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Assessment of Detritus Decaying/Mineralization Base on Weight in Terrestrial Farmland of Nigerian Army University Biu, Borno State

Lawal Muhammed Shittu and Goodness Bulus

Department of Biology, Faculty of Natural and Applied Sciences, Nigerian Army University, PMB 1500, Biu Borno State

Corresponsing Author: daprinx1@gmail.com

ABSTRACT

Detritus/dead organic matter decaying and recycling in ecosystem requires wildspecies called detritivore. This research focuses on detritivores activities in different soil types in heavily cultivated farmland. Four soil samples were used. Detritus size was weighed and re-weighed after three months of experiment. One-way ANOVA and Fischer's Least Significant Difference (LSD) were employed to determine the rate of activities of detritivores in all the sixteen pots used for the experiment. 15N Isotope pool dilution techniques was employed to determine mineralization rate in the soil. Loamy soil has highest detritivore activities and nutrification, whereas clay has the least. Soil types have significant effects on detritus breakdown and mineralization. Fischer's LSD follow-up test (0.05) was 1.1 indicating variation in the rate of decaying of each soil types. Detritivores composition observed and recorded during this study were eighty percent of arthropods and twenty percent other animals. Also noted are heavy farming activities constitutes limiting factors to detritivores abundance and affecting rate of decaying and nutrients release in the study. Wildspecies (detritivores) are naturally responsible for releasing stored-up nutrients in detritus through decaying process and this unique role occurs in every ecosystems.

Keyword: Detritivore species, detritus, decaying rate, nutrient recycling, ecosystem

INTRODUCTION

Detritivores are small/medium-sized invertebrates that break down dead organic matter (of plant and animal origins) to smaller sizes for decomposer to act on. Examples of dead organic matter could be animals, leaves, and roots, particularly within or upon the soil surface Lindsey *et al.*, (2019). The class of detritivores organisms are: Annelids, Athropods, mollusca among others. Detritivores significantly speed up the incorporation of organic matter into the soil, such as leaves and litter, and contribute significantly to soil formation over time. Detritivores are animals that feed on the waste products of primary producers as well as herbivores and carnivores. As a result, they can be found at all trophic levels in an ecosystem. With these their activities, detritivores could be assumed to contribute significantly to the ecosystem energy cycle by taking energy from other creatures and frequently being eaten by secondary consumers. It is understood that soil invertebrates play a significant functional role in soil processes and are in charge of delivering ecosystem goods and services such as matter decomposition, water cycling, and primary productivity. These creatures are extremely vulnerable to both human activities and natural disturbances. Due to their role in disintegrating dead plant or animal debris, detritivores are crucial players in the food chain. As a result, the ecosystem receives the vital nutrients it needs and is kept from being overburdened with decaying or dead matter that could harbor pathogens or cause other

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problems. The composition of detritivores has a direct impact on the rate of breakdown and possible fertility of the soil. Detritivores are established nutrient recyclers by reintroducing stored nutrient in dead organic matter to the environment through their Niche activities. It is important to note that decaying rate is equally influenced by pH, oxygen, water and temperature factors.

Major ethnic groups in Biu community are predominantly farmers specializing in cereal, legumes and vegetable cultivation Year in year out, people till the land for one farming activity or the other. There is thus need for fertile soil replenish to sustain grown crops in the area. Natural nutrient recycling is a natural duty of dentritivores which are part of the wildlife in an ecosystem. Any accumulated nutrients in the body of dead matter are released for recycling by this group of animals. Most of these wild creature are very small in size, thus many of this day farmers rarely understand their crucial functionalities in an ecosystem. According to Paoletti *et al.,* (2007) detritivores make up the majority of the invertebrate biomass and play critical roles in soil nutrient recycling and turnover of organic matter. However, the heavy use of synthetic compounds, modern machine/tools in farm field has impacts natural functionalities and population of detritivores. Free use of non-biodegradable chemicals in farm operations are toxic to the environment and detritivores that operates therein. Their level of activity and/or community diversity may be drastically reduced by improper land use, which could, in some extreme circumstances, result in significant soil dysfunction and ecosystem degradation (Hedde *et al.,* 2007). The more the population of detritivores, the better for nutrient recycling in foodweb and ecosystem.

