VOL. 8, NO. 2, FEBRUARY 2013 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

INSECT SPECIES DIVERSITY IN FRAGMENTED HABITATS OF THE UNIVERSITY OF PORT HARCOURT, NIGERIA

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ABSTRACT

The beneficial roles of insects in facilitating pollination of many cultivated and uncultivated plants, and as natural enemies of pest species cannot be overemphasized. This study was carried out to ascertain the impact of habitat fragmentation and loss on the composition and diversity of the insect populations within the premises of the University of Port Harcourt, Nigeria. Four fragmented sites - the Biodiversity Conservation Area (BCA), Monoculture Plantation of *Hevea brasilensis* (MP), Gambiama Residential Area (GRA), and Arable Farmland (AF) - reflecting different land uses/covers and varying degrees of disturbance, were purposively chosen for the study. Pan-trap and pit-fall methods were used to trap insects at the above-ground and ground levels, respectively. Alpha diversity was measured in each site using Simpson, Shannon, Menhinick and Margalef indices, while insect species compositional similarity between each pair of the sites was assessed using Sorensen's similarity index. Insect species richness was highest in BCA followed by AF and GRA respectively, while it was lowest in MP. *Dorylus Sp.* was the most abundant insect species in all the fragments with the highest number of individuals occurring in AF. AF also had the highest total number of individuals for all the species, followed by MP and GRA respectively, while the BCA had the lowest total number of individuals. Alpha diversity was highest in BCA followed by GRA and AF respectively, while MP had the lowest diversity. The level of similarity between each pair of the fragments in terms of their insect species composition was generally low (below 23%). The highest variation (91.67%) was observed between BCA and MP, followed by MP and AF (90.91%); while the least variation (77.27) was observed between BCA and GRA. The highest species richness and diversity observed in the BCA underscores the importance of the site for insect species conservation and calls for better protection and management.

Keywords: Insect populations, habitat fragmentation, university of Port Harcourt, land use change

INTRODUCTION

Insects have long provided man with valued products - silk and honey in particular, and supplemented protein, in more recent years. The beneficial roles of insects in facilitating pollination of many cultivated/uncultivated plants and as natural enemies of pest species have been recognized. The visitation of flowers by pollinating insects is crucial for the reproduction and maintenance for almost 70% of angiosperm plant species (Kearn and Inouye, 1997). However, changes in land use like intensification of agriculture, habitat fragmentation and invasion of alien species have led to the decline of species such as butterflies (Dover *et al.*, 1990; Thomson, 2001), bees (Calabuig, 2000; Cane and Tepedino, 2001), and bumblebees (Kwak and Bergman, 1996). Several authors (Cox and Elmqvist, 2000; Kremen and Ricketts, 2000; Paton, 2000; Roubik, 2000) have expressed great concern for the consequence of pollinator fauna decline for wild plant and insect-pollinated crops.

Habitat loss poses the greatest threat to the long-term survival of species on earth. Habitat fragmentation (the reduction of continuous habitat into several smaller spatially isolated remnants), decreases area, increases edge effects, alters ecological processes and decreases connectivity (Debinski and Holt, 2000). Smaller, more isolated fragments are expected to retain fewer species than larger, less isolated patches. Decreases in species richness, in density and in species abundance, and alteration of interspecific interactions are some possible biotic effect of habitat loss and fragmentation recognized as the major causes of the current biodiversity crisis (Saunders *et al*., 1991; Baguette, 2001).

Work on the effect of habitat fragmentation on insects has several implications for landscape management aimed at population survival. First, increasing similarity of habitat patches (i.e., homogenization of landscape) homogenizes species assemblages among habitat patches. In order to maintain diverse species assemblages in a landscape, it is important to maintain heterogeneity of habitat. Given the importance of movement to the spatial ecology of insects, it should be no surprise that the size and physical arrangement of habitat patches on landscape plays a fundamental role in determining the abundance and diversity of insects.

The vegetation of the University of Port Harcourt has been seriously fragmented and modified through the construction of building and road networks. Even some of the fragmented areas are being further modified through the introduction of different land use and land cover types. However, no study had been carried out to ascertain the impact of habitat fragmentation, modification, and loss, on the composition and diversity of the insect populations. This study was a step in that direction. It was conducted with a view to providing a comprehensive understanding on the effect of habitat fragmentation and land use/land cover changes on insect populations in the university environs, and to establish a baseline upon which further monitoring and studies could be based. The specific objectives of the study were to: (i) identify the insect

VOL. 8, NO. 2, FEBRUARY 2013 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

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species in each fragment; (ii) determine and compare the diversity of insect species among the different fragments and land use/land cover types; and (iii) ascertain the level of similarity or otherwise of insect species assemblages between each pair of the fragmented land use/ land cover types.

