EFFECT OF ECOSYSTEM CHANGES ON GROUND-DWELLING ARTHROPODS IN AGU-AWKA AREA OF AWKA TOWN.

ANIZOBA, M.A and OBUDULU C.
Department of Zoology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

ABSTRACT

The impact of ecosystem changes on ground-dwelling arthropods was studied in the Agu-Awka Area of Awka, Anambra State Capital. Species richness, faunal abundance, faunal diversity and dominant species were investigated at five sites using pitfall traps containing 5% formalin. The sites were roadsides (tarred and untarred); cultivated agricultural (cassava farms and oil palm plantations; developed (residential and industrial); uncultivated fallow (primary and secondary succession) and the forest site which acted as control. Each site had a total area of 1,800 m^2. Across the study sites, species richness increased from 10 in the forest site to 14 in each of the cultivated agricultural and uncultivated fallow sites and decreased to 8 in the residential sub-unit of the developed sites. The differences were not significant ($P > 0.05$). There was a significant increase in average faunal abundance from 75 in the forest to 219 in the roadsides ($P < 0.05$). There was a decrease in faunal diversity from 0.831 in the forest to 0.526 in the roadsides, but the differences were not significant ($P > 0.05$). The five dominant species encountered were *Lepisiota capensis* (Formicidae), *Camponotus acvapimensis* (Formicidae), *Trochosa cinerea* (Araneae), *Bourletiella hortensis* (Collembola) and *Macrotermis* species (Isopoda). Ecosystem changes at Agu-Awka area of Awka reduced the abundance of *Macrotermis* species in the disturbed sites but increased the abundance of *Lepisiota capensis, Camponotus acvapimensis, Trochosa cinerea* and *Bourletiella hortensis* in the disturbed sites.

Keywords: Ecosystem Changes, Ground-dwelling Arthropods, Agu-Awka.

Introduction

Man often causes ecosystem changes due to activities such as agricultural clearing, rangeland grazing, urbanisation, road construction and mining (Majer and Beeston, 1996). Such activities can affect genetic diversity, species diversity and ecosystem diversity (WRI, IUCN and UNEP, 1992). Loss of biodiversity is a great problem of environmental and ecological consequences and humanity depends on biodiversity for fuel, food, medicine and raw materials. The continuous removal of forests for various agricultural and industrial purposes has caused the loss and degradation of the primary tropical forests, leaving only man-made ones. This destruction causes extinction or loss of richness for those species whose habitats have been altered by man (Adebayo, 1995).

Studies of arthropod responses to ecological change can enhance man's understanding of the effects of human disturbance and landscape modification on the terrestrial ecosystem. In addition, species diversity can be measured using the number of species present and their relative abundance (Watt *et al*, 2002). Agu-Awka, located at the edge of Awka, the Anambra State Capital, is about 7.6 km^2. The area has been witnessing ecosystem changes, such as agricultural clearings, road construction and urbanisation. This study was carried out to determine the impact of man-made ecosystems on the species richness, abundance, diversity and dominance of ground-dwelling arthropods.

Materials and Methods

Five major sites were chosen at Agu-Awka to cover automobile roadsides, cultivated agricultural, developed, uncultivated fallow and forest sites. The forest site was used as the control. The study was carried out during the rainy season (May – July). The roadsides had sub-units of two

Coresponding Author

tarred and two untarred roads. The cultivated agricultural sites comprised two cassava farms and two oil-palm plantations as sub-units. The developed sites had two residential and two industrial sub-units, while the fallow uncultivated agricultural sites were made up of two primary succession and two secondary succession sub-units. Each major site had of a total area of 1800 m^2. The forest site was also of 1800 m^2 in area. Ten pit-fall traps containing 5% formalin were placed between 8 and 11 a.m, at 100 m intervals along the length and breath of all major sites except for the roadsides where they were placed 0.5 m from road edges, 100 m apart at alternate points along both sides of the roads.

