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Species composition of soil macroarthropods in vegetable plots under continuous cultivation in Jos North Local Government Area of Plateau State, North Central Nigeria

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ABSTRACT

Soil organisms are an integral part of agricultural ecosystems. Thus, species composition of soil macroarthropods in vegetable plots under continuous cultivation in Jos North Local Government Area of Plateau State, North Central Nigeria was carried out from August to October 2014. Two sampling techniques were used to collect macroarthropods from six different vegetable plots in three selected villages in Jos North LGA. A total of 3,346 macroarthropods were collected and identified into 5 classes, 20 orders, 79 families, 102 genera, 139 species and 2 unidentified. There was a significant difference ($P < 0.001$) in the mean abundance of macroarthropods in relation to classes. Hymenoptera 1552 (46.4%) were the most dominant taxa. Macroarthropods abundance and as well as species richness in relation to types of vegetable plots varied significantly ($P < 0.001$). The diversity of macroarthropods in the villages surveyed was high ($H' > 2.5$). Thus, conservation and augmentation of species in vegetable plots should be encouraged.

Keywords: Macroarthropods, vegetable plots, abundance, diversity, villages

INTRODUCTION

Soil organisms are an integral part of agricultural ecosystems. The presence of a range of soil organisms is essential for the maintenance of healthy productive soils. Excessive reduction in soil biodiversity, especially the loss of species with unique functions, may have catastrophic effects, leading to the long-term degradation of the soil and loss of agricultural productive capacity (FAO, 2008). In each agro-ecosystem, soil fauna is an important component that sustains the health and quality of the soil for improved agricultural productions (Moron-Rios *et al.*, 2010). Majorities of these soil fauna are invertebrate members of the decomposer community (Wolter, 2001).

Soils are critical transition zones and have addressed possible effects of global change on soil biota (Bardgett *et al.*, 2001). Soil is a large reservoir of biodiversity, often little known (Alfred *et al.*, 1991, Henri *et al.*, 2002). Soil communities are among the most species-rich compartments of terrestrial ecosystems (Anderson, 1975; Usher *et al.*, 1979; Giller, 1996). "A soil macrofauna taxon is an invertebrate group found within terrestrial soil samples which has more than 90 percent of its specimens (individuals) in such samples visible to the naked eye" (IBOY Workshop, 2000). The soil fauna may also be referred to as exopedonic i.e. those that live outside the soil body and endopedonic which are those living inside the soil body (Alfred *et al.*, 1991). Soil macrofauna groups include organisms like earthworms, millipedes, centipedes, ants, Coleoptera (adults and larvae), Isopoda, spiders, slugs, snails, termites, Dermaptera, Lepidoptera larvae and Diptera larvae (Castner, 2000). The effects of macroarthropods in and on soil result in changes in soil size, soil shape, arrangement of soil components and soil composition (Timo *et al.*, 2006, Stephen *et al.*, 2006, Takafumi and Nubohiro, 2006).

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Soil normally supports a diverse assemblage of macro arthropods, as distinct from microarthropods. The macroarthropods include Chilopoda, and Diplopoda larvae and sometimes adults of many Orders of insects of which the Coleoptera, the Diptera, the Isoptera and Hymenoptera are the most abundant. Some of the larger members of the Arachnida may also be included (Manasseh, 2005).

Crop type may influence the distribution of those members of the soil fauna which are specifically associated with particular food plant. Monoculture will eliminate those arthropods' species which are associated with other plants. Crop rotation decreases species diversity to even greater extent (Edwards and Lofty, 1969). There is a general decrease in the diversity and abundance of soil fauna when soil is ploughed and planted with crops. Crop types that require high agricultural inputs like fertilizers, herbicides and pesticides also influence the diversity and abundance of arthropods. For example, cabbage, tomato, tobacco etc. are crop types prone to arthropods pest attack, so application of synthetic pesticides to control these pests has deleterious effect on the natural enemies of these pests thereby resulting in population explosion of these pests (Croft, 1990). On the other hand, application of insecticides may lead to increase in the number of insects as a result of insect resurgence (Mafuyai, 2014).

Humans activities are known to alter the environment in diverse ways which tend to change the structure and organization of animal and plant communities or creating communities with unusual structures which has a far reaching consequences on biodiversity in a given area (McKinney, 2002; Gatson, 2003; Scharleman *et al.*, 2004; Monirul and Khan, 2005; Lees and Peres, 2006; Vitousek *et al.*, 2007; Kirika *et al.*, 2008; McKinney, 2008; Buczkowski and Richmond, 2012). The diversity of animals and plants generally declines as an inverse function of the intensity with which crops are cultivated using mechanized methods and agrochemicals. The intensity with which soils are cultivated also depletes soil-organism communities as a consequence of the toxic effects of agrochemicals, the physical disruption of their habitats, and the reduction in litter availability and hence the soil organic matter resource base. To such extent, management practices have important consequences on the composition and abundance of soil macrofauna communities (Lavelle *et al.*, 1999). Therefore, there was a need to understand species composition of soil macroarthropods in vegetable plots under continuous cultivation in Jos North Local Government Area of Plateau State, North Central Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out in Jos, the capital of Plateau State of Nigeria located at the extreme north of the state between August and October 2014. Jos North Local Government Area is located at 9°55´N and 8°54´E (Figure 1). It has average height of about 1200 m above sea level. The natural vegetation of Jos Plateau is the Northern Guinea Savannah grassland. The edaphic feature is that of laterite and sandy soil type, differing from place to place on the Plateau (University of Jos Meteorological Station, 2012).

