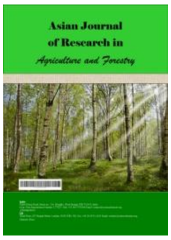

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Macro Faunal Diversity in Date Palm Plantation Soils of Yola, Adamawa State, Nigeria

A. A. Gujja [a*], M. R. Umar [b], W. S. Isa [c] and A. M. Amshi [c]

[a] Department of Forestry Technology, Yobe State College of Agriculture, Science and Technology Gujba, P.M.B. 1104, Damaturu, Yobe State, Nigeria.
[b] Department of Forestry and Wildlife Management, Modibbo Adama University, Yola, Adamawa State, Nigeria.
[c] Department of Forestry Technology, Adamawa State College of Agriculture, P.M.B. 2088, Ganye, Adamawa State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author AAG design the study, performed the statistical analysis, wrote the protocol and wrote the first manuscript. Authors MRU and WSI manage the analysis and author AMA manage the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This research assessed the macro-faunal diversity in soil of date palm plantation of Modibbo Adama University, Yola, Adamawa State. Parameters evaluated included; assemblage and diversity of soil macro invertebrates based on growth performances of the date palm. The plantation was divided according to growth variabilities. Assessment of macro fauna species was carried out using plots of 20m × 20m which was randomly selected, using plots of 1m x 1m that where laid at each anger point,Top soil for biological assessment of soil samples, were collected using trowels at depths ranging from 0-30cm depth. The soil samples was immediately spread on board of about $60cm^2$ and sorted for the presence of macro fauna. Soil macro-invertebrates 'identification and enumeration. Soil macro-invertebrate assemblage was analyzed for diversity indices of species using relevant formulae. Results showed a total of 648 macro fauna scattered within the study area. Seventeen (17) Families of macro fauna were also identified in the study. *Lumbricus terrestris* (earthworm), the *Heterotermes species* (termites) and those belonging to the

**Corresponding author: E-mail: akiagujja2465@gmail.com;*

Formicidae family (ants) were the groups having the highest number of individuals. Leading to the conclusion that soil Macro fauna were present in the study area. However, the numbers of macro fauna were very active in the date palm plantation soil. This is an indication that strong relationship exists between macro fauna-invertebrates the date palm trees.

Keywords: Diversity; date palm; macro-faunal and soil.

1. INTRODUCTION

Macro fauna are the most conspicuous group of organisms which have great potential to modify the soil environment through their activities. Earthworms and termites are widely recognized for their role in soil structure formation, organic matter incorporation and decomposition and nutrient mineralization. Adriano et al. [1] consider these organisms as “ecosystem engineers’’, which are defined as organisms that directly or indirectly modulate the availability of resources to other species, by causing physical state changes in biotic or abiotic materials; in so doing they modify, maintain and create habitats. Earthworms and termites ingest organic matter or a mixture of mineral soil and organic matter and create channels and nests in the soil, thus creating solid organo-mineral structures that may persist longer than the organisms that produced them. They developed highly efficient digestion systems based on internal mutualism with micro flora and protozoa that live in their gut. Earthworms and termites constitute >90% of the biomass of the invertebrate fauna in soils of sub-Saharan Africa [1]. The date palm (*Phoenix dactylifera* L.) tree belongs to the family *Arecaceae* and is considered as a symbol of life in the desert, as it tolerates high temperatures, water stress, and salinity more than many other fruit crops [2]. Date palm can be planted in a wide range of soils with varying amounts of organic and mineral nutrients. Many parts of the world where date palm is grown still follow the traditional mixed planting of dates of various ages at irregular spacing. Moreover, inadequate fertilizer application and lack of proper tree and bunch management, such as pruning and fruit thinning, lead to the production of low fruit quality and thus lower market values [3].

Soil macrofauna contribute, greatly to biodiversity in agro ecosystems and are important as effective components of natural soil ecosystems. Terrestrial ecosystems are divided into belowground and aboveground subsystems. These subsystems are intricately dependent upon one another since above the ground primary producers (plants) are the main source of organic carbon for sustenance of the belowground system, while below ground organisms are in charge of recycling organic matter and mineralization of nutrients therein resulting from above ground primary production [4,5].