MATERIALS AND METHODS

Description of the study area and the study sites

The study was conducted within the University of Port Harcourt environs. University of Port Harcourt Choba is located in Obio Akpor Local Government Area of Rivers State.

The University of Port Harcourt is located at 4^o 54'14"N and 6 ^{o}55'7" E. It lies in the humid tropical zone with annual rainfall that ranges from 2000-2470 mm, with an annual temperature ranging from 23^{0}C minimum to 32^{0}C maximum and a high relative humidity amounting to 70-90% (NDES, 2001).

Four sites separated by building and/or road networks were purposively chosen for the study. The fragmented sites were also chosen to reflect varying land use/land cover types and degrees of disturbance. The sites were chosen from: (i) The Biodiversity Conservation Area; (ii) Monoculture Plantation of *Hevea brasilensis;* (iii) An Arable Farmland; and (iv) Gambiama Residential Area. These four sites are located in the University Park (Abuja Campus) of the University of Port Harcourt. Figure-1 is the Map of Nigeria showing Rivers State while Figure-2 is the Map of University of Port Harcourt showing the study sites.

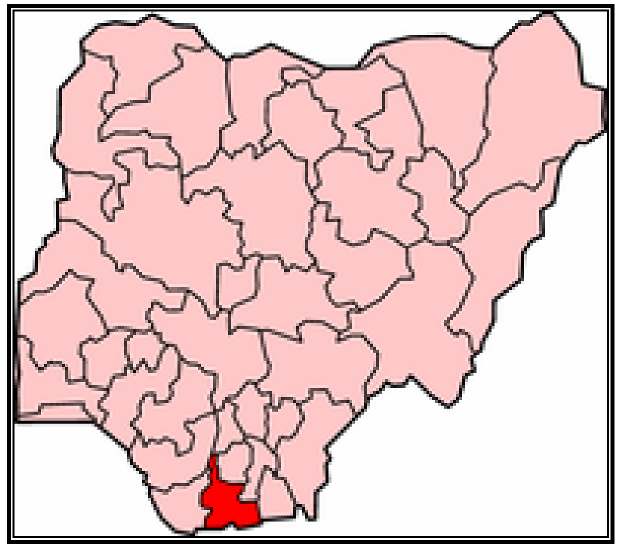

Figure-1. Nigeria showing the location of Rivers State.

