Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 12 ~ Issue 6 (June 2026) pp: 22-31
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Genus-level patterns of ground-active Scarabaeidae in regenerating forests of the BAEGO landscape, central Congo Basin

Kosele, K. J. [1]*; Musakay, M. B[2]., Bakondongama, B. J.[3]; Toengaho, S. A.[1], Kambale, J-L.[1], & Kankonda, O.M.[1,2]

[1] *Biodiversity Monitoring Centre, University of Kisangani*
[2] *Faculty of Renewable Natural Resources Management.*
[3.] *Faculty of Sciences, University of Kisangani*
* *Corresponding author: jonathan.kosele@unikis.ac.cd*

Abstract
Tropical forest regeneration can promote the recovery of soil-surface insect communities, yet information on Scarabaeidae assemblages remains limited in the central Congo Basin. This study assessed genus-level composition, abundance, temporal variation, taxonomic diversity, and indicator value of ground-active Scarabaeidae in regenerating forests of the BAEGO landscape, central Congo Basin, Democratic Republic of the Congo. Beetles were sampled using 100 pitfall traps distributed across 20 sampling plots (50 × 50 m), with five traps installed per plot. Sampling was conducted from February 2024 to March 2025, and traps were checked every 21 days. Captured specimens were identified in the laboratory based on external morphological characters. Three genera were recorded: Onthophagus, Scarabaeus, and Augosoma. The assemblage was strongly dominated by Onthophagus, which remained the most abundant genus throughout the sampling period. Monthly abundance patterns showed moderate temporal variation, whereas Scarabaeus and Augosoma were less abundant and more irregularly represented. Shannon diversity remained generally low, reflecting dominance by a few taxa, while Simpson diversity varied more clearly across regeneration stages, suggesting changes in dominance structure rather than a simple increase in richness. Indicator value analysis identified Onthophagus as the genus with the highest indicator value, followed by Scarabaeus. However, these results should be considered preliminary because identifications were conducted at the genus level and no habitat variables were directly measured. The high indicator value of Onthophagus suggests that it was the most frequent and consistent taxon across the sampled habitats, although its usefulness as an ecological indicator requires confirmation through species-level identification and the inclusion of measured environmental variables. These findings provide baseline information on Scarabaeidae assemblages in regenerating tropical forests of the BAEGO landscape and contribute to the limited knowledge of insect community recovery in the central Congo Basin.

Keywords: *dung beetles; Scarabaeidae; forest regeneration; chronosequence; pitfall traps; taxonomic diversity; Congo Basin; Tshopo Province.*

*Received 10 June., 2026; **R**evised 18 June, 2026; **A**ccepted 20 June., 2026 © The author(s) 2026.*
P**ublished with open access at **www.questjournals.org

I. Introduction

Tropical rainforests are among the most diverse terrestrial ecosystems, playing central roles in carbon storage, climate regulation, nutrient cycling, and biodiversity conservation (FAO, 2020; Laurance *et al.,* 2014). Despite their ecological importance, these forests are increasingly threatened by deforestation, fragmentation, agricultural expansion, and other forms of human disturbance (FAO, 2020). As a result, forest regeneration has become an important pathway for biodiversity recovery and ecosystem restoration in many tropical regions. Regenerating forests can serve as dynamic reservoirs of biodiversity and ecosystem services, although the trajectories and rates of ecological recovery may vary considerably depending on disturbance history, landscape context, and time since abandonment (Chazdon, 2014).

Invertebrates are valuable for evaluating ecological recovery because they often respond rapidly to changes in habitat structure, resource availability, and disturbance intensity. Among these, beetles of the family Scarabaeidae, particularly dung beetles, are widely recognized as useful indicators of habitat condition in tropical ecosystems (Spector, 2006). Many scarabaeids contribute to dung removal, nutrient recycling, soil aeration, secondary seed dispersal, and organic matter decomposition (Nichols *et al*., 2008). The abundance and community structure of Scarabaeidae frequently vary with forest disturbance, vegetation recovery, and habitat modification, making them relevant organisms for monitoring regenerating forests (Scheffler, 2005; Beiroz *et al*., 2020).

Although the ecological importance of Scarabaeidae has been documented in several tropical regions, studies examining their responses to forest regeneration remain scarce in the Congo Basin. This knowledge gap is particularly pronounced in the Democratic Republic of the Congo, where insect-based assessments of forest recovery are still limited despite the region containing one of the largest and most biologically important tropical forest blocks in the world. In Tshopo Province and surrounding areas, information on ground-active Scarabaeidae assemblages, their diversity patterns, and their potential use as ecological indicators is especially limited. Consequently, the lack of baseline ecological data constrains the development of biodiversity monitoring programmes and the integration of insect indicators into forest restoration initiatives across the central Congo Basin.

