomposition activity, which in turn increases nutrient availability for soil detritivores. Litter decomposition activity by soil detritivores not only produces high organic carbon, but also organic acids and humus that play an important role in the formation of soil organic matter. Leaf litter, especially those that are low in lignin and rich in base cations, are ideal substrates for soil detritivores to accelerate the decomposition process. Although under these conditions plantation vegetation thrives and productivity increases, which can meet the needs of farmers, the results of our research on soil detritivores in the field decreased on plantation land, which means there is a potential threat to the balance of soil ecosystems (Marsandi et al. 2024). The plantation system, through intensive high intensity cropping practices, will reduce the amount of land cover that provides many benefits to soil detritivore.

Aboveground litter has different qualities of organic matter, with the quality of the litter being determined by the quality of its organic matter. The higher the quality of the organic matter in the litter, the easier the litter will decompose, and conversely, the lower the quality of the organic matter, the harder the litter will decompose, resulting in a thick accumulation of litter on the soil surface. The results showed that forests had higher litter accumulation than mixed and monoculture plantations. Although plant litter that accumulates above the soil surface will increase the abundance of soil detritivores, the process of decomposition of litter from non-native plants (plantation crops) has a higher decomposition rate than native plants, caused by changes in litter characteristics (Bassett et al. 2011, Ulyshen et al. 2020, Woodworth et al. 2020). Differences in the chemical properties of litter on forest and plantation land affect the decomposition process by soil detritivores (Ulyshen et al. 2020, Woodworth et al. 2020). The results showed that the carbon content of forest land was higher than that of monoculture plantations and, conversely, the nitrogen content of forests was lower than that of monoculture plantations. In this context, Woodworth et al. (2020) reported that soil detritivores tend to decompose litter with higher nitrogen content and lower carbon content.

In addition, the accumulation of aboveground litter plays an important role in the presence of soil detritivores. Litter accumulation leads to an increase in soil surface land cover, which affects temperature, soil moisture, soil pH and soil chemical properties (Wolkovich et al. 2010, Vilardo et al. 2018). These conditions create an effective space for the activity of soil detritivores, which support the litter decomposition process. The results showed that the estimation of litter accumulation and litter carbon content had a significant impact on the total number of individuals and species of soil detritivores. This is related to the decomposition of litter by soil detritivores. Although they are not active decomposers that have a real impact on the decomposition process like soil microbes, this group of soil macroarthropods, which includes soil detritivores, provides space and facilities for soil microbes to be more effective in decomposing litter. The abundance of Blaberidae with bacterial colonies capable of decomposing cellulose and lignin in the gut will aid the litter decomposition process. This group of soil detritivores will take the initial role in the litter decomposition process by chopping, breaking, tearing and ripping the litter. According to Kamruzzaman et al. (2019), leaves account for 58.4% of the total production of fallen litter, with fresher green leaves decomposing faster than leaves that have started to dry or mix (Wang et al. 2016). At the beginning of the litter decomposition process, the carbon content of the litter increases until it reaches a relative value of 46%-49% for 196 days (Toth et al. 2021). Furthermore, Davis et al (2003) added that the C content of the litter increases during the first three months and decreases at the end of the experiment. The functional groups of soil detritivores showed different responses to land use change, with the proportion of soil detritivores being higher on natural land with vegetation cover and abundant litter accumulation.



## Conclusion

Soil macroarthropods play an important role in litter decomposition for the sustainability of tropical rainforest ecosystems. Land use change in the Bukit Pinang-Pinang tropical rainforest area is causing changes in the abundance of litter accumulation, which significantly affects the presence of detritivores soil macroarthropods. Soil variation in this area showed a tendency for total individuals and species of soil macroarthropods to decrease, with the presence of Blaberidae from the order Blattodea and Leiodidae from the order Coleoptera being relatively dominant, making it a potential indicator of soil health in the area. Soil pH, soil C, and litter C were abiotic factors that significantly influenced the total number of individuals and species of soil macroarthropods. Thus, the resilience of tropical rainforest soil ecosystems is influenced by changes in environmental conditions, particularly land use change.