Sampling Sites

The study area was divided into three sampling sites. These sites were selected based on their involvement in mass vegetable production. They are Lamingo, Amazah (Mazah) and Kunga villages. A total of six major vegetable crops grown in Jos North LGA were selected. Each sampling site was subdivided into four plots. In Lamingo village, the following crops were selected: tomato, potato, maize and carrot; in Mazah village, cabbage, potato, carrot and maize were selected, while in Kunga village, potato, maize, carrot and lettuce were selected.

Sampling Materials and Techniques

A 10 x 10 metres quadrat was used in all the vegetable plots (tomato, potato, maize, carrot, cabbage and lettuce). Five pitfall traps made from bottles measuring 7 cm in height were filled up with formalin so as to immobilize trapped insect and thereafter funnels placed at the top were set in the corners and center of each quadrat. Samples were collected once a week for a standing period of 24 hours (Bater, 1996) in each site. This sampling procedure measures epigeic activity of soil-dwelling animals (Zimmer et *al.,* 2000; Sfenthourakis *et al.,* 2005; Santos *et al.,* 2007). While pitfall traps were set and collection was in progress, hand picking technique as adopted by Ellis (2013) and Tuf (2015) was used to collect available macroarthropods that were seen in the morning hours within the experimental plots. The collected macroarthropods from hand-picking technique were placed in separate collecting jars containing cotton wool soaked in chloroform so as to immobilize active macroarthropods and were further preserved in formalin for identification (Imam *et al.*, 2010). The collected macroarthropods from both pitfall traps and hand-picking technique were transferred into well labeled collection bottles and taken to the insectary for further processing.

Identification of Macroarthropods

At the completion of the collection work, all the preserved macroarthropods were emptied into a petri dish one after the other from their various sample containers, identified and counted. The identification was done in the departmental insectary with the use of dissecting microscope and identification keys and illustrations provided by Borror and White (1970), Skaife (1979), Castner (2000) and Shattuck (2000). The identified macroarthropods were then grouped into Classes, Orders, Families, Species and common names based on the date of collection, technique used and total numbers present in each sample container.

Statistical Analysis

The data obtained was analyzed using R Console Software version 2.9.2. One-way analysis of variance (ANOVA) was used to compare the mean abundance of macroarthropods between Classes and as well as study sites. Pearson's Chi-square test was used to compare proportions of macroarthropods abundance and as well as species richness between types of vegetable plots. P-values < 0.05 were considered statistically significant. Macroarthropod species diversity was calculated using the Shannon-Wiener diversity index (H´):

$$H' = -\sum_{i=1}^{S} (Pi)\,(\ln Pi)$$

Where:
H' is the diversity index.
Pi is the proportion of individual species.
S is the total number of species in the habitat and,
i is the proportion of *S* species (Begon *et al.*, 2003).

RESULTS

Soil macroarthropods' species checklist generated at the end of this study is shown in Table 1. A total of 3346 individuals of soil arthropods distributed into 5 Classes, 20 Orders, 79 Families, 102 Genera and 139 Species were collected (Table 1). Two individuals belonging to class Diplopoda and order Diptera could not be identified beyond Class and Order levels respectively. The most abundant class was Insecta while Chilopoda was the least. Soil microarthropod species identified as the most abundant were members of the family Formicidae having 1552 individuals (46.4%) followed by the Coleopterans with 744 individuals (22.2%) and Orthopterans with 299 individuals (8.9%).

Out of the 79 families identified, 11 families (13.9%) have been identified to contain some predaceous insects and these families include Anthocoridae, Mantidae, Lygaeidae, Nabidae, Pentatomidae, Cantharidae, Coccinellidae, Carabidae, Staphylinidae, Araneae and Tachinidae. On the other hand, phytophagous macroarthropods belonging to 66 families (83.5%) were identified and 2 (2.5%) were dipterans (haematophagus and scavengers in nature). Among the phytophagous families are Anthicidae, Tetrigidae, Gryllidae, Curculionidae, Tettigoniidae, Formicidae, Meloidae, Nitidulidae, Thripidae, Chrysomelidae, Aphididae and Miridae.

Lamingo village had the highest abundance of macroarthropods while Kunga village had least. There was no significant difference (F_{56} = 0.5835, Adjusted R^2 = -0.01457, P = 0.5613) in the mean abundance of macroarthropods in relation to study sites (Figure 2). Mazah had the most diverse species of macroarthropods in vegetable plots (H' = 2.920), followed by Lamingo (H' = 2.585) and the least diverse site was Kunga (H' = 2.558) as shown in Table 2. However, the Shannon-Wiener index values in the three sites showed no significant difference (χ^2 = 0.0303, df = 2, P = 0.985).

DISCUSSION

The high abundance and diversity recorded in this study clearly shows that the vegetable plots in the three selected sites are homes to a lot of macroarthropods in Jos North L.G.A. of Plateau State. This also implies that these vegetables are exposed to macroarthropod pest's attack. The abundance and diversity of soil macroarthropods observed in this study could be attributed to the availability of resources, principal of which is food. This agrees with the findings of Seastedt and Crossley (2004), who reported that in the presence of abundant resources, arthropods population can grow geometrically or exponentially and when the resources become depleted, the population growth rate slows down and reproductive output by adults become reduced.