The contents were collected 24 hours later. Trapping was conducted only once per site during the study period. The Shannon-Weaver index of diversity (Shannon-Weaver, 1963) was used to assess species diversity in the study sites (H' = *nlogn* – *∑filogfi/n*, where *i* = the categories, f = the number of observations in category *i*, and n = the sample size). The total number of species in each site was used to assess species richness while the average faunal abundance/average number of individuals per site was computed from the total number of individuals of the various species encountered in the sub-units. The percentage dominance of the various species was used to determine the dominant species. A one-way analysis of variance was used to compare the biodiversity indices between the study sites. Insect identification was done with the help of the *Check-list of Insects of Nigeria* (Medler, 1980).

Results

Species Richness: The species distribution over the sites is shown in Tables I and II. The highest number of species was recorded from the cassava farms (14) and the primary succession site (14), while the industrial site had the least number of species (8). The forest site recorded only 10 species. The differences in species richness over the study sites were not significant ($P > 0.05$). Percentage distribution of the various species across the study sites is shown in (Fig. 1) with *Camponotus acvapimensis, Acheta domestica, Trochosa cinerea, Lepisiota capensis* and *Harparus pennsylvanicus* displaying a wider distribution than the rare species such as *Nezara viridula, Dermacentor andersoni, Fontaria* sp.; *Stichopoegon* sp. *Cnidocampa flavescens* and *Oxidus gracilis*.

Average Faunal Abundance: The roadsides recorded the highest average faunal abundance (219), while the lowest was from the forest site (75) Table II. The differences in average faunal abundance for the species across the study sites were significant ($P < 0.05$).

Faunal Diversity: The index of diversity (Table II) was highest in the forest sites (0.831) and decreased gradually from 0.796 in the uncultivated fallow sites to 0.526 in the roadsides. The differences between the sites were not significant ($P < 0.05$).

Dominant Species: Five arthropod species were dominant over the study sites

Lepisiota capensis (Formicidae) was dominant in the untarred (75%) and tarred (64%) roadsides, dominant also in the cassava farms (68%), the oil-palm plantations (48%) and secondary succession sub-unit of the uncultivated fallow sites (45%), while *Camponotus acvapimensis* (Formicidae) was dominant in the residential sub-unit (38%), primary succession (21%) and secondary succession sub-unit (20%) of the uncultivated fallow sites. *Trochosa cinerea* (Araneae) was dominant in the industrial sub-unit of the developed sites (31%). *Bourletiella hortensis* (Collembola) was dominant in the residential sub-unit (39%) and forest site (35%), while *Marcoterms* sp. (Isopoda) was dominant only in the forest site (27%).

Table I: Species Richness/Composition of Ground-Dwelling Arthropods in Agu-Awka Area, Awka