In many terrestrial ecosystems, detritivorous soil organisms ingest large amounts of leaf litter returning most of it to the soil as faeces (Jes and Nico, 2023). Nutrient recycling is a non-stop natural process carried out by detritivores on dead biomass that keeps the all biota in perpetual living existence. For this reason, a comprehensive understanding of the activities of detritivores cannot be overemphasized in living existence, soil fertility and nutrient recycling process. In addition, many detritivores have been identified by many researchers as dependable soil aerators outside the fact that could equally prevent possible outbreak of diseases through the biodegradation activities on dead biomass. Man understanding of detritivorous is still developing in a number of ways to broaden the knowledge of bioecology and nutrition (Louzada *et al.*, 2012). It is based on stated above points that this research is carried out to determine rate of activities of detritivores in nutrient recycling in different soil types: sandy, clayey, loamy and the last one which is the proportional mixture of the three other soil types (sandy, clay and loamy) to get blended or hybrid fourth soil type to add to scientifically based knowledge on detritrtivores. Also, the research focuses on ascertaining variation in different organisms that constitutes detritivores in each soil sample. This research would be of help in accepting and appreciating the roles of wild species called detritivores in our environmental sustainability and conservation.

MATERIALS AND METHODS

Study Area

Biu Local Government Area is located in the southern part of Borno State, Nigeria. It lies between latitudes 10°40' and North and longitudes 12°03' East. The rainy season lasts for about five months (June – October) with an average rainfall of about 700 - 1000mm per annum (BOSADP, 2009). The vegetation is characterized by Guinea Savanna.

Experimental Design

i. Four different types of soil: Samples are clay, loamy, sand and mixed soil (blended mixture of the three types of soil to serve as fourth soil type) were used. Each soil type were further divided into four each making sixteen soil sample.

a). Clay soil was divided into four samples ($_{1-4}$).

b). Loamy soil was divided into four samples ($_{1-4}$).

c). Sandy soil was divided into four samples ($_{1-4}$).

d). Mixed soil sample of the three soil type was divided into four samples ($_{1-4}$).

ii. Four class of detritus were equally used: The (Iced fish, Fresh meat, Fresh fish and Leaves)

Each of these detritus were also divided into four parts given sixteen samples in all to be individually put in one pot each. Fresh meat ($_{1-4}$), Iced fish ($_{1-4}$), Fresh fish ($_{1-4}$) and Leaves ($_{1-4}$). After a week, decaying rate were systematically measured every week to determine the activities of the organism that breakdown dead organic matter (detritus).

iii. Sixteen Polythene bags serves as experimental pots (to house soil and detritus samples). Polythene pots are opened for adequate aeration of the detritivores.

iv. Electronic weighing machine was used for accurate measurement of each detritus size and soil weight in the laboratory.

Data Analysis

Data analysis was carried out using table of percentage and One-way ANOVA using the car package was used to determine the effects of detritivores on the four soil types follow by Fischers' Least Significant Difference (LSD).

Mineralization rate in the soil was determined using Isotope pool dilution techniques. The isotope dilution techniques enable gross rates of nitrification (or mineralization) to be determined by monitoring the decline in the ^{15}N abundance in a nitrate or ammonium pool, labeled at t = 0 and receiving unlabeled N via nitrification or mineralization (Murphy et al., 2003).

RESULTS

Table 1: Experimental Design: Detritus and Soil types weight measured by electronic weighing machine at the start of experiment

Soil Types	Detritus samples				Total
	Fresh fish	Ice fish	Meat	Leave	
	1	2	3	4	
Clay ($_{1-4}$)	62.231	116.622	60.549	9.229	248.631
Loamy ($_{1-4}$)	36.381	84.078	113.341	9.433	243.233
Sandy ($_{1-4}$)	61.231	104.856	74.20911	9.643	249.939
Mixed soil ($_{1-4}$)	50.191	04.850	73.603	8.388	237.032
Total	210.034	410.406	321.702	36.693	978.835

