Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.4, 2014

Effect of Agriculture on Abundance and Diversity of Arthropods with Chewing Mouth Parts at Sokoine University of Agriculture Main Campus

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The research is financed by Higher Education Student Loan Board (HESLB) of the Government of United Republic of Tanzania

Abstract
This report concerns the effect of agriculture on abundance and diversity of arthropods with chewing mouth parts at Sokoine University of Agriculture (SUA) main campus. The purpose of the study was to determine and compare abundance and diversity between the two strata. Data collection involved the use of pitfall traps and species diversity was analyzed with Shannon-Weiner diversity index as in table 1-2, Sorenson similarity index and plot averaging to get species total abundance as in table 3-4 in the list of tables.The results where, bush land had high diversity index (2.199) compared to that of cultivated land (2.103) with a range of 0.096 this could be due to several factors e.g. burning or application of the agro-chemical which are extensively used in the cultivated site. Also the total abundance in the bush land was 103 and that of cultivated land was 91, that of bush land being greater than cultivated land by 12 individuals, possibly due to the same reasons.These results implies that agriculture has effect on arthropods with chewing mouth parts because of different agriculture techniques applied in cultivated land e.g. tilling, burning, chemical application, all these pose effect to the chewing arthropods.
Keywords: Agriculture practices, chewing arthropods, abundance, diversity

Introduction

Arthropods (Greek; arthro, joint+podos, foot) are jointed legged invertebrates with an exoskeleton. The animals show metamerism (Greek, meta, after +mere, parts) with tagmatization (Greek tagma, arrangement) and a ventral nervous systems. There are around 1.3 million different kinds arthropods that have been found. Every year some 12,000 new arthropod species are discovered (British museum, 1991).

Invertebrates which are foragers with chewing/biting mouth parts are of the orders Isoptera e.g. Termites; Odonata e.g. Damselflies, Dragonflies; Coleoptera e.g. Beetles; Hymenoptera e.g. Ants, Bees, Wasps; Orthoptera e.g. crickets, grasshopper. They are very successful and lead to inhabiting many different types of habitats, agriculture fields being one of them (British museum, 1991 in Msyani, 2005).

A combination of structural properties and the complex behaviors such as social systems in termites and bees (waggle dancing) have made them successful creature on the earth hence increase in diversity. The structural properties include the versatile exoskeleton, which protects the animals against dehydration, together with groups of segments and their appendages, which are specialized for a great variety of functions, e.g. walking in ants; swimming in crabs; feeding in play mantis; sensory reception in flies; and copulation and defense in scorpion and bees. Others are direct passage of air to the cells through various mechanisms such as spiracles and gills; highly developed sense organs like the compound eyes in bees and simpler senses like those of touch, hearing, balance and chemical reception which are in hairy part, with ability to detect wind direction (Barnes *et al.,* 1988).

Invertebrates account for the majority of animal life. Some are pollinators, and others are decomposers of organic matter, hence help with nutrient cycling in an ecosystem. Therefore, it is important for wildlife managers to be able to identify and estimate their abundance and have an understanding on the distribution and diversity of a range of invertebrate taxa(Msyani, 2005).

Pollinators are integral part of our environment and our agriculture systems. They are important in 35% of global crop production and they produce the seeds and fruits that sustain wildlife as diverse as songbirds and black bears. Pollinators include butterflies, moths, wasps' flies, beetles, bats, hummingbirds and bees. However, development or economic activities such as construction of road and buildings, and agriculture involve clearing of vegetation. These contribute to either habitat fragmentation or total habitat loss of small patches. Herbivorous insects like grass hoppers, bees and beetles subsequently suffers due to loss of forage. This in turn results to reduced numbers and loss of biodiversity. Moreover, clearing of an area renders it bare, and therefore reduce the moisture content of the soil as result of increased evaporation, a situation which will affect arthropods (Jared, 2005). Similarly, agrochemicals such as fertilizers and pesticides affect them according to Bjarni (2002), yet, every year, areas around SUA main campus are cultivated leading to removal of vegetation which is crucial for