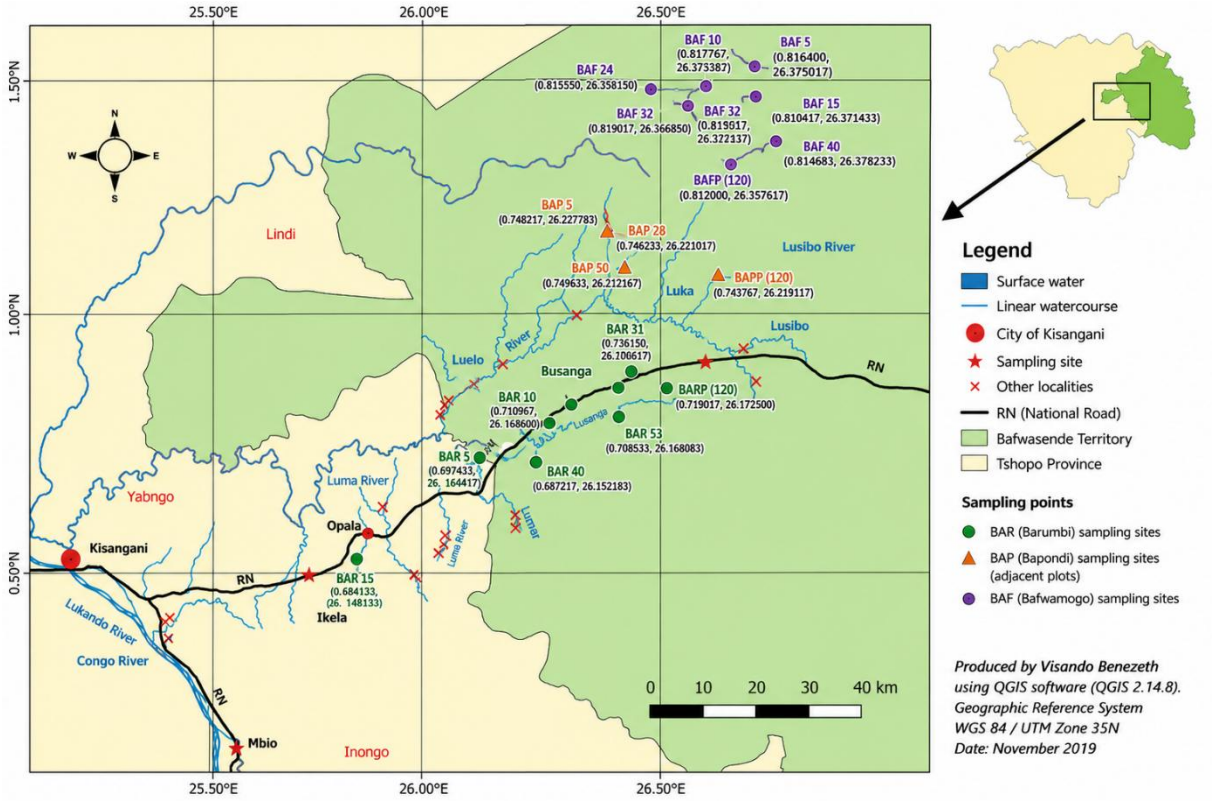
The BAEGO forest landscape provides an opportunity to improve understanding of Scarabaeidae assemblages in regenerating tropical forests and to contribute to the limited body of knowledge available for the Congo Basin. Accordingly, this study aimed to assess the genus-level composition, abundance, temporal variation, taxonomic diversity, and indicator value of ground-active Scarabaeidae along a forest regeneration chronosequence. Specifically, the study addressed the following questions: (i) Which Scarabaeidae genera dominate the sampled assemblage? (ii) How does genus-level abundance vary over time and across regeneration stages? (iii) Which genera show the highest indicator values within regenerating forest habitats?

II. Materials and methods

2.1 Study area

The study was conducted in the BAEGO forest landscape, located in the Bakeni-Kondolole sector along the Kisangani–Ituri road axis, Bafwasende Territory, Tshopo Province, Democratic Republic of the Congo. Sampling was carried out in forest localities including Barumbi, Bapondi and Bafwamogo. The area belongs to the humid tropical forest zone of the central Congo Basin and is characterized by high humidity, warm temperatures and rainfall distributed across most of the year.

Figure 1 : Location of the study area and sampling plots in the BAEGO forest landscape, Tshopo Province, Democratic Republic of the Congo. Sampling sites were distributed among the Barumbi, Bapondi, and Bafwamogo community forests and represented a forest regeneration chronosequence ranging from 8 to 120 years.



The broader Kisangani region is drained by the Congo River and several tributaries, including the Maiko, Lindi, Tshopo, Uma, Aruwimi-Ituri and Lulu rivers. This hydrographic network contributes to landscape heterogeneity and the separation of forest blocks. The study sites represented regenerating forest habitats of different ages, allowing the assessment of Scarabaeidae assemblages along a forest recovery gradient.

