© IIJP 2026 | Volume 2, Issue 3, pp. 1333-|1344 ISSN: 2636-4484

SPECIES COMPOSITION, DIVERSITY AND ABUNDANCE OF DUNG BEETLES (*Onthophagus gazella* and *Onitis alexisi)* IN RELATION TO SOIL PHYSICOCHEMICAL PROPERTIES AND HABITAT TYPES IN DEMSA LOCAL GOVERNMENT AREA, ADAMAWA STATE, NIGERIA

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ARTICLE INFO
Article No.: 0515
Accepted Date: 02/08/2026
Published Date: 25/08/2026
Type: Research

ABSTRACT

Dung beetles are important ecological indicators that contribute to nutrient cycling, soil aeration, and ecosystem stability; however, limited information exists on their species composition, diversity and relationship with soil physicochemical properties and habitat types in northern Nigeria. This study investigated species composition, diversity and abundance of dung beetles (*onthophagus gazella* and *onitis alexisi)* in relation to soil physicochemical properties and habitat types in Demsa Local Government Area, Adamawa State, Nigeria. Dung beetles were collected using dung-baited pitfall traps from Mbula Kuli, Demsa, and Borrong, while soil samples were analyzed for pH, moisture content, organic matter, organic carbon, total nitrogen, phosphorus, exchangeable acidity, and potassium. Data were analyzed using Shannon diversity index, Pearson correlation, ANOVA, and Chi-square statistics. A total of 154 dung beetles belonging to two species, *Onthophagus gazella* and *Onitis alexis,* were identified. *Onthophagus gazella* was the dominant species, accounting for 146 individuals (94.8%), while *O. alexis* recorded only 8 individuals (5.2%). Borrong recorded the highest abundance (65 individuals), followed by Demsa (49) and Mbula Kuli (40). Shannon diversity indices were generally low, ranging from 0.08 in Borrong to 0.42 in Mbula Kuli. Pearson correlation analysis showed strong positive relationships between dung beetle abundance and soil moisture ($r = 0.72$), organic matter ($r = 0.76$), total nitrogen ($r = 0.74$), phosphorus ($r = 0.81$), and potassium ($r = 0.67$), while exchangeable acidity showed a negative relationship ($r = –0.52$). Habitat type significantly influenced abundance ($\chi^2 = 6.25$, $P < 0.05$). Soil fertility and habitat heterogeneity strongly influence dung beetle communities. Sustainable grazing, reduced agrochemical use, and improved soil fertility management are recommended to conserve dung beetle diversity and ecosystem functions.

Keywords: Dung Beetle, Nutrient Cycling, Relative Abundance, Soil Physicochemical Properties, Species Diversity.

Introduction

Dung beetles (Coleoptera: Scarabaeidae) represent one of the most ecologically significant insect groups in terrestrial ecosystems. They are widely distributed across tropical and temperate regions, performing crucial ecological functions such as nutrient cycling, secondary seed dispersal, soil aeration, and suppression of livestock parasites (Nunes et al., 2021). Their activities enhance soil fertility by incorporating organic matter into the soil, promoting microbial activity, and improving soil structure (Slade et al., 2011). In an ecosystem that has been modified by humans for the purpose of agricultural production, dung beetles play a central role by breaking down and burying livestock dung, thereby preventing pasture fouling, reducing greenhouse gas emissions, and controlling pests such as parasitic flies and nematodes (Horgan, 2015; Bogoni et al., 2020).

