Assemblages of avian communities in forest elephant (*Loxodonta cyclotis*) range in Ghana

Edward D. Wiafe[1], Kwaku Brako Dakwa[2], and Samuel Yeboah[2]**

[1]Kakum National Park, P. O. Box 427, Cape Coast, Ghana

[2]Dept. of Entomology and Wildlife, School of Biological Sciences, University of Cape Coast, Cape Coast. Ghana; email: dakb92@yahoo.com and syeboah@yahoo.com

*Corresponding authors

Abstract

The bird assemblages occurring in the habitats altered by the forest elephant (*Loxodonta cyclotis*) in Kakum Conservation Area, Ghana were examined. The conservation area was divided into five blocks and then four circular plots of 30-m-radius were established in each of three identified habitat types: close forest, open forest and swamp forest. Thus each habitat type was represented by 20 plots of 0.30 ha each, and altogether, 60 plots covering 18 ha of the study area were sampled. The degree of elephant use in each plot was recorded, and, all the birds were identified and counted. The elephants were found to alter all the three habitats with the highest intensity recorded in the swamp forest, followed by open forest and close forest with 49, 59 and 57 species of birds respectively. The species similarity found among bird assemblages range between 55 and 59%. The mean abundance of birds per ha in close forest was 30.2 ± 1.9 significantly lower than in open forest with 42.8 ± 3.9 and swamp forest with 39.3 ± 2.5. Diversity indices (Shannon) ranging between 3.63 and 3.86 indicated high diversity of bird assemblages in the three habitat types. The relationships between the intensity of elephant habitat alteration and both abundance and bird species were weak and not significant. Though the forest elephant's habitat alteration may have some influence on bird assemblages, other factors may act in concert to affect the avian communities.

Key words: avian communities, forest elephant (*Loxodonta cyclotis*), habitat types

Résumé

On a examiné les rassemblements d'oiseaux qui se produisent dans les habitats modifiés par les éléphants de forêt (Loxodonta cyclotis) dans l'Aire de Conservation de Kakum au Ghana. L'Aire de Conservation a été divisée en cinq blocs, puis quatre lopins de terre circulaires de 30 m de rayon ont été créés dans chacun des trois types d'habitats identifiés: la forêt fermée, la forêt claire et la forêt marécageuse. Ainsi, chaque type d'habitat était représenté par 20 lopins de terre de 0,30 ha chacun, et au total, 60 lopins de terre couvrant 18 ha de la zone d'étude ont été échantillonnés. On a enregistré le degré d'utilisation des éléphants dans chaque parcelle, et tous les oiseaux ont été identifiés et comptés. On a trouvé que les éléphants modifiaient tous les trois habitats avec l'intensité la plus élevée enregistrée dans la forêt marécageuse, suivie par la forêt claire et la forêt fermée, habitats occupés par 49, 59 et 57 espèces d'oiseaux respectivement. La similitude entre les espèces qui se trouvent dans les rassemblements d'oiseaux varie entre 55 et 59%. L'abondance moyenne des oiseaux par hectare dans la forêt fermée était de 30,2 ± 1,9 significativement moins que dans la forêt claire avec 42,8 ± 3,9 et la forêt marécageuse avec 39,3 ± 2,5. Les indices de diversité (Shannon) compris entre 3,63 et 3,86 ont révélé une grande diversité de rassemblements d'oiseaux dans les trois types d'habitats. Les rapports entre l'intensité d'altération des habitats par les éléphants et l'abondance et les espèces d'oiseaux étaient faibles et non significatifs. Bien que l'altération des habitats par l'éléphant de forêt puisse avoir une certaine influence sur les rassemblements d'oiseaux, d'autres facteurs peuvent agir de concert pour affecter les communautés aviaires.