2.2 Beetle sampling

Ground-active Scarabaeidae were collected using pitfall traps, also known as Barber traps. Pitfall trapping is a widely used method for sampling arthropods moving on the soil surface, including ground-active beetles. However, pitfall catches reflect activity-density rather than absolute population abundance, because captures depend both on the number of individuals present and on their movement activity.

Sampling was conducted from February 2024 to March 2025 in regenerating forest habitats within the BAEGO landscape. A total of 100 pitfall traps were deployed across 20 sampling plots, each measuring 50 × 50 m. Five pitfall traps were installed in each plot to ensure standardized sampling effort across the study area. Traps were checked every 21 days throughout the study period, resulting in a continuous monitoring programme covering 14 months.

Each trap consisted of a plastic container buried in the soil with its rim level with the ground surface to intercept ground-active beetles moving across the forest floor. Captured insects were collected during each sampling session, preserved, and transferred into labelled containers for laboratory processing and identification. Information on plot identity, regeneration age, habitat category, sampling date, and locality was recorded for each sampling event to ensure traceability of the material.

The sampling design provided a standardized effort of 100 pitfall traps distributed among 20 regenerating forest plots representing different stages of forest recovery. This approach allowed comparisons of Scarabaeidae assemblages across the regeneration chronosequence while maintaining consistent sampling intensity throughout the study period.

2.3 Laboratory processing and taxonomic identification

Specimens were processed at the Centre de Surveillance de la Biodiversité. Upon reception, samples were checked for preservation status and sorted under a binocular microscope. Scarabaeidae were separated from other beetles using general external morphological characters, including robust body form, lamellate antennae, fossorial forelegs and elytral structure.

Before identification, specimens were cleaned to remove soil particles and organic debris that could obscure diagnostic characters. Identification was based on visible morphological traits, including antenna structure, pronotum shape, elytral sculpture, tibial spines and pygidium form. Specimens were compared with

reference material and available taxonomic illustrations. Because some individuals could not be reliably identified to the species level, all analyses were conducted at genus level.

2.4 Data analysis

Data analysis focused on genus-level abundance, temporal variation, taxonomic diversity and indicator value. Monthly abundance was summarized for the recorded genera: *Onthophagus*, *Scarabaeus* and *Augosoma*. Abundance values were transformed using log(x + 1) for graphical interpretation and to reduce the influence of highly abundant taxa. Taxonomic diversity was described using genus richness, Shannon diversity and Simpson diversity. Shannon diversity was used to assess the combined effects of richness and evenness, whereas Simpson diversity was used to evaluate dominance patterns within the assemblage.

Indicator value analysis was used to identify genera associated with particular habitat or regeneration conditions. The indicator value combines specificity, which reflects the degree to which a taxon is restricted to a given condition, and fidelity, which reflects how consistently the taxon occurs within that condition. A high and statistically significant value indicates that a taxon may be considered a useful ecological indicator. Because environmental variables such as canopy cover, litter depth, soil moisture, temperature and resource availability were not measured, the study did not test direct environmental drivers of Scarabaeidae assemblage structure. Similarly, functional traits were not measured; therefore, no functional diversity analysis was performed.

III. Results

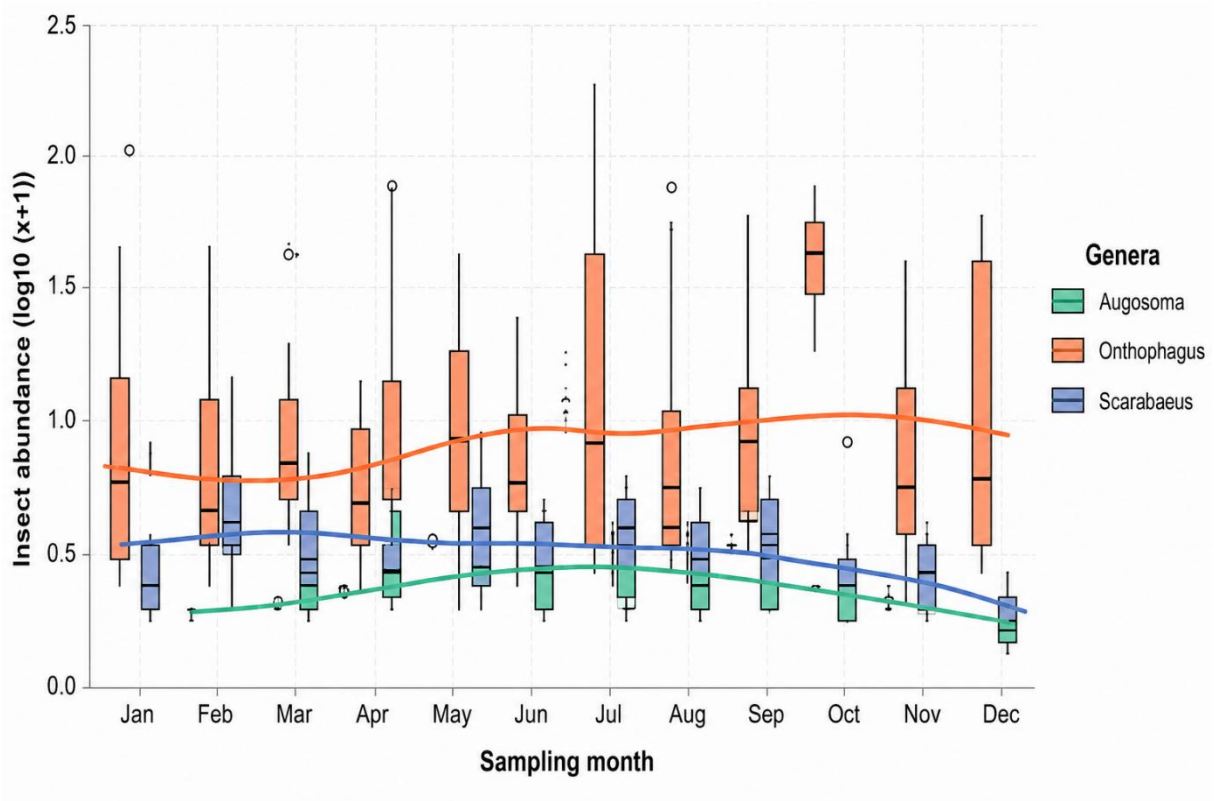
3.1 Genus-level composition and abundance