Research has shown that intensive farming practices such as heavy reliance on chemical fertilizers, pesticides, and continuous soil tillage have considerable impacts on dung beetle assemblages by modifying soil physicochemical conditions and diminishing the availability of dung resources (Braga et al., 2022). Within African savanna ecosystems, dung beetles play a crucial role in sustaining ecological balance and agricultural productivity, especially in areas dominated by livestock farming (Davis et al., 2021). Through their tunneling and dung-burying behavior, they contribute to soil turnover, promote nutrient recycling, and facilitate seed germination. This function is especially important for plant species with larger seeds that depend on secondary dispersal agents for regeneration (Nichols et al., 2008). In Nigeria, however, research on dung beetles remains relatively limited in scope and distribution. Existing studies have predominantly focused on the southwestern part of the country (Adeyefa et al., 2014), leaving northern regions, particularly Adamawa State, largely unexplored. This gap restricts understanding of the biodiversity patterns and ecological functions that dung beetles contribute in these underrepresented areas. Soil physicochemical attributes including pH, organic matter, moisture levels, and texture are known to play a key role in shaping dung beetle occurrence and activity patterns (Braga et al., 2022). These properties influence the suitability of soils for burrowing, dung incorporation, and larval growth, thereby determining the composition and functional roles of beetle communities. Examining the distribution, diversity, and abundance of dung beetles in relation to soil physicochemical conditions is crucial for biodiversity conservation, sustainable land use, and improved agricultural outcomes. Such insights provide essential baseline information for incorporating dung beetle driven ecosystem services into agricultural development policies and broader environmental management plans. The present study aims to address existing gaps by investigating dung beetle diversity, abundance, and distribution in farmlands within Demsa Local Government Area, while also analyzing how soil properties affect their prevalence.

Materials and Methods

1 Study Area

The study was carried out in Demsa Local Government Area (LGA) of Adamawa State, Nigeria. Demsa lies between latitudes 9°27′ and 9°36′ N and longitudes 12°02′ and 12°08′ E, within the Sudan Savanna ecological zone of northeastern Nigeria. The study adopted a field-based quantitative research design using a cross-sectional ecological survey approach for assessment of dung beetle species composition, diversity, abundance, and distribution of Onthophagus gazella and Onitis alexis in relation to soil physicochemical properties and habitat types in Demsa Local Government Area (LGA), Adamawa State, Nigeria

2 Study Design

Sampling sites were selected to represent three habitat types within the agricultural landscape: fallow land (Mbula Kuli), cultivated land (Demsa), and grazing land (Borrong). The sites were selected to capture spatial variation in dung beetle communities and soil conditions. At each site, standardized sampling procedures were used to ensure comparability among habitats. Dung beetles were collected using baited pitfall traps with fresh cattle dung. Sampling was conducted from December 2025 to March 2026. Soil samples were collected from the same plots in which the beetle traps were deployed.

3 Dung Beetle Collection

Dung beetles were collected using the baited pitfall-trap method. Five pitfall traps were installed in each 20 × 20 m quadrat, with one trap at each corner and one at the centre. Each trap consisted of a plastic container approximately 10 cm in diameter and 12 cm deep, buried so that the rim was level with the soil surface. Fresh cattle dung (approximately 250 g) was used as bait. The bait was wrapped in muslin cloth and suspended approximately 2 cm above the trap opening to release its odour while preventing direct feeding. Each trap was protected with a small rain shield made from palm fronds or plastic sheets positioned approximately 10 cm above the trap. Traps remained active for 48 hours during each sampling period, from 08:00 h on the first day to 08:00 h on the third day. Captured beetles were removed with forceps, preserved in 70% ethanol, and labelled with habitat, quadrat, trap, and collection-date information. Specimens were transported in sealed containers to the Entomology Laboratory, Department of Zoology, Modibbo Adama University, Yola, where they were sorted and identified using appropriate taxonomic keys.

4 Laboratory Analysis

Soil pH was determined using a digital pH meter following a 1:2.5 soil-to-water ratio. Soil texture was determined by the hydrometer method. Soil moisture content was determined by the gravimetric method. Organic matter and organic carbon were determined using the Walkley–Black wet oxidation method. Total nitrogen was determined using the Kjeldahl digestion method. Available phosphorus was determined using the Bray method. Exchangeable acidity was determined using the 1 N potassium chloride (KCl) extraction method. Potassium was determined after extraction with ammonium acetate (NH_4OAc), followed by flame-photometric measurement (AOAC, 2016).