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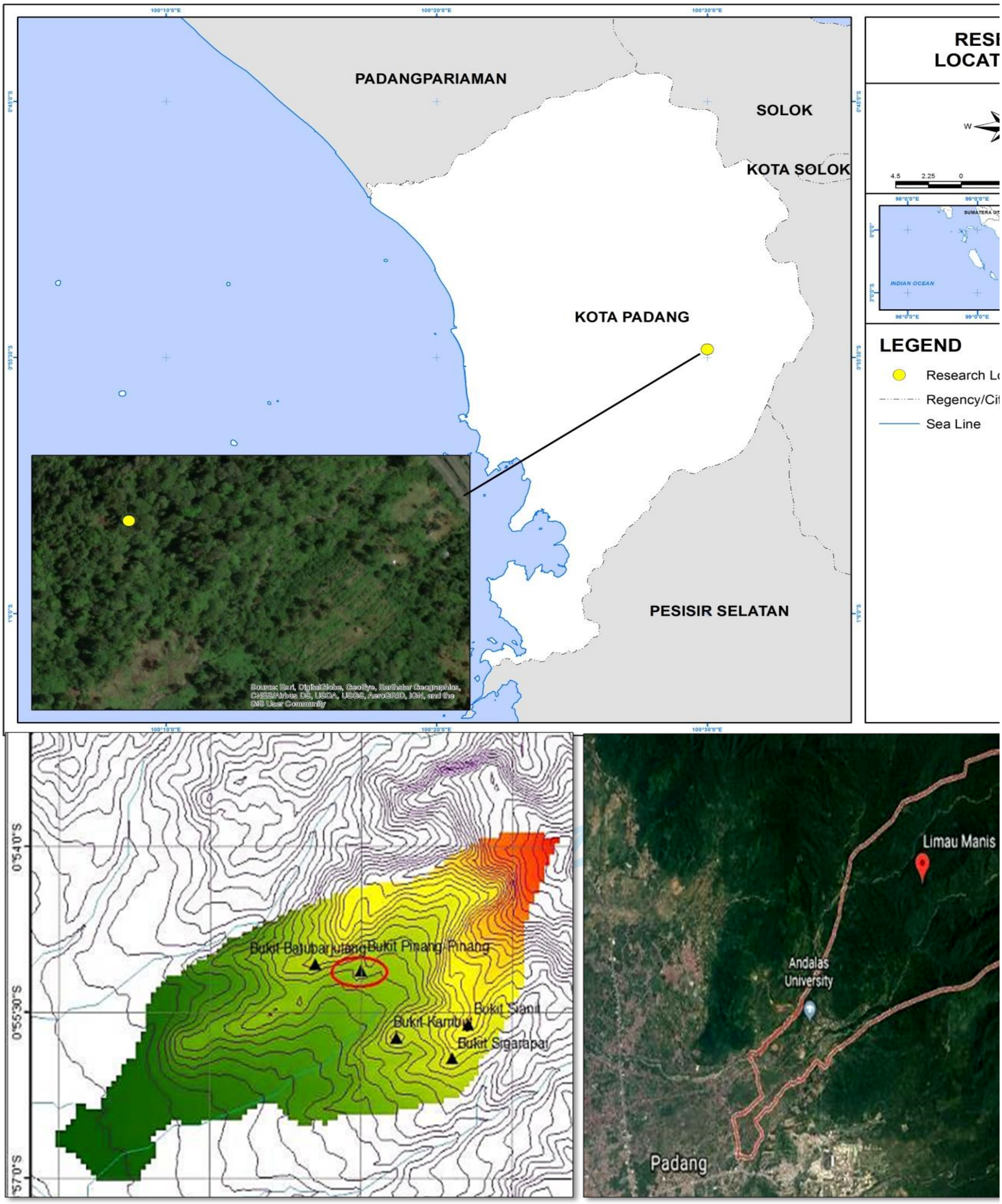
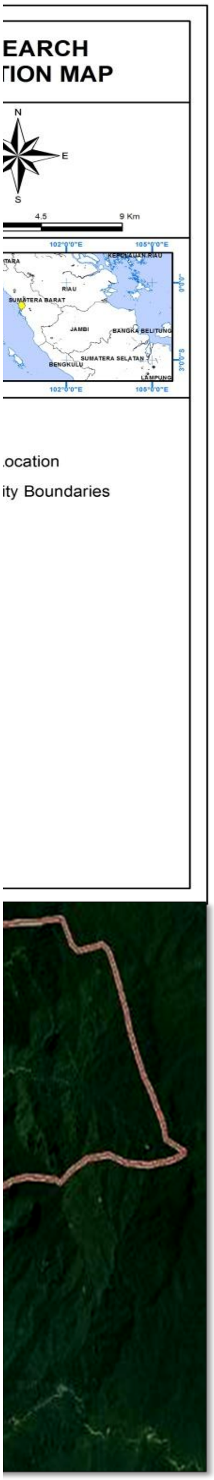