Introduction

The forest elephant (*Loxodonta cyclotis*) is the largest rainforest mammal remaining on earth and remains an important component of the forest ecosystem. They once roamed throughout the moist forests of Ghana, however, hunting and deforestation have drastically reduced the number to a mere handful and their occurrence has been limited to a few protected areas (Pareen and De Graff 1995). The ecological importance of this species cannot be overemphasized. Forest elephants play a major role in maintaining the linkages in the rainforest food web. They have a dominant position within ecosystems due to their enormous size, large food requirements, effects on plant species composition, dispersal of seeds and fruits and their role in nutrient recycling, which makes nutrients found in woody plants available to other species (Kortland 1984). They also have enormous influence on forest structure. For instance, in certain parts of Krahn-Bassa National Forest, Liberia, between 10 and 60% of the area was altered by elephant activity and in Grebo National Forest, Liberia, at least two-thirds of the close forest was found to have a structure clearly altered by forest elephants (Sachter and Hamer 1967). Campbell (1991) also concluded that forest elephants maintain and modify the forest canopy by trampling and debarking. The feeding and other habitat interactions create clearings, which serve as niches for certain specialized species. The IUCN/AESG (1999) have expressed concern that the extermination of the species would cause dramatic changes or extinctions in ecosystems.

Birds, in the same vein, are the best known group of vertebrates. They play an important role in the rainforest as pollinators and dispersers of seeds. Many eat large numbers of insects, other arthropods and

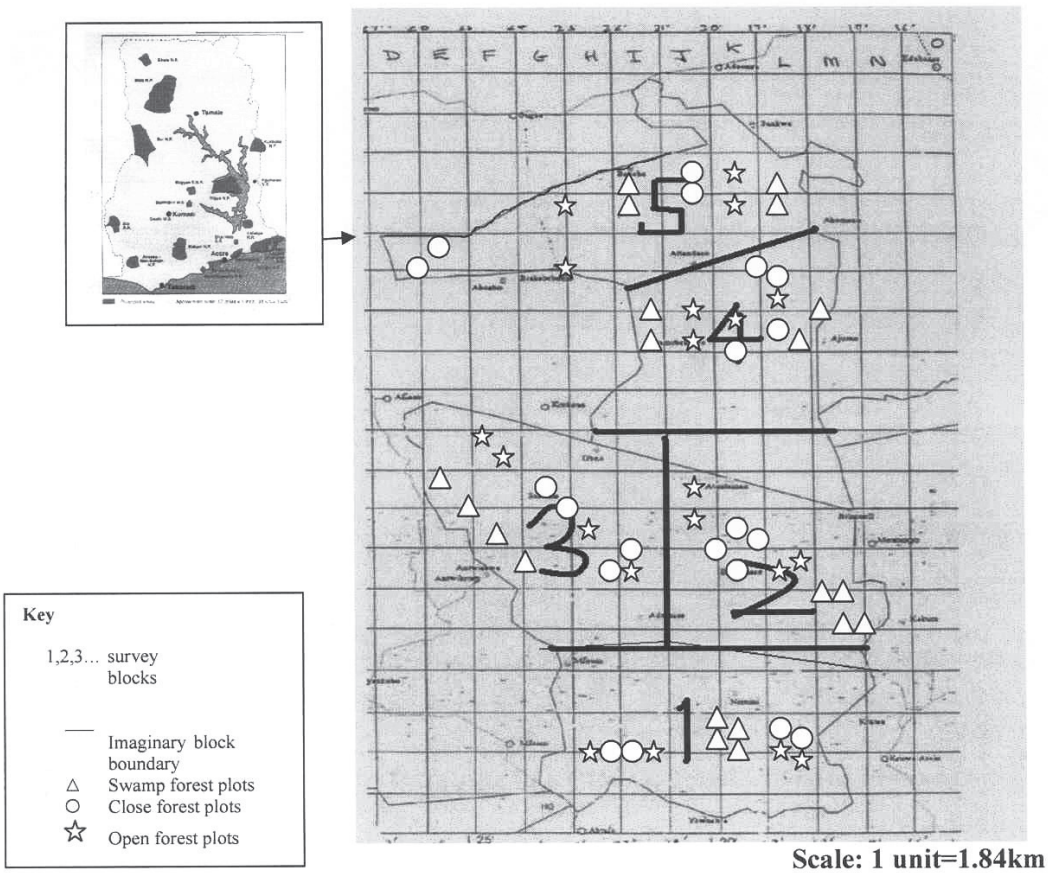

Figure1. Map of Kakum Conservation Area showing the division into blocks.