The observed variation in the abundance of classes of macroarthropods for both techniques suggests that the vegetable plots favour the breeding success of the Class Insecta in the three sites. The diversity and abundance of members of the Class Insecta across the three sites may also be linked with the availability of resources across the study sites. This is consistent with the work of Njila *et al.* (2013), who reported that the health of an ecosystem is often measured by the biodiversity it holds, which is synonymous to its species abundance and diversity. Moreover, the class Insecta is the most diverse of all animal groups.

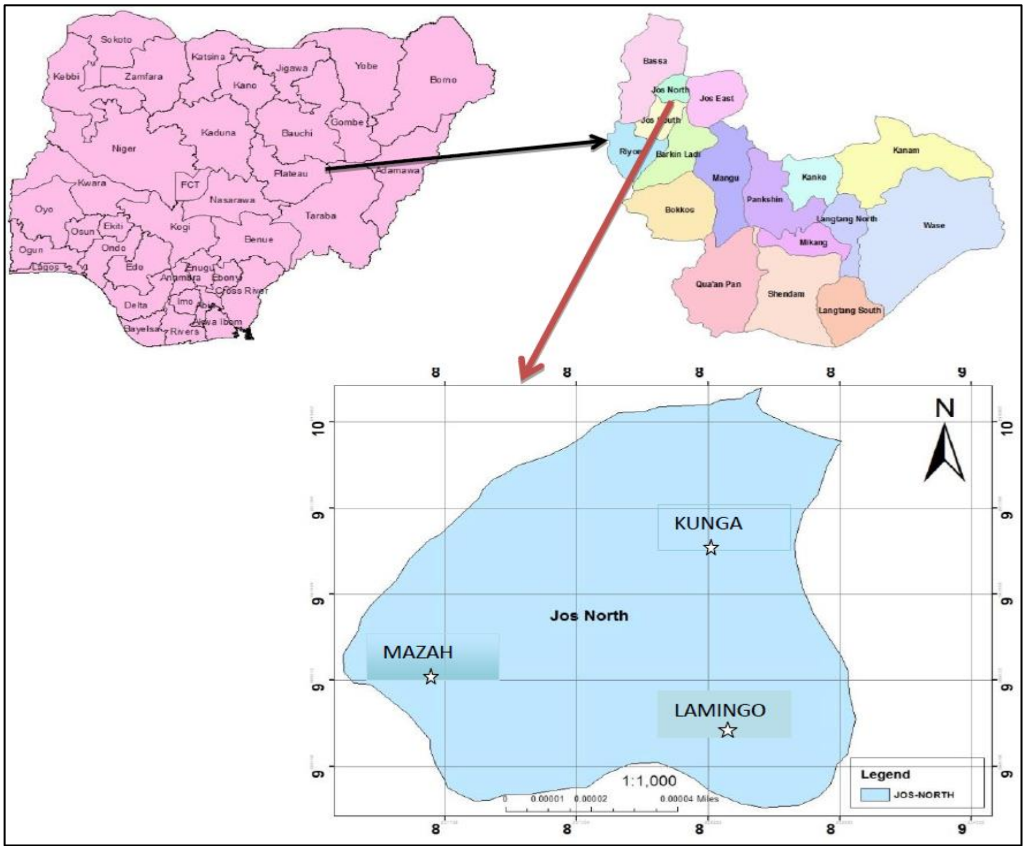

Figure 1: Map of Nigeria showing Plateau State and Plateau State showing Jos North LGA in relation to the three selected study sites
(Source: Ishaya *et al.,* 2018)

There are more species of insects than there are species of all other animals combined (Hickman *et al*., 2006). It could also be linked to the soil in the study sites being good for agriculture as reported by Scheu (2002) that the abundance and diversity of mesofauna is a good biological indicator of soil conservation status. The abundance of Hymenoptera is in line with the works of Liu *et al.* (1999), Liao *et al.* (2002), Xiong (2005) and Ishaya *et al.* (2018). They reported that Hymenoptera and Coleoptera were the dominant groups found in the tropical rainforest in China. Similarly, the abundance of Hymenoptera, mostly members of the family Formicidae is similar to the work of Frouz and Ali (2004) who found Formicidae to be the dominant group of soil macroarthropods in Florida upland habitats. This could probably be linked with their burrowing habit which enables them to escape natural enemies and effects of insecticides. This also agrees with the findings of Hickman *et al.* (2001) who reported high number of ants of the family Formicidae in a study carried out in Aldabra rainforest of India where dominance was linked to their foraging and feeding habits. Similarly, a study carried out on the impact of soil disturbance on insect abundance in Amurum Forest and surrounding farmlands in Jos East L.G.A of Plateau state, Nigeria revealed that the Familiy formicidae were the most abundant arthropods (Ombugadu *et al.,* 2017).

The lack of variation in macroarthropods abundance in relation to sites suggests that vegetable plots are subject to the same microclimatic conditions. This is contrary to Hughes *et al.* (2000) who reported that species abundance differs with various habitats. The calculated Shannon Weiner diversity index (H') indicated that the vegetable plots surveyed support diverse macroarthropod population since species diversity index H' for biological communities is not below 2.5 and does not exceed 5.0 (Hughes *et al*., 2000) as reported by Njila *et al.* (2014).