5 Data Analysis

Pearson correlation analysis and descriptive statistics were performed using SPSS version 23. The Chi-square test was used to assess differences in the distribution of dung beetle individuals among study areas and habitat types. Species composition was summarized using Microsoft Excel 2013. Total abundance and taxonomic richness were obtained using PAST version 4.04. The Shannon–Wiener diversity index (H′) was used to compare dung beetle diversity among sampling sites. Soil variables were expressed as mean ± standard deviation. One-way analysis of variance (ANOVA) was used to compare means, and Fisher's Least Significant Difference (LSD) test was used for multiple comparisons at $p < 0.05$.

$$\text{Richness (\%)} = \frac{\text{number of species in a system}}{\text{Total number of species from the different areas}} \times 100$$

To determine the diversity indices, the Paleontological Statistics Software Package for Education and Data Analysis (PAST) version 4.04 were used to generate the diversity indices for different study areas. The Shannon-Wiener Index (H') was used to compare the species diversity of dung beetle assemblages in the different study areas. Shannon–Wiener Index, (H′) integrates both richness and evenness into a single value, providing a measure of the overall heterogeneity of the community (Shannon & Weiner, 1949). Values of the soil analysis were expressed as mean ± standard deviation. One- way analysis of variance (ANOVA) were used to compare the means of the variables, and multiple comparisons were performed using Fisher's Least Significant Difference (LSD) test at $p<0.05$.

Result

1 Species of dung beetle identified in the study area.

A total of 154 dung beetles belonging to two species of the family of Scarabaidae were identified across the study area. The species recorded were *Onthophagus gazella* and *Onitis alexis*. *Onthophagus gazella* was the dominant species with 146 individuals (94.8%) while *Onitis alexis* accounted for 8 individuals (5.2%) **(Table 1)**.

Table 1 Species of dung beetle identified in the study area.

Species	Family	No. of Individuals	percentage
Onthophagus gazella	Scarabaidae	146	94.8
Onitis alexis	Scarabaidae	8	5.2

2 Species diversity of dung beetle communities identified in the study area.

The Shannon–Wiener diversity index varied among the sampling sites. Mbula Kuli had the highest diversity value (H′ = 0.42), followed by Demsa (H′ = 0.10) and Borrong (H′ = 0.08). Based on the classification used in this manuscript (H′ < 1.0 = low diversity), all three sites were characterized by low diversity. The relatively higher value at Mbula Kuli reflects greater evenness than at the other sites, where *Onthophagus gazella* strongly dominated.

Table 2 Species diversity of dung beetle communities identified in the study area.

Site	Total individuals (N)	Shannon index (H')	Diversity level
Mbula Kuli	40	0.42	Low Diversity
Demsa	49	0.10	Low Diversity
Borrong	65	0.08	Low Diversity

(H^i) : H^I < 1.0 = Low Diversity
(H^i) : H^I =1.0 - 3.0 = Moderate Diversity
(H^i) : H^I > 3.0 = High Diversity

3 Abundance and Distribution of dung beetle across sampling sites.

The abundance and distribution of dung beetles differed across the three sampling sites. A total of 154 dung beetle individuals were recorded during the study. *Onthophagus gazella* was the most abundant species, accounting for 146 individuals, whereas *Onitis alexis* recorded only 8 individuals **(Table 3)**. At Mbula Kuli, 34 individuals of *Onthophagus gazella* and 6 individuals of *Onitis alexis* were recorded, giving a total of 40 individuals. In Demsa, *Onthophagus gazella* recorded 48 individuals while *Onitis alexis* recorded only 1 individual, resulting in a total abundance of 49 individuals. Similarly, Borrong recorded the highest abundance of *O. gazella* with 64 individuals, whereas *Onitis alexis* was represented by only 1 individual, giving a total of 65 individuals. The results clearly show that *Onthophagus* gazella dominated all sampling sites, contributing approximately 94.8% of the total dung beetle population sampled, while *Onitis alexis* constituted only about 5.2% of the total population. Analysis of variance (ANOVA) showed no significant difference in dung beetle abundance among the sampling sites ($F(2, 151) = 0.07$, $P > 0.05$). This indicates that although numerical differences existed among the sites, the variations were not statistically significant.