The decomposers are responsible for breakdown of organic matter, release, and cycling of nutrients [6]. Hence activity of decomposers results in increased plant growth and plant nitrogen content [7]. Soil macrofauna communities in landscapes are rapidly changing due to land use conversions and agricultural intensification, hence the (soil macrofauna communities) are highly transient systems, where interactions between species or trophic levels are being seriously disturbed or lost. Influence of farming practices in modifying effects of soil organisms on aboveground systems is poorly understood, despite the fact that while these anthropogenic disturbances influence soil macrofauna communities at a local scale, they are a result of large-scale processes, such as increase in human population, change in land size by fragmentation or consolidation of original landscapes and use such as crop types. Hence a change in distribution patterns of soil organisms [8,9].

In the five years of the establishment of the date palm plantation, studies have not been done on biological constituents of the soil. The growth of the individual date palm plants have not been uniform, while some are performing very well, others have indication of stunted growth. Since the growth of every plant depends largely on the nutrient status which is in turn affected by the activities of soil macro fauna, information on the soil macro fauna diversity in the date palm plantation becomes a pre requisite to understanding the differences in the performances of individual plants. The aim of this study is to assess the macro faunal diversity in the study area. The specific objectives was to Identify and evaluate the macro faunal diversity in the study area.

At the end of the study the diversity of soils macro fauna of the date palm plantation will had been ascertained. The information on macro fauna diversity will be, baseline information for future management of the date palm plantation and by extension any other date palm plantation that may be grown under similar conditions. The results of the research will be an invaluable tool to the date palm plantation managers in the Department of Forestry, Yola and indeed many other organizations and individuals that are in Evolved in Date Palm Research and production.

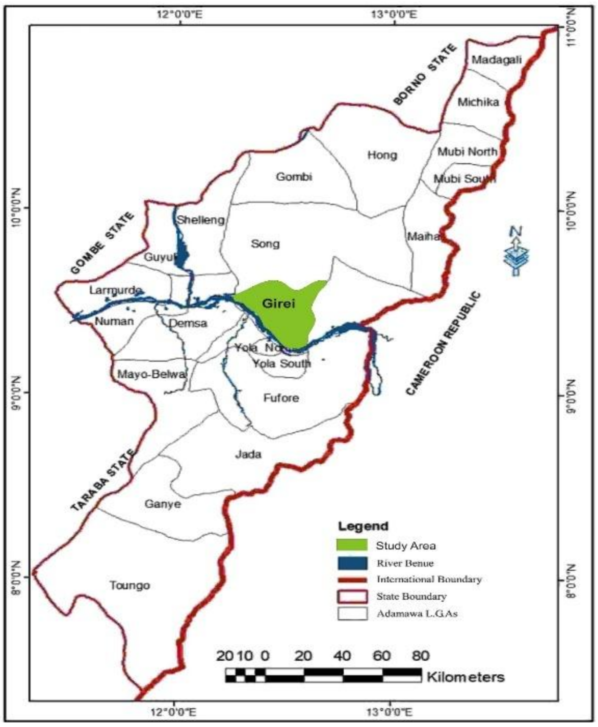
2. MATERIALS AND METHODS

2.1 The Study Area

Adamawa State is located at the North Eastern part of Nigeria. It lies between latitude 7° and 11° N of the equator and longitude 11° and 14° E. (Fig. 1) [10]. The date palm plantation of the Department of Forestry and Wildlife Management Modibbo Adama University, Yola, Adamawa State is located between latitude 8°N and 11°N Longitude 11.5°E and 13.5°E (Fig. 2). Adamawa state falls under the Sudan, southern and guinea savannah type of vegetation and its experience distinct dry and wet seasons with temperature and humidity varying with seasons. The wet or rainy season falls between April and November, which is characterized by single maximum in august and September. During this season, the moisture laden south west trade wind from the Atlantic Ocean blow over the area. Seventy percent of the total rainfall in the area happen to fall within four month of May- September [10].

The area has an average of 62 rainy days, while average amount of rainfall recorded in the area is 972mm.the dry season which is the harmattan period between December March. The period is characterized by dry, dusty and hazy northern trade wind that blows over the area from desert. Temperature within the area varies with season. Temperature of the area ranges from 27°C-40°C. The natural vegetation of the area is Sudan savannah type which is characterized by thick vegetation around hills and mountain ranges. The vegetation has a wide variety of savannah trees species among which area are; *Acacia spp, Adansonia spp, Anogeisus spp*. [11].

