A Rapid Assessment of the Existence (or Survival) of Macro Fauna in Different Land Uses in Kween District of Mount Elgon

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Research note

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Abstract

Objective

We explored the effect of different land uses on soil macro fauna species richness, abundance and diversity in Mount Elgon areas of Kween District, Uganda.

Results

Species richness was higher on the subsurface of the different land uses than belowground. A total of 647 individuals of both subsurface and belowground macro fauna were identified from the different land uses. Macro fauna abundance significantly varied across the five different land uses (H=10.1, d.f.=4, p=0.04). The average diversity of the subsurface was higher (0.71) than that belowground (0.20). The highest diversity of macro fauna was found in the intercrop of maize-beans followed by natural vegetation. Maize monocrop had the least abundance and diversity of both surface crawling and belowground macro fauna. This could be due the diversity of food and living environments as mixed cropping introduces landscape heterogeneity that accommodates diverse organisms across different land use systems. This study recommends extended studies on taxonomy, ecology and management of soil macro fauna with detailed inventories on the functional groups across land use/cover types and evaluations of varied agricultural intensification regimes on abundance and diversity of soil above and below ground macro fauna.

Introduction

Several studies focus on above-ground flora and fauna species [1] [2]. Yet, below and above ground terrestrial ecosystems are interlinked, and the former potentially being more diverse but less explored than aboveground ecosystems [3]. Consequently, information on the diversity and abundance of belowground fauna in different landscapes is still insufficient especially in agriculture dependent countries like Uganda [2]. Due to such unsustainable land uses, pristine sub surface and below ground fauna has been lost. This is mainly attributed to intensified deforestation, forest degradation and unsustainable agricultural intensification or expansion [4]. For instance, the conversion of natural systems to modified agro-ecological systems is leading to shifts in species and, in extreme cases, local extinctions [5] [6] [7]. The loss of species inevitably has consequences on diversity, community structure and ecosystem processes [8] [9]. Equally, such changes have a more profound impact on soil properties and productivity [10] [11] [12]. Therefore, soil, and the macro fauna therein, is significantly important for ecological and economic reasons [13] [14] [15]. This justifies the need to measure and monitor macro fauna found in soil to support agriculture and functionality of related agroecosystems [16] [17].

Methodology

Study area

This study was undertaken in Kween District located at 01 25N, 34 31E found in the Mount Elgon agro-pastoral landscape. This highland district is located on the Northern slopes of Mount Elgon, at an average altitude of about 1,900 meters (6,200 Feet, above sea level). The slopes of Mt. Elgon are characterized by high and well-distributed rainfall (averaging 1,200 mm/year), high altitude with deep valleys (ranging from 700 to 2,800 meters above sea level), cool temperatures (averaging 17˚C), and predominantly volcanic soils.

The major economic activity is subsistence farming and the major crops grown are; maize, beans, bananas, wheat, barley, and cowpeas. Whereas the soils of the area are perceived to be fertile, the area experiences a lot of inorganic fertilizer application. Farmers apply fertilizers due to the loose nature of the soils and the problem is aggravated by heavy rains. The study sites -Kaptum and Cheminy sub-counties- were selected because they have approximately three-quarters of the five main land uses considered for this study, which include grassland, maize mono-crop, natural forest, maize-beans, and coffee-banana land uses.

Study design

Within each land use, three plots were established and replicated 50 m apart. In each replicate, a sampling point for surface and below ground biota assessment was randomly selected. For surface and below biota assessment, a pitfall trap and monolith were installed respectively. The pitfall trap method was used to trap the surface crawling macro fauna, both diurnal and nocturnal ones. The pitfall method involved laying a *3liter* bucket into the ground; the top leveling off with the surface. The surrounding area of the bucket was restored to its natural state. In the bucket, 50 ml of 70% ethanol was added in order to demobilize and preserve the trapped organisms. The trapped organisms were removed every after 24 hours for 3 days and packed in well-labelled plastic bottles containing 70% ethanol. On the other hand, the monolith measuring 30 × 30 × 30 cm was used to collect below-ground macro-organisms. The monolith was built into the soil but 8 m from the pitfall trap in each land use. All the soil within the monolith was put in clean and marked plastic bags. All the organisms collected using the pitfall trap and monolith were taken to Makerere University College of Agricultural and Sciences Soil Laboratory for analysis and macro fauna identification.

Data analysis

Data was analyzed using Real Statistica Statistical Software Package. Descriptive statistics were used to obtain frequencies and consequently species richness and abundance. Simpson’s diversity index was used to compute the species diversity. Differences in diversity between subsurface and belowground macro fauna was tested using Wilcoxon’s rank sum test whereas the Kruskal-Wallis H test was used to test differences in diversity between the different land uses [18].