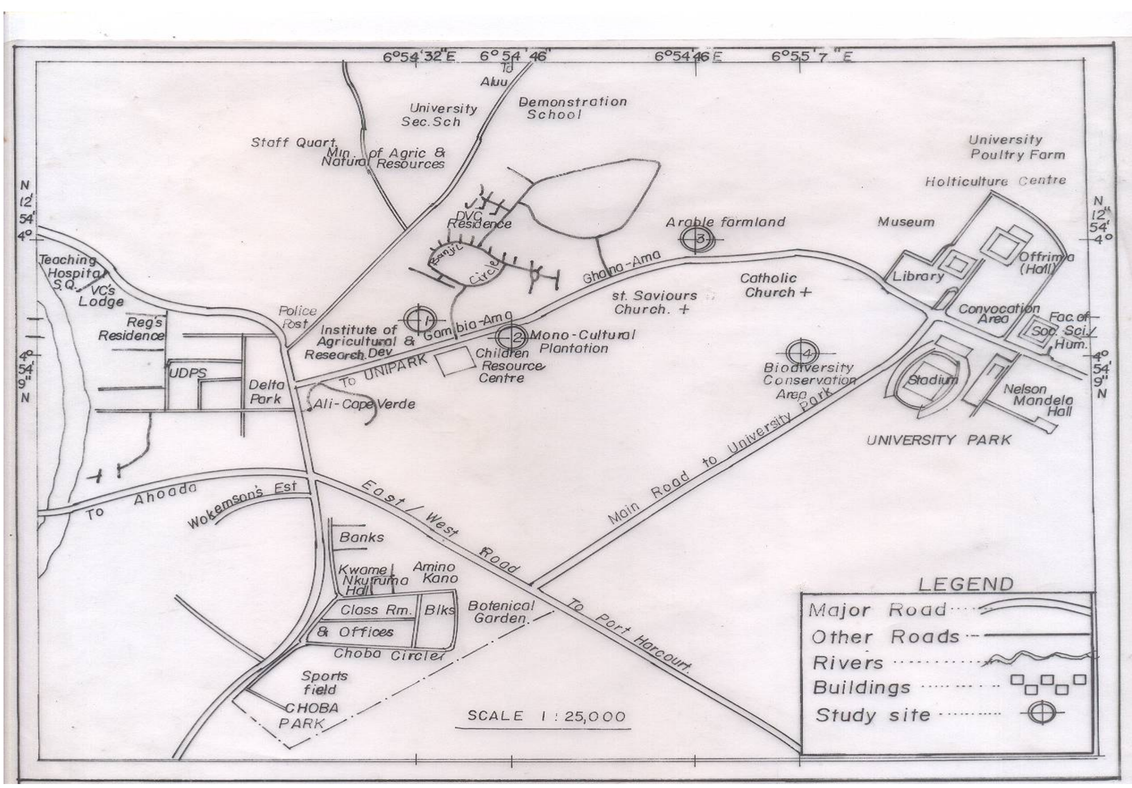

Figure-2. University of Port Harcourt showing the study sites

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Method of data collection

The pan-trap and pit-fall methods of trapping insects were used in this study. Six (6) pan-traps of 15cm diameter and 20cm depth were randomly distributed on trees/shrubs' canopies in each of the sites. The 6 pans were divided into 3 sets of 2 pans each. The 3 sets of the pan traps were painted with different colours namely: blue, yellow and white; and half-filled with a mixture of water, formalin (10%), insecticide and detergent, before hanging on trees/shrubs. Previous studies indicate that insect taxa are differently attracted to various colours and that blue, white and yellow colours have been shown to be effective (Westphal, *et al*., 2008). In addition, six (6) pit-falls were dug at six randomly selected locations in each of the sites. Also, transparent plastic container of 15cm diameter and 20cm depth, half-filled with water, formalin (10%), insecticide, and detergent were placed in each of the pit-falls.

The sites were visited every other day for a period of two months for insect collection. The insects collected were stored separately for each site in 70% alcohol prior to identification. Insect identification was done at the Insect Reference and Collection Centre, Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. The insects were identified up to species level, and the number of individuals counted and recorded, for each of the fragments. However, seventeen insect species that could not be identified were numbered and presented as Unknown spp. 1-17.

Methods of data analysis

Measurement of alpha diversity

Two common approaches for measuring alpha diversity are species richness and evenness/heterogeneity (Ojo, 1996). Species richness simply refers to the number of species in the community while evenness/heterogeneity refers to the distribution of individuals among the species.
In this study, species richness was computed as the total number of insect species encountered in each site. In addition, both Margalef (Clifford and Stephenson, 1975) and Mehinick indices were computed for each of the sites.

- Margalef Index (ml) = (S - 1) / lnN

Where

S = number of species

N = total number of individuals encountered

- Menhinick Index (Mh) = S/√N

Where

S = number of species

N = total number of individuals encountered

For the measurement of evenness/heterogeneity, Simpson Index (Simpson, 1949), and Shannon Index were computed for each of the sites.

- Simpson's Index is expressed as:

$$D = \frac{\sum_{i=1}^{q} ni(ni-1)}{N(N-1)}$$

Where

N = total number of individuals encountered
ni = number of individuals of i^{th} species enumerated for i=1……q
q = number of different species enumerated.

- Shannon Index is expressed as:

$$H = -\sum_{i=1}^{s} \text{pi} \log \text{pi}$$

Where

pi = the proportion of individuals in the ith species

s = the total number of species

Evaluation of insect species compositional similarity and/or variation between fragments

Sorensen's similarity index was used to measure insect species compositional similarity and/or variation between fragments.

- Sorensen's index (Pielou, 1969) is expressed as:

SI = [a / a + b + c] * 100

Where

a = number of species present in both Sites under consideration
b = number of species present in Site 1 but absent in Site 2
c = number of species present in Site 2 but absent in Site 1

RESULTS

Insect species composition of the various fragments and land use types

The insect species encountered in the various fragments are shown in Tables 1, 2, 3 and 4, for BCA, MP, GRA, and AF, respectively. The highest number of species was found in the BCA followed by AF and GRA respectively, while the lowest number of species was found in MP (Table-6). The populations of the various species are shown in Table-5 for the different fragments. *Dorylus Sp.* had the largest population in all the fragments with the highest number of individuals occurring in AF. The AF also had the highest total number of individuals for all the species, followed by MP and GRA respectively, while the BCA had the lowest total number of individuals.