The soils of Adamawa State are classified as ferruginous tropical soils. These types of soils are defined often generally as having a marked differentiation of horizons and an abundance of free iron oxides usually deposited as red or yellow mottles or concretions, The soils of Adamawa State as derived from this system include Luvisols, Legosols, Cambisols, Vertisols and Lithosols [10].



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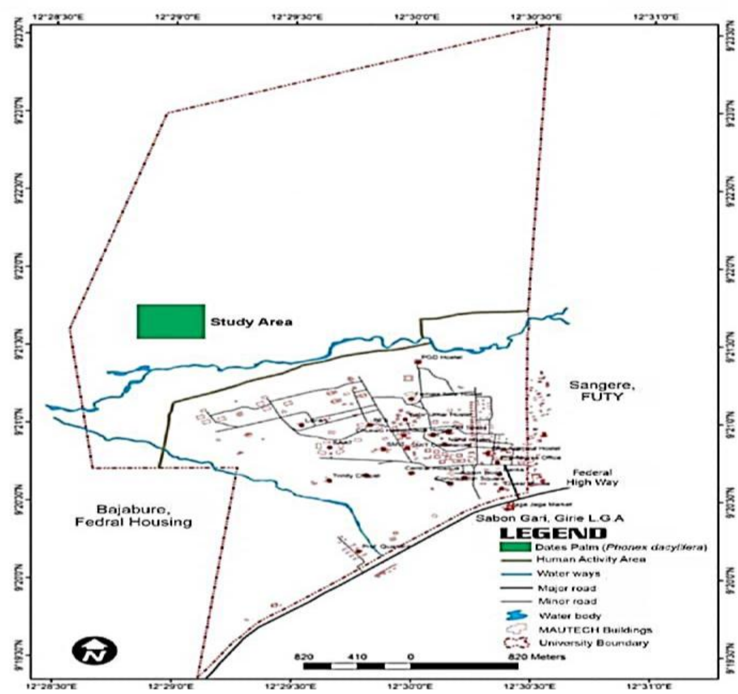

(2)

Fig. 1. Map of Nigeria showing Adamawa State
Fig. 2. Map of MAU, Yola showing the study area
Source: GIS Laboratory, Geography Department MAU, Yola [12]

2.2 Assessment of Species of Soil Macro Invertebrates

Assessment of macro fauna species was carried out using plots of 20m × 20m which was randomly selected from the assessment of macro fauna spp was done using plots of 1m x 1m that where laid at each anger point (Clegg et al. (1996) and Dishan et al. [13]. Top soil for biological assessment of soil samples, were collected using trowels at depths ranging from 0-30cm depth. The soil samples was immediately spread on board of about 60cm^2 and sorted for the presence of macro fauna (earthworms, crickets, termites, scorpions, spiders, mites, centipedes, millipedes, ants, beetles etc). The soil macro invertebrates' encountered in each of the sites was counted and recorded. Identification was done using literatures. Pictures of unidentified soil macro invertebrates were taken for the purpose of identification. The computation of species diversity indices per study site was done.

i. Data on macro faunal diversity was determined using Shannon Diversity Index: This is illustrated as follows:

$$H^1 = -\sum_{i-1}^{s} PiIn(Pi) \quad [14]$$

Where;

H^1 = Shannon Diversity Index

n_i = number of individuals in species

N = total number of all individuals

Pi = relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community: n_i/N.

In = natural logarithm [14].

3. RESULTS

3.1 Diversity of Macro Invertebrate Species in the Study Areas

Table 1 shows a checklist of macro-invertebrate species diversity of the Study Area. A total of 365, 139 and 153 individual species belonging to 14, 13 and 10 Taxa from the studied sites were performance site respectively. Species encountered included; Earthworm (*Lumbricina terrestris*), Ant (*Monomorium minimum*), Subterranean Termite (*Heterotermes species*), Millipede (*Eurymerodesmidae spp*), Giant centipede (*Scolopendra gigantea*), Crickets (*Gryllus assimillis*), Ground Beetle (*Scaritinae clivinini*) Brown marmorated stink Bug (*Halyomorpha halys*), Spider (*Araneus angulatus*), Giant Snail (*Achatina fulina),* common centipede (*Scutigera coleoptrata)* and Small snail (*Helix pomatia*).