	Major Sites	Sub-Units	No. of Species	Arthropod Species
1	*Roadsides*	*: Untarred Roads*	10	*Lepisiota capensis, Camponotus acvapimensis, Acheta domestica, Zonocerus variegatus, Nabis blackburni, Aphis* sp. *Aedes* sp., *Leptopterna dolabrata, Dermacentor andersoni, Trochosa cinerea.*
		: Tarred Roads	13	*Lepisiota capensis, Camponotus acrapimensis, Crematogaster* sp., *Aedes* sp., *Drosophila melanogaster, Silphidae; Macrotermis* sp., *Epilachna varivestis, Acheta domestica, Balelutha hospes, Thermobia domestica, Musca domestica, Trochosa cinerea.*
2	*Cultivated Agricultural*	*: Cassava Farms*	14	*Lepisiota capensis, Camponotus acvapimensis, Epilachna varivestis, Bourletiella hortensis, Harparus pennsylvanicus, Acheta domestica, Aedes* sp., *Leptopterna dolabrata, Tenthredinidae, Fontaria* sp., *Drosophila melanogaster, Balelutha hospes, Zonocerus variegatus, Trochosa cinerea.*
		: Oil Palm Plantations	11	*Lepisiota capensis, Camponotus acvapimensis, Thermobia domestica, Harparus pennsylvanicus, Epilachna varivestris, Acheta domestica, Crematogaster* sp., *Tenthredinidae, Stichopoegon* sp., *Balelutha hospes, Trochosa cinerea.*
3	*Developed*	*: Residential*	11	*Camponotus acvapimensis, Bourletiella hortensis, Harparus pennsylvanicus, Acheta domestica, Tetramorium caespitum, Lepidoptera dolabrata, Balelutha hospes, Lepisiota capensis, Philaenus spumarius, Oxidus gracilis. Trochosa cinerea.*
		: Industrial	8	*Acheta domestica, Camponotus acvapimensis, Drosophila melanogasster, Aphis* sp., *Tetramorium caespitum, Pheidole megacephala, Aedes sp. Trochosa cinerea.*
4	*Uncultivated Fallow*	*: Primary Succession*	14	*Lepisiota capensis, Camponotus acvapimensis, Dropophila melanogaster, Aedes sp., Tenthredinidae, Harparus pennsylvanicus, Bourletiella hortensis, Epilachna varivestris, Acheta domestica, Tetramorium caespitum Crematogaster* sp., *Amara* sp., *Balelutha hospes, Trochosa cinerea.*
		: Secondary Succession	13	*Lepisiota capensis, Camponotus acvapimensis, Harparus pennsylvanicus, Nezara viridula, Acheta domestica, Drosophila melanogaster, Bourletiella hortensis, Tenthredinidae, Nabis blackburni, Cnidocampa flavescens, Zonocerus variegatus, Leptopterna dolabrata, Trochosa cinerea.*
5	*Forest (Control)*		10	*Lepisiota capensis, Camponotus acvapimensis, Bourletiella hortensis, Macrotermis sp., Harparus pennsylvanicus, Acheta domestica, Labidura riparia, Tenthredinidae, Periplaneta brunnea, Trochosa cinerea.*

Table II: Biodiversity Indices Of Ground-Dwelling Arthropods In Agu-Awka Area, Awka.

Major Study Sites	Sub-Units of the Study Sites	Species Richness (Approximate No. of Species Present)	Average Faunal Abundance		Shannon-Weaver Diversity Index (H)	
			Sub-Units	Major sites	Sub-Units	Major sites
Roadsides	Untarred roads	10	128	219	0.477	0.526
	Tarred roads	13	310		0.563	
Cultivated Agricultural	Cassava farms	14	135	119	0.633	0.662
	Oil-palm Plantations	11	102		0.692	
Developed	Residential	11	277	163	0.492	0.629
	Industrial	8	48		0.761	
Uncultivated Fallow	Primary Succession	14	220	195	0.860	0.796
	Secondary Succession	13	169		0.731	
Forest (Control)	-	10	-	75		0.831