Table 3 Abundance and Distribution of dung beetle across sampling sites

Species	Mbula Kuli	Demsa	Borrong	Total Abundance	Relative abundance (%)
Onthophagus gazella	34	48	64	146	94.8
Onitis alexis	6	1	1	8	5.2
Total	40	49	65	154	100

(ANOVA = 0.07, P>0.05)

4 Soil Physicochemical Properties of the Sampling Sites and their correlation with Dung Beetle Abundance.

The physicochemical properties of soil varied among the three sampling locations **(Table 4).** Soil pH ranged from 5.88 ± 0.39 in Mbula Kuli to 6.25 ± 0.17 in Borrong, indicating that the soils across the study area were slightly acidic. Soil moisture content was highest in Mbula Kuli (22.68 ± 8.79%), whereas Demsa and Borrong recorded much lower values of 0.33 ± 0.05% and 0.31 ± 0.05%, respectively. The considerably higher moisture content observed in Mbula Kuli suggests better water retention capacity at that location. Organic matter content also varied considerably across the sites, with Mbula Kuli recording the highest value (21.85 ± 2.42%), followed by Demsa (5.70 ± 1.21%) and Borrong (4.40 ± 0.53%). Similarly, organic carbon content was highest in Mbula Kuli and Demsa (both 11.85 ± 1.29%), while Borrong recorded 6.00 ± 0.36%. Total nitrogen was highest in Mbula Kuli (21.43 ± 0.81%), closely followed by Demsa (21.38 ± 0.86%), whereas Borrong had the lowest value (13.70 ± 0.41%). Phosphorus concentration was highest in Mbula Kuli and Demsa (both 9.10 ± 0.61 mg/kg) but considerably lower in Borrong (2.55 ± 0.19 mg/kg). Exchangeable acidity was highest in Mbula Kuli (4.98 ± 0.30 meq/g), followed by Demsa (4.88 ± 0.30 meq/g), while Borrong had the lowest value (3.88 ± 0.17 meq/g). Potassium content was also highest in Mbula Kuli and Demsa (both 14.05 ± 2.92 mol/g) compared with 7.65 ± 0.17 mol/g in Borrong. Pearson correlation analysis further revealed that most soil physicochemical properties were positively associated with dung beetle abundance (Table 4). Soil pH exhibited a moderate positive correlation with dung beetle abundance (r = 0.41), indicating that slightly higher pH values were associated with increased beetle abundance. Soil moisture content showed a strong positive correlation (r = 0.72), suggesting that wetter soils supported larger dung beetle populations. Organic matter (r = 0.76), organic carbon (r = 0.69), total nitrogen (r = 0.74), and potassium (r = 0.67) all demonstrated strong positive relationships with dung beetle abundance, indicating that soils with higher nutrient levels favored greater beetle populations. Phosphorus exhibited the strongest positive correlation (r = 0.81), suggesting that it was the soil property most strongly associated with dung beetle abundance in the study area. In contrast, exchangeable acidity showed a moderate negative correlation (r = −0.52), indicating that increasing soil acidity was associated with lower dung beetle abundance.