Shannon wiener Diversity Index, Dominance, Evenness and Equitability indices values of macro-invertebrate species for the studied sites are presented in Table 3. The values followed the order; Shannon wiener Diversity Index 1.383 > 1.823 > 1.252, Dominance values 0.511 > 0.235 > 0.198, Evenness values 0.628 > 0.476 > 0.249 and Equitability indices values were 0.798 > 0.710 > 0.474 respectively (Table 3).

Table 1. Macro fauna present in the study area according to soil variability

S/N	Family Name	Scientific Name	High	Medium	Low
1	Lumbricidae	*Lumbricina terrestris*	*	*	-
2	Formicidae	*Monomorium minimum*	*	*	*
3	Rhinotermitidae	*Heterotermes species*	*	*	*
4	Eurymerodesmidae	*Eurymerodesmidae spp*	*	-	-
5	Sclopendridae	*Scolopendra gigantea*	*	-	-
6	Gryllidae	*Gryllus assimillis*	-	*	-
7	Acrididae	*Conozoa hyaline*	-	*	-
8	Carabidae	*Scaritinae clivinini*	-	*	
9	Pentatomidae	*Halyomorpha halys*	*	-	-
10	Achantinidae	*Achatina spp*	*	*	-
11	Scutigeridae	*Scutigera coleoptrata*	-	-	*
12	Formicidae	*Lasius niger*	*	*	*
13	Helicidae	*Unidentified*	-	-	*
14	Uloboridae	*Achaeranea tepideariorum*	*	*	*
16	Formicidae	*Staphylinus caesareus*	-	-	*
17	Staphyliridae	*Centruroides Sculpturatus*	-	-	-

Keys: present (*) and absent (-).
Source: Field Survey, (2021)

Table 2. Some macro-fauna species of the study area

S/N	English Name	Scientific Name	High	Medium	Low
1	Earthworm	*Lumbricina terrestris*	25	12	5
2	Ant	*Monomorium minimum*	-	2	3
3	Subterranean Termite	*Heterotermes species*	258	54	43
4	Millipede	*Eurymerodesmidae spp*	9	1	6
5	Giant centipede	*Scolopendra gigantea*	7	4	2
6	Crickets	*Gryllus assimillis*	10	3	-
7	Grasshopper	*Conozoa hyaline*	14	6	-
8	Ground Beetle	*Scaritinae clivinini*	8	4	2
9	Brow marmorated stink bug	*Halyomorpha halys*	2	-	-
10	Snail	*Achatina spp*	18	-	-
11	common centipede	*Scutigera coleoptrata*	7	2	5
12	Black ant	*Lasius niger*	40	35	15
13	Soil mites	*Unidentified*	-	1	-
14	Spider	*Achaeranea tepideariorum*	6	2	1
16	Rove beetle	*Staphylinus caesareus*	29	14	1
17	Scorpion	*Centruroidees Sculpturatus*	1	-	-
Total			426	140	81

Source: Field Survey, 2021

Table 3. Diversity of Macro fauna in the study area

Variables	High	Medium	Low
Taxa_S	14	13	10
Individuals	365	139	153
Dominance_D	0.5113	0.235	0.1977
Simpson_1-D	0.4887	0.765	0.8023
Shannon_H	1.252	1.823	1.838
Evenness_e^H/S	0.2499	0.4763	0.6283
Brillouin	1.189	1.686	1.73
Menhinick	0.7328	1.103	0.8085
Margalef	2.203	2.432	1.789
Equitability_J	0.4745	0.7108	0.7982
Fisher_alpha	2.888	3.51	2.397
Berger-Parker	0.7068	0.3885	0.281
Total	389.69	165.13	174.27

Source: Field Survey, 2021

4. DISCUSSION

4.1 Diversity of Macro Invertebrate Species in the Study Sites

Findings of the soil macro-invertebrates showed that there was a total of 365, 139 and 153 individual species belonging to 14, 13 and 10 Taxa from the studied sites. This result is similar to the findings of Kabir [15] but at variance with the report of FAO [16], which observed that lands that are subjected to application of chemicals decimation of soil organisms. Although the Shannon wiener Diversity Indices of the study areas where within the same range, the species lists indicated higher number of soil macro-invertebrates 'species in the higher growth performance site than the other two sites. These macro faunas are important components of forest soil biodiversity and are essential to the ecosystem function and play a vital role in decomposition, carbon and nutrient cycles, soil structure and water movement in soil [17,18]. Some factors are believed to be responsible for these organisms' distribution, abundance, diversity and richness in forest soils [19,20].

