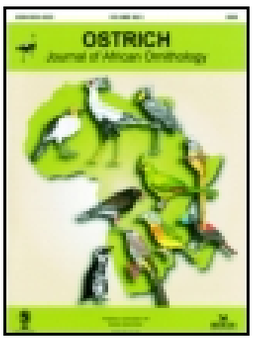

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Distribution and abundance of forest birds in Ghana

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Forest reserves within the Ghanaian rain forest have been classified into categories (Condition I–VI) on the basis of their botanical importance and status of the vegetation. We present data on the distribution and abundance of avifauna of 28 Condition II and III forest reserves in southern Ghana based on line transect counts and mist-net captures. A total of 227 species were recorded for all the sites; species records for individual sites ranged from 78–119. The dominant groups in the overall survey were Muscicapidae (represented by 40 species), Pcynonotidae (21) and Cuculidae (12). The most abundant bird species in the Ghanaian forests were Yellow-whiskered Greenbul, Green Hylia, Green Pigeon and Olive Sunbird. Species encounter rates ranged from 16.7 to 50.7 species per km with individual bird encounter rates of 27.9 to 172.0 birds per km. Capture rates in mist-nets ranged from 1.2 to 3.9 birds per 100 metre net-hr (mnh). A total of 183 species were recorded in Condition II forest as compared with 167 in Condition III forests. The effects of forest condition and vegetation types on the total number of species recorded were, however, not statistically significant. The Similarity Index for bird communities within Condition II and III forests was 0.72. Bird species composition in the two forest types also differed: e.g., seven primary forest species, as well as 40% of the species associated with primary and matured secondary forest which were recorded in Condition II forests, were absent from Condition III forests. Bird communities of Moist Evergreen, Upland Evergreen and Moist semi-Deciduous were more similar than communities in the Wet Evergreen forest type. The implication of the results for conservation of the Ghana's forests is discussed.

INTRODUCTION

The pattern of bird species distribution gradients usually observed in the succession from primary undisturbed forest to various forms of secondary forest is a rapid decrease in species composition and considerable change in population structure. Initially, bird species closely associated with dense forest disappear, then local species increase and finally edge species appear and dominate the avifauna (Thiollay 1986). This would imply that the level of maturity or degradation of a rain forest could be evaluated from the structure and composition of the avifauna. Bird species associated with the Upper Guinea lowland forests, however, are known to generally have widespread ranges within West Africa (Fjeldså 1994) and are remarkably tolerant of habitat disturbance (Thiollay 1985; Holbech 1992). The effects of forest disturbance on the avifauna appear to vary depending on the degree of disturbance (Allport *et al.* 1989; Dutson & Branscombe 1990; Gartshore *et al.* 1995), and whereas disturbance may have little or no effect on species richness and overall diversity, species composition and community structure may be severely affected. In a study of the effects of selective logging on rainforest bird community, Holbech (1992) found that 15% of bird species recorded were affected negatively by logging, 25% positively, while 60% were not affected. Kofron & Chapman (1995) found 70% of rain forest species in Liberia were absent from deforested sites and concluded that the clearest impact of destruction of the Upper Guinea rainforest on its bird communities was a dramatic change in species composition and a decrease in numbers of forest species.

The forest zone in Ghana extends over the south western parts of the country and constitutes the eastern end of the Upper-Guinea forest block, an area considered to be of high conservation priority because of the high species diversity and endemicity (Bibby *et al.* 1992). Seven main forest types have been recognised within the zone (Hall & Swain 1981): the Wet Evergreen, Moist Evergreen, Upland Evergreen, Moist semi-Deciduous, Dry semi-Deciduous, Southern marginal and the South-east Outlier forest. The forest zone in Ghana originally covered 82 200 km^2 and accounted for 34% of the country's total land area. It is estimated, however, that over 70% of the country's original closed forest has been destroyed (IIED 1992), leaving only about 11% as intact forests, the bulk of which is within protected areas. Deforestation is attributed mainly to clearing for agricultural ventures, timber logging and bush fires and is estimated at a rate of 220 km^2 per annum (Hawthorne 1990). The high rate of deforestation has resulted in a patchwork of secondary vegetation types and farmlands outside reserved lands, while the reserved lands have been subjected to various degrees of disturbance with implications for environmental degradation and loss of biological diversity. Hawthorne and Abu-Juam (1995) have classified the Ghanaian forest reserves into categories (Condition I-VI) based on status of the vegetation and prioritises the reserves for conservation action on the basis their Genetic Heat Index[1]. Thus Condition I forest would be an excellent forest with few signs (<2%) of human disturbance or fire damage, with good canopy and virgin or late secondary forest throughout, while Condition VI will have no significant forest left.