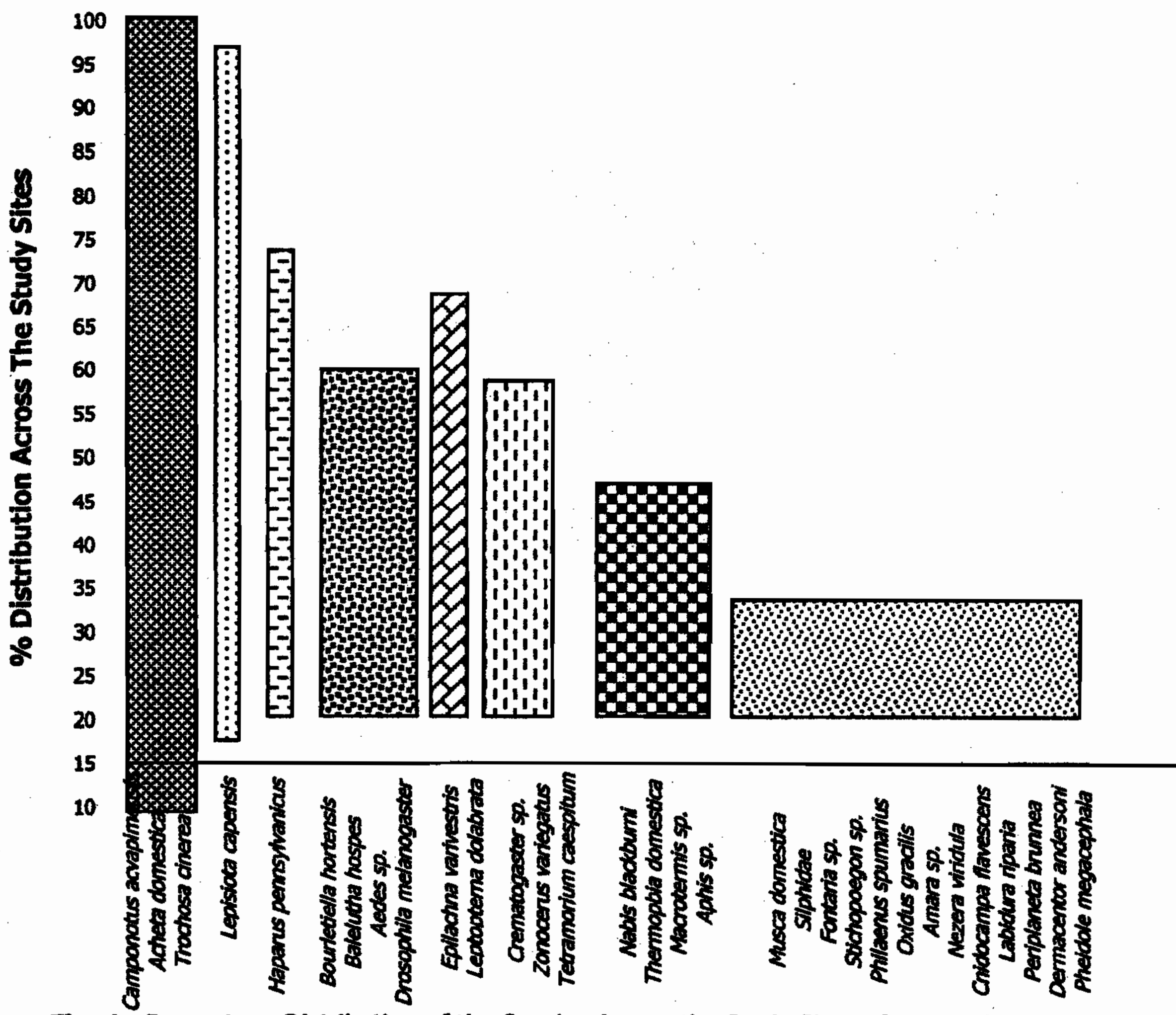

Fig. 1: *Percentage Distribution of the Species Across the Study Sites of Agu-Awka Area, Awka.*

Table III: Dominant Species In The Study Sites Of Agu-Awka Area, Awka.

Dominant Species	Roadsides		Cultivated Agricultural		Developed		Uncultivated Fallow		Forest
	Untarred roads	Tarred roads	Cassava farms	Oil palm Plantations	Residential	Industrial	Primary Succession	Secondary succession	Forest (Control)
1. *Lepisiota capensis* (Formicidae)	78%	64%	68%	48%	--	--	19%	45%	8%
2. *Camponotus acvapimensis* (Formicidae)	5%	15%	9%	17%	38%	8%	21%	20%	9%
3. *Trochosa cinerea* (Araneae)	3%	5%	1%	10%	3%	31%	16%	5%	3%
4. *Bourletiella hortensis* (Collembola)	--	--	3%	--	39%	--	1%	10%	35%
5. *Macrotermis sp.* (isopoda)	--	1%	--	--	--	--	--	--	27%

Discussion

Ecosystem changes in the Agu-Awka area of Awka were brought about by urbanization, agricultural activities, road constructions, fuel wood gathering and infrastructure. Arthropods are important in ecological studies as they contribute significantly to the biodiversity of the biosphere and are important to the overall health of the terrestrial ecosystem. At the base of many food chains, arthropods are important components of the diet of invertebrates and vertebrates. They form an integral part of the nutrient and energy-processing ability of the soil and as they demonstrate rapid responses to ecosystem change, they can be used to measure results of environmental disturbances (Coleman and Crossley, 1996).