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Table-1. Checklist of insect species found in the biodiversity conservation area

Species	Family	Order
Heteroligus appius	Scarabacidae	Coleoptera
Gryllus bimaculata	Gryllidae	Orthoptera
Dorylus Sp.	Formicidae	Hymenoptera
Dorylus nigricans	Formicidae	Hymenoptera
Chlaemius congaonus	Chlaniinae	Coleoptera
Acraea parrhasia	Acracidae	Lepidoptera
Trochalus corrinatus	Scarabaeidae	Coleoptera
Xylocopa niguta	Anthophoridae	Hymenoptera
Blattela loviventus	Blattidae	Dictyoptera
Unknown Sp. 1	Blattidae	Dictyoptera
Unknown Sp. 2	Unknown	Orthopetera
Unknown Sp. 3	Unknown	Unknown
Unknown Sp. 4	Cerambycidae	Coleoptera
Unknown Sp. 5	Unknown	Unknown
Unknown Sp. 6	Cercopidae	Homoptera

Table-2. Checklist of insect species found in the monoculture plantation

Species	Family	Order
Alacus excavalus	Flateridae	Coleoptera
Dorylus nigricans	Formicidae	Hymenoptera
Dioscores esculenta	Tenebrionidae	Coleoptera
Gryllus sp.	Gryllidae	Orthoptera
Ptecticus elongates	Stratiomyidae	Hymenoptera
Pochazia fasciata	Ricaniidae	Homoptera
Unknown Sp. 7	Unknown	Unknown
Unknown Sp. 8	Unknown	Unknown
Unknown Sp. 9	Unknown	Unknown
Unknown Sp. 10	Cerambycidae	Coleoptera
Unknown Sp. 11	Unknown	Unknown

Table-3. Checklist of insect species found in gambiama residential area

Species	Family	Order
Gryllus bimaculatus	Gryllidae	Orthoptera
Periplaneta americana	Blattidae	Dictyoptera
Acraea parrhasia	Acracidae	Lepidoptera
Carcelia coniformis	Techinidae	Diptera
Opatropis Sp.	Cerambycidae	Coleoptera
Dorylus nigricans	Formicidae	Hymenoptera
Dorylus Sp.	Formicidae	Hymenoptera
Unknown Sp. 4	Cerambycidae	Coleoptera
Unknown Sp. 7	Unknown	Unknown
Unknown Sp. 8	Unknown	Unknown
Unknown Sp. 15	Unknown	Unknown
Unknown Sp. 16	Formicidae	Hymenoptera
Unknown Sp. 17	Unknown	Unknown

Table-4. Checklist of insect species found in the arable farmland

Species	Family	Order
Chlaentes columbus	Chlaeniinae	Coleoptera
Acraea parrhasia	Acracidae	Hepidoptera
Opatrius ovalis	Tenebrionidae	Coleopteran
Chlaenius Sp.	Chlaeniinae	Coleopteran
Acanthaspis sulapes	Reduvidae	Heteroptera
Trochalus carrinatus	Scarabacidae	Coleoptera
Sarcophaga Sp.	Sarcophagidae	Diptra
Tonochiilus Sp.	Chlaeniinae	Coleoptera
Dorylus nigricans	Formicidae	Hymenoptera
Dorylus Sp.	Formicidae	Hymenoptera
Unknown Sp. 12	Unknown	Diptera
Unknown Sp. 13	Unknown	Unknown
Unknown Sp. 14	Tenebrionidae	Coleoptera

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ARPN Journal of Agricultural and Biological Science