Three Scarabaeidae genera were recorded in the sampled material: *Onthophagus*, *Scarabaeus* and *Augosoma*. The assemblage was strongly uneven, with *Onthophagus* clearly dominating the community. This genus showed consistently higher abundance than the other recorded genera across the sampling period. *Scarabaeus* was present at a lower abundance, while *Augosoma* was the least represented genus. The overall assemblage, therefore, showed low genus richness and strong dominance by a single genus. This pattern suggests that the sampled Scarabaeidae community consisted of a few genera, with notable differences in how abundant each genus was within the assemblage.

3.2 Temporal variation in abundance

Monthly abundance patterns showed that *Onthophagus* remained dominant throughout the sampling period. Its abundance was relatively stable, although slight increases were observed during some months, particularly around July, October and December. These temporal changes indicate moderate seasonal variation in activity or capture rate. By contrast, *Scarabaeus* showed lower and more variable abundance, with a slight increase around May and June. *Augosoma* remained rare throughout the sampling period and showed only limited temporal fluctuation. Overall, temporal variation in the assemblage was driven mainly by changes in the abundance of *Onthophagus*, whereas the other genera contributed relatively little to total abundance. Because climatic conditions and resource availability were not measured directly, the observed temporal patterns cannot be attributed to specific environmental drivers. Therefore, these results should be interpreted as descriptive observations of seasonal variation in beetle activity as reflected by pitfall trap catches.

Figure 2. *Monthly variation in the abundance of recorded Scarabaeidae genera in regenerating forests of the BAEGO landscape, central Congo Basin.*