Morris, (2000) and Hannay, (2001) stated that by studying arthropod responses to ecological changes, one can better understand the effects of human disturbance and landscape modification on terrestrial systems. In the study sites of Agu-Awka, ground-dwelling arthropods responded to ecosystem changes by a decrease in species richness in the industrial sub-unit (8) when compared to the forest site (10). This decrease, though not significant, was likely due to the effect of drastic habitat destruction during urbanization (Adebayo, 1995; Pielou, 1996; Hannay, 2001 and Watt *et al* 2002). On the other hand, the relative increases of species richness in the tarred road (13), secondary succession (13), primary succession (14) and cassava farms (14) as against 10 in the forest site were also not significant. These observations appear to support the report by Duelli *et al* (2002) that open areas in intact forests due to storm action contained relatively more animal species than the intact forest plot.

Lubertazzi and Tschinkel (2003) observed that when ecosystem changed from close shrubby ground cover to one dominated by wiregrass, the ground-foraging ant community became less diverse. Similarly in the Agu-Awka major study sites, faunal diversity decrease from 0.832 in the close forest site to 0.526 in the open roadside site was not significant and as such the faunal diversity of ground-dwelling arthropods in these sites could be described as less diverse.

Across the sub-unit sites, the higher faunal diversities in the primary succession (0.860) and the secondary succession (0.731) sub-units could be attributed to the activities of invasive pioneer species from adjacent sites as reported by Haskell (2000) and Hannay (2001) in their studies on impact of roads on ground-dwelling arthropods. The fairly low faunal diversities observed in the untarred (0.477) and residential sub-units could be attributed to the report by Numata (1989), Zimmy (1994) and Hannay (2001) that roads and infrastructure destroy and fragment ground-dwelling arthropod habitats leading to reduced faunal diversity.

Ecosystem changes significantly increased the faunal abundance as was observed in the open major study sites in Agu-Awka area of Awka when compared with the close forest site. The high average faunal abundance in the uncultivated fallow site (195) may be due to a shift from close forest to open environment during urbanization and agricultural practices which could attract invasive and exotic species (Haskell, 2000 and Hannay, 2001). Also, the high average faunal abundance in the roadsides (219) and developed sites (163) could be attributed to litter and refuse from urban dwellers and travellers who dropped unfinished food items from moving vehicles. This could attract more ground-dwelling arthropods. In the residential sub-units, refuse dumps with organic food remains will always abound while such dumps will be minimal in the industrial sub-units which could explain its low average fauna abundance (48). Numata, 1989; Sukopp, 1990 and Zimmy, 1994 had pointed out that the availability of large amounts of human food in urban areas led to influx of invasive arthropods which could increase the faunal abundance. The *Macroterms species* was prominent in the close forest site, probably due to the abundance of dead plant materials in the forest which it decomposes. Its presence was insignificant in the tarred roadside sub-unit and absent in the other sites which had experienced levels of deforestation for agricultural and urbanization activities. Eggleton *et al* (1996) cited in Watt *et al* (2002), reported that complete forest clearance in parts of the Mblamayo Forest Reserve, Cameroon reduced the termite species abundance.

Burletiella hortensis (Collembola) and *Macrotermis* species (termite) were dominant in the close forest environment. Also, *Bourletiella hortensis* was not restricted to the close forest environment but with *Camponotus acvapimensis* (Formicidae) were dominant in the open residential sub-unit which had undergone environmental changes. *Lepisiota capensis* (Formicidae) dominated the roadsides, cultivated agricultural sites and the secondary succession fallow sub-unit. In addition, *Trochosa cinerea* (Araneae) was dominant only in the industrial sub-unit. These open environments have more sunlight and increased air movement at the ground surface with hotter and drier conditions which tended to favour exotic species from warmer and drier areas (Numata, 1989; Zimmy 1994 and Lubertazzi & Tschinkel, 2003). Lubertazzi and Tschinkel (2003) also pointed out that competition was important in structuring ant communities and the strongest ant competitor was likely to monopolise food finds and prevent other ant colonies from nesting in their vicinity. This could be the case with *Lepisiota capersis* (Formicidae) which appeared to have a negative influence on *Camponotus acvapimensis* (Formicidae) in the roadsides, cultivated agricultural and secondary succession sub-unit of Agu-Awka area of Awka.