cover and food. In this regard, loss of these pollinators may have a profound effect on agricultural productivity.
Unfortunately, information regarding abundance and diversity of these arthropods at SUA and the immediate environs is lacking. Their ecological roles are the motivation for setting up this study to compare abundance and diversity of various groups between cultivated and non-cultivated areas. This will provide an approximate effect of cultivation on the taxa on assumption that cultivation may affect arthropods negatively by decreasing their numbers because of the agrochemicals application and burning to clear the fields, or positively by favouring their flourishing as result of agriculture activity (Bjarni, 2002).
In this study, I assess the effect of agriculture on biting/chewing arthropods by determining and compare abundance and diversity between the two strata (cultivated and non-cultivated land).

Methodology

Study sites

The study sites were bush-land fragment, and cultivated land, both located opposite Department of Animal Science and Production (DASP)adjacent to crop science field trial plots. The bush-land served as a control site and is characterized by bushes and trees with *Lantana camara*being dominant tree whereas the cultivated land is dominated by *Hyperemia roofer* when it is not planted with crops. The assumption is that the 2 sites do not differ significantly in edaphic conditions.
I chose this particular site because the cultivated field has been subjected to different agriculture practices such as burning and variety of agrochemicals applications such as herbicides, pesticides, fertilizers. The bush land is less disturbed and it is used by Faculty of Veterinary Medicine to graze horses, which enhances nutrient circulation through addition of dungs.

Data collection

Pitfall Trapping

The pitfall traps were laid down in three rows as shown in the figure below. The distance between rows was 3 m, and the traps were spaced at an inter-distance of 3m along the row. Subsequently, all 15 traps were placed in a 72 m^2 plot. This set up was replicated twice at each study site. A suitable sized hole to place the trap (plastic tins) was excavated using bulb planter. Then, the tin was placed in such a way that its rim was flat with the ground. In each trap, 10cc of soap detergent was added. Each trap was labeled using permanent marker to show the site ID. The site ID consisted of vegetation type/land use, plot number and trap number (e.g. CTP1T1). The traps were left over night but were visited in the morning, from 7:00-11:30 am for collection of the specimen. Daily catches were emptied into glass vials, each site separate for identification later on in the SUA Zoology Laboratory. Date of collection and site ID were indicated on each glass vial (Rogers and Sheals, 1985 in Msyani, 2005).The data collected are recorded in table 3-4 below.

Specimen Identification

Daily catches, one site at a time were emptied into a large plastic tray. Identification was done to species level with the aid of microscope and guidebook as well as other sources such as identification keys. This laboratory work was conducted at the SUA Zoology laboratory.

Data analysis

Species diversity
The Shannon-Weiner diversity index (H') for each site was computed as:-

$$\mathbf{H' = -\sum_{i=1}^{s} (\mathit{p}_i)(I_n \mathit{p}_i)}$$

Where;
∑refers to "the sum of" there area *s* species in the community.
***P*i**= is the relative abundance (proportion) of the i^{th} species in the community. Is the proportion of individuals that each species contributes to the total in the sample on the scale of (0-1), i.e. the proportion is *p*i for i^{th} species.
ln*p*i= Natural logarithm of *p*i.

Results

Diversity and abundance

Results show high diversity index for bush land compared to that of cultivated land (Fig. 1, Tables 1 and 2) by a difference of 0.096. Similarly, total abundance is higher in the bush-land than cultivated by 12 individuals (Fig.2, Tables 3 and 4).