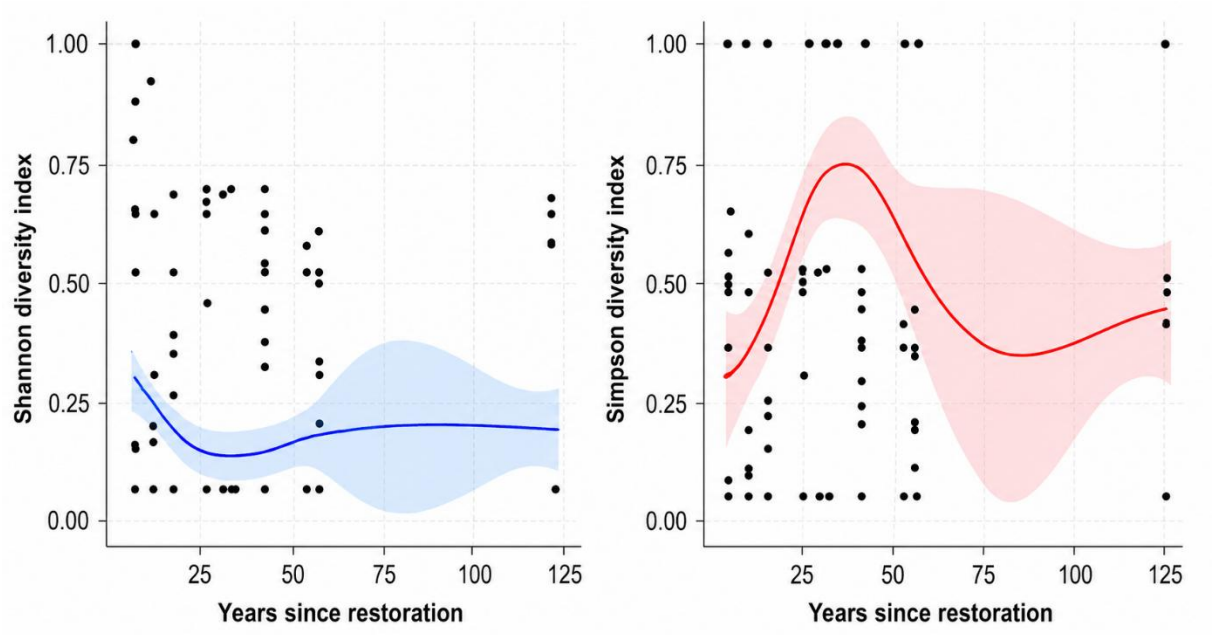


Boxplots represent the distribution of log-transformed abundance values [log10(x + 1)] for each genus across sampling months. Colored trend lines illustrate the general temporal pattern in abundance throughout the study period. Onthophagus remained the dominant genus across all months, whereas Scarabaeus and Augosoma occurred at lower abundances and showed more limited temporal variation.

3.3 Taxonomic diversity across regeneration stages

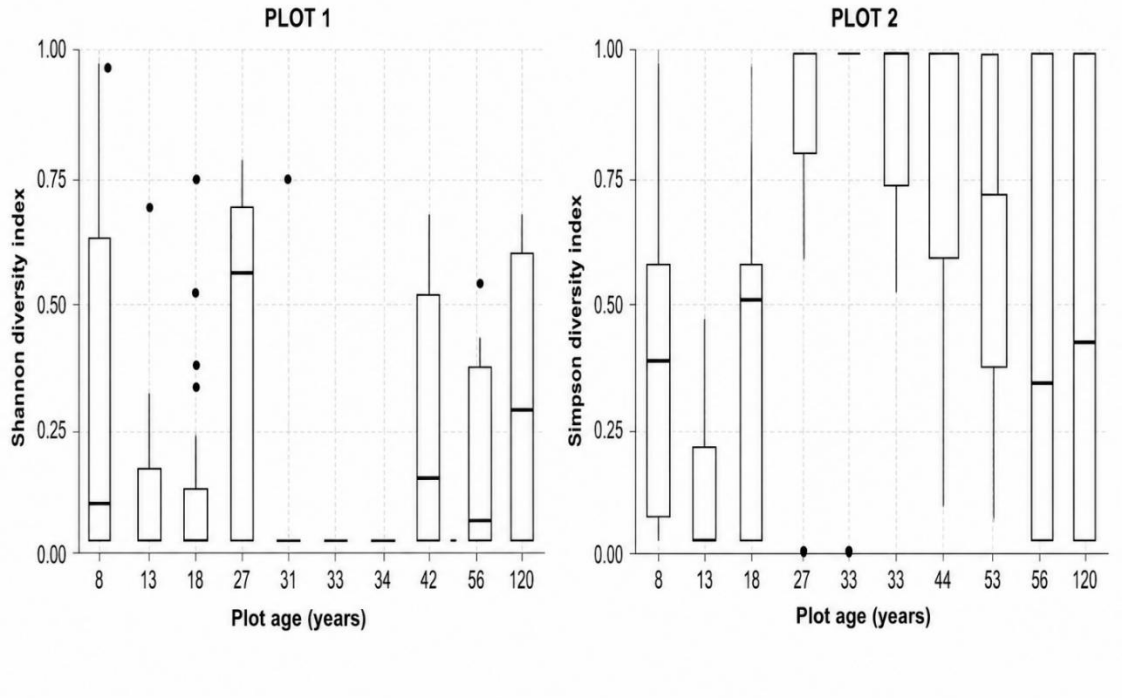
Diversity indices suggested that Scarabaeidae diversity did not follow a simple linear increase with forest regeneration time. Shannon diversity remained generally low across regeneration stages. This reflects the strong dominance of a few taxa, especially *Onthophagus*, and indicates limited evenness within the assemblage. Simpson diversity showed clearer variation across the regeneration gradient. Higher values were observed around intermediate regeneration stages, suggesting that dominance was less pronounced or that the assemblage was more balanced during some phases of forest recovery. In older regeneration stages, diversity appeared to stabilize at moderate levels, although dominance by a few genera remained evident.

Figure 3. Variation in Shannon and Simpson diversity indices across forest regeneration ages in the BAEGO landscape, central Congo Basin. Points represent individual observations, while solid curves illustrate LOESS-smoothed trends and shaded areas represent 95% confidence intervals. Shannon diversity remained generally low across regeneration stages, whereas Simpson diversity showed greater variation, indicating changes in assemblage dominance during forest recovery.



Points represent individual observations, while solid curves illustrate LOESS-smoothed trends and shaded areas represent 95% confidence intervals.

Figure 4. Distribution of Shannon diversity index and Simpson diversity index indices across forest regeneration ages in the BAEGO landscape, central Congo Basin. Boxplots summarize diversity values recorded in forest plots representing different regeneration ages (8–120 years). The central horizontal line indicates the median, the box represents the interquartile range (Q1–Q3), whiskers indicate the range of non-outlier observations, and black dots represent outliers. Shannon diversity remained generally low across regeneration ages, whereas Simpson diversity showed greater variability among regeneration stages, indicating differences in assemblage dominance during forest recovery.