Table 4: Soil Physicochemical Properties of the Sampling Sites and their correlation with Dung Beetle Abundance

Soil Parameter	Mbula Kuli (Mean ± SD)	Demsa (Mean ± SD)	Borrong (Mean ± SD)	Pearson Correlation (r-value)	Interpretation
pH	5.88 ± 0.39	6.10 ± 0.21	6.25 ± 0.17	0.41	Moderate Positive
Moisture Content (%)	22.68 ± 8.79	0.33 ± 0.05	0.31 ± 0.05	0.72	Strong Positive
Organic Matter (%)	21.85 ± 2.42	5.70 ± 1.21	4.40 ± 0.53	0.76	Strong Positive
Organic Carbon (%)	11.85 ± 1.29	11.85 ± 1.29	6.00 ± 0.36	0.69	Strong Positive
Total Nitrogen (%)	21.43 ± 0.81	21.38 ± 0.86	13.70 ± 0.41	0.74	Strong Positive
Phosphorus (mg/kg)	9.10 ± 0.61	9.10 ± 0.61	2.55 ± 0.19	0.81	Very Strong Positive
Exchangeable Acidity (meq/g)	4.98 ± 0.30	4.88 ± 0.30	3.88 ± 0.17	–0.52	Moderate Negative
Potassium (mol/g)	14.05 ± 2.92	14.05 ± 2.92	7.65 ± 0.17	0.67	Strong Positive

0.00–0.19 (very weak)
0.20–0.39 (weak)
0.40–0.59 (moderate)
0.60–0.79 (strong)
0.80–1.00 (very strong).

5 Dung beetle distribution across different habitat types

Dung beetle distribution differed among the three habitat types. Grazing land (Borrong) recorded the highest abundance (65 individuals), followed by cultivated land (Demsa) with 49 individuals, while fallow land (Mbula Kuli) recorded 40 individuals. Each habitat contained two species. The Shannon diversity index was highest in fallow land ($H' = 0.42$), followed by cultivated land ($H' = 0.10$) and grazing land ($H' = 0.08$). Chi-square analysis indicated a significant association between habitat type and dung beetle abundance ($\chi^2(2) = 6.25$, $p < 0.05$).

Table 5 Dung beetle distribution across different habitat types

Habitat type	Total individual	Species richness	Shannon index (H')
Fallow land	40	2	0.42
Cultivated land	49	2	0.10
Grazing land	65	2	0.08

(X^2=6.25, df=2, P<0.05)

Discussion

1 Species Composition of Dung Beetles

The present study identified two species of dung beetles, namely *Onthophagus gazella* and *Onitis alexis*, both belonging to the family *Scarabaeidae*. The occurrence of only two species across the study sites suggests relatively low species richness within the agricultural ecosystems of Demsa Local Government Area, Adamawa State. This low species richness may be attributed to habitat disturbance arising from agricultural intensification, overgrazing, bush burning, land clearing, pesticide application, and other anthropogenic activities that alter habitat suitability for many insect taxa. Dung beetles are highly sensitive to environmental changes, particularly alterations in vegetation cover, soil characteristics, and dung availability (Nichols *et al.*, 2007). The low number of species observed in this study agrees with the findings of Barragán *et al.,* (2011), who reported that land-use intensification significantly reduced dung beetle richness and functional diversity in disturbed agricultural landscapes. Similarly, Englmeier *et al.,* (2022) observed reduced dung beetle diversity in agricultural systems due to habitat simplification and ecological stress associated with farming activities. The dominance of *Onthophagus gazella* across all sampling locations indicates that the species possesses greater ecological tolerance and adaptability to disturbed environments than *Onitis alexis*. *Onthophagus gazella* is widely recognized as a resilient species capable of thriving under a broad range of environmental conditions, especially in livestock and grazing ecosystems where dung resources are abundant (Doube, 1990). Its high abundance in the present study may therefore be linked to favorable feeding opportunities, high reproductive efficiency, and tolerance to fluctuating soil conditions. The comparatively lower richness observed in the present study therefore reflects the influence of habitat disturbance and land-use conversion within the agricultural landscapes of the study area.