Fig 1. Map of Research Site in The Bukit Pinang-Pinang, Padang, Indones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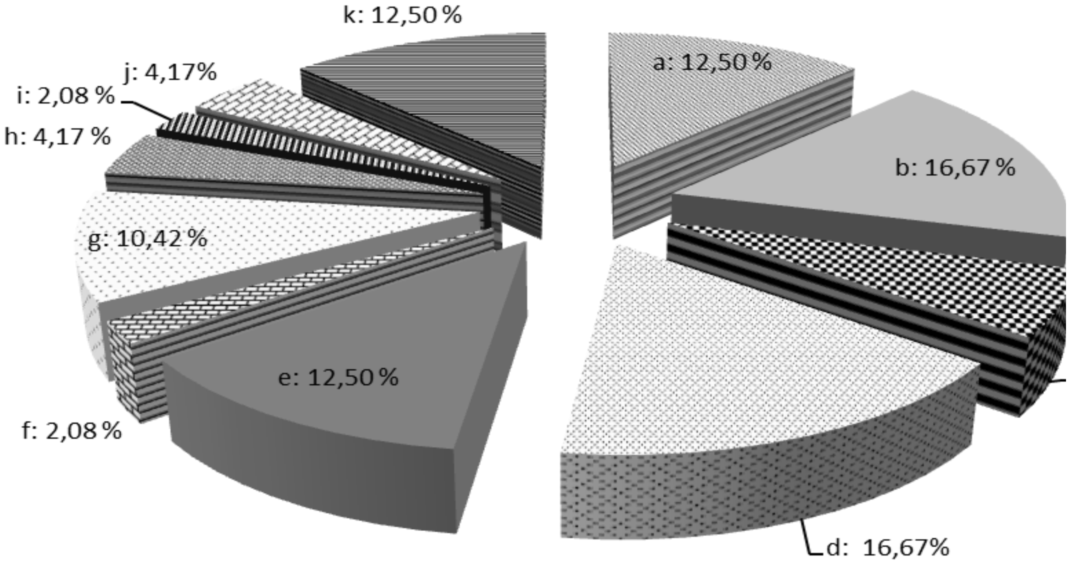


Fig. 2. Percentage of total abundance of soil detrivores in the Bukit Pinang-Pinang tropical r
area (a: Blattidae; b: Blaberidae; c: Cryptocercidae; d: Leiodidae; e: Dryophthoridae; f: Clan
Latridiidae; h: Liposcelididae; i: Platyarthridae; j. Porcellionidae; k: Armadillidiidae




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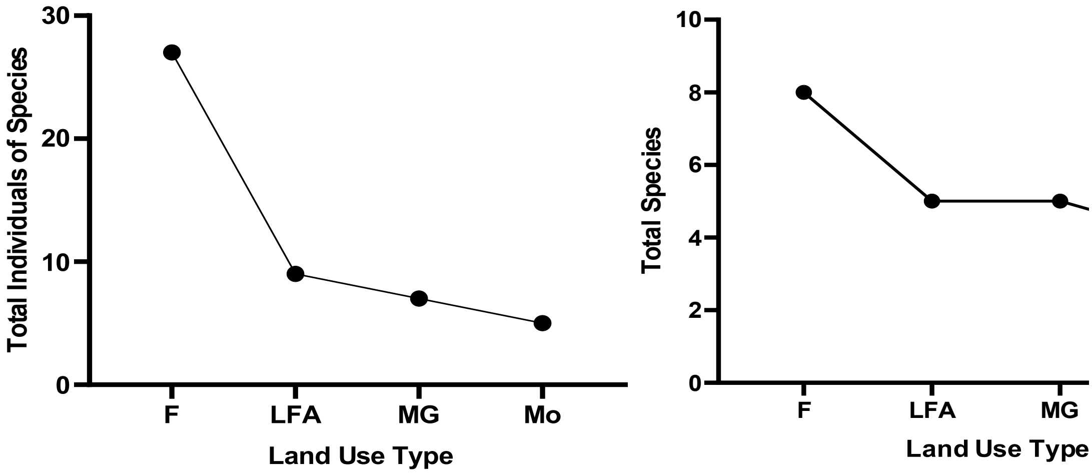
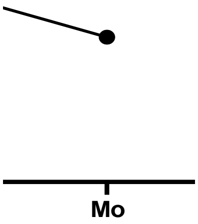



Fig. 3. Total Detrivora individuals and species based on different land types in the Bukit Pi
rainforest area.