Table 1: Checklist of soil macroarthropods of vegetable plots from 3 selected sites in Jos North L.G.A., Plateau State

Class	Order	Family	Species	Kunga		Lamingo		Mazah		Total (%)
				Pitfall trap	Hand picking	Pitfall trap	Hand picking	Pitfall trap	Hand picking	
Arachnida	Acari	Thrombidiidae	*Thrombidium* sp.	1	-	2	-	3	-	6 (0.18)
		Ixodidae	*Amblyomma* sp.	-	-	-	1	-	-	1 (0.03)
	Araneae	Agelenidae	*Agelenopsis* sp.	9	3	13	11	12	5	53 (1.58)
		Corinnidae	*Castianeira longipalpis*	1	-	-	-	-	-	1 (0.03)
		Corrinidae	*Trachelas* sp.	-	-	1	-	9	-	10 (0.30)
		Gnaphosidae	*Gnaphosa* sp.	-	1	-	-	1	-	2 (0.06)
		Pholcidae	*Pholcusphalagioides*	-	-	-	-	1	-	1 (0.03)
		Sicariidae	*Loxosceles recluse*	16	6	27	11	85	4	149 (4.45)
		Thomisidae	*Xysticus* sp.	-	-	-	2	1	-	3 (0.09)
	Opiliones	Phalangiidae	*Phalangium opilio*	-	-	1	-	-		1 (0.03)
Chilopoda	Geophilomorpha	Chilenophilidae	*Zelanion* sp.	1	-	1	1	3	1	7 (0.21)
		Geophilidae	*Geophilus* sp.	-	-	-	-	1	-	1 (0.03)
Crustacea	Isopoda	Oniscoidae	*Oniscus* sp.	-		1		-		1 (0.03)
			Oniscusasellus	-	1	-	-	-	-	1 (0.03)
			Porcellio scaber	2	-	-	-	-	-	2 (0.06)
Diplopoda	Polydesmida	Polydesmidae	*Polydesmus* sp.	1	1	-	18	1	-	21 (0.63)
	Unidentified	Unidentified	Unidentified	-	-	-	-	1	-	1 (0.03)
Insecta	Blattaria	Blatellidae	*Blattella germanica*	-	-	2	-	-	-	2 (0.06)
			Blattella lituricolis	5	-	-	-	-	-	5 (0.15)
			Supella longipalpa	-	-	-	-	-	1	1 (0.03)
		Blattidae	*Periplaneta Americana*	-	-	-	-	-	1	1 (0.03)
	Coleoptera	Alleculidae	*Pseudocistela pingius*	-	-	1	-	-	-	1 (0.03)
		Anthicidae	*Anthelephila* sp.	2	-	5	1	133	-	141 (4.21)
		Brentidae	*Altica* sp.	-	-	-	1	-	-	1 (0.03)
		Cantharidae	*Cantharis tuberculata*	-	-	3	1	-	-	4 (0.12)
		Carabidae	*Loxandrus* sp.	-	-	6	5	2	-	13 (0.39)
			Nebria brevicollis	-	-	-	-	5	-	5 (0.15)
			Scarites sp.	-	4	5	-	12	-	21 (0.63)
		Cerambycidae	*Petrognatha gigas*	-	-	-	-	1	-	1 (0.03)
		Chrysomelidae	*Podagrica uniformis*	-		4		-		4 (0.12)
			Deloyala guttata	-	-	-	1	-	-	1 (0.03)
			Diabrotica undecimpunctata	-	-	-	-	-	2	2 (0.06)

Table 1 contd.: Checklist of soil macroarthropods of vegetable plots from 3 selected sites in Jos North L.G.A., Plateau State