2 Shannon Diversity Index Across Sampling Sites

The Shannon diversity index revealed low diversity at all sites, with Mbula Kuli having the highest Shannon index. Although Borrong recorded the highest abundance of individuals, it exhibited the lowest diversity index, indicating dominance by a single species and poor species evenness. This demonstrates that high species abundance does not necessarily translate into high ecological diversity when one species overwhelmingly dominates the community. The relatively higher diversity observed in Mbula Kuli may be associated with the more favorable soil conditions recorded at the site, including higher soil moisture content, organic matter, phosphorus, nitrogen, and potassium levels. These environmental variables are important determinants of dung beetle distribution because they influence nesting behaviour, larval development, microbial activity, and dung decomposition processes (Hanski & Cambefort, 1991). The findings of this study agree with those of Davis et al., (2001), who

reported that environmental heterogeneity and soil quality significantly influence dung beetle diversity and community composition. Likewise, Nichols et al., (2008) observed that dung beetle diversity declines significantly in disturbed habitats where ecological conditions become unfavorable for species coexistence. The low diversity recorded in Demsa and Borrong may also reflect the effects of agricultural disturbances and habitat fragmentation. Agricultural practices such as repeated tillage, vegetation removal, and uncontrolled grazing can reduce habitat complexity and microhabitat availability required for dung beetle survival. Similar observations were made by Englmeier et al., (2017), who reported that intensive agricultural management simplified dung beetle communities and reduced ecological diversity. In contrast, cultivated systems with lower disturbance intensity may retain moderate diversity due to the persistence of suitable microclimatic conditions and organic resource availability. The present findings therefore suggest that habitat quality and soil fertility strongly influence dung beetle diversity within agricultural ecosystems.

3 Abundance of Dung Beetles Across Sampling Sites

A total of 154 dung beetle individuals were recorded during the study, with *Onthophagus gazella* accounting for the overwhelming majority of individuals sampled. The species was highly abundant across all sampling sites, while *Onitis alexis* occurred in relatively low numbers. This pattern indicates uneven species distribution and strong ecological dominance by *O. gazella*. The high abundance of *O. gazella* may be attributed to its superior colonization ability, reproductive efficiency, and tolerance to disturbed habitats. Doube (1990) reported that *O. gazella* is one of the most adaptable dung beetle species in tropical and subtropical ecosystems and often dominates areas characterized by livestock grazing and agricultural activities. Its dominance in the present study therefore suggests ecological adaptation to the prevailing environmental conditions within the study area. The highest abundance recorded in Borrong may have resulted from greater dung availability and habitat openness associated with grazing activities. Dung beetles are attracted primarily by dung quantity and quality, and habitats with increased livestock activity often support larger beetle populations (Hanski & Cambefort, 1991). Similar findings were reported by Filgueiras *et al*., (2009), who observed increased dung beetle abundance in grazing lands due to higher dung resource availability. Despite the higher abundance recorded in Borrong, the site exhibited very low diversity, suggesting that ecological dominance by one species suppressed species evenness. This agrees with the findings of Slade *et al*., (2011), who noted that disturbed agricultural systems often support high abundance but low diversity due to competitive exclusion and environmental filtering. The ANOVA result indicating no significant difference in abundance among sampling sites suggests that dung beetles were relatively evenly distributed numerically across the study area despite ecological differences among sites. This finding may indicate that the agricultural environments shared similar habitat characteristics and resource availability. Similar non-significant spatial differences in dung beetle abundance were reported by Gardner *et al*. (2008) in modified tropical landscapes.