The boxplots (Figure 4) further highlight the variability of diversity indices within each regeneration age class. Shannon diversity exhibited generally low median values across most age classes, reflecting the numerical dominance of *Onthophagus*. In contrast, Simpson diversity showed higher median values in several intermediate and older regeneration stages, suggesting a more even distribution of genera during these phases of forest

recovery. Nevertheless, the broad dispersion observed within several age classes indicates substantial heterogeneity among sampling plots, implying that local habitat characteristics, in addition to regeneration age, may contribute to patterns of Scarabaeidae diversity.

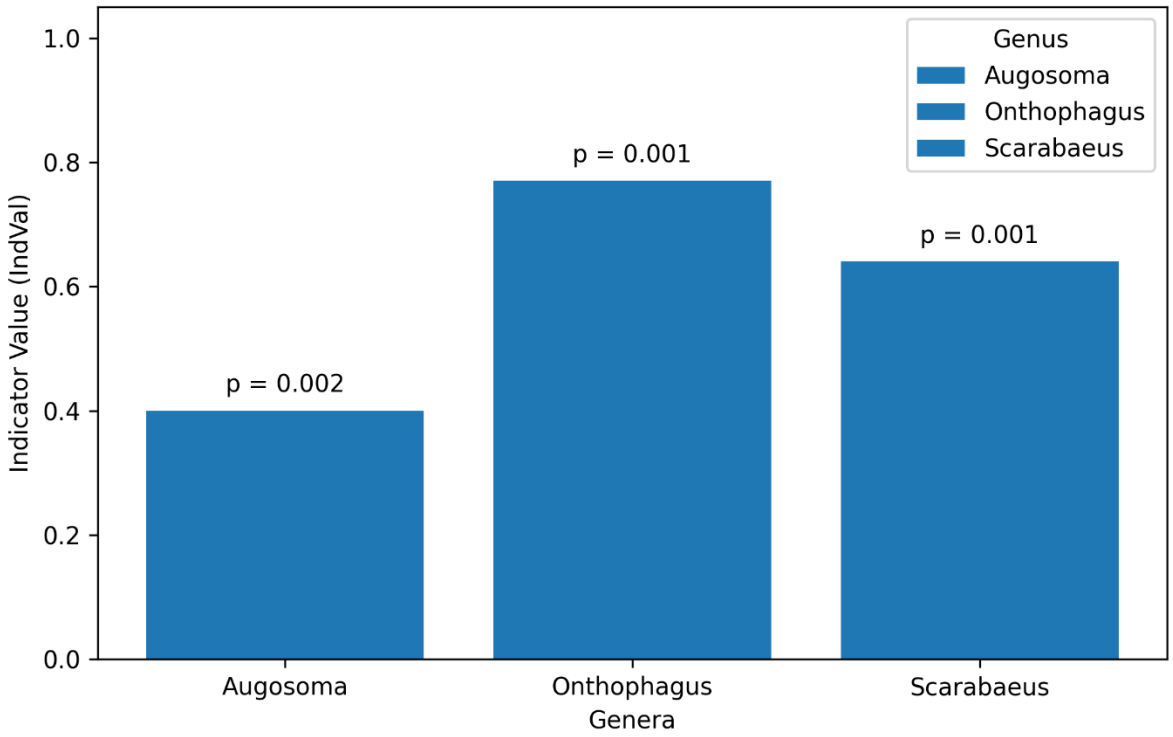
3.4 Indicator value of recorded genera

Indicator value analysis revealed significant associations between the recorded Scarabaeidae genera and the sampled regeneration habitats. *Onthophagus* exhibited the highest indicator value (IndVal = 0.77, p = 0.001), followed by *Scarabaeus* (IndVal = 0.64, p = 0.001), while *Augosoma* showed a lower but still significant indicator value (IndVal = 0.40, p = 0.002).

The high indicator value of *Onthophagus* reflects its frequent occurrence and consistent representation across the sampled habitats. This result is consistent with its numerical dominance in the assemblage, accounting for 1,508 individuals recorded during the study. *Scarabaeus* was less abundant, with 158 individuals, but still exhibited a relatively high indicator value, suggesting an association with particular regeneration conditions.

The analysis was based on samples collected from 20 regenerating forest plots (50 × 50 m each) distributed across the BAEGO landscape and sampled using 100 pitfall traps. These plots represented different stages of forest recovery and were monitored repeatedly throughout the sampling period. The significant indicator values suggest that the recorded genera were not randomly distributed among habitats and that *Onthophagus* was the most characteristic taxon within the sampled assemblages. Because identifications were conducted at the genus level and environmental variables were not directly measured, these indicator relationships should be considered preliminary and require confirmation through species-level analyses and habitat-based investigations.