Table-5. Populations of insect species at the various fragments

Species	No. of individuals			
	BCA	**MP**	**GRA**	**AF**
Heteroligus appius	15	0	0	0
Gryllus bimaculata	85	0	120	0
Dorylus Sp.	145	604	306	802
Dorylus nigricans	77	57	68	21
Chlaemius congoanus	12	0	0	0
Acraea parrhasia	24	0	44	21
Trochalus carinatus	43	0	0	32
Xylocopa niguta	8	0	0	0
Blattela loviventus	32	0	0	0
Alacus excavates	0	22	0	0
Dioscores esculenta	0	16	0	0
Ptecticus elongates	0	40	0	0
Pochazia fasciata	0	13	0	0
Chlaentes columbus	0	0	0	79
Opatrius ovalis	0	0	0	13
Chlaenius Sp	0	0	0	13
Acanthaspis sulapes	0	0	0	9
Sarcophaga Sp	0	0	0	37
Tonochilus Sp	0	0	0	10
Periplaneta americana	0	0	0	0
Carcelia coniformis	0	0	39	0
Opatropis Sp.	0	0	56	0
Unknown Sp. 1	22	0	0	0
Unknown Sp. 2	8	0	0	0
Unknown Sp. 3	37	0	0	0
Unknown Sp. 4	9	0	56	0
Unknown Sp. 5	30	0	0	0
Unknown Sp. 6	15	0	0	0
Unknown Sp. 7	0	19	10	0
Unknown Sp. 8	0	13	17	0
Unknown Sp. 9	0	17	0	0
Unknown Sp. 10	0	8	0	0
Unknown Sp. 11	0	18	0	0
Unknown Sp. 12	0	0	0	53
Unknown Sp. 13	0	0	0	34
Unknown Sp. 14	0	0	0	7
Unknown Sp. 15	0	0	42	0
Unknown Sp. 16	0	0	16	0
Unknown Sp. 17	0	0	24	0
Total	562	827	798	1131

VOL. 8, NO. 2, FEBRUARY 2013 ISSN 1990-6145
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Distribution of insect species among insect families and orders in the different fragments

The distribution of insect species among insect families in the various fragments is shown in (Figure-3). Unknown insect families were highest in the MP and GRA and lowest in AF. Insect families - Formicidae and Ricaniidae had the highest number of the identified species in GRA and AF, respectively. The family - Cerambycidae, had the highest number of identified species in MP, while the families - Scarabacidae, Blattidae and Formicidae, had the highest number of identified species in BCA. The distribution of insect species among insect orders in the various fragments is shown in (Figure-4). The insect order - Coleoptera had the highest number of species in both BCA and MP, while the insect order - Hymenoptera, had the highest number of species in both GRA and AF.

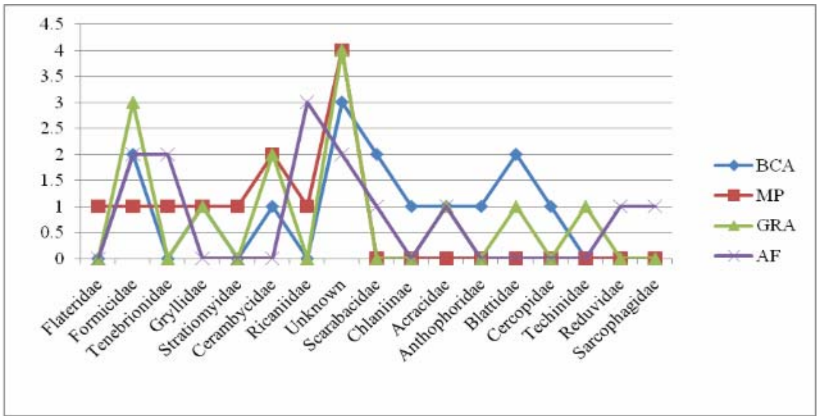

Figure-1. Distribution of insect species among insect families in the various fragments

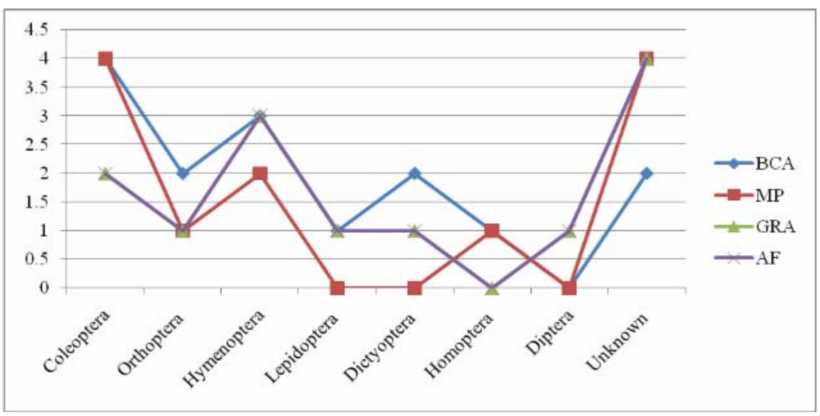

Figure-2. Distribution of insect species among insect orders in the various fragments

Insect species diversity at the various fragments

Alpha diversity indices for the various fragments are shown in Table-6. The number insect species was highest in BCA, followed by AF and GRA respectively, while MP had the lowest number of species. Alpha diversity was highest in BCA followed by GRA and AF respectively, while MP had the lowest diversity.