In conclusion, ecosystem changes due to urbanization and agriculture in Agu-Awka area of Awka did not have significant impact on species richness and faunal diversity. A dominant forest arthropod such as *Macrotermis* species was replaced in the disturbed environments by dominant and abundant invasive species such as *Lepisiota capensis*, *Camponotus acvapimensis* and *Trochosa cinerea*. Urbanization and agricultural activities should be drastically scaled down in Agu-Awka area of Awka since deforestation eradicates the nesting areas and hiding places essential to arthropod survival.

Acknowledgment

The authors are very grateful to the staff of the Departments of Zoology, University of Nigeria, Nsukka and Nnamdi Azikiwe University, Awka for their immense assistance.

References

Adebayo, C. O. (1995). Impacts of Land Uses on Biodiversity In: Impact of human activities on the West African Savanna. Proceedings of the Regional Training Workshop held at the Federal University of Technology, Akure, Nigeria. UNESCO – Dakar/Man and Biosphere (MAB) National Committee, Nigeria. Section B: Biodiversity and Conservation, pp. 153 – 155.

Coleman, D. C. and Crossley, J. (1996). *Fundamentals of Soil Ecology*: Academic Press, San Diego, pp. 1 – 6.

Duelli, P; Obrist, M. K. and Wermelinger, B. (2002). Wind-throw induces changes of faunistic biodiversity in alpine spruce forests. *Forest, Snow and Landscape Research*, 77: 117 – 131.

Hannay, L. (2001). Effect of roads on arthropods. *The Road Reporter*, 6 (4).http:/www.wildlandscpr.org/data bases/biblionotes/bibilio6.4.html, accessed 2/28/06.

Haskell, D. G. (2000). Effects of forest roads on macroinvertebrate soil fauna of the Southern Appalactian Mountains. *Conservation Biology*, 14 (1): 57 – 63.

Lubertazzi, D. and Tschinkel, W. (2003). Ant Community Change across a ground vegetation gradient in north Florida's longest pine flatwoods. *Journal of Insect Science*, 3: 21.

Majer, J. D. and Beeston, G. (1996). The biodiversity integrity index: An illustration using ants in Western Australia. *Conservation Biology*, 10: 65 – 73.

Medler, J. T. (1980). *Insects of Nigeria – Checklist* and *Bibliography*: Mem. Amer. Ent. Inst., No. 30.

Morris, M. G. (2000). The effects of structure and its dynamics on the ecology and conservation of arthropods in British grasslands. *Biological conservation*, 95: 129 - 142.

Numata, M. (1989). Methodology of Urban Ecosystems Studies. In: Numata, *M. (ed). Studies in Urban Ecosystems*: Tokyo University Press, Tokyo, pp. 1 – 44.

Pielou, E. C. (1996). The Measurement of Diversity in Different Types of Biological Collections, *J. Theoret. Biology*, 13: 131 – 144.

Shannon, C. E. and Weaver, W. (1963). A mathematical theory of communications. *Bull Syst. Tech. J.*, 27: 379 – 423.

Sukopp, H. (1990). *Stadtoekologie – das Beispiel, Berlin*: Dietrich Reimer Verlag, Berlin.

Watt, A. D.; Stork, N. E. and Bolton, B. (2002). The diversity and abundance of ants in relation to forest disturbance and plantation establishment in Southern Cameroon. *J. of Applied Ecology*, 39 (1): 18 – 30.

WRI, IUCN and UNEP (1992). *Global Biodiversity Strategy: Guidelines for Action to Save, Study and Use Earth's Biotic Wealth Sustainably and Equitably*: World Resource Institute Publications, Baltimore.

Zimmy, H. (1994). The city as an ecological system and its impact on environmental quality. *Memorabilia Zoologicae*, *49*: 21 – 125.