Figure 5*. Indicator values (IndVal) of the three recorded Scarabaeidae genera in regenerating forests of the BAEGO landscape, central Congo Basin.*



Indicator values combine the specificity and fidelity of each genus to the sampled regeneration habitats. Higher values indicate stronger associations with the sampled habitat conditions. Onthophagus showed the highest indicator value (IndVal = 0.77, p = 0.001), followed by Scarabaeus (IndVal = 0.64, p = 0.001) and Augosoma (IndVal = 0.40, p = 0.002). P-values were obtained from permutation tests and indicate the statistical significance of indicator-habitat associations.

IV. Discussion

This study provides a preliminary assessment of ground-active Scarabaeidae assemblages in regenerating forests of the BAEGO landscape, central Congo Basin. The assemblage was characterized by low genus richness and strong dominance of Onthophagus, which accounted for most of the recorded individuals. Similar patterns of dominance by a limited number of dung beetle taxa have been reported in disturbed and regenerating tropical forests, where a few adaptable taxa often become numerically dominant while overall community composition remains simplified (Scheffler, 2005; Beiroz *et al*., 2020). These findings suggest that regenerating forests of the BAEGO landscape currently support Scarabaeidae assemblages dominated by a small number of genera.

Onthophagus remained the most abundant genus throughout the sampling period, whereas Scarabaeus and Augosoma were recorded at lower abundances. Previous studies have shown that some dung beetle taxa are able to persist across a broad range of habitat conditions and disturbance levels, contributing to their dominance in regenerating landscapes (Nichols *et al*., 2008; Beiroz *et al*., 2020). However, because environmental variables such as vegetation structure, canopy cover, soil moisture, and resource availability were not measured in the present study, the mechanisms underlying the observed dominance of Onthophagus cannot be determined. Consequently, the observed abundance patterns should be interpreted as descriptive evidence rather than proof of ecological preferences or habitat requirements.

The diversity patterns observed along the regeneration chronosequence suggest that Scarabaeidae recovery does not follow a simple linear trajectory. Shannon diversity remained generally low, reflecting strong dominance and limited evenness within the assemblage, whereas Simpson diversity showed greater variation across regeneration stages. Similar non-linear responses have been reported in tropical forest regeneration studies, where biodiversity recovery may depend on local habitat conditions, landscape connectivity, and the legacy effects of past disturbances rather than forest age alone (Hérault & Piponiot., 2018 ; Derhé *et al*., 2016). The higher Simpson diversity observed at some intermediate regeneration stages may indicate temporary reductions in dominance, resulting in a more balanced assemblage structure during particular phases of forest recovery.

Indicator value analysis identified Onthophagus as the genus with the highest indicator value (IndVal = 0.77, p = 0.001), followed by Scarabaeus (IndVal = 0.64, p = 0.001) and Augosoma (IndVal = 0.40, p = 0.002). These results indicate that Onthophagus was the most frequent and consistent genus across the sampled habitats. Nevertheless, its use as an ecological indicator should be considered preliminary because identifications were conducted at the genus level and environmental variables were not directly measured. Species-level identification and habitat-based analyses are necessary before firm conclusions can be drawn regarding indicator status. Similar recommendations have been made in previous studies emphasizing the importance of taxonomic resolution for ecological interpretation of dung beetle assemblages (Spector, 2006; Nichols *et al*., 2008).

Several limitations should be considered when interpreting the results. First, identifications were restricted to the genus level, which may have underestimated taxonomic diversity and masked species-specific responses to forest regeneration. Second, the absence of measured environmental variables prevented direct evaluation of the ecological drivers of assemblage variation (Chazdon, 2014). Third, functional traits were not assessed, limiting the ability to examine functional diversity and ecosystem functioning (Petchey & Gaston, 2006). Finally, pitfall traps measure activity-density rather than absolute abundance, meaning that differences in captures may reflect both population size and movement activity (Boetzl *et al*., 2018; Petchey & Gaston, 2006; Mlambo, 2014) . Finally, pitfall traps measure activity-density rather than absolute abundance, meaning that differences in captures may reflect both population size and movement activity (Boetzl *et al*., 2018).

Despite these limitations, this study provides valuable baseline information on Scarabaeidae assemblages in a poorly documented region of the central Congo Basin. The results contribute to filling an important knowledge gap on insect communities in regenerating forests of the Democratic Republic of the Congo and demonstrate that genus-level data can reveal meaningful patterns of dominance, diversity, and habitat association. Future studies should combine species-level identification, standardized sampling, environmental measurements, and functional trait analyses to improve understanding of the role of Scarabaeidae in forest regeneration and biodiversity monitoring.