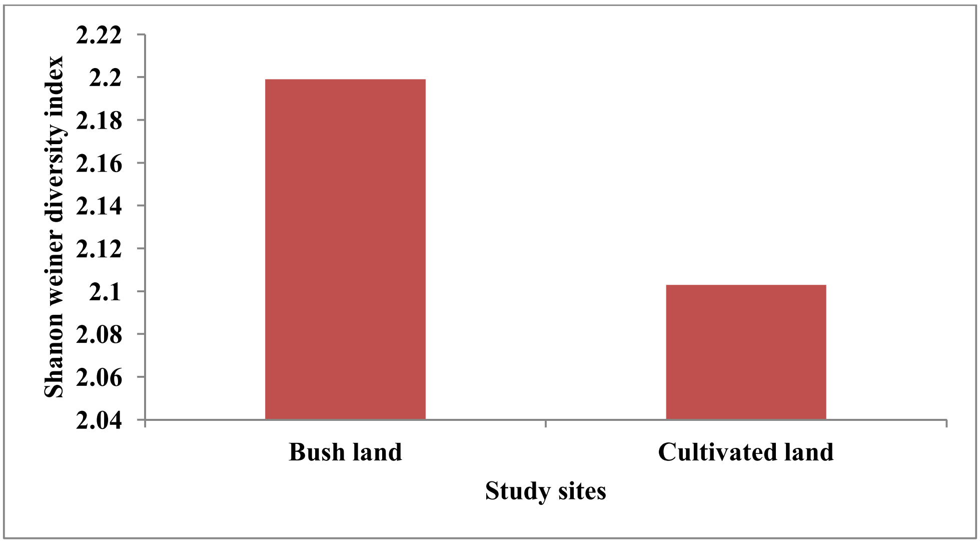

Figure 1: Shannon Weiner diversity index for arthropods with chewing mouthparts in bush-land and cultivated land at SUA main campus.

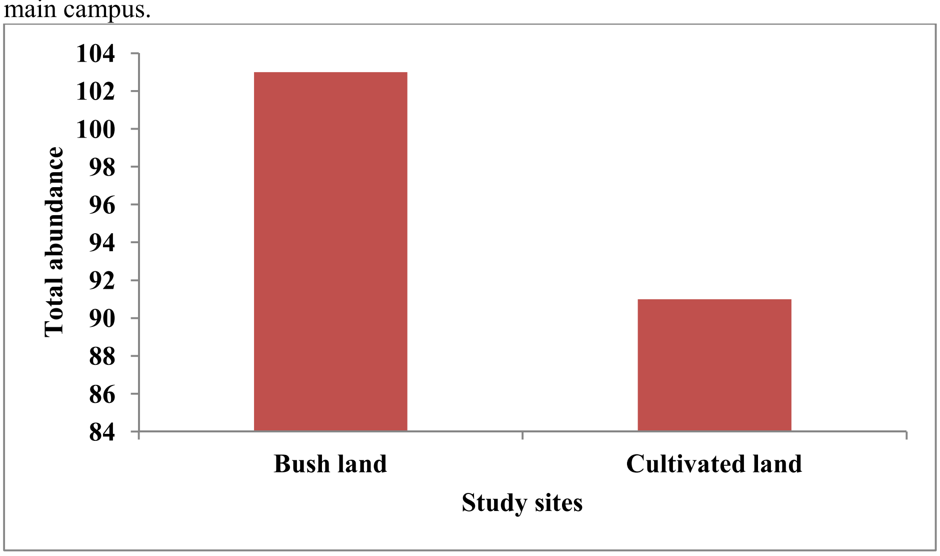

Figure 2: Total abundance of arthropods with chewing mouthparts in bush-land and cultivated land at SUA main campus.

Similarity index

Comparison of similarity in species composition between bush-land and cultivated land using Sorenson similarity index result to a value of 0.48.This value is less than 50% (0-1) suggesting less similarity in communities of arthropods with chewing mouth parts between the two sites under different land uses.

Discussion

From results above, bush land has high diversity index compared to that of cultivated land. Moreover, bush land has high abundance compared to cultivated field. The result may be associated with several factors including cultivation of land, burning or application of the agro-chemicals. Use of agrochemicals and fire may result to death of the arthropods whereas cultivation removes vegetation cover thus less food and place to shelter and breed. On the other hand, the small similarity between the two sites may be due to the closeness of the two sites i.e. cultivated and bush-land. This means the majority of species in the two area move about the two areas thus exposed to the dangers in the cultivated area.