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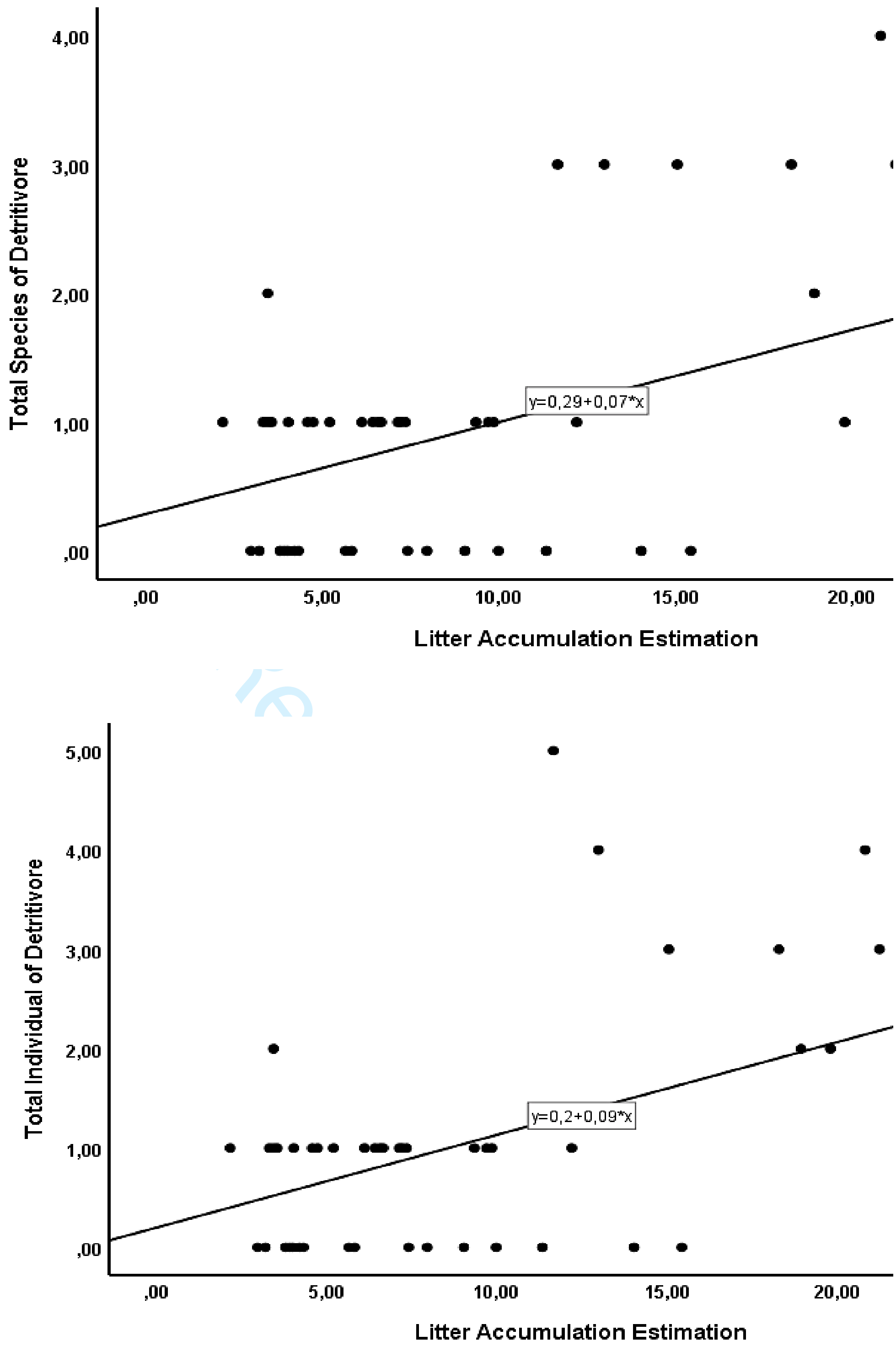
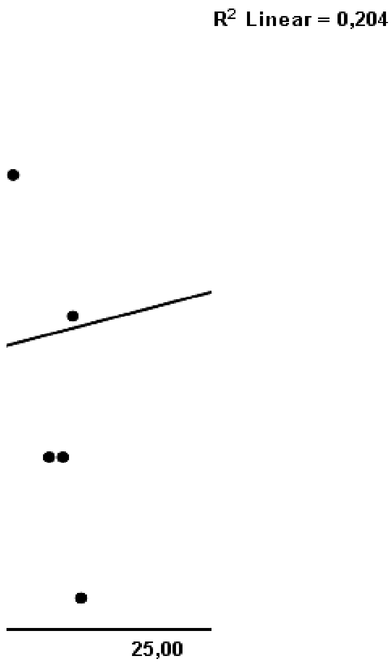
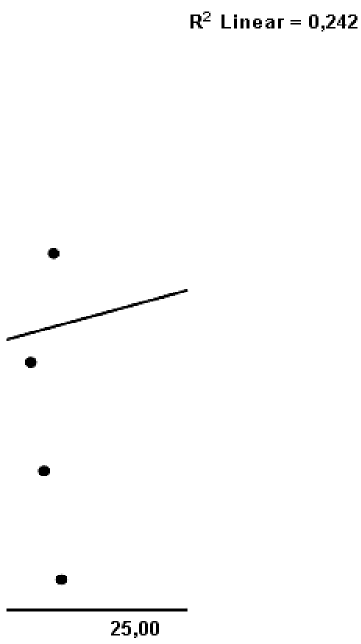



