EFFECT OF ECOSYSTEM CHANGES ON AIR-BORNE AND VEGETATION-DWELLING ARTHROPODS IN AGU-AWKA AREA OF AWKA

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ABSTRACT

The study on the impact of ecosystem changes on air-borne and vegetation-dwelling arthropods was carried out in the Agu-Awka area of Awka, Anambra State capital. Areas investigated were roadsides, cultivated agricultural, built-up, uncultivated agricultural and forest sites using the sweep net for arthropods on vegetation and the sticky trap for air-borne flying arthropods. The forest site acted as control. Ecosystem changes from close forest to open environments reduced species richness for vegetation-dwelling arthropods but increased the species richness of air-borne arthropods. For the vegetation-dwelling fauna, the forest site recorded 14 species while the disturbed built-up sites had only 4 species. The differences between the sites were significant ($P < 0.05$). For the air-borne arthropods, there were no species in the forest while the highest number of species (7) was recorded in the uncultivated agricultural sites. The differences over the study sites for air-borne species were not significant ($P > 0.05$). The ecosystem change decreased significantly the species abundance of vegetation-dwelling arthropods from 42 in the forest to 14 in the built-up sites ($P < 0.05$), while the species abundance of air-borne fauna was significantly increased from 0 in the forest to 43 in the uncultivated agricultural sites ($P > 0.05$). The species diversity for the vegetation-dwelling arthropods decreased significantly from 0.856 in the forest to 0.384 in the built-up sites ($P < 0.05$), while it increased significantly from 0.000 in the forest to 0.611 in the uncultivated agricultural sites for the air-borne arthropods ($P < 0.05$). For the vegetation-dwelling arthropods, 6 insect species and 6 spider species were dominant in the sites that had undergone environmental changes while 1 insect species and 3 spider species were dominant in the forest. For the air-borne fauna, no species was found in the forest while 7 insect species were dominant in the sites which had experienced ecosystem changes.

Keywords: Ecosystem change, Flying insects, Vegetation-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 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 and diversity of vegetation-dwelling and air-borne arthropods.

MATERIALS AND METHODS

Five major sites were chosen at Agu-Awka to cover roadsides, cultivated agricultural, built-up, uncultivated agricultural and forest sites. The forest site was used as the control. The study was carried out during the rainy season (May – July).

Study Site: Roadsides had sub-units of two tarred and two untarred roads giving a total area of 1000 m^2. The cultivated agricultural sites comprised two cassava farms and two oil-palm plantations as sub-units with a total area of 1800 m^2. The built-up sites had two residential and two industrial sub-unit giving a total area of 1875 m^2, while the uncultivated agricultural sites were made up of two primary succession and two secondary succession sub-units of a total area of 1800 m^2. The slight variations in the total areas of sites studies were not significant.

Sampling Techniques: The sweep net was used to sample arthropods on vegetation while the sticky tap was used to catch air-borne flying arthropods (Sutherland, 1997). Ten sweeps were taken along each roadside, 5 sweeps for each side of the road, 0.5 m from the road edge at alternating intervals of 100 metre between 8 am and 11 am on sampling days. For each of the other sites (cultivated and uncultivated agricultural sites, built-up and the forest sites), perpendicular lines were marked out in each site and 5 sweeps taken along each of the perpendicular lines at designated intervals of not less than 7 m and not more than 10 m apart.

The sticky traps were green-coloured beer bottles, smeared with venoline jelly to act as an adhesive substance and were hoisted upside-down on 1.5 m wooden poles. The traps were set up between 8 am and 11 am in the morning and examined after 24 hours. Ten (10) traps were used for each roadside, five for the left side and five at alternate intervals of 100 m on the right side each placed 0.5 m from the road edge. In each of the cultivated and uncultivated agricultural and the forest sites, traps were positioned along the marked out perpendicular lines: five (5) along the horizontal and five (5) along the vertical lines at intervals not less than 6 m and not more than 8 m. In the building sites, due to the stratification of the vegetation, 8 traps were placed in a straight line across the sites in areas with low vegetation at 4 m intervals, while 2 traps were set along the sides with high vegetation cover at 10 m intervals. 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

Vegetation-Dwelling Arthropods

Species richness: The species richness of vegetation-dwelling arthropods is displayed in Table 1. The highest number of arthropod species on vegetation was recorded in the forest site (14), while the industrial sites had the least number of 3 species (Table 2). The differences in species richness over the study sites were significant ($P < 0.05$).