Studies on the avifauna of the Ghanaian forests include those of Macdonald and Taylor (1977), Dutson and Branscombe (1990), Holbech (1992, 1995) and Moyer (1994). Most of these earlier studies covered single or a few sites. Holbech's survey of 15 forest reserves was the first attempt to document the avifauna of several forest reserves and analyse the effects of forest disturbance on the avifaunal communities (Holbech 1995). Avifaunal surveys were undertaken in key forest and savannah sites in Ghana as part of the Important Bird Areas of Africa project, co-ordinated by BirdLife International. In this paper, we present data on distribution and abundance of avifauna in 28 forest reserves and compare the avifaunal communities in relation to forest condition and vegetation types.

STUDY AREAS AND METHODS

The avifauna of 28 forest reserves in the Ghanaian forest zone, comprising five Condition II forests and 23 Condition III forests, were surveyed between June 1995 and August 1996. The co-ordinates for the reserves studied are given in Table 1. The sites comprised forests of four vegetation types, Upland Evergreen (UE), Wet Evergreen (WE), Moist Evergreen (ME) and Moist semi-Deciduous (MSD); and ranged in size from 73 km^2 to 482 km^2 (Hall & Swain 1981; Hawthorne & Abu-Juam 1995). The Ghanaian

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forest zone has the two-peak type rainfall pattern, with maxima in May–June and September–October. Annual rainfall in the zone varies from 1 750 mm to over 2 000 mm in the WE and 1 200 mm to 1 800 mm in the MSD. Floristically, the evergreen forests are the richest in terms of tree species; 200 species per 0.0625 ha in the WE to 170 species per 0.0625 ha in the ME; as compared with 100 species per 0.0625 ha in the MSD (Hall & Swain, 1981).

Each of the forest reserves was visited at least once for periods of up to 10 days during the study period. At each visit, all bird species observed by sight and sound, on *ad hoc* basis as well as in systematic surveys using transect counts (1.5 km transects); timed species counts (20-minute duration) and mist-netting were recorded. Details of the procedure adopted for each of the three methods are given in Ntiamoa-Baidu *et al.* (2000). The numbers of species reported for each site is the overall total number of species recorded in any particular reserve throughout the study period. The quantitative measure of relative species abundance (reported as species and individual bird encounter rate per km and catch per 100 metre net-hour) is based on transect counts and mist net catches. Comparisons of bird communities within the two forest Categories and four vegetation types were based on Sorenson's Similarity Index measurements and ANOVA test using SYSTAT (Maguran 1988; Wilkinson *et al.* 1992). Key references used for bird identification were Mackworth-Praed & Grant (1970, 1973), Brown *et al.* (1982), Urban *et al.* (1986), Fry *et al.* (1988), Keith *et al.* (1992), Serle *et al.* (1992).

RESULTS

Species richness and composition

A total of 227 species belonging to 35 families were recorded from all the sites studied. Of the total, 13 were species associated with primary forests, 72 were primary and secondary forest species, while 123 were species associated with secondary forest, forest edge and clearings (based on habitat associations given by Brown *et al.* 1982; Grimes 1987; Urban *et al.* 1986; Fry *et al.* 1988; Keith *et al.* 1992; Serle *et al.* 1992); the rest were open habitat and savannah species. The species total for individual reserves ranged from 78 in the Asenanyo Forest Reserve to 119 in the Pra-Sushien (Table 1). The dominant groups in the overall survey were Muscicapidae (represented by 40 species), Pcynonotidae (21) and Cuculidae (12). Eleven species of raptors were recorded including the African Goshawk *Accipiter tachiro* which was recorded for the first time for Ghana. A juvenile of this species was captured in mist-net at the Oda River Forest Reserve. The species lists also included nine species of hornbills and four species of parrots.

SPECIES OF CONSERVATION CONCERN

Six threatened[2] species were recorded in the survey, comprising two Vulnerable species: the Yellow-throated Olive Greenbul *Criniger olivaceus* and Green-tailed Bristle-bill *Bleda eximia,* and four Near-Threatened species: the Copper-tailed Glossy Starling *Lamprotornis cupreocauda,* Yellow-casqued Hornbill *Ceratogyma elata*, Brown-cheeked Hornbill *Ceratogyma cylindricus* and Rufous-winged Illadopsis *Illadopsis rufescens*. Two restricted range species Sharpes Apalis *Apalis sharpii* and Ussher's Dusky Flycatcher *Muscicapa ussheri*, were also recorded.