Fig. 4. Correlation of total individuals (a) and species (b) of soil detrivores with estimated lit






tter accumulation in the Bukit Pinang-Pinang

**Fig 5**

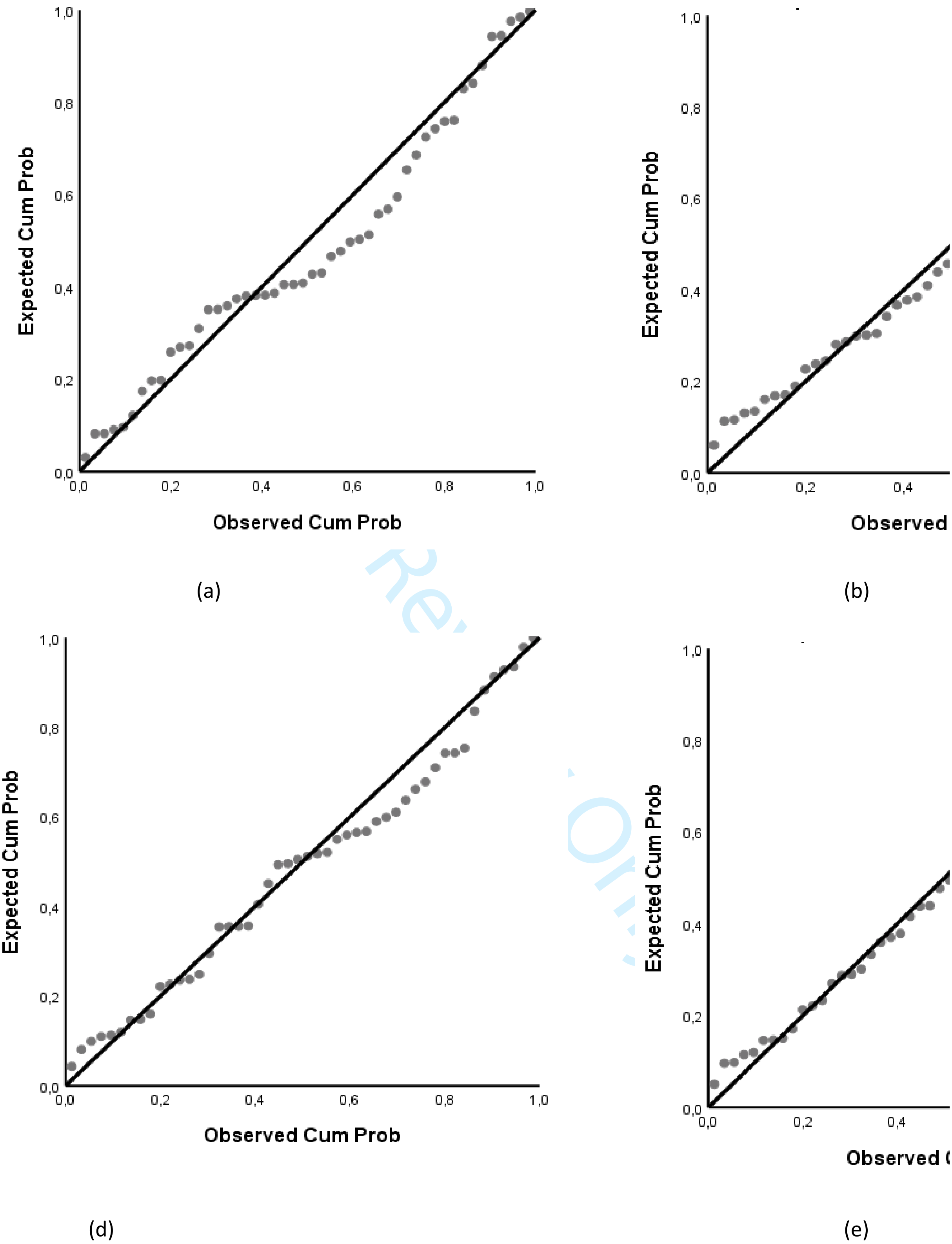
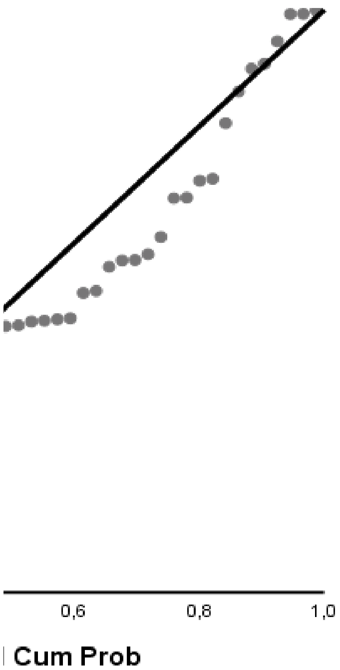