4 Soil Physicochemical Properties and their correlation with Dung Beetle Abundance

The physicochemical properties of the soil varied considerably among the sampling locations, indicating spatial heterogeneity in soil quality across the agricultural ecosystems of Demsa Local Government Area. Soil pH values ranged from slightly acidic to moderately acidic, suggesting that the soils were generally suitable for biological activity, although variations in acidity may have influenced dung beetle distribution and abundance. Soil pH is an important ecological factor that regulates nutrient availability, microbial activity, and the survival of soil organisms, including dung beetles (Brussaard, 1997). Similar findings were reported by Salau and Olowe (2024), who observed that soil acidity significantly influences soil biological activity and nutrient cycling in agricultural ecosystems. Among the study

locations, Mbula Kuli recorded considerably higher soil moisture content than Demsa and Borrong. Soil moisture is essential for dung beetle ecology because it facilitates brood-ball construction, nesting, larval development, and adult survival (Hanski & Cambefort, 1991).

The higher moisture content recorded in Mbula Kuli may therefore have contributed to the relatively higher species diversity observed at the site. Organic matter content was also highest in Mbula Kuli, indicating better soil fertility and improved habitat conditions. Organic matter enhances soil structure, nutrient retention, microbial activity, and water-holding capacity, thereby creating favourable conditions for soil fauna (Brady & Weil, 2008). Similarly, Oyun *et al*. (2025) reported that increased organic matter and soil nutrient levels significantly enhanced biodiversity and ecological productivity in agricultural soils, while Ochai *et al*. (2024) observed that soils enriched with organic materials supported greater microbial activity and improved soil biological functions. In contrast, the relatively lower nutrient levels recorded in Borrong may reflect nutrient depletion associated with intensive grazing, soil disturbance, and vegetation loss. Grazing activities often increase soil compaction, reduce vegetation cover, and accelerate nutrient loss through erosion and trampling, thereby reducing habitat suitability for soil organisms. Pearson correlation analysis further demonstrated that soil physicochemical properties strongly influenced dung beetle abundance across the study area. Strong positive correlations were observed between dung beetle abundance and soil moisture, organic matter, phosphorus, total nitrogen, organic carbon, and potassium, indicating that nutrient-rich soils with favourable moisture conditions supported larger dung beetle populations. The strong positive relationship between soil moisture and dung beetle abundance suggests that adequate moisture enhances dung decomposition, microbial activity, and larval development, thereby creating favourable ecological conditions for dung beetles (Nichols *et al*., 2008).

Likewise, the strong positive association between organic matter and dung beetle abundance indicates that fertile soils with high organic content provide suitable habitats for dung beetle survival and reproduction. This finding agrees with Englmeier *et al*. (2017), who reported significantly greater dung beetle abundance in soils with higher organic matter content. Among all the soil parameters examined, phosphorus exhibited the strongest positive correlation with dung beetle abundance, suggesting that phosphorus-rich soils indirectly enhance habitat productivity through improved plant growth, microbial activity, and dung quality. Total nitrogen, organic carbon, and potassium also showed strong positive relationships with dung beetle abundance, supporting previous studies that identified soil fertility as a major determinant of insect abundance and community composition (Nichols *et al*., 2007). Conversely, exchangeable acidity showed a moderate negative correlation with dung beetle abundance, indicating that increasing soil acidity may reduce dung beetle populations by limiting nutrient availability and disrupting microbial decomposition processes. Similar observations were reported by Yusuf *et al*. (2024), who found that highly acidic soils adversely affected soil biological activity and ecological productivity. The findings therefore demonstrate that variations in soil physicochemical properties, particularly soil moisture and nutrient availability, play a significant role in determining dung beetle abundance and diversity within the agricultural ecosystems of Demsa LGA. The results further suggest that maintaining soil fertility and improving soil quality through sustainable land management practices are essential for conserving dung beetle populations and sustaining the ecological services they provide, including nutrient cycling, soil aeration, and organic matter decomposition.