NB: C= Clay, L= Loamy, S= Sandy and CLS= Mixture of the three types of soil sample

Table 2: Weighed detritus specimen before and after the study

S/N	Fresh fish		Ice fish		Meat		Plants	
Detritus Division	Before	After	Before	After	Before	After	Before	After
1	56.26	6.00	36.15	11.69	60.32	0.74	40.43	0.01
2	104.93	0.24	83.68	0.40	104.84	0.40	98.80	0.00
3	59.81	0.91	112.94	0.02	73.55	0.66	72.73	0.62
4	9.22	2.76	9.43	6.06	9.02	0.87	6.69	1.70

Table 1 and Table 2 described the experimental set-up of this work. From these two tables, it is determined that all the sixteen pots of soil used in this work had detritivores activities though at different rate. Detritivores being group of different wild species, requires different soil condition for their optimum performance. Therefore, the best condition for decaying varies according to their physiological and morphology nature. Performance of these organisms are influenced by soil particles among other factors. For this reason, the four groups of soil give different outcome results. No matter the soil condition, decaying activities continue as far as there detritivores species. The results here reflect that decaying and nutrients recycling from detritus is a nature constant process. Plant detritus in loamy soil sample shows 0.00g (Table 2) which indicates that it has completely decayed and nothing is seen to measure it weight. However, plant litter decomposition is a key process in the biosphere, as 90% of the annual plant production escapes herbivory and eventually becomes litter (Cebrian, 1999).

Table 3: Cumulative Weight of Detritus in each soil type before and after the experiment

Cumulative Weight of Detritus before the experiment		**Cumulative Weight of Detritus after the experiment**	
Soil types	Detritus weight (g)	Soil types	Detritus weight (g)
Clay	57.56	Clay	4.61
Loamy	80.87	Loamy	0.26
Sandy	62.10	Sandy	0.55
Clay, Loam, Sandy	54.66	Clay, Loam, Sandy	4.60
LSD (0.05)	6.6	LSD (0.05)	1.1

Key**:** LSD= Least Significant Difference

Table 4: Percentage Analysis of Detritus breakdown in each soil after the Experiment

Soil Types	Soil Samples Distribution				Average total Activities %
	Pot 1	Pot 2	Pot 3	Pot 4	
Clay	89.3	89.8	98.7	99.8	94.4
Loamy	99.3	99.5	99.6	100	99.6
Sandy	98.5	99.9	99.1	93.5	97.8
Mixed (Clay, Loam & Sandy soils)	75.8	93.9	98.8	79.7	87.1

H_O = Soil types does not significantly determine detritus breakdown rate by detririvores.
H_A = Soil types does significantly determine detritus breakdown rate by detririvores.

The Hypothesis test revealed soil types significantly determine detritus breakdown rate by detririvores. The Follow-up test of Fischer LSD (0.05) result is 1.1 indicating variation in the rate of decaying of each soil types (Table 3). The record of the experiment indicated a great difference in detritivores rate of decaying in the four soil types used for the experiment (Table 3 and 4). Loamy soil had the highest rate of nutrient release with (99.6%) decaying which is possibly due to nature of the soil particles which favourably improves the detritivores activities and their population. Therefore, detritivores are more actives in loamy soil than three other soil types considered in this study (Table 4). This result is in line with finding of Lindsey *et al.*, (2019) who suggested that incorporating soil macroinvertebrate abundance into management strategies for agricultural soil may increase soil health of agroecosystems, preserve freshwater ecosystems, and protect the valuable services they both provide for humans.

The mixed soil sample (Clay, Loam & Sandy soils) had the least percentage of decaying rate (87.1%). The mixed soil recorded the least decaying rate probably because of the physical manual mixing of the sample. The mixing together of the fourth soil type is not a natural soil formation thus, it may not that suitable for high concentrations of detritivores and also hinder their reproductive rate. This result shows that soil profile distortion will definitely hampers detritus decaying rate has shown in table 4. Rachana *et al*., (2021) opined that swift steps need to be taken to improve biodegradable activities of detritus/waste to reduce environmental damages.