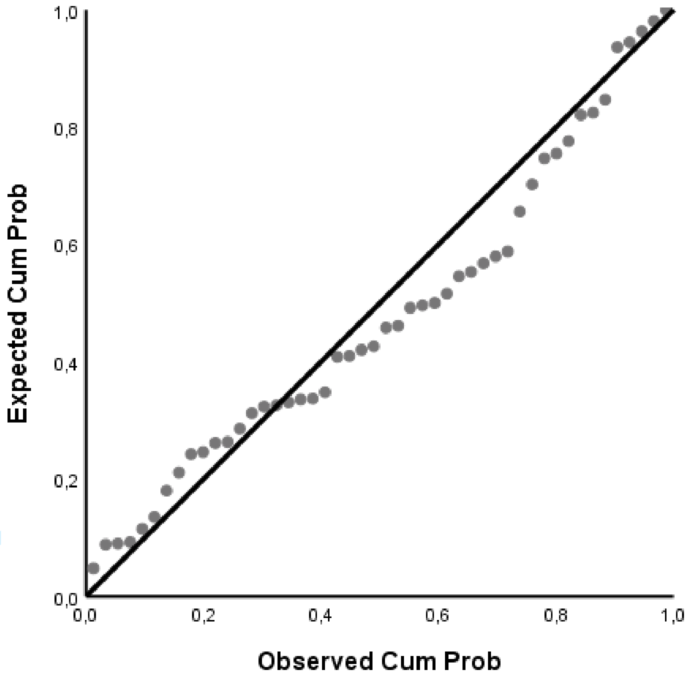


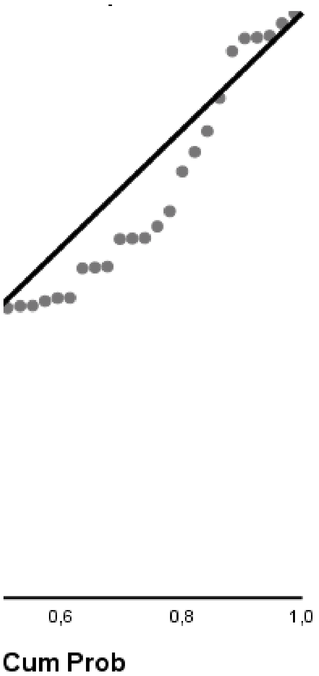

Fig. 5. Normal P-P Plot of Regression Standardised Residual Effect of litter accumulation and cl
Chemical Properties on total detrivore individuals; b. Soil physical characteristics on total detriv