Average faunal abundance: The forest site recorded the highest average faunal abundance (42), while the lowest was in the built-up sites (14) Table 2. The differences in average faunal abundance for the species over the study sites were significant ($P < 0.05$).

Faunal diversity: The index of diversity (Table 2) was highest in the uncultivated agricultural sites (H = 0.863), followed by the forest site (H = 0.856) and lowest, in the built-up sites (H = 0.384). The differences between the sites were significant ($P < 0.05$).

Dominant species: For the vegetation-dwelling arthropods, there were 6 dominant species. On the roadsides were *Lepisiota capensis* (52%), *Camponotus acvapimensis* (26%) and *Balelutha hospes* (22%). In the cultivated agricultural sites, the dominant species were *Camponotus acvapimensis* (44%), *Lepisiota capensis* (38%) and *Bemisia tabaci* (17%), while in the built-up sites, the dominants were *Camponotus acvapimensis (73%) and Nabi's balckburni* (27%). In the uncultivated agricultural sites, the dominants were *Leptopterna dolobrata* (58%), and *Camponotus acvapimensis* (42%). The forest site was dominated by only *Camponotus acvapimensis* (Table 3). For the spiders, 7 species were dominant over the study sites. On the roadsides were *Amaurobius spirilis* (40%), *Peucetia viridan* (30%), *Heteropoda venatoria* (20%) and *Sceliform coementarium* (10%). In the cultivated agricultural sites, the dominants were *Sceliform coementarium* (60%) and *Amaurobius spirilis* (40%). In the built-up sites, the only dominant species was *Sceliform coementarium* while in the uncultivated agricultural sites, the dominant species were *Sceliform coementarium, Heteropoda venatoria, Gasteracantha areuata and Peucetia viridan* each showed 25% dominance. In the forest site, the dominant species were *Amaurobius spirilis, Salticus sp.,* and *Misumena vatia*, each was approximately 30% dominant.

Air-borne Flying Insects

Species richness: The species richness of air-borne flying insects is shown in Table 4. The highest number of species (7) was recorded in the primary succession sub-unit and the least (0) in the forest site where no flying insect was recorded (Table 5). The differences in species richness over the study sites were not significant ($P > 0.05$).

Average insect abundance: The uncultivated agricultural sites had the highest average insect abundance of 43 while the built-up sites and the forest recorded 12 and 0 respectively (Table 5). The differences in average abundance for air-borne flying insects over the study sites were significant ($P < 0.05$).

Insect diversity: The uncultivated agricultural sites recorded the highest insect diversity of H = 0.611, while the forest site recorded the lowest insect diversity of H = 0.000 (Table 5). The differences between the sites were significant ($P < 0.05$).

Dominant species: There were 7 dominant insect species. In the roadsides, the dominant insect species were *Drosophila melanogaster* (86%) and *Hippodamia convergens* (14%). In the cultivated agricultural sites, the dominant species were *Drosophila melanogaster* (49%), *Tenthredinidae* (19%), *Aedes sp.* (16%), *Camponotus acvapimensis* (8%) and *Sitophilus sp.* (8%). In the built-up sites, the dominant species were *Drosophila melanogaster* (62%), *Hippodamia convergnes* (19%) and *Camponotus acvapimensis* (19%). In the uncultivated agricultural sites, the dominant species were *Drosophila melanogaster* (74%), *Epilachna varivestis* (15%) and *Aedes sp.* (11%). In the forest site, no air-borne insects were recorded (Table 6).

DISCUSSION

Ecosystem changes in the Agu-Awka area of Awka were brought about by urbanization, agricultural clearings, 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.

Table 1: Species richness/composition of vegetation-dwelling arthropods in Agu-Awka area, Awka