Table 5: Percentage Rate of Detritivores action on each detritus after experimental completion

Samples Distribution	Detritus samples			
	Fresh fish	Ice fish	Meat	Leave
1	89.3	89.8	98.7	99.8
2	99.3	99.5	99.6	100
3	98.5	99.9	99.1	93.5
4	75.8	93.9	98.8	79.7
Average decaying rate	90.7	95.8	99.1	93.3

Detritivors have been reported to transport the nutrients into the various stores of nutrients in the soil system, even having indirect effects on plant uptake and the erosion or leaching of nutrients (Josephine *et al.,* 2019). The processes of mineralization and immobilization create changing levels of available nutrients to plants as they move between organic and inorganic forms (Josephine *et al.,* 2019). In all the detritus specimens considered under this experiment shows rapid rate of nutrients released/decaying across the detritus. The rate of decaying and release of stored nutrients stood at over ninety percent for each detritus. Meat however had the highest breakdown rate (99.1%) of the stored nutrients, while fresh fish recorded the least with 90.7% in Table 5. Animal-based detritus oozed out offensive odour during the first week of experiment, indicating that decaying and tissues breakdown had commenced by the detritivores. At this point in time, no such odour was noticed in plant detritus (leave) used for the experiment.

Table 6: Some sighted detritivores identified in the experimental soils

S/N	Scientific Name	Common Name
1.	Musca domestica	Housefly
2.	Diplopoda	Millipedes
3.	Periplaneta spp	Cockroach
4.	*Gryllus bimaculatus*	African cricket
5.	Scarabaeidae	White grubs
6.	Diptera	Mosquitoes
7.	Lumbricus terrestris	Earth worm

DISCUSSION

Cardinale, 2011 discovered in their research that the primacy of detritivores as species that can influence multiple ecosystem functions by simultaneously influencing green and brown energetic pathways. Scathophagidae (Dung flies) and carrion flies are the first detritivores that were seen visiting the detritus in the experimental pots. They are surface detritivores found on top of soil. The population of the detritivores seen during the first week of experimentation increases during the second observation. New species such as crickets and beetles were seen. Also, *Musca domestica* and mosquitoes were observed frequenting the experimentation ground. Between the first and second week, surface detritivores were more prominent. Less diverse natural ecosystem communities consistently produce less biomass, and typically support reduced ecosystem process rates because of unimpressed numbers of detritivores (Cardinale, 2011). Third week of observation revealed no new species, but the population of the existing detritivores had greatly increased, nevertheless; the intensity of the odour from the decaying animal detritus had drastically reduced. However, the plant detritus specimen had no observed detritivores activities thus no visible signs of recycling activities. Several large-scale studies and meta-analyses reported increased litter disappearance in the presence of soil fauna compared to when it was excluded (García *et al.,* 2013).

By fourth week of experiment, new set of detritivores were seen and further signs of activities like little and tiny holes, and burrow were recorded in all the sandy and loamy pots. This indicate that subsurface detritivores were present in the pots. In the pots containing plant detritus, there was no such indicating slow decaying process. With these signs pronounced decaying process was undergoing in animal detritus and not plant. Decomposition and mineralization of nutrients in organic matter, manure, and plant residue is directly influenced by the consumptive activities of detritivores (Crumsey *et al.,* 2015).

Additionally, the fifth week of experiment, shows massive increase in the population of the detritivores generally leading to invitation of predators such as lizard, wall gecko among others showing up to prey on them. Furthermore, decaying odour has completely gone in the experimental pots. Timothy (2013), stated that detritivores utilize living and dead biomass, respectively, to build their own tissues; and these organisms are in turn consumed by predatory species.