Broza&Izhaki (1997) did a similar study in Mediterranean and came up with similar results saying that," fire alters the quantitative and qualitative composition of soil arthropod community. In the burned sites the combination of low vegetation cover and low precipitation results to a poor composition of the arthropod fauna. Crickets which are able to persist under the unfavorable conditions in the soil sub-system are highly represented. In early September and October there were large biomass of cassava in cultivated land and fire was used to clear the biomass, that possibly lead to low arthropod diversity and abundance in the cultivated plot than in the bush land as shown in fig. 1 above.

Total weed killers were also applied in the area, e.g. Lasso GD with the formulation 350g/l alachlor and 200g/l atrazin selective pre-emergence herbicides was used for maize.The effect of these chemicals on soil ecosystems is that it reduces the molting rate of arthropods under normal doses of fluchoralin and alachlor. Another applied herbicide was 2, 4-Dichlorophenoxyacetic Acid Ester 800g/l, for bees it is not toxic, moderate doses have impaired brood production but for other arthropods it is toxic with deleterious effect observed by Ashton and Crafts (1981), might also be the reason for lowering the arthropods diversity and abundance in the cultivated field.

However, any herbicide can also indirectly affect arthropod populations and species composition in an area by its effects on vegetation. Furthermore, changes in cropping systems (e.g., changing from tillage to no-tillage) can drastically influence arthropod population according to Altman (1993), if that is the case resembles my observations that bush land is not tilled hence has got high diversity and abundance of chewing arthropods.

Control for maize worms are ordinary pesticides which kills by contact through suffocating the insects, this is likely to lower the arthropods species diversity and abundance in the cultivated field. Endosulfan is commonly applied to the study site with the following classes Chlorinated hydrocarbon– cyclodieneorganochlorine which disrupt insects' nervous system. Nervous system interprets the signals and coordinates the body's responses and movements. When an insect has been poisoned by a cholinesterase (Endosulfan) inhibitor, the cholinesterase is not available to help break down the Acetylcholine, and the neurotransmitter continues to cause the neurons to "fire," or send its electrical charge. This causes overstimulation of the nervous system, and the insect dies (Brown, 2006), hence lower diversity and abundance in the cultivated land.

Urea in the Shawinigan experiment was applied in March when the soil was still very wet, the osmotic effect or ammonia production, which is probably the main toxic component of urea hydrolysis, would be minimal and so would soil-faunal mortality, the same applies to my case Urea was applied at the same time of the year with the likely rainy situation, therefore the arthropods were not significantly affected by fertilizer treatment.

In the bush land as shown on fig. 1 and 2 has high diversity and abundance probably because they get all their necessary requirements like food, similar to George *et.al* (1979) findings, shows that litter invertebrates contribute to the breakdown of organic matter in several ways. Fragmentation of the litter by movements and activities of these animals exposes a greater surface area to the process of leaching and to the action of fungi and bacteria. Recently, it has been observed that the forest floor invertebrates exert regulatory forces on micro flora decomposers population by their feeding on bacteria and fungi colonies, their transport of spores, and by their contribution of their feces and bodies for decomposition resulting to high diversity and abundance, this is a similar case to mine. Also from table 3 and 4, crickets are abundant compared to other species found in the study sites. They are swarm insects moving in large groups with their distribution being ideal free distribution-territorial formation in areas with high resources with their feeding characteristics showing that they feed on tender leaves that made them more available in the cultivated field because the place was covered with newly grown leaves few weeks after it was being cleared.

Crickets after mating, the female search for a place to lay her eggs, preferably in warm, damp soil, but again prefers to live outdoors, but will move inside when environmental conditions become unfavorable (cold). Their method of entry into buildings includes open doors and windows as well as cracks in poorly fitted windows, foundations, or siding. Unlike house crickets, which can adapt themselves to indoor conditions, the brown cricket will die by early winter. So during that time it was warm that is why they were a lot of their encounters. With such sunny moment made them highly available in the canopy less cultivated fields.