Class	Order	Family	Species	Kunga		Lamingo		Mazah		Total (%)
				Pitfall trap	Hand picking	Pitfall trap	Hand picking	Pitfall trap	Hand picking	
Insecta	Coleoptera	Chrysomelidae	*Podagrica dilecta*	-	-	-	17	-	-	17 (0.51)
		Cicindelidae	*Cicindela* sp.	-	-	4	-	3	-	4 (0.12)
		Coccinellidae	*Coccinella septempunctata*	1	97	1	14	-	28	141 (4.21)
			Epilachna varivestis	4	-	-	-	-	-	4 (0.12)
		Curculionidae	*Otiorhynchus* sp.	1	-	-	6	-	2	9 (0.27)
			Anthonomus grandis	-	-	-	2	9	-	2 (0.06)
			Omphalapion hookerorum	-	-	-	1	1	1	2 (0.06)
			Xyleborus sp	4	-	-	-	1	-	86 (2.57)
		Cydnidae	*Cydus aterrimus*	-	-	-	-	85	-	1 (0.03)
		Gyrinidae	*Dineutus* sp.	-	-	5	-	1	-	5 (0.15)
		Helodidae	*Macrodascillus* sp.	-	-	1	-	-	-	1 (0.03)
		Lanthridiidae	*Melanophthalma* sp.	-	-	-	-		-	1 (0.03)
		Lucidae	*Calopteron* sp.	-	-	1	-	3	-	1 (0.03)
		Lycidae	*Calopteron* sp.	-	-	-	-	1	1	1 (0.03)
			Calopteron discrepans	-	-	-	-		1	1 (0.03)
		Meloidae	*Epiacuta pennsylvanica*	2	9	3	51	3	2	70 (2.09)
		Nitidulidae	*Carpophilusobsoletus*	2	-	4	-	6	-	12 (0.36)
		Passalidae	*Passalus* sp.	1	-	3	-	6	-	10 (0.30)
		Scarabaeidae	*Ataeniusalternatus*	1	-	1	1	2	1	6 (0.18)
			Anomala distinguenda	-	-	-	-	-	1	1 (0.03)
			Anomala tibialis	-	-	-	-	1	-	1 (0.03)
			Larva	1	-	-	-	1	-	2 (0.06)
		Scolytidae	*Scolytus* sp.	-	-	-	-	-	-	1 (0.03)
		Silphidae	*Necrophila Americana*	-	-	1	-	2	-	1 (0.03)
	Coleoptera	Staphylinidae	*Creophilus maxillosus*	-	-	2	-	-	-	4 (0.12)
			Ocypus sp.	-	8	15	12	72	8	115(3.43)
			Paederus olens	-	-	3	-		-	3 (0.09)
			Paederus littoralis	-	-	-	-	-	6	6 (0.18)
		Tenebrionidae	*Tenebrio molitor*	3	-	12	9	10	2	36 (1.08)
	Collembola	Poduridae	*Podura* sp.	3	-	230	-	5	1	239 (7.14)
	Dermaptera	Forficulidae	*Forficula auricularia*	-	-	1	-	-	1	2 (0.06)
	Diplura	Japygidae		-	-	1	-	-	-	1 (0.03)
	Diptera	Bombyliidae	*Bombylius major*	-	-	1	-	-	-	1 (0.03)
			Bombylius sp.	-	-	-	-	1	-	1 (0.03)
		Drosophilidae	*Drosophila* sp.	1	-	14	-	23	1	39 (1.17)
		Tipulidae	*Tipula* sp.	-	-	-	-	-	1	1 (0.03)
		Tephritidae	*Euleia fratria*	-		4		1		5 (0.15)
		Phoridae	*Megaselia scalaris*	-		-		1	-	1 (0.03)
		Muscidae	*Musca domestica*	-		1		-	-	1 (0.03)
			Stomoxys calcitrans	-		1		-	-	1 (0.03)
		Simuliidae	*Simulium* sp.	-		-		1	-	1 (0.03)

Table 1 contd.: Checklist of soil macroarthropods of vegetable plots from 3 selected sites in Jos North L.G.A., Plateau State

Class	Order	Family	Species	Kunga		Lamingo		Mazah		Total (%)
				Pitfall trap	Hand picking	Pitfall trap	Hand picking	Pitfall trap	Hand picking	
Insecta	Diptera	Tachinidae	*Tachina* sp.	-		1		-	-	1 (0.03)
		Unidentified	Unidentified	-	-	-	-	1	-	1 (0.03)
	Hemiptera	Alydidae	*Alydus calcaratus*	-	-	2	1	2	2	7 (0.21)
		Cydnidae	*Cydnus aterrimus*	1	1	-	-	2	1	5 (0.15)
		Coreidae	*Leptoglossus* sp.	-	-	-	2	-	-	2 (0.06)
		Miridae	*Peritropis saldaeformis*	-		-		2		2 (0.06)
		Nabidae	*Nabis roseipennis*	-	-	-	4	-	3	7 (0.21)
			Lygus lineolaris	-	1	-	-	-	-	1 (0.03)
		Pentatomidae	*Alcaeorrhynchus grandis*	-	2	-	2	-	2	6 (0.18)
		Anthocoridae	*Anthocoris nemoralis*	-	1	-	-	-	-	1 (0.03)
		Geocoridae	*Geocoris* sp.	2	-	-	-	-	-	2 (0.06)
		Pentatomidae	*Halyomorpha halys*	-	2	-	-	-	2	4 (0.12)
		Pyrrhocoridae	*Pyrrhocoris* sp.	-	-	-	-	-	1	1 (0.03)
	Homoptera	Aphididae	*Aulacorthum solani*	-	-	1	-	-	-	1 (0.03)
		Cicadellidae	*Delphacodes* sp.	-	-	-	-	3	-	3 (0.09)
			Empoasca dolichi	-	-	1	-	-	-	1 (0.03)
			Empoasca sp.	-	-	-	-	1	-	1 (0.03)
			Graphocephala sp.	-	-	2	-	-	1	3 (0.09)
			Oncometopia nigricans	-	-	2	1	-	-	3 (0.09)
			Oncometopia sp.	2	-	-	-	-	-	2 (0.06)
		Dictyopharidae	*Dictyopharidae microrhina*	-	-	-	1	-	-	1 (0.03)
		Issidae	*Balduza bufo*	-	-	1	-	-	-	1 (0.03)
	Hymenoptera	Formicidae	*Camponotus consobrinus*	1		1		-	11	13 (0.39)
			Camponotus sp.	14	-	18	3	66	1	102 (3.05)
			Dasymutilla quadriguttata	1	-	12	1	2	-	16 (0.48)
			Formica sp.	212	-	439	2	7	-	658 (19.67)
			Hodotermes sp.	1	-	-	-	-	-	1 (0.03)
			Monomorium mini	120	-	356	2	264	2	744 (22.24)
			Pogonomyrmex sp.	3	-	12	1	2	2	20 (0.60)
			Paltothyreus tarsatus	22	-	4	-	4		30 (0.90)
			Occopyylla sp.	-	-	-	-	1	-	1 (0.03)
			Solenopsismandibularis	-	-	-	-	11	-	11 (0.33)
			Solenopsis sp.	-	-	4	-	1	-	5 (0.15)
		Ichnemonidae	*Dusoria* sp.	-	-	1	-	-	-	1 (0.03)
		Tiphiidae	*Myzinum maculate*	1	-	-	-	-	-	1 (0.03)
	Lepidoptera		Caterpillar	5	39	5	9	1	11	70 (2.09)
	Orthoptera	Acrididae	*Achurum carinatus*	2	-	-	1	-	2	5 (0.15)
			Chorthippus sp.	1	-	1	1	1	1	5 (0.15)