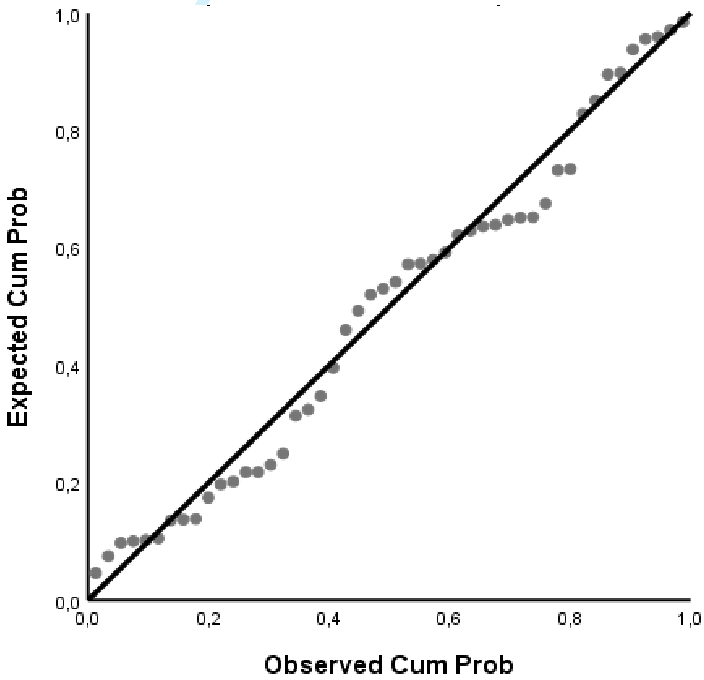
properties against total detrivore species: e. Soil physical properties against total detrivore specie




(c)




(f)

haracteristics of soil physical and chemical properties on total detrivore individuals and species (a
ore individuals; c. Litter accumulation and nutrients on total detrivore individuals; d. Soil chemic

es; f. Litter accumulation and nutrients)

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# TABLE

**Table 1:** Frequency of Presence (FR), Relative Density (KR), and Importance Index of Soil (INP) Detritivores in Several Land Types of Bukit Pinang-Pinang Tropical Rainforest Area

| Family | FR (%) | | | | KR (%) | | | | INP (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F | LFA | MG | Mo | F | LFA | MG | Mo | F | LFA | MG | Mo |
| Blattidae | 17.36 | 0.,00 | 0.00 | 0.00 | 4.85 | 0.00 | 0.00 | 0.00 | 22.21 | 0.00 | 0.00 | 0.00 |
| Blaberidae | 21.70 | 11.11 | 0.00 | 0.00 | 4.85 | 0.81 | 0.81 | 0.00 | 26.55 | 11.92 | 0.81 | 0.00 |
| Cryptocercidae | 13.02 | 0.00 | 0.00 | 0.00 | 2.43 | 0.00 | 0.00 | 0.00 | 15.45 | 0.00 | 0.00 | 0.00 |
| Leiodidae | 17.36 | 22.22 | 0.00 | 39.68 | 3.24 | 1.62 | 0.00 | 1.62 | 20.6 | 23.84 | 0,00 | 41.3 |
| Dryophthoridae | 4.34 | 33.33 | 19.84 | 19.84 | 0.81 | 2.43 | 0.81 | 0.81 | 5.15 | 35.76 | 20.65 | 20.65 |
| Clambidae | 0.00 | 0.00 | 0.00 | 19.84 | 0.00 | 0.00 | 0.00 | 0.81 | 0.00 | 0.00 | 0.00 | 20.65 |
| Latridiidae | 4.34 | 22.22 | 19.84 | 0.00 | 0.81 | 1.62 | 1.62 | 0.00 | 5.15 | 23.84 | 21.46 | 0.00 |
| Liposcelididae | 0.00 | 11.11 | 19.84 | 0.00 | 0.00 | 0.81 | 0.81 | 0.00 | 0.00 | 11.92 | 20.65 | 0.00 |
| Platyarthridae | 4.34 | 0.00 | 0.00 | 0.00 | 0.81 | 0.00 | 0.00 | 0.00 | 5.15 | 0.00 | 0.00 | 0.00 |
| Porcellionidae | 0.00 | 0.00 | 39.68 | 0.00 | 0.00 | 0.00 | 1.62 | 0.00 | 0.00 | 0.00 | 41.3 | 0.00 |
| Armadillidiidae | 17.36 | 0.00 | 0.00 | 19.84 | 4.05 | 0.00 | 0.00 | 0.81 | 21.41 | 0.00 | 0.00 | 20.65 |