As shown in table 3-4 below ants appeared in all the four sites, they are a conspicuous component of virtually all ecosystems on Earth. Colonies of ant species that occur in the same general area often compete with one another for access to food. This competition over food may be subtle, with colonies never directly interacting with one another and simply trying to collect the food faster than they neighbors, or it can overt, with colonies literally fighting and killing one another's workers. One way we can measure the effects of competition in communities of ant species is by quantifying the spacing between ant colonies. If colonies compete for food resources, then we might expect that colonies would be "over‐dispersed" or "evenly" dispersed in the environment, simply because over‐dispersion would reduce the number of confrontations among colonies. In contrast, if colonies do no compete for food, then we would expect that colonies would be "randomly" distributed or even "clumped" in the environment. This is the same with the situation which I encountered in all the sites, the ants where randomly distributed.

The amount and nature of the vegetation is undoubtedly a prime factor in determining the success of the harvester ant colonies. Cole (1993) states that the ant is nutritionally dependent upon seeds from vegetation adjoining its nest and that an abundance of annual and perennial grasses with readily available seeds is an inducement to establishment and a factor influencing the continued existence of the granivoruos species of ants. Bohert and Knowlton (1953) reported that harvester ants may range about 100 feets from their nest and that seeds are their principle diet, but other dry protein rich substances such as pollen and dead insect may be taken also. For my case they appeared more in the bush lands because there are a lot of grasses with seeds.

The harvester ants nevertheless face a host of unintimidated, fearsome enemies, some of them so threatening that the colony has to engage them in full-scale combat. While the ant suffers predation by birds, amphibians, reptiles, insects, spiders and other organisms, it must see the horned lizard, the so-called "horny toad," as a dragon. The colony that faces a horned lizard feeding on the ants near the entrance to the nest may mount a swarming attack against the menacing ogre. "A [horned] lizard besieged but determined to stay will remain motionless as dozens of ants crawl over its scaly armor, biting and stinging as they go," said Taber. Unfortunately for the ants, the horned lizards have "an immunity or defense against ant venom in the form of a detoxifying substance in their blood plasma…, and when mobbed they simply hunker down with closed eyes until the ants leave." The horned lizards then simply resume feeding. So due to absence of such enemies in the study sites could also be the reason for making the ants more prominent in the areas.

Conclusion

Therefore agriculture activities has effect on arthropods with chewing mouth parts, this is due to the findings gathered as they showed that the bush land had high diversity and abundance than cultivated land, this is possible due to the agriculture techniques applied in the cultivated site e.g. tilling, burning of biomass, agro-chemical application showing to have deleterious effect to chewing arthropods. Also Broza&Izhaki (1997) did a similar study in Mediterranean and came up with similar conclusion saying that," fire alters the quantitative and qualitative composition of soil arthropod community, also changes in cropping systems (e.g., changing from tillage to no-tillage) can drastically influence arthropod population according to Altman (1993), this resembles my findings that bush land is not tilled hence has got high diversity and abundance of chewing arthropods.

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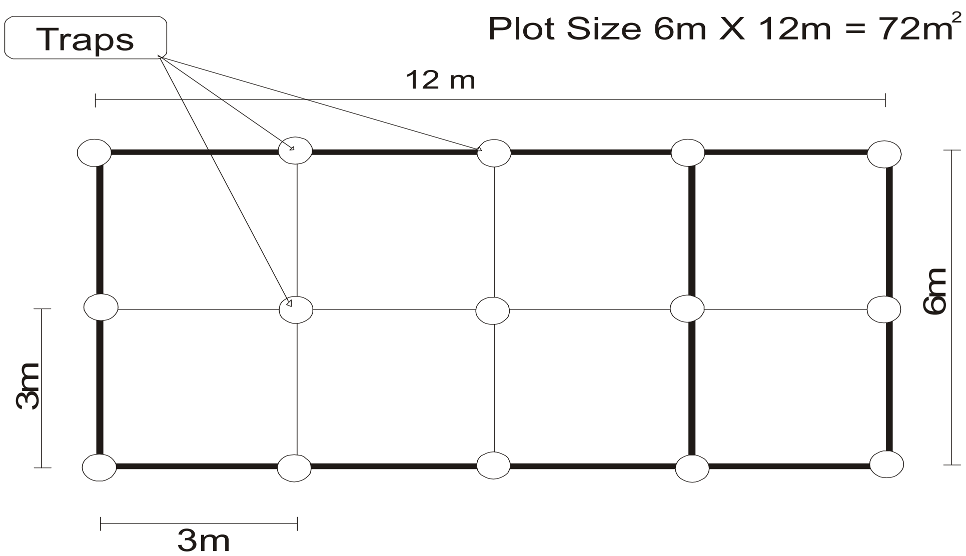