Table 1 contd.: Checklist of soil macroarthropods of vegetable plots from 3 selected sites in Jos North L.G.A., Plateau State

Class	Order	Family	Species	Kunga		Lamingo		Mazah		Total (%)
				Pitfall trap	Hand picking	Pitfall trap	Hand picking	Pitfall trap	Hand picking	
Insecta	Orthoptera		*Leptysma marginicollis*	9	8	-	-	-	3	20 (0.60)
			Romalea guttata	-	14	-	1	-	2	17 (0.51)
		Gryllidae	*Allonemobius* sp.	4	-	35	-	16	-	55 (1.64)
			Gryllus assimilis	32	2	60	14	9	1	120 (3.56)
			Hapithus sp.	-	-	1	-	2	-	3 (0.09)
		Tetrigidae	*Tetrix* sp.	4	11	8	15	10	11	59 (1.76)
			Tetrix aresona	2		1		-		3 (0.09)
			Paratettix sp.	-	-	-	3	-	-	3 (0.09)
			Unidentified	-	-	3	-	3	-	6 (0.18)
		Tettigoniidae	*Meconema thalassinum*	-	1	-	-	-	-	1 (0.03)
			Neoconocephalus sp.	-	-	-	1	-	-	1 (0.03)
			Ruspolis sp.	-	1	-	1	-	-	2 (0.06)
	Mantodea	Mantidae	*Archima latistyla*	-	1	-	1	-	-	2 (0.06)
			Sphodromantis viridis	-	1	-	-	-	1	2 (0.06)
	Phasmida	Diapheromeridae	*Bactrododema* sp.	-	-	1	-	-	-	1 (0.03)
	Thysanoptera	Thripidae	*Thrips* sp.	1	-	-	-	2	-	3 (0.09)
	Total (%)			**500 (14.94)**	**215 (6.43)**	**1366 (40.82)**	**236 (7.05)**	**914 (27.32)**	**115 (3.44)**	**3346 (100)**

The result from this survey also agreed with that of McDonald (2003) who reported that in natural systems, the value of H´ has been found to range from 1.5 for systems with low species richness and evenness to 3.5 for systems with high species evenness and richness. Mazah was the most diverse site over the other two sites; this may be due to series of insecticides spray most especially in the cabbage vegetable plot which might have led to resurgence of macroarthropods in high number in the site. Why Lamingo was the second most diverse site could probably be due to the use of insecticide in the tomato vegetable plot, thus giving rise to macroarthropods resurgence as well. This is similar with the work of Hardin *et al.* (1995), who reported that one of the causes of insect resurgence was their resistance to insecticides.

CONCLUSION

All the sites surveyed in the course of this study had good representation of all classes of macroarthropods encountered. The abundance of macroarthropods shows that the selected sites are good agricultural soil. Most of the families identified contain many phytophagus species which may constitute pest problems to the vegetables. However, there were also a good number of families containing predaceous species which help keep some of the pest species in check.

The population dynamics of the phytophagous groups should be carefully studied to know those that are capable of reaching pest status in the near future so that control measures would be put in place to check-mate them. The population of the predaceous species should be studied to know which among them may be potential biological control agents. Also, in view of the fact that most soil macroarthropods such as insects especially at their larval and adult stages are serious pests to agricultural crops, a detailed study of these organisms would be of great significance to enhance systematic actions such as collection and destruction of their adults and larval stages in order to fully undertake biological, chemical and cultural control.

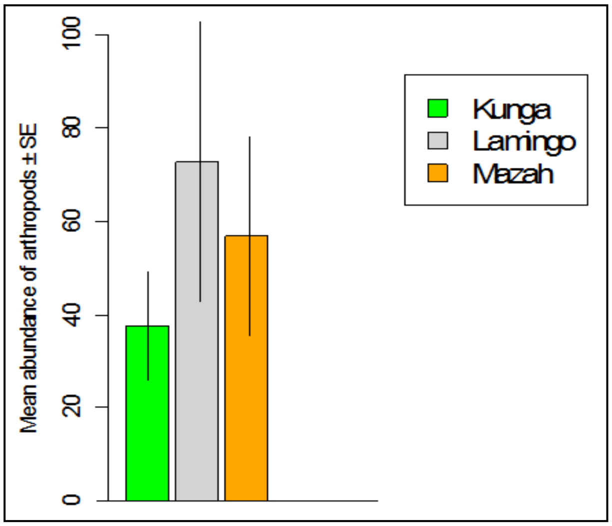

Figure 2: The mean abundance of macroarthropods in relation to sites for both collection techniques in Jos North, Plateau State

Table 2: Diversity of soil macroarthropods collected from three selected villages in Jos North L.G.A, Plateau State

Site	H′
Kunga	2.558
Lamingo	2.585
Mazah	2.920

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Conflict of interest

None declared.