F: Forest, LFA: Logged Forest Area, MG: Mixed Garden, Mo: Monoculture Garden

**Table 2:** Diversity index of soil detritivores.

| Parameter | F | LFA | MG | Mo |
|---|---|---|---|---|
| Diversity | 1.377 ± 0.105 | 0.963 ± 0.106 | 0.685 ± 0.075 | 0.639 ± 0.083 |
| Evenness | 0.574 ± 0.084 | 0.401 ± 0.079 | 0.286 ± 0.069 | 0.266 ± 0.075 |
| Dominance | 0.054 ± 0.006 | 0.035 ± 0.005 | 0.011 ± 0.001 | 0.014 ± 0.002 |

F: Forest, LFA: Logged Forest Area, MG: Mixed Garden, Mo: Monoculture Garden

**Table 3:** Estimated litter accumulation and soil physical and chemical properties.

| Soil Parameter | Land Type | | | |
|---|---|---|---|---|
| | F | LFA | MG | Mo |
| soil pH | $4.85^{a} \pm 0.394$ | $5.00^{a} \pm 0.232$ | $5.68^{b} \pm 0.330$ | $5.78^{b} \pm 0.323$ |
| Soil C (%) | $5.88^{a} \pm 2.569$ | $5.83^{a} \pm 3.517$ | $7.32^{a} \pm 3.068$ | $6.88^{a} \pm 1.892$ |
| Soil N (%) | $0.44^{a} \pm 0.101$ | $0.34^{a} \pm 0.076$ | $0.47^{ab} \pm 0.064$ | $0.56^{b} \pm 0.107$ |
| BD ($gr/cm^3$) | $0.73^{a} \pm 0.080$ | $0.79^{b} \pm 0.058$ | $0.70^{a} \pm 0.059$ | $0.66^{a} \pm 0.046$ |
| SMC | $0.37^{b} \pm 0.127$ | $0.24^{a} \pm 0.082$ | $0.26^{a} \pm 0.109$ | $0.24^{a} \pm 0.067$ |
| Estimated AS (tons/ha) | $19.1^{c} \pm 0.695$ | $4.97^{a} \pm 0.803$ | $5.24^{a} \pm 2.052$ | $9.57^{b} \pm 2.736$ |
| N litter (%) | $1.22^{a} \pm 0.101$ | $1.02^{a} \pm 0.095$ | $1.13^{a} \pm 0.057$ | $1.29^{a} \pm 0.040$ |
| C litter (%) | $50.10^{a} \pm 1.290$ | $48.98^{a} \pm 0.954$ | $49.67^{a} \pm 2.634$ | $47.64^{a} \pm 2.299$ |

BD: Bulk density, SMC: Soil moisture content, AS: Estimated litter accumulation, F: Forest, LFA: Logged Forest Area, MG: Mixed Garden, Mo: Monoculture Garden

**Table 4:** Multiple regression analysis of the effect of litter accumulation and soil physical and chemical characteristics on total detritivore individuals and species.

| Variable | T Test | | | | | | | | F Test | | | Determination Coefficient (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Chemicals | | | Soil Physics | | Litter Accumulation | | | KT | FT | S | KT | FT | S |
| | pH | Nso | CSo | BD | SMC | LAE | LNC | LCC | | | | | | |
| Total Individual | -3.364* | 0.568 | -2.227* | 1.417 | 1.541 | 3.791* | -0.553 | 2.688* | 5.979* | 1.972 | 7.914* | 29.0 | 8.1 | 35.0 |
| Total Species | -2.583* | 0.347 | -2.223* | 1.585 | 1.592 | 3.403* | -0.970 | 2.407* | 4.405* | 2.270 | 6.450* | 23.1 | 5,. | 30.5 |

* p-value <0.05 at 95% confidence level, Nso (Soil N), Cso (Soil C), BD (Bulk Density), SMC (Soil Moisture Content), LAE (Litter Accumulation Estimate), LNC (Litter Nitrogen Content), LCC (Litter Carbon Content), KT (Soil Chemical), FT (Physical Chemical), S (Litter).