Fig: Sample Plot Settings

Table 1: Shannon Weiner diversity index for the chewing arthropods in the bush land, with also the total abundance of the site

			BUSH LAND					
S/N	COMMON NAME	SCIENTIFIC NAME	FAMILY	ORDER	ABUNDANCE	*pi*	In*p* i	$-\sum (p_i)(I_n p_i)$
1	Garden locust	*Acanthacris ruficornis*	Acrididae	Orthoptera	**8**	0.078	-2.551	**-0.199**
2	Cricket	*Carabus spp*	Carabidae	Orthoptera	**20**	0.194	-1.64	**-0.318**
3	Pygmy bush cricket		Gryllotalpidae	Orthoptera	**1**	0.01	-4.605	**-0.046**
4	Mute cricket	*Cophogryllus spp*	Gryllidae	Orthoptera	**13**	0.126	-2.071	**-0.261**
5	Brown cricket	Acanthacris fortipes	Gryllidae	Orthoptera	**26**	0.252	-1.378	**-0.347**
6	Harvest ants	*Messor capensis*	Formicidae	Hymenoptera	**11**	0.107	-2.235	**-0.239**
7	Cocroach	*Derocalymma spp*	Blaberidae	Blaberidae	**4**	0.039	-3.244	**-0.127**
8	Dung beetle	*Onthopagus nidiicornis*	Scarabidae	Coleoptera	**3**	0.029	-3.54	**-0.103**
9	Lunate blister beetle	*Decapotoma lunata*	Meloidae	Coleoptera	**4**	0.039	-3.244	**-0.127**
10	Peaceful giant ground bee	*Tefflus spp*	Carabidae	Coleoptera	**4**	0.039	-3.244	**-0.127**
11	Grooved dung beetle	*Heteronitis castelnaui*	Scarabidae	Coleoptera	**3**	0.029	-3.54	**-0.103**
12	Large black nest chafer	*Diplognata gagate*	Scarabaeidae	Coleoptera	**2**	0.019	-3.963	**-0.075**
13	Red legged millipede	*Orthoporoides spp*	Spirostreptidae	Spirobolida	**4**	0.039	-3.244	**-0.127**
			Total		**103**			**2.199**

Table 2: Shannon Weiner diversity index for the chewing arthropods in the cultivated land, with also the total abundance of the site

			CULTIVATED LAND					
S/N	COMMON NAME	SCIENTIFIC NAME	ORDER	FAMILY	ABUNDANCE	*pi*	In*p* i	$-\sum (p_i)(I_n p_i)$
1	Cricket	*Platygryllus spp*	Orthoptera	Gryllidae	**12**	0.132	-2.025	**-0.268**
2	House cricket	*Acheta domesticus*	Orthoptera		**19**	0.209	-1.565	**-0.328**
3	Brown cricket	*Acanthogryllus fortipes*	Orthoptera	Gryllidae	**22**	0.242	-1.419	**-0.344**
4	Sand Wasps	*Bembix spp*	Hymenoptera	Sphecidae	**12**	0.132	-2.025	**-0.268**
5	Harvest ants	*Messor capensis*	Hymenoptera	Formicidae	**4**	0.044	-3.124	**-0.137**
6	Burrowing bug		Hemiptera	Cydnidae	**3**	0.033	-3.411	**-0.113**
7	Fireflies		Coleoptera	Meloidae	**1**	0.011	-4.51	**-0.05**
8	Felt blister	*Mylabius burmeisteri*	Coleoptera	Meloidae	**2**	0.022	-3.817	**-0.084**
9	Lunate blister	*Decapotoma*	Coleoptera	Meloidae	**7**	0.077	-2.564	**-0.197**
10	Grooved dung beetle	*Heteronitis castelnai*	Coleoptera	Scarabaeidae	**6**	0.066	-2.718	**-0.18**
11	Large black nest chafer	*Diplognata gagate*	Coleoptera	Scarabaeidae	**2**	0.022	-3.817	**-0.084**
12	Rhinocerus beetle	*Oryctes boas*	Coleoptera	Scarabidae	**1**	0.011	-4.51	**-0.05**
				Total	**91**			**2.103**