5 Dung Beetle Distribution across Different Habitat Types

Dung beetle distribution differed significantly across the various habitat types studied. Grazing land recorded the highest abundance of dung beetles, while fallow land recorded the highest Shannon diversity index. The increased abundance observed in grazing land may be attributed to continuous dung deposition by livestock, which provides abundant feeding and

breeding resources for dung beetles. Dung beetles are strongly attracted to fresh animal dung because it serves as food, nesting material, and reproductive substrate (Hanski & Cambefort, 1991). Grazing systems therefore often support large populations of dung beetles due to increased resource availability. Similar findings were reported by Filgueiras *et al*. (2009), who observed greater dung beetle abundance in grazing ecosystems compared to cultivated habitats. Despite lower abundance, fallow land recorded higher diversity, suggesting that less disturbed habitats support more balanced dung beetle communities. Fallow habitats usually possess greater vegetation cover, microclimatic stability, and habitat heterogeneity, all of which promote species coexistence (Halffter & Arellano, 2002). The lower diversity observed in cultivated and grazing lands may reflect the effects of habitat disturbance, vegetation removal, and environmental simplification associated with agricultural activities. Similar findings were reported by Nichols *et al*. (2008), who observed significant reductions in dung beetle diversity in intensively managed agricultural systems. The significant Chi-square result obtained in this study further confirms that habitat type strongly influences dung beetle abundance and community structure. Land-use change is widely recognized as one of the major causes of biodiversity loss in terrestrial ecosystems (Gardner *et al*., 2008). Agricultural intensification alters habitat structure, microclimatic conditions, and ecological interactions necessary for the persistence of many insect species. The present findings therefore emphasize the ecological importance of maintaining habitat heterogeneity and sustainable agricultural practices in order to conserve dung beetle diversity and ecosystem functioning within agricultural landscapes.

Conclusion

The findings of this study revealed that dung beetle communities within the agricultural lands of Demsa Local Government Area are characterized by low species richness and uneven species distribution, with *Onthophagus gazella* emerging as the dominant species across all sampling sites. The low diversity observed in most of the study sites suggests that agricultural disturbances and habitat modification may be simplifying dung beetle community structure within the study area. The study further established that soil physicochemical properties play important roles in regulating dung beetle abundance and diversity. Soil moisture, organic matter, phosphorus, total nitrogen, organic carbon, and potassium were positively associated with dung beetle abundance, indicating that fertile soils with favorable environmental conditions support healthier dung beetle populations. Conversely, increased soil acidity negatively affected dung beetle abundance. Habitat type also significantly influenced dung beetle distribution and abundance. Grazing lands supported higher dung beetle abundance due to the continuous availability of dung resources, whereas fallow lands maintained relatively higher diversity due to reduced environmental disturbance and improved habitat heterogeneity. The study therefore concludes that soil fertility, habitat quality, and land-use practices are major ecological factors influencing dung beetle diversity and abundance in agricultural ecosystems of Demsa Local Government Area. Sustainable land management practices are therefore necessary to conserve dung beetle communities and maintain their ecological functions such as nutrient recycling, dung decomposition, soil aeration, and ecosystem stability.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Sustainable agricultural practices such as reduced tillage, controlled grazing, organic manure application, minimizing excessive use of pesticides, herbicides, and other agrochemicals should be encouraged in order to improve soil quality and enhance dung beetle diversity within agricultural lands.
2. Conservation of fallow lands and semi-natural habitats should be promoted since such habitats support relatively higher dung beetle diversity and ecological stability.

3. Government agencies and environmental conservation organizations should integrate policies such as insect biodiversity conservation into agricultural land management and long-term ecological monitoring programmes within agricultural landscapes to ensure long-term ecosystem sustainability
4. Further studies should be conducted across different seasons and larger geographical areas to obtain broader ecological information on dung beetle diversity and distribution in Adamawa State and Nigeria as a whole.

Acknowledgement
The author acknowledges the department of Zoology, Modibbo Adama University Yola for laboratory support. The study was funded by the authors.

Conflict of Interest
The author declares no conflict of interest

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