Table-6. Alpha diversity indices for the various fragments

	BCA	MP	GRA	AF
No. of species	15	11	12	13
Shannon H	2.327	1.158	2.018	1.254
Simpson 1-D	0.8696	0.4564	0.8031	0.4862
Menhinick	0.6327	0.3825	0.4248	0.3866
Margalef	2.211	1.489	1.646	1.707

Insect species compositional variation/similarity between fragments

The similarity indices for the different fragments are shown in Table-7. The level of similarity between each pair in terms of their insect species composition was generally low (below 23%). The highest variation (91.67%) was observed between BCA and MP, followed by MP and AF (90.91%); while the least variation (77.27) was observed between BCA and GRA.

Table-7. Sorensen's similarity indices for the different sites

	BCA	MP	GRA	AF
BCA	*	8.33	22.73	16.67
MP		*	21.05	9.09
GRA			*	13.64
AF				*

DISCUSSION

The highest insect species richness and diversity in the Biodiversity Conservation Area could be as a result of higher diversity of plant species, restriction of human-induced activities, and fragment area. Insect species in protected forests are found abundant because of their protection from human induced activities. Because of the diverse nature of plant species in protected forests, insects are more attracted to plant species for the forging purpose which could result in richness and abundance (FAO, 2001). In addition, large patches provide usually higher heterogeneity and thereby support different communities (Ricklefs and Lovette, 1999). The Arable Farmland was the second highest in terms of insect species richness and also had the highest number of individuals. This could be as a result of diverse food sources provided by different crops (some of which were flowering) in the mixed cropping system. However, the lower alpha diversity in the Arable Farmland than in Gambiama Residential Area which recorded lower number of species and individuals is as a result of more evenly distribution of the individuals among species in the latter than in the former. It was observed that *Dorylus sp.* dominated the insect populations in the arable farmland, accounting for about 70% of the total individuals found in it.

Higher insect diversity in Gambiama Residential Area than in the Monoculture Plantation could be as a result of habitat heterogeneity, and presence of ornamental plants within the former. The higher the trophic level, the larger the spatial domain, for example, in plant-insect-bird chains (Thies *et al.,* 2003). One possible explanation for a positive relationship between food plant and animal species richness is that a greater number of plant species could potentially provide more niches for the coexistence of animal species (Hutchinson, 1959). Perrins *et al.* (1991) equally asserted that the distribution of any species is restricted by the distribution of its habitat and within that habitat the availability of food and other resources. However, the lowest diversity observed in MP may be attributed to lack of diversity of habitats and food sources in the site since it is a monoculture plantation. Despite the fact that forest plantations are being established at an increasing rate throughout much of the world, and now account for 5% of global forest cover (FA0, 2001), their status with regard to insect species conservation has been less positive, particularly where natural forest has been cleared for plantation establishment.

Dorylus sp. was the most abundant of all the insect species in all the fragments. Insect families - Formicidae and Ricaniidae had the highest number of the identified species in GRA and AF, respectively. The family - Cerambycidae, had the highest number of identified species in MP, while the families - Scarabacidae, Blattidae and Formicidae, had the highest number of identified species in BCA. The insect order - Coleoptera had the highest number of species in both BCA and MP, while the insect order - Hymenoptera, had the highest number of species in both GRA and AF.

The very low species compositional similarity (high beta diversity) recorded between fragments is probably due to habitat fragmentation which blocks the ecosystem corridors needed for insect forging. Ecosystem loss and separation are noticed as the main causes of the current biodiversity problems (Sih *et al*., 2000; Baguette, 2001). Debinski and Holt (2000) equally observed that habitat fragmentation reduces area, increases edge effect, changes ecological processes and reduces connectivity.

CONCLUSION

Insect species diversity in the Biodiversity Conservation Area which enjoys some level of protection was higher than in each of the unprotected fragments. This underscores the importance of the site for insect species conservation and calls for better protection and management. However, the very low species compositional similarity (high beta diversity) between each pair of the fragments indicates that habitat fragmentation and land use changes increase beta diversity. The lowest insect diversity observed in the monoculture plantation underscores the need for diverse plant communities if diversity in insect communities must be achieved.

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VOL. 8, NO. 2, FEBRUARY 2013 ISSN 1990-6145
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