Results

Species richness of subsurface and belowground macro fauna in the different land uses

Results revealed that macro fauna species richness was higher on the subsurface of the different land uses than belowground (*Table 1*). The maize-bean intercrop subsurface land use was richest of macro fauna whereas the grassland and maize monocrop land uses were both the least rich. Natural forest and maize monocrop land uses were richest with belowground macro fauna compared to the rest of the land uses. In all, the maize-bean intercrop land use had the highest species richness. Grassland had the lowest species richness. *Table 1* details species richness of subsurface and belowground macro fauna in the different land uses.

Abundance of subsurface and belowground macro fauna in the different land uses

A total of 647 individuals of both subsurface and belowground macro fauna was identified from the different land uses. *Table 1* shows the abundance of each macro fauna species identified from each land use. Macro fauna abundance was higher on the subsurface (75%) than belowground (25%). Overall, natural forests had the highest (44%) macro fauna compared to the maize-bean intercrop (22%), coffee-banana intercrop (14%), grassland (13%) and maize monocrop (8%) land uses (Fig. 1). The macrofauna abundance significantly varied across the five different land uses ($H = 10.1$, d.f.=4, $p = 0.04$).

Diversity of subsurface and belowground macro fauna in the different land uses

From Table 2, the average diversity of the subsurface was higher (0.71) than that belowground (0.20). Considering both the subsurface and belowground macro fauna, natural forests had the highest mean diversity index (0.65) followed by maize monocrop (0.58), maize-bean intercrop (0.42), coffee-banana intercrop (0.34) and least grasslands (0.32). The diversity of subsurface and belowground macro fauna significantly varied in the different land uses.

Discussion

Effect of land-use management on surface crawling macro fauna diversity and abundance

The existence of more macro organisms in mixed cropping systems can be linked to the enhanced physical characteristics of soil like temperature and moisture content [19] [20]. For the natural forest to have relatively less macrofauna could be due to the high level of degradation. Most forests in Uganda have been disturbed through anthropogenic and natural processes [21] [22] [23] [24]. Such disturbances can be linked to the less diversity of soil macro fauna in this study. Also, the short period during which this study was conducted could be one of the factors that influenced this result. This thus warrants for large scale studies to be conducted within such landscapes.

Effect of land use practices on the diversity and abundance of belowground macro fauna

Belowground macro fauna diversity and abundance was higher in a natural forest compared to the other four different land uses. There were only two orders of macro fauna (*Megadrilacea* and *Coleoptera*) trapped in the five different land-use systems. Conversion from natural to managed ecosystems generally induces a substantial decrease in soil carbon stock thus modifying belowground biodiversity [25] [26] [27] [28] which is likely to impact on aboveground biodiversity carbon storage, biomass and soil and may substantially alter carbon sink. It also may result in a change in the amount and quality of organic matter input to that particular ecosystem or, may alter the microclimate such as temperature, humidity and soil water significantly [29] [30] [31]. These changes undoubtedly affect the faunal composition and their activities in the soil [31] [32].

It has been reported in other studies that increased organic matter content positively affects the activity and existence of soil organisms [33]. This is because organic matter acts as energy sources for soil organisms to grow and strive. However, the results of this study indicate that macro fauna existence was negatively affected by carbon content which varies across different land-use systems. This could probably be due to the quality of carbon derived from the ecosystems by organisms as food. Plant residues are known to have different chemical compositions that influence their palatability to soil fauna [34] [35] [36]. Some organisms (e.g. termites) can digest several resistant compounds such as tannin-protein complexes and lignin [37] [38].

Conclusion And Recommendations

Conclusion

Natural forests and mixed legume crop ecosystems had the richest soil macro fauna diversity and abundance than other land uses. However, soil belowground macro fauna was less rich, abundant and diverse. It is important to improve below ground macro fauna as well as encourage mixed cropping systems. This will ensure soil functionality as well as agricultural productivity.

Recommendations

There is a need of more detailed studies to ascertain the effects of land uses on macro fauna in different land uses. This will be important in understanding which land uses could affect macro fauna presence and subsequently soil fertility. This will facilitate design of recommendations to farmers to ensure soil and biodiversity conservation

Limitations

The period during which this study was conducted was short to make sufficient recommendations. Future studies ought to enhance the rigor of the study through use of methods like randomized control trials.

Declarations

Ethics approval and consent to participate

Although the study did not require ethical approval, consent to undertake the study was obtained from the Kween District Natural Resources Department and farmers that agreed to collect soil samples from their gardens.