small mammals. African crown eagles (*Stephanoaetus coronatus*), for example, are top predators in some forests, and may even prey upon mammals as large as a colobus monkey (*Colobus polykomos*) (Bennun and Howell 2002) and may in turn, be preyed upon by reptiles, mammals and other birds. Birds are often considered as a useful indicator group, either for monitoring environmental change (Furness and Greenwood 1993) or for assessing biodiversity importance (Stattersfield et al. 1998). Many forest birds form 'guilds', that is, birds not necessarily taxonomically related feed or behave in a similar way. Bennun and Fanshawe (1998) showed that classification according to guilds could be useful for understanding the effects of forest management, since various guilds respond differently to particular structural changes. Knowledge about the effects of forest elephants' activities on other taxa is scant compared to that of the savannah counterpart (Hawthorne and Parren 2000). The hypothesis is that forest elephants' activities have influenced their environments, which in turn influence the bird communities. For example, the forest elephant browses on many tree species that numerous birds depend on for habitation and feeding sources (Sachter and Hamer 1967). The main goal of the study therefore, is to determine bird communities that occur within the different stages of habitat use by elephants and to evaluate the species interaction network in the tropical forest ecosystem

The study area

Kakum Conservation Area is made up of Kakum National Park and Assin Attandansu Resource Reserve, located in the Twifu Hemang Lower Denkyira and Assin Districts of the Central Region of Ghana (Fig. 1). This conservation area forms about 360 km^2 of contiguous forest. The area lies between longitudes 1°51' W and 1°30" W and latitude 5°40' N and 5°20" N. It has been identified that 105 species of vascular plants and about 266 bird species occur in the Reserve (Wildlife Department 1996).

Materials and methods

The study relied on a field study of sampled plots that were representative of three habitat types—namely close forest, open forest and swampy forest—according to the canopy coverage.

To equalize sampling effort, the study area was outlined into five blocks of approximately 72 km^2 each. The blocks were labeled 1, 2, 3, 4 and 5 (Fig. 1). In each block, four circular plots of a 30-m-radius each were established in each habitat type, thus 12 plots covering 6 ha per block, and in all 60 plots summing up to18 ha were covered by this study. Even though the plots did not necessarily follow a straight line, the interval between two plots was not less than 200 m as per Herreman (1995).

The fieldwork was conducted in April/May 2007 between 0530 h and 1100 h when the temperature ranged from 35º to 40º C. Winds were low and there was no precipitation. Four experts participated in the survey: one person identified and counted birds, another recorded the vocalized species. The third person collected data on elephant habitat use while the fourth was armed to provide protection against wild animals.

Habitat classification

For the purpose of this study the habitat type in each plot was classified according to light penetration and swamp forest was classified based on edaphic forest formations (Table 1).

Measurement of habitat use by elephants

The degree of habitat use by elephants was measured by signs of elephant's presence or absence. The observer conducted a search through the plot and looked for signs left behind as a result of habitat utilization by the elephants. The degree of use was coded: 0 for no sign of elephant presence; 1 for signs of elephant presence (trail, footprints, dung piles), but no identified utilization; 2 for signs of elephant presence and ≤ 50% browsing; and 3 for signs of elephant presence (debarking, bulldozing, wallowing, trampling) and > 50% browsing of the area. The codes scored in each plot in the respective habitat types were ranked according to the magnitude (1st for habitat that had high average recorded code, 2nd for the next and 3rd for habitat that recorded the least number).

Bird census

In the bird census the observer stood at the centre of a plot and after a 10–minute settling-in period, the next 10 minutes were spent recording all birds detected in all directions by visual observation, song or call note. Ten minute increments were enough to record all the birds in a plot and brief enough to avoid or reduce

Table 1. Habitat classification according to canopy coverage for open forest (<75%) and close forests (>75%) and edaphic factors for swamp forest

Forest type	Characteristics
Close forest	light penetration to forest floor <25% (>75% canopy coverage)
Open forest	light penetration to forest floor > 25% (<75% canopy coverage)
Swamp forest	edaphic forest formations on poorly drained soil (with characteristic vegetation e.g. dominated by Raphia spp.)

double counting. Sounds of all vocalized birds in all directions were recorded using a Marantz digital recorder, for confirmation of species identification and documenting purposes. Additional notes were taken on different species observed to have been feeding together and classified them as guilds. Over-flying species were excluded from the recordings because their particular location would be difficult to determine. Only species encountered during the survey period were considered.