Table 3: Abundances for the chewing arthropods in the bush land, two plots were used and the data was collection

		TOTAL ABUNDANCES IN THE BUSH LAND					
S/N	COMMON NAME	SCIENTIFIC NAME	ORDER	FAMILY	ABUNDANCES		
					PLOT-1	PLOT-2	TOTAL
1	Garden locust	*Acanthacris ruficornis*	Orthoptera	Acrididae	5	11	16
2	Brown cricket	Acanthacris fortipes	Orthoptera	Gryllidae	18	30	48
3	House cricket	*Acheta domesticus*	Orthoptera		0	1	1
4	Cricket	*Carabus spp*	Orthoptera	Carabidae	14	9	23
4	Pygmy bush cricket		Orthoptera	Grylotalpidae	1	0	1
5	Mute cricket	*Cophogryllus spp*	Orthoptera	Gryllidae	19	8	27
6	Harvest ants	*Messor capensis*	Hymenoptera	Formicidae	6	13	19
7	Cocroach	*Derocalymma spp*	Blaberidae	Blaberidae	5	3	8
9	Rhino beetle	*Coptprhina klugi*	Coleoptera	Scarabidae	2	0	2
8	Grooved dung beetle	*Heteronitis castelnaui*	Coleoptera	Scarabidae	3	2	5
9	Large black nest chafer	*Diplognata gagate*	Coleoptera	scarabaeidae	0	3	3
10	Peaceful giant ground beetle	*Tefflus spp*	Coleoptera	Carabidae	4	3	7
11	Lunate blister beetle	*Decapotoma lunata*	Coleoptera	Meloidae	3	4	7
12	Red legged millipede	*Orthoporoides spp*	Streptidae	Spirobolida	3	6	9
13	Dung beetle	*Onthopagus nidiicornis*	Coleoptera	Scarabidae	4	1	5

Table 4: Abundances for the chewing arthropods in the cultivated land, two plots were used and the data was collection

		TOTAL ABUNDANCES IN THE CULTIVATED LAND					
S/N	COMMON NAME	SCIENTIFIC NAME	ORDER	FAMILY	ABUNDANCES		
					PLOT-1	PLOT-2	TOTAL
1	Cricket	*Platygryllus spp*	Orthoptera	Gryllidae	30	13	43
2	House cricket	*Acheta domesticus*	Orthoptera		20	20	40
3	Brown cricket	*Acanthogryllus spp*	Orthoptera	Gryllidae	14	23	37
4	Sand wasps	*Bembix spp*	Hymenoptera	Sphecidae	12	11	23
5	Harvest ants	*Messor capensis*	Hymenoptera	Formicidae	3	5	8
6	Burrowing bug		Hemiptera	Cydnidae	3	21	24
7	Lunate blister	*Decapotoma lunata*	Coleopteera	Meloidae	6	8	14
8	Grooved dung beetle	*Heteronitis castelnai*	Coleoptera	Scarabaeidae	4	7	11
9	Garden fruit chafer	*Pachnoda sinuata*	Coleoptera	Scarabidae	3	1	4
10	Large black nest chafer	*Diplognata gagate*	Coleoptera	scarabaeidae	1	0	1
11	Fireflies		Coleoptera	Meloidae	1	0	1
12	Felt blister	*Mylabius burmeisteri*	Coleoptera	Meloidae	3	0	3
13	Rhinocerus beetle	*Oryctes boas*	Coleoptera	Scarabidae	0	1	1