Consent for publication

Consent to publish was sought prior commencement of data collection.

Availability of data and materials

Data and materials are available on request from the corresponding author.

Competing interests

The authors declare no competing interests.

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The study was privately funded by the corresponding author.

Authors' contributions

AS designed the study, collected data and drafted the manuscript. AMK analyzed data and presented results. AE and KCL participated in interpretation of results and reviewing the manuscript.

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Tables

Table 1

Species richness and abundance of subsurface and belowground macro fauna in the different land uses

Macro fauna type	Land use					Species richness of macro fauna type
	Coffee-banana intercrop	Grassland	Maize monocrop	Maize-bean intercrop	Natural Forest	
Sub surface	*Coleoptera (27) Hymenoptera (10) Isoptera (5) Lepidoptera (11)*	*Coleoptera (13) Lepidoptera (19) Orthoptera (32)*	*Hymenoptera (8) Lepidoptera (13) Orthoptera (4)*	*Coleoptera (15) Diplopoda (5) Hemiptera (19) Hymenoptera (12) Isoptera (22) Lepidopera (24) Orthoptera (23)*	*Coleoptera (42) Diplopoda (17) Hymenoptera (28) Isoptera (58) Lepidopera (61) Orthoptera (17)*	7
Belowground	*Megadrilacea (39)*	*Megadrilacea (18)*	*Megadrilacea (11) Coleoptera (13)*	*Megadrilacea (20)*	*Megadrilacea (35) Coleoptera (26)*	2
Species richness of land use	5	3	5	8	7	

Table 2

Simpson's Diversity Index of subsurface and belowground macro fauna for the different land uses

Macro fauna type	Land use				
	Coffee-banana intercrop	Grassland	Maize monocrop	Maize-bean intercrop	Natural Forest
Subsurface	0.67	0.63	0.63	0.84	0.8
Belowground	0	0	0.52	0	0.5

Figures

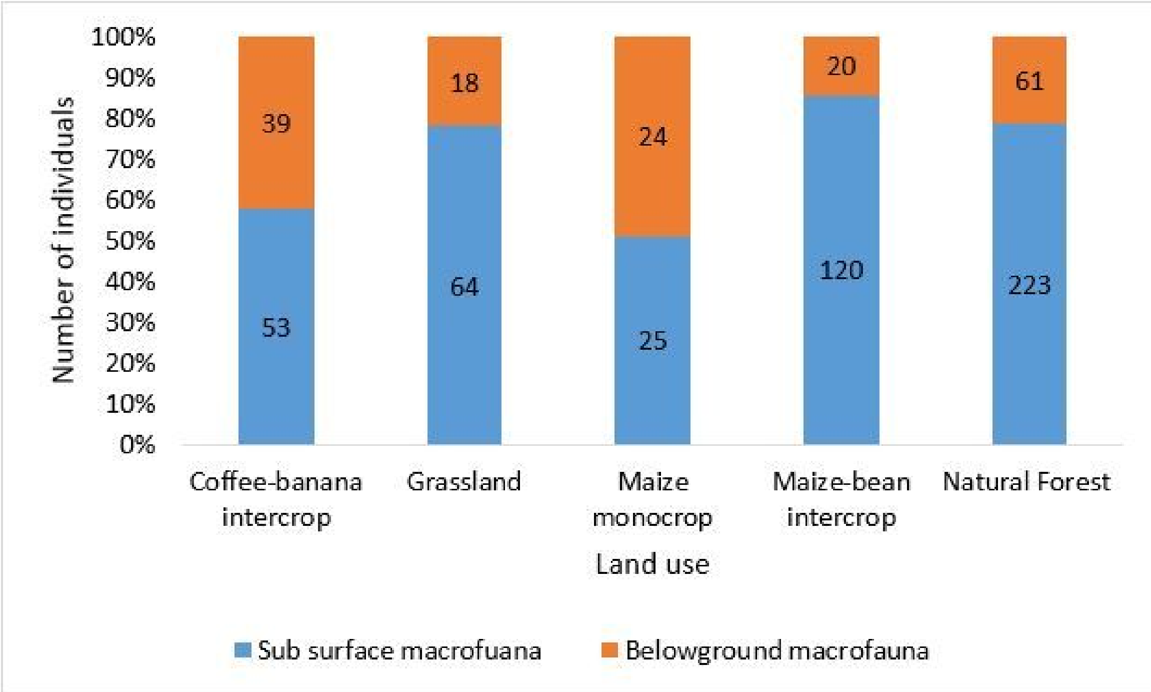

Figure 1

Abundance of subsurface and belowground macro fauna in the different land uses