Moreover, the sixth week of experiment indicated the observance of subsurface detritivores hitherto not seen in the early weeks of experiment because of their more population level. On the other hands, incidence of more cockroach population was seen. Population of the surface detritivores had reduced due to increase in predator's population and reduction in the size of detritus used for the experiment as weeks turns to months. After the completion of the experiment, each experimental pot was dismantled and any leftover detritus (where found) were reweighed. Some of the dismantled soil has in them detritivores carcass, eggs and larvae. Also, millipedes, white grubs, earth worm and some other forms of maggot (Table 6). Millipedes and earthworms are defined as "ecosystem engineers" for soil health and nutrient dynamics (Jouquet *et al*., 2006). The experiment further shows that there are diverse types of animal that constitutes detritivore, some were sub-surface and others were surface-dwelling animals as seen in this work in line with the work of Luz *et al*., (2021). Studies have established the existences of different detritivores species interactions driving either positive or negative effects, which can compensate for each other and sometimes result in overall neutral effects among themselves. This view is supported by Paul and Yann (2003) which established that Detritivorous organisms feed on the biofilm, embrittle it, encourage loosening, decrease biomass volume and accelerate mineralization. Mineralization is a process of releasing inorganic nutrients, such as Nitrogen, Phosphorus and Sulphur into the ecosystem. These nutrients become available for uptake by living creatures both micro and macro.

Final decaying process by wild species otherwise known as detritivores on detritus (dead organism) is the only fundamental means by which stored nutrients recycling in all ecosystems and maintain livings. The stored nutrient in detritus and consequent uptake by biota in the environment guarantee healthy ecological settings which cannot be supplanted by any other means. This research highlight the latent and crucial roles of detritivores as the backbone of replenishing and releasing stored nutrients in dead organisms in every ecological setting. It is further seen from this work that no matter how slow or fast it might be, the decaying process continues to take place in all living habitats as a result of detritivivore. The result of this work is in consonant with the work of Josephine *et al.,* (2019) which concluded that detritivores significantly improve soil health by contributing to nutrient immobilization, mineralization and mobilization.

CONCLUSION

Wild species identified in this work establishes the fact that detritivores are essentially the organisms that can perform biodegradable process on each of the detritus in the conducted experiment. Therefore, decaying process is incomplete without detritivores without which nutrients will not be available to the next user in every ecosystem. This work further highlight the fact that irrespective of the soil types, detritivores still carries out their niche as the final processor of releasing stored nutrients in detritus and setting up process of mineralization. Therefore, detritivores role in sustainable nutrient recycling is irreplaceable. Furthermore, it was further seen that the rate of detritus decaying varies according to divergent factors such as: soil particles, nature of detritus to be biodegraded and type of detritivores species to involve according to the result of this research. For this reason, detritus decaying rate is faster in one type of soil than other in this experiment. This find is in line with the work of Joly *et al.,* (2019) which asserted that soil detritivore feeding activity and isopod-driven decomposition are highly contingent on soil moisture and texture.

To conclude, Eighty percent (80%) of detritivores animals sighted during the course of this research are arthropods while the rest twenty percent (20%) are other organisms like Mollusca and Earthworm whose activities are more pronounced in loamy soil than others. Therefore, natural soil mineralization relies heavily on detritivores activities. Without detritivores, plants, animals including humans and wildlife species would be denied the required nutrients needed for perpetual survival in their environment.

Recommendation

Heavy farming activities, reckless waste dump, application of pesticides, herbicides, and fertilizers in this region should be scientifically managed to decrease the negative and inimical impacts effects on the detritivores communities.

If tremendous progress is to be made in this direction of detritivores conservation; trusted synergy must exist between the local farmers' associations, staff of Ministry of Environment, Agriculture and researchers in the field of detritivores so that minimal negative effects will be felt by detritivores communities in the course of man exploration of the environment. Once this network of understanding is established among the various interest holders, there could be robust understanding that will foster trust with regards to: the efficient and perpetual functionality of detritivores for man and environmental benefits. This goes with the conclusion of Hines (2015), that experiments reporting a broader array of ecosystem functions that are more clearly linked to food web dynamics and realistic species changes are needed to assess the more multifunctional role of detritivores in ecosystems.

Elimination of hazardous use of environmental which have catastrophic impacts on detritivores and their ecological niche. Proper awareness by public on the roles of detritivores will highlight the hidden facts that fundamentally, human continuous survival revolves round constant returning of stored nutrients in detritus to soil by detritivores.

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