Calculation of community parameters

Diversity (Hs) of the study area was calculated for each of the three habitat types using various diversity indices after Magurran (1988). Thus, Shannon index (Hs) was calculated using the following formula:

$$Hs = -\sum_{I=1}^{s} Pi \ln Pi$$

Pi =n*i*/N, where P*i* is proportion of individuals found in the *i*th species, n*i* is the number of individual of species and N is the total number of individuals.

Evenness (E), the ratio of the observed to maximum diversity was calculated as:

E = Hs/lnS. S is the number of species in each community

Dominance (d): expresses the proportional importance of the most abundant species and was calculated as d= n*i*/N*100

Söerenson index (Cs) was also calculated as:

Cs =2S1.2/(S1+S2)

Where S1 or S2 is the number of species in each community and S1.2 the number of species shared between them. Cs is constrained between 0(no species in common) and 1.0 (all species in common).

Frequency of occurrence (%) was determined from the raw data by dividing the number of plots where a particular species was present by the total number of plots and multiplying by 100. For the purpose of this study the relative status of each species based on the frequency of occurrence was defined as follows:

- Super-common: species occurring within more than 50% of the census plots
- Common: species found in between 20–49% of the census plots
- Uncommon: species occurring within between 11–19% of the census plots
- Rare: species found in between 1–10% of the census plots.

All the computations and statistical analyses were done using JMP5.0 (2002) statistical software.

Results

Distribution of birds in different habitat types

In the close forest, the mean number of individual birds (abundance) was 30.2 ± 1.9, N=20 per ha; the open forest recorded 42.8 ± 3.9, N=20 whilst the swamp forest recorded 39.3 ± 2.5, N=20.

Analyses of variance (ANOVA) indicated a significant difference of bird numbers between the three habitat types (p=0.00038). The student t-test indicated no significant difference between open and swamp forest (p>0.05), but the differences in bird numbers between close and open forest (p=0.00033) and close and swamp forest (p=0.00023) were significant. Also 59, 49 and 57 different species were recorded in the close, open and swamp forests respectively.

Species diversity, evenness and dominance

The Shannon diversity index of bird species surveyed in close forest was 3.86 (3.57, 3.79 at 95% confidence limit (C.L.)); open forest was 3.63 (3.43, 3.61 at 95% C.L); and swamp forest was 3.77 (3.54, 3.74 at 95%C.L.). The diversity t-test indicated a significant difference between diversity of birds in close and open

Table 2. Frequency of occurrence of bird species in the study area

Habitat type	Status of occurrence (%)			
	Super-common	Common	Uncommon	Rare
Close forest	2	25	10	63
Open forest	0	30	13	57
Swamp forest	4	16	23	57

forest ($p<0.05$) but the differences between close and swamp forest, and open and swamp forests were not significant ($p>0.05$).

The Söerenson index of species similarity indicated that 59% of bird species were found between close and open forest, 57% were found in both open and swamp forests and 55% found between close and swamp forests.

Different species dominated at different habitat types. The community in the close forest was dominated by green hylia (*Hylia prasina*) and tambourine dove (*Turtur tympanistria*); the open forest was dominated by velvet-mantled drongo (*Dicrurus modestus*), naked-faced barbet (*Gymnobucco calvus*), western black-headed oriole (*Oriolus brachyrhynchus*) and blue-headed wood dove (Turtur brehmeri); and, the swamp forest was dominated by black-cap illadopsis (*Illadopsis cleaveri*), swamp-palm bulbul (*Thescelocichia leucopleura*) and white-spotted flufftail (*Sarothrura pulchra*).

Most of the bird species (57-63%) were classified as rare in the study area, few as uncommon (10-23%) and common (16-30%), and very few (0-4%) as super common (Table 2). No bird species was found to be super-common in the open forest (Table 2).