	Major Sites	Sub-Units	Insect Species	Spiders	Ticks
1	Roadsides	: Untarred Roads	*Camponotus acvapimensis, Balelutha hospes, Leptopterna dolabrata, Lepisiota capensis*	*Amaurobius spirilis, Sceliform coementarium*	*Demodex canis*
		: Tarred Roads	*Lepisiota capensis, Camponotus acvapimensis, Hippodamia convergens, Nabis blockburni, Zonocerus variegatus, Mantis religiosa*	*Amaurobius spirilis, Heteropoda venatoria, Peucetia viridian*	---
2	Cultivated Agricultural	: Cassava Farms	*Lepisiota capensis, Bemisia tabaci, Camponotus acvapimensis, Leptopterna dolabrata*	*Sceliform coementarium, Peucetia viridian*	---
		: Oil Palm Plantation	*Camponotus acvapimensis, Bemisia tabaci, Lepisiota capensis, Sitophilus sp., Crematogaster sp.*	*Sceliform coementarium, Peucetia viridian*	---
3	Built-up	: Residential	*Nabis blackburni, Camponotus acvapimensis, hippodamia convergens, Bemisia tabaci*	*Sceliform coementarium*	---
		: Industrial	*Camponotus acvapimensis. Harparus pennsylvanicus Bemisia tabaci*	---	---
4	Uncultivated Agricultural	: Primary Succession	*Leptopterna dolabrata, Camponotus acvapimensis, Labidura riparia, Nezara viridula, Zonocerus variegatus, Nabis blackburni, Tenthredinidae, Drosophila melanogaster*	*Gasteracantha sp., Salticus sp.*	---
		: Secondary Succession	*Camponotus acvapimensis, Lepisiota capensis, Hippodamia convergens, Nezara viridula, Leptopterna dolabrata, Zonocerus variegatus, Tenthredinidae.*	*Sceliform coementarium, Heteropoda venatoria*	---
5	Forest	: Control	*Camponotus acvapimensis, Hippodamia convergens, Lepisiota capensis, Aedes sp., Periplaneta brunnea, Bemisia tabaci, Copa occidentalis, Krausara angulifera, Fannia canicularis, Bourletiella hortensis, Neotennes connexus*	*Amaurobius spirilis, Salticus sp., Misumena vatia.*	---

Table 2: Biodiversity Indices of vegetation-dwelling arthropods in Agu-Awka area, Awka

Major Study Sites	Sub-Units of the Study Sites	Species Richness (Approx. No. of Species Present)			Average Faunal Abundance			Shannon-Weaver Diversity Index (H)	
			Insects	Spiders		Insects	Spiders	Sub-Units	Major sites
Roadsides	Untarred roads	6	4	2	20	18	2	0.675	0.721
	Tarred roads	9	6	3	32	24	8	0.766	
Cultivated	Cassava farms	6	4	2	27	24	3	0.523	
Agricultural	Oil-palm Plantations	6	5	1	28	26	2	0.551	0.537
Built-up	Residential	5	4	1	14	11	3	0.529	0.384
	Industrial	3	3	=	13	13	=	0.239	
Uncultivated	Primary Succession	10	8	2	22	19	3	0.885	
Agricultural	Secondary Succession	9	7	2	20	18	2	0.840	0.863
Forest (Control)	-	14	11	3	42	39	3	0.856	

Table 3: Dominant vegetation-dwelling insect species in Agu-Awka area, Awka

Dominant Species	Average Number of Individuals Per Site								
	Roadsides		Cultivated Agricultural		Built-Up		Uncultivated Agricultural		Forest
	1	2	3	4	5	6	7	8	9
1. ***Camponotus acvapimensis*** (Hymenoptera)	7	--	--	15	--	11	--	5	6
2. ***Lepisiota capensis*** (Hymenoptera)	--	14	13	--	--	--	--	--	--
3. ***Leptopterna***									

	1	2	3	4	5	6	7	8	9
dolabrata **(Hemiptera)**	--	--	--	--	--	--	7	--	--
4. *Nabis blackburni* (Homoptera)	--	--	--	--	4	--	--	--	--
5. *Balelutha hospes* (Homoptera)	6	--	--	--	--	--	--	--	--
6. *Bermisia tabaci* (Homoptera)	--	--	6	9	--	--	--	--	--

Key: 1 tarred roads, 2 Tarred roads, 3 Cassava farms, 4 Oil palm Plantations, 5 Residential, 6 Industrial, 7 Primary Succession, 8 Secondary succession, 9 Control

Table 4: Species Richness/Composition of Air-Borne Flying Insects In Agu-Awka Area, Awka