REFERENCES

Alfred JRB, Darlong VT, Hattar SJS, Paul D (1991). Microarthropods and their conservation in some North East Indian soil. Pp 309-319. In: Veeresh GK, Rajagopa lD, Virak Tamath CA (Eds). Advances in Management and Conservation of Soil Fauna. Bangalore.

Anderson JM (1975). The enigma of soil animal species diversity. In: Vanek J (Ed.). Progress in soil zoology. Prague: Czech. Acad. of Sciences. Pp. 51–58.

Bardgett RD, Anderson JM, Behan-Pelletier V, Brussard L, Coleman DC, Ettema C, Moldenke A, Schimel JP, Wall DH (2001). The influence of soil diversity on hydrological pathways and the transfer of materials between terrestrial and aquatic ecosystem. Ecosystems 4: 421-429.

Bater JE (1996). Micro- and macro-arthropods. In: Hall GS (Ed.). Methods for the examination of organismal diversity in soil and sediments. Wallingford, UK: CAB International. Pp. 163-174.

Borror DJ, White RE (1970). A field guide to the insects of America north of Mexico. Boston: Houghton Mifflin Company.

Buczkowski G, Richmond DS (2012). The effect of urbanization on ant abundance and diversity: a temporal examination of factors affecting biodiversity. PLoS One **7**(8): e41729.

Castner JL (2000). Photographic atlas of entomology and guide to insect identification. Gainesville, FL, USA: Feline Press.

Croft BA (1990). Arthropod biological control agents and pesticides. New York: John Wiley and Sons Inc.

Edwards CA, Lofty JR (1969). The influence of agricultural practice on soil microarthropods population. In: Sheals JG (Ed). The Soil Ecosystem. London: Systematics Association. Pp. 234-247.

Ellis M (2014). Impacts of pit size, drift fence material and fence configuration on capture rates of small reptiles and mammals in the New South Wales rangelands. The Australian Zoologist 36 (4): 404-412.

FAO (2008). Soil Macrofauna Field Manual- Technical Level. Rome: Food and Agricultural Organization of the United Nations. Available at: https://www.fao.org/3/a-i0211e.pdf [Last accessed on 2019 October 27].

Frouz J, Ali A (2004). Soil macroinvertebrates along a successional gradient in central Florida. Florida Entomology, 87 (3):386-390.

Gatson KJ, Blackburn TM, Goldewijk KK (2003). Habitat conservation and global avian biodiversity loss. Proceedings of the Royal Society B. Biological Science 270 (1521): 1293-1300.

Giller PS (1996). The diversity of soil communities, the “poor man’s tropical rainforest”. Biodiversity and Conservation 5: 135–168.

Hardin MR, Benrey B, Colt M, Lamp WO, Roderick GK, Barbosa P (1995). Arthropod pest resurgence: an overview of potential mechanisms. Crop Protection 14: 3-18.

Henri MA, Xavier D, Phillipe L (2002). Soil biodiversity: myth, reality or conning? Oikos 96 (1): 3-24.

Hickman CP, Roberts LS, Larson A (2001). Integrated principles of zoology. 11th ed. Boston, Mass: MC Graw Hill.

Hickman CP, Roberts LS, Keen SL, Larson A, I'Anson H, Eisenhour DJ, Ober WC, Garrison CW et al (2008). Integrated principles of zoology. 14th ed. Boston, Mass: McGraw-Hill.

Hughes JB, Daily GC, Ehrlich PR (2000). Conservation of insect diversity: a habitat approach. Conservation Biology 14 (16):1788-1797.

International Biodiversity Observation Year (2000). Soil macrofauna: an endangered resource in a changing world. Report of an international workshop held at IRD, Bondy (France) 19–23 June 2000.

Imam TS, Yusuf AU, Mukhtar MD (2010). A survey of some insect pests of cultivated vegetables in three selected irrigation areas along Jakara river, Kano, Nigeria. Int. J. Biol. Chem. Sci. 4 (2): 400-406.

Ishaya M, Mwansat GS, Ombugadu A, Njila HL, Mafuyai MJ, Lapang MP (2018). A comparison of pitfall traps and hand-picking techniques for studying macroathropods abundance in vegetable plots and the influence of abiotic factors on their abundance in Jos, Nigeria. J. Agric. Sci. Practice 3(4): 79-89.

Ishaya M, Ombugadu A, Daniel DG, Akemien N, Madaki D, Adejoh VA, Lapang MP, Ahmed HO (2018). Comparative study on composition of insect in close and open nursery of Federal College of Forestry Jos, Plateau State, Nigeria. J. Res. Forestry Wildlife and Environment 10 (1): 11-19.

Kamitani T, Kaneko N. (2006). The Earthtron Facility for below ground manipulation study. Ecological Research 21(3): 483-487.

Kautz T, Lopez-Fando C, Elimer FE (2006). Abundance and biodiversity of soil microarthropods as influenced by different types of organic manure in long term field experiment in Central Spain [2006]. Applied Soil Ecology 33(3): 278-285.