Three species of special conservation concern were encountered: the near threatened yellow-casqued hornbill (*Ceratogymna elata*) occurred in the swamp forest, and crested guinea-fowl (*Guttera pucherani*) and Sharpe's apalis (*Apalis sharpii*), a restricted-range species, occurred in the close forest.

Levels of elephant habitat use and relationship between bird assemblages

The elephant habitat encounter was the highest in the swampy area (53.0), followed by the open forest (45.0) and close forest (23.0). The differences among these levels of habitat use were found to be significant ($p<0.05$) (ANOVA). In the close and open forests the correlation between the bird assemblages and elephant habitat use were negative; that is, the more elephants use the habitat the fewer birds were found, but the coefficients of determinations were very weak ($r=-0.3555$ and $r=-0.2270$ respectively for close and open forests). The model explained only 22% and 12% ($p>0.05$) of the relationship respectively. However, in the swamp forest, there was positive correlation ($r=0.3482$), that is the more the elephants use the habitat types the more the birds assembled, and the model explained only 12% of the relationship ($p>0.05$) thus the relationships were not significant enough to any conclusions.

Discussion and conclusion

Distribution and abundance of bird species in the different habitat types

Though the study was not extensive enough, lacking seasonal satisfaction and without replication due to logistic concerns, the nature of the animals studied and the moderately effective law enforcement in the Park suggest a stable situation that makes year effects of recorded data minimum in addition to the intensive nature of the study that gave respectable results over the brief period. The number of species recorded, however, lies well below expectation for such an area, which is the only intact forest considered as refuge for species from the surrounding degraded forest. But this could be better explained by under recording and exclusion of overflying, hypothetical and nocturnal species than environmental effects. Though the under recording appeared reasonable at first sight, vocalizations played major role in detection, therefore detection could not be considered a major bias. However, the behaviour of the close forest species might contribute to this low density. Close forest species tend to be habitat specialists and are normally confined to a specific area. This is supported by Bennun and Howell (2002) who stated that forest-specialist birds tend to have a smaller distribution range than that of other categories of birds. Newmark (1991) also noted that close forest species spend their whole lives within a small area of forest and may be reluctant to cross even small gaps between forest patches. Diet may be a major determinant factor of the relatively high density in the open and swamp forest habitats. In

these habitat types the vegetation pattern is not static, but rather in the process of development. Therefore they offer the best opportunities for numerous categories of feeders—both specialized and non-specialized feeders. Similarly, Waltert (2000) found more opportunistic behaviour in species at the heavily logged areas (equal to open canopy forest) in the Bossematie Forest in Cote d'Ivoire.

Avifaunal composition in communities

The abundance structure among bird communities in the close, open and swamp forests habitat types in the Kakum Conservation Area indicates some similarities and differences in species composition. The evenness in distribution did not differ strongly among all the habitat types, which might suggest that various levels of elephants' habitat interactions are not considered as disturbances to the birds' communities, sufficient to have much influence on their assemblages. This is opposite to other anthropogenic-based disturbances like logging, which tends to influence bird communities in forests (Waltert 2000; Fanshawe 1995). The differences among the avifauna of the three habitat types might be due to other factors such as the specific relationship of particular birds to certain conditions that are specific to a particular habitat type. This phenomenon, where a higher number (i.e. greater abundance) of birds in the open and swamp forests where more elephants activities were recorded than the close forest with low recorded number of birds, conforms to Herremans (1995), who recorded higher number of birds in heavily impacted vegetation than the more intact woodland in northern Botswana. However, some birds occur only in one habitat type, which suggests that such species only exist where their ecological requirements are met. For example, white-spotted flufftail and African jacana (*Actophilornis africanus*) occur only in swamp forests because of their water requirements.

As far as global preservation of genetic diversity is concerned, the heterogeneous pattern of the forest appears to favor the existence of certain endemic bird species. For example shape's apalis occurred in both close and swamp forest whilst yellow–casqued hornbill and crested guineafowl, both near-threatened species were recorded in the open and close forest respectively. This suggests that the various levels of elephant's impacts have no detrimental effects on the general avian community. With the inter-specific relationships that occur in the rainforest ecosystem, a careful conclusion could be that, with only some exceptions, almost all the forest birds could be recorded in all the three habitat types considered with variation in abundance.