	Major Sites	Sub-Units	Insect Species
1	Roadsides	: Untarred Roads	*Drosophila melanogaster, Hippodamia convergens, Componotus acvapimensis*
		: Tarred Roads	*Drosophila melanogaster, Hippodamia convergens, Tenthredinidae*
2	Cultivated Agricultural	: Cassava Farms	*Drosophila melanogaster, Aedes sp., Tenthredinidae, Sitophilus sp.*
		: Oil Palm Plantations	*Drosophila melangaster, Camponotus acvapimensis Sitophilus sp.*
3	Built-up	: Residential	*Drosophila melonogaster, Hippodamia convergens, Musca domestica*
		: Industrial	*Camponotus acvapimensis. Drosophila melanogaster*
4	Uncultivated Agricultural	: Primary Succession	*Drosophila melanogaster, Epilachna varivestis, Camponotus acvapimensis, Lepisiota capensis, Aedes sp., Aphis sp., Nezara viridula*
		: Secondary Succession	*Drosophila melanogaster, Epilachna varivestis, Camponotus acvapimensis, Aedes sp., Hippodamia convergens*
5	Forest		NIL

Table 5: Biodiversity Indices Of Air-Borne Flying Insects In Agu-Awka Area, Awka

Major Study Sites	Sub-Units of the Study Sites	Species Richness (Approx. No. of Species Present)	Average Faunal Abundance		Shannon-Weaver Diversity Index (H)	
			Sub-Units	Major sites	Sub-Units	Major sites
Roadsides	Untarred roads	3	26	26	0.174	0.209
	Tarred roads	3	26		0.244	
Cultivated Agricultural	Cassava farms	4	29		0.567	0.500
	Oil-palm Plantations	3	13	21	0.433	
Built-up	Residential	3	12	12	0.431	0.344
	Industrial	2	12		0.257	
Uncultivated Agricultural	Primary Succession	7	40	43	0.680	0.611
	Secondary Succession	5	45		0.542	
Forest (Control)		0	0			0.000

Table 6: Dominant Air-Borne Flying, Arthropod Species In Agu-Awka Area, Awka

Dominant Species	Average Number of Individuals Per Site								
	Roadsides		Cultivated Agricultural		Built-Up		Uncultivated Agricultural		Forest
	Untarred roads	Tarred roads	Cassava farms	Oil palm Plantations	Residential	Industrial	Primary Succession	Secondary succession	Control
1. *Drosophila melanogaster* (Diptera)	23	21	11	7	6	7	17	23	--
2. *Hippodamia convergens* (Coleoptera)	3	4	--	--	4	--	--	--	--
3. *Epilachna varivestis* (Coleoptera)	--	--	--	--	--	--	--	8	--
4. *Sitophilus sp.* (Coleoptera)	--	--	--	3	--	--	--	--	--
5. *Aedes sp.* (Diptera)	--	--	6	--	--	--	6	--	--
6. *Tenthredinidae* (Hymenoptera)	--	--	7	--	--	--	--	--	--
7. *Camponotus acvapimensis* (Hymenoptera)	--	--	--	3	--	4	--	--	--

At the base of many food chains, arthropods are important components of the diet of invertebrates and vertebrates. They also form an integral part of the nutrient and energy-processing ability of the soil and demonstrate rapid responses to ecosystem change (Coleman and Crossley, 1996).

Morris 2000 cited in 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, arthropods on vegetation responded to ecosystem changes by decreases in species richness in the roadsides (8) cultivated agricultural (6), built-up (4) and uncultivated agricultural (10) sites when compared to the forest site (14). The decrease in species richness was likely due to destruction of the habitat on which the fauna lived during the course of urbanisation (Adebayo, 1995; Pielou, 1996; Kozlov and Zvereva, 1997 and Watt *et al*, 2002). The greatest reduction in species richness was recorded in the built-up sites and Blair and Launer (1997) had observed that the greater the degree of urbanisation, the greater the decline in species richness of vegetation-dwelling arthropods. The number of species recorded in the uncultivated agricultural sites (10) appeared to indicate that long fallow periods could restore species richness in agriculturally disturbed lands. Eggleton *et al* (1996) cited in Watts *et* al, (2002), reported that complete forest clearance reduced the number of termite species in the Mblamayo Forest Reserve, Cameroon, but partial manual forest clearance and establishment of a forest plantation was not detrimental to termite species richness.

For the air-borne insects at Agu-Awka, there was an increase in species richness in the other study sites compared to the forest site which recorded no air-borne species. Hetrick *et al* (1998) remarked that there was increase in species composition of aerial insects as the ecosystem changed from close forest to open environment. This could be the case in the primary succession sub-unit sites with open environment where an average of 7 species was recorded. The low species richness recorded on the roadsides (3) and built-up sites (3) could be due to severe habitat destruction and fragmentation during urbanisation (Ofomata, 1981 and Hannay, 2001).