Findings revealed the impact of date palm tree on diversity of soil macro invertebrates in the plantation, showed that there was a substantial degree of interaction between the date palm and soil macro fauna in the study area. Forests conversion or anthropogenic activities of humans may have resulted in the consistent changes in soil macro invertebrate diversity among the soils variation in the plantation. From the findings in this study higher diversity was found in soil variable A than the other two. This may perhaps be due to the differences in soil litter accumulation across the plantation, since with macro invertebrates diversity is associated with, plant diversity, availability of soil nutrients, as well as soil and litter quality. It may also be related to water retention in the soil since Water Holding Capacity is negatively with macro invertebrate's assemblage [21].

The results shows that the diversity of soil macro invertebrates can be linked to shifts from its natural state to a new land use, resulting to changes in soil ecosystem. This has previously been reported by Siqueira et al. [8] in there study of Land use intensification effects in soil arthropod community of an Entisol in Pernambuco State, Brazil. These changes may as well lead to the loss of the ability of soil to function properly, and hence the loss of the capacity of the soil to maintain the growth of plants, and agricultural productivity [22]. Soil physical properties are affected by soil macro invertebrates' activity and in turn affect soil macro invertebrate's activity which may also include changes in soil physical attributes comprising soil aggregation, porosity and water holding capacity [23]. Anthropogenic activities or conversion from forest to other land uses can also accompany a progressive increase in soil bulk density and continuous decrease in pore space (soil compaction) which may decrease the niche availability for many small soil animals. Also, reduction in soil carbon via anthropogenic activities may also be a factor, soil carbon provides a resource for fungi and bacteria, on which many soil micro- and mesofauna community feeds, and thus changes in this food source could adversely affect their diversity.

Macro fauna species diversity in the study area as seen in the results is significantly different.

The high number of these organisms in the plantation area shows rich but for the anthropogenic activities and agricultural practices had highly reduced, not just the number (population) but the type (species) of these organisms. This is not unexpected because when an area is disturbed, the organisms that previously lived there will either find a way to adapt or look for a new environment/niche to colonize. This agrees with the report of Holden and Treseder (2013) stating that abiotic and biotic disturbances change a variety of soil properties in forests, which may in turn alter soil macrofauna biomass and respiration. For example, abiotic disturbances (fire, storm) usually kill or remove (harvest) aboveground vegetation. Post-disturbance reductions in aboveground vegetation decrease plant litter inputs and root exudation into soil and thus can result in long-term declines in soil Carbon (Johnson and Curtis, 2001; Fang et al., 2012; Zhou et al., 2013) and total soil nitrogen (Claridge et al., 2009).

In general, the studies by Olivares et al. [24] and Olivares et al. [25] establish that soil macrofauna communities are often considered as bio indicators of soil quality in commercial plantations, as they are sensitive to environmental changes that can cause variations in their abundance and composition. At a global level, climate change has become a main topic to study soil ecology, since it has been shown that the functions provided by soil macrofauna depend on climate, with emphasis on tropical territories [26,27,28]. Temperature and precipitation, in particular, play an important role along the altitudinal gradient and affect the dynamics of soil macrofauna [29,30,31].

5. CONCLUSION

Based on the findings of this study, it can be concluded that;

Macro fauna were present in the study area. However, the numbers of macro fauna Present in the soil variable C were low compared to variable A and B in the study areas. This is an indication that strong relationship exists between macro fauna, and the date palm trees. The macro fauna breakdown complex organic matter, giving fertility to the soil, others like earthworm burrow through the ground, making the soil porous, allowing water and nutrients pass through and absorbed by the plant. The plants on the other hand produce food for the soil macro fauna through litters and exudates.

6. RECOMMENDATIONS

The following recommendations are hereby made:

i. The Agricultural practices which combine trees and crops should be encouraged and application of agrochemicals is deleterious to the interrelationship of macro fauna and date palm, It also interferes with the varieties of food chains and food webs of the ecosystem.
ii. Further research should be carried out on their biology and ecological requirement of macro invertebrate

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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