V. Conclusion

Ground-active Scarabaeidae assemblages in the BAEGO landscape were represented by three recorded genera: Onthophagus, Scarabaeus, and Augosoma. The assemblage was characterized by a strong dominance of Onthophagus, which also exhibited the highest indicator value among the recorded genera. Diversity analyses suggested that the Scarabaeidae assemblage structure did not follow a simple linear pattern along the forest regeneration gradient. Instead, differences among regeneration stages appeared to be associated primarily with changes in dominance and relative abundance.

The results provide preliminary information on Scarabaeidae assemblages in regenerating forests of the central Congo Basin and contribute to filling an important knowledge gap for this region. Although Onthophagus showed the highest indicator value and was consistently abundant across sampled habitats, its potential use as an ecological indicator should be considered preliminary until confirmed through species-level identification and studies incorporating measured environmental variables.

Overall, the findings suggest that Scarabaeidae assemblages may provide useful information for biodiversity monitoring in regenerating tropical forests. However, further research based on broader sampling, species-level identification, and environmental measurements is needed to improve ecological interpretation and to better evaluate the role of Scarabaeidae in forest regeneration processes.

References

[1]. Beiroz, W., Sayer, E. J., Slade, E. M., Audino, L., Braga, R. F., Louzada, J., & Barlow, J. (2018). *Spatial and temporal shifts in functional and taxonomic diversity of dung beetles in a human-modified tropical forest landscape*. *Ecological Indicators, 95*, 518–526. https://doi.org/10.1016/j.ecolind.2018.07.062

[2]. Boetzl, F. A., Schneider, G., Krauss, J., & Steffan-Dewenter, I. (2018). Pitfall trap sampling bias depends on body mass, temperature, and trap number. *PLOS ONE, 13*(1), e0189478. https://doi.org/10.1371/journal.pone.0189478

[3]. Cambefort, Y. (1984). *Étude écologique des coléoptères Scarabaeidae de Côte d'Ivoire*. Travaux des Chercheurs de la Station de Lamto (Côte d'Ivoire), 3, 1–294. École Normale Supérieure, Paris.Chazdon, R. L. (2014). *Second growth: The promise of tropical forest regeneration in an age of deforestation*. University of Chicago Press.

[4]. Derhé, M. A., Murphy, H., Monteith, G., & Menéndez, R. (2016). *Measuring the success of reforestation for restoring biodiversity and ecosystem functioning*. Journal of Applied Ecology, 53(6), 1714–1724. https://doi.org/10.1111/1365-2664.12728

[5]. Food and Agriculture Organization of the United Nations (FAO). (2020). *The state of the world's forests 2020: Forests, biodiversity and people*. FAO.

[6]. Feer, F. (2000). Dung and carrion beetles (Scarabaeidae s. str. et Aphodiidae) of the rain forest of French Guiana: Species composition and structure of populations. *Annales de la Société Entomologique de France, 36*(1), 29–43.

[7]. Hérault, B., & Piponiot, C. (2018). Key drivers of ecosystem recovery after disturbance in a neotropical forest. *Forest Ecosystems*, *5*(1). https://doi.org/10.1186/s40663-017-0126-7

[8]. Laurance, W. F., Clements, G. R., Sloan, S., O'Connell, C. S., Mueller, N. D., Goosem, M., Venter, O., Edwards, D. P., Phalan, B., Balmford, A., van der Ree, R., & Arrea, I. B. (2014). A global strategy for road building. *Nature, 513*(7517), 229–232. https://doi.org/10.1038/nature13717

[9]. Mlambo, M. C. (2014). Not all traits are 'functional': insights from taxonomy and biodiversity-ecosystem functioning research. *Biodiversity and Conservation*, *23*(3), 781–790. https://doi.org/10.1007/s10531-014-0618-5

[10]. Nichols, E., Spector, S., Louzada, J., Larsen, T., Amezquita, S., & Favila, M. E. (2008). Ecological functions and ecosystem services provided by Scarabaeinae dung beetles. *Biological Conservation, 141*(6), 1461–1474. https://doi.org/10.1016/j.biocon.2008.04.011

[11]. Petchey, O. L., & Gaston, K. J. (2006). Functional diversity: Back to basics and looking forward. *Ecology Letters, 9*(6), 741–758. https://doi.org/10.1111/j.1461-0248.2006.00924.x

[12]. Scheffler, P. Y. (2005). Dung beetle (Coleoptera: Scarabaeidae) diversity and community structure across three disturbance regimes in eastern Amazonia. *Journal of Tropical Ecology, 21*(1), 9–19. https://doi.org/10.1017/S0266467404001683

[13]. Spector, S. (2006). Scarabaeine dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae): An invertebrate focal taxon for biodiversity research and conservation. *The Coleopterists Bulletin, 60*(Monograph 5), 71–83. https://doi.org/10.1649/0010-065X(2006)60[71:SDBCSS]2.0.CO;2

[14]. Zhu, L., Lefcheck, J. S., & Fu, B. (2016). *Do current definitions and methods promote the general application of functional traits and functional diversity*? Peerj. https://doi.org/10.7287/peerj.preprints.2631v1