Kirika JM, Farwig N, Bohning-Gaese K (2008). Effects of local disturbance of tropical forests on frugivorous and seed removal of small-seeded afrotropical tree. Conserv. Biol. 22(2): 318-28.

Lees AC, Peres CA (2006). Rapid avifaunal collapse along the Amazonian deforestation frontier. Biol. Conservation 133: 198-211.

Liao C, Li J, Yueping Y (2002). The Community of soil animals in the tropical rain forest in Jianfeng Mountain, Hainan Island, China: composition and characteristics of community. Acto Ecologica Sinica 22 (11): 1866-1872.

Liu X, Liu Y, Guo L (1999). A comparative study on soil animals in different steppe types in Neimongol. Acto Scientiarum Naturalium Universtatis NeiMongol, (in Chinese) 30 (1):74-78.

Mafuyai HB (2014). Insect resurgence: implication for agriculture, health and sustainable environment. Being a key note address of the 45th Annual Conference of the Entomological Society of Nigeria, University of Abuja, Nigeria on 8th October.

Manasseh MT (2005). A comparative study on the diversity, distribution and abundance of microarthropods fauna in Plateau. Unpublished M.Sc. Thesis, Department of Zoology University of Jos, Nigeria.

McDonald GM (2003). Biogeography: Introduction to space, time and life. New York: John Wiley and Sons Inc.

McKinney ML (2002). Urbanization, biodiversity, and conservation, Bioscience, 52: 883–890.McKinney ML (2008). Effects of urbanization on species richness: a review of plants and animals. Urban Ecosystems 11(2): 161–176.

Monirul M, Khan H (2005). Species diversity, relative abundance and habitats use of the birds in the Sundarbans East Wildlife Sanctuary, Bangladesh. Forktail 21: 79-86.

Moron-Rios A, Rodriguez MA, Perez-Camacho L, Rebollo S (2010). Effects of seasonal grazing and precipitation regime on the soil macroinvertebrates of a Mediterranean old-field. European J. Soil Biol. 46(2): 91-96.

Njila HL, Mwansat GS, Imandeh GN (2013). Species abundance and diversity of soil mites (Arachnida: Acari) along the bank of River Benue in Adamawa state, North-Eastern Nigeria. Biol. Environ. Sci. J. Trop. 10 (4): 37-44.

Njila HL, Mwansat GS, Imandeh GN, Onyiba IA (2014). Abundance and distribution of adult and juvenile stages of soil microarthropods along the western bank of River Benue in Adamawa state North-Eastern Nigeria. African J. Natural Sciences 17: 37-47.

Ombugadu A, Mwansat GS, Chaskda AA, Njila HL (2017). Comparative insect abundance and diversity in Amurum Forest Reserve and surrounding farmlands, Jos, Nigeria. Ethiopian J. Environ. Stud. Manag. 10(9): 1200-1210.

Santos SAP, Cabanas JE, Pereira JA (2007). Abundance and diversity of soil arthropods in olive grove ecosystem (Portugal): effect of pitfall trap type. European J. Soil Biol. 43(2): 77-83.

Scharleman JPW, Green RE, Balmford A (2004). Land use trend in endemic bird areas: global expansion of agriculture in areas of high conservation value. Global Change Biol. 10(12): 2046-2051.

Scheu S (2002). The soil food web: structure and perspectives. European J. Soil Biol. 38(1):11-20.

Seastedt TR, Crossley DA (2004). The influence of arthropods on ecosystems. Bioscience 34:157-161.

Sfenthourakis S, Anastasiou ST (2005). Altitudinal terrestrial isopod diversity. European J. Soil Biol. 41(3): 91-98.

Shattuck SO (2000). Australian ants, their biology and identification. Collingwood, Australia: CSIRO Publishing.

Skaife SH, Ledger JI, Bannister A (1979). African insect life. Capetown: C Stuik Publ. Partsch S, Scheu S, Milcu A (2006). Decomposers (Lumbricidae, Collembola) affect plant performance in model grasslands of different diversity. Ecology 87 (10): 2548-58.

Tuf IH (2015). Different collecting methods reveal different ecological groups of centipedes (Chilopoda). Zoologia 32(5): 345-350.

University of Jos Meteorological Station (2012). The vegetation and edaphic features of Plateau State. A Seminar in the Department of Geography and Planning, Faculty of Environmental Science, University of Jos, Jos-Nigeria.

Usher MB, Davis PR, Harris JRW, and Longstaff BC (1979). A profusion of species? Approaches towards understanding the dynamics of the populations of the micro- arthropods in decomposer communities. In: Anderson RM, Turner BD. Taylor LR (eds). Population dynamics. Oxford: Blackwell Scientific Publications.

Vitousek PM, Mooney HA, Lubchenico MJ, Melillo JM (1997). Human domination of earth's ecosystems. Science 277(5325): 494–499.

Wolter V (2001). Biodiversity of soil animals and its function. European J. Soil Biol. 37: 221-227.

Xiong Y (2005). The community diversity of soil animals in the tropical and subtropical forests and the phylogeny of Collembola. PhD Thesis, East China Normal University, Shanghai.

Zimmer M, Brauckmann HJ, Broll G, Topp W (2000). Correspondence analytical evaluation of factors that influence soil macroarthropod distribution in abandoned grassland. Pedobiologia 44(6): 695-704.

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