Elephant habitat interaction and bird assemblages Although there is much speculation about the influence of elephants' habitat use on other taxa (Cumming et al. 1997; Kortland 1984) bird community assemblages and elephants' habitat use have been found to be poorly correlated in different habitat types in the same conservation area. This could imply that different species that have lived together in the same place for a long period have evolved mechanisms to coexist harmoniously. This may appear to be contradictory at first sight to Cumming et al. (1997), who stated that large generalist herbivores can have a devastating effect on biodiversity, but indeed their study was about savannah ecosystems in South Africa, which is different from a rainforest ecosystem of West Africa. The results imply that elephant activities have no effect on bird population, and vice-versa, in this Park; further, it suggest that any special conservation measures for birds or for elephants to promote population growth should be encouraged without fear of impacting negatively on the other.

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References

Bennun L, Fanshawe J. 1998. Using forest bird to evaluate forest management: an East African perspective. In: *African Rainforest and Conservation of Biodiversity*, pp. 10–12 (Ed. Doolan S.). Earthwatch Europe, Oxford, UK.

Bennun L, Howell K. 2002. Birds. In: *African forest biodiversity; a field survey manual for vertebrates*, pp. 121-161 (Ed. Davis G.). Earthwatch Europe, Oxford, UK.

Campbell DG. 1991. Gap formation in tropical forest canopy by elephants, Oveng, Gabon, Central Africa. *Biotropica* 23(2):195–196

Cumming DHM, Brock Fenton M, Rautenbach I.L, Taylor RD, Cumming SG, Cumming MS, Dunlop JM, Gavin FA, Hovorka MD, Johnston DS. Kalcounis M, Mahlangu Z, Portfors CVR. 1997. Elephants, Woodlands and Biodiversity in southern Africa, South Africa. *Journal of Science* 93:231–236.

Fanshawe JH. 1995. The effects of selective logging on bird community of Arabuko Sokoke Forest, Kenya. DPhil thesis, University of Oxford, Oxford, U.K.

Furness RW, Greenwood JJD. 1993. *Birds as Monitors of Environmental Change*. Chapman & Hall, London, UK.

Hawthorne WD, Parren MPE. 2000. How important are forest elephants to the survival of woody plant species in upper Guinea forests? *Journal of Tropical Ecology* 16:133–150.

Herremans M. 1995. Effects of woodland modification by African elephant *Loxodonta africana* on bird diversity in northern Botswana. *Ecography* 18:440–454.

IUCN/AESG. 1999. Review of African Elephant Conservation Priorities; A working document of the IUCN/SSC African Elephant Specialist Group. 74pp.

JMP 5.0 software (2002). SAS Institute Inc., Cary, NC. USA.

Kortland, A. 1984. Vegetation research and the 'bulldozer' herbivores of tropic Africa. In: *Tropical rain-forest. The Leeds symposium*. Eds. Chadwick AC, Sutton SL. Leeds Philosophical and Literary Society Ltd., Leeds, UK, pp. 205–226.

Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton University. Press, Princeton, New Jersey, USA. 179 pp.

Matthias W. 2000. Diversity and structure of bird community in a logged forest in south-east Cote d'Ivoire. PhD thesis. Georg-August-University of Gottingen.

Newmark WD. 1991. Tropical forest fragmentation and the local extinction of understorey birds in the eastern Usambara Mountains, Tanzania. *Conservation Biology* 5:67–78.

Pareen MPE, de Graff NR. 1995. The quest for natural forest management in Ghana, Cote d'Ivoire and Liberia. Tropenbos series 13. 199 pp.

Sachter M, Hamer K. 1967. Inventory of Krahn-Bassa and Sapo national forest. Technical report 7. Monrovia, Liberia, German Forestry mission/ Bureau of Forest and Wildlife Conservation. 148 pp.

Stattersfield AJ, Crosby MJ, Long AJ, Wege DC. 1998. Endemic bird areas of the world: Priorities for Biodiversity conservation. Birdlife Conservation series no. 7. BirdLife International, Cambridge, UK.

Wildlife Department 1996. The Management Plan of Kakum National Park and Assin Attandanso Resource Reserve. Accra. 76 pp.