Faunal abundance of vegetation-dwelling arthropods showed a significant decrease from 42 in the forest site to 13 in the built-up sites. This could be attributed to the devastating impact of road construction, urbanisation and agricultural practices on biodiversity (Ofomata, 1981; Coyle 1981 and Wells *et al,* 1983). Blair and Launer (1997) also remarked that there was a decrease in population of arthropods on vegetation from natural to urban areas due to a shift in habitat structure. The fairly high average abundance in the cultivated agricultural (28) and roadsides (26) sites may be due to the spread of exotic and invasive species as was reported by Hannay (2001) in his study on the impact of roads on arthropods. In the industrial sub-unit of the built-up sites, no spider was recorded. Rypstra *et al.*(1999) reported that structural complexity of the environment enhanced spider abundance. The industrial infrastructure in Agu-Awka had limited areas for spiders to attach their webs. The tarred road sub-unit recorded 8 spiders as opposed to 3 in the forest site. This situation may be due to fact that open environments with vegetation, as seen on roadsides, cultivated and uncultivated agricultural sites, with their abundant insects, fauna, provided much food and cover to the spiders that preyed on insects. Faunal abundance for air-borne or free-flying insects increased in the other sites compared to the forest. The increase could be due to a shift from close forest to open environment during urbanization which attracted invasive pioneer species (Haskell, 2000 and Hannay, 2001).

Species diversity of fauna on vegetation decreased from 0.856 in the forest site to 0.384 in the built-up sites. This decline in species diversity was probably caused by habitat destruction during urbanization and subsequent migration to new habitats. This resulted in great faunal concentration in a few habitats and reduced evenness in distribution (Pielou, 1996; Kozlov and Zvereva, 1997 and Ofomata, 1981). The high faunal diversity in the uncultivated agricultural sites could be attributed to the fallow length and apparent recovery of the site (0.863) from the initial impact of agricultural practice and invasion by fauna from adjacent sites to occupy vacant ecological niches (Mader, 1984 and Hannay, 2001). The fairly low faunal diversity of the built up sites (0.384) may be attributed to these areas experiencing greatest loss of vegetation and faunal species through destruction and construction activities (Ofomata, 1981; Kozlov, 1997 and Hannay, 2001). Faunal diversity of the air-borne or free-flying insects increased in other study sites compared to the forest (0.000 to 0.611). The increase could be due to change from close forest to open environment (Hetrick *et al,* 1998). The differences in the faunal diversity were significant showing that faunal diversity increased unevenly in the different sites. The uncultivated agricultural sites had the highest diversity of 0.611 due to these areas having relatively low vegetation and open environment from where the air-borne insects could fly freely. The low diversity of the roadsides (0.209) was probably due to high wind movement from passing vehicles that does not permit easy insect flights despite the low vegetation and open environment (Hannay, 2001).

In the forest, site with close vegetation and no ecosystem change, only one insect species (*Camponotus acvapimensis*) and three (3) spider species were dominant while in the other sites which had open environment and experienced varying ecosystem changes, five other insect species apart from *Camponotus acvapimensis* and six (6) spider species were dominant. For the air-borne insects, the forest close environment did not favour the flying insects which accounted for their absence. In the other sites which had open environment due to ecosystem changes, 7 dominant insects were encountered. Whitney and Forster (1988) and Motzkin *et al*; (1996) had observed that land use strongly influenced the upsurge of more arthropod species at the local as well as landscape scale during their study in New England and through competition, those favoured by the disturbed environments become dominant. For vegetation-dwelling species, *Camponotus acvapimensis* was dominant both in the forest and disturbed environments, showing that the species could be endowed with broad tolerances or adaptations to close forest and open environments. *Drosophila melano gaster* was more abundant than every other air-borne insect species in all the disturbed sites indicating that it might have a wider ecological tolerance range and adaptability to the disturbed habitats than other aerial species.

In conclusion, urbanization should be drastically scaled down in the Agu-Awka area of Awka because of its negative impact on plant and animal biodiversity. Certain areas should be designated as forest reserves where stable natural ecosystems can be maintained in the interest of promoting biodiversity. Finally, crop lands should be subjected to long fallows of 4 – 5 years in order to restore lost species richness and diversity.

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