Records of the Yellow-throated Olive Greenbul consist of 6 sightings in three reserves, Atewa Range (1), Tano-Offin (1) and Furi-Headwaters (4). The four at Furi Headwaters were sighted during 20-minute spot count while the remaining two were sighted outside the systematic counts. 46 observations of Green-tailed Bristle-bill were recorded in 14 forest reserves, out of which 44 were captured in mist nets. 48% of the Green-tailed Bristle-bill records were accounted for by captures from Upland Evergreen Forest type, represented by the Atewa Range and Tano Offin forest reserves. Two other sites, Nkrabea and Neung-south Forest reserves accounted for 11% each of the Green-tailed Bristle-bill records.

The Copper-tailed Glossy Starling was sighted only once at the Atewa Range Forest Reserve while the Yellow-casqued Hornbill was also represented by one sighting of two individuals at the Pra-Sushien Forest Reserve. The records of the Brown-cheeked Hornbill was accounted for by six observations in four reserves, Pra-Sushien (7), Ayum (3;1), Pra-Anum (2;2) and Nsuensa (2). 56 sightings of Rufous-winged Illadopsis were recorded in 21 reserves, of which the Atewa Range contributed 25% of the sightings and four other

Table 1. *Species numbers and encounter rates recorded in the different reserves studied.*

Site (Forest reserves)	Co-ordinates	Vegetation type	Forest Condition	Size (km²)	Total species	Encounter rate (per km)		Mist net catch per 100 mnh
						Species	Birds	
1. Bowiye	5° 43'N, 2° 03'W	ME	2	120	95	24.2	63.3	3.9
2. Pra-sushien	5° 16'N, 1° 32'W	ME	2	104	119	50.7	112.7	3.0
3. Furi Headwaters	5° 32'N, 2° 23'W	WE	2	170	107	20.2	42.8	2.9
4. Ndumfri	5° 10'N, 2° 09'W	WE	2	73	95	23.3	58.5	1.8
5. Dampia	6° 00'N, 1° 40'W	MSD	2	80	89	27.7	86.3	1.7
6. Atewa Range	6° 10'N, 0° 36'W	UE	3	232	105	24.2	52.6	3.8
7. Tano-Offin	6° 40'N, 2° 10'W	UE	3	402	108	31.2	98.2	2.8
8. Bimpong	5° 43'N, 1° 28'W	ME	3	104	94	38.0	120.0	2.0
9. Bonsa-Ben	5° 40'N, 1° 45'W	ME	3	155	90	22.2	66.2	2.4
10. Opong-Manse	5° 45'N, 2° 53'W	ME	3	117	88	21.5	41.8	2.6
11. Tonton	6° 00'N, 2° 05'W	ME	3	146	93	21.0	62.7	2.8
12. Upper Wassaw	6° 55'N, 2° 23'W	ME	3	101	79	16.2	27.9	1.2
13. Tano-Anwhia	6° 50' N, 2° 35'W	ME	3	153	90	23.2	57.3	3.2
14. Neung South	5° 07'N, 2° 02'W	WE	3	113	113	17.2	50.7	3.1
15. Anwhiaso-East	6° 18'N, 2° 10'W	MSD	3	124	85	20.0	48.3	2.9
16. Asenanyo	6° 27'N, 2° 07W	MSD	3	228	78	26.0	66.0	1.5
17. Asukawkaw	7° 47'N, 0° 25'W	MSD	3	122	95	35.0	137.7	3.1
18. Ayum	6° 45'N, 2° 41'W	MSD	3	113	100	37.0	125.3	3.9
19. Bosomtwe Range	6° 30'N, 1° 25'W	MSD	3	79	114	21.3	65.3	1.7
20. Fum Headwaters	6° 15'N, 1° 21'W	MSD	3	73	101	25.3	101.7	2.2
21. Krokosua Hills	6° 30'N, 2° 49'W	MSD	3	482	84	19.2	50.8	2.6
22. Nsuensa	6° 09'N, 1° 59'W	MSD	3	63	81	36.7	172.0	3.4
22. Oda river	6° 08'N, 2° 56'W	MSD	3	164	106	30.7	91.3	2.4
24. Pra-Anum	6° 15'N, 1° 10'W	MSD	3	123	87	25.0	109.0	1.9
25. Tinte-Bepo	7° 58'N, 2° 00'W	MSD	3	116	84	29.0	76.3	3.3
26. Mankrang	7° 21'N, 2° 04'W	DSFZ	3	86	114	21.3	67.3	2.1
27. Nkrabea	6° 00'N, 1° 35'W	ME-MS	3	100	87	24.0	85.0	1.5
28. Sui River	6° 10'N, 2° 44'W	ME-MS	3	334	80	40.0	28.2	1.8

reserves, Nsuensa, Neung-South, Tonton and Ahwiaso-east, each accounted for 5–7% of the sightings.

Relative abundance of avifauna in the reserves

Table 1 gives the species and bird encounter rates recorded during transect counts and capture rates in mist nets within the different forest reserves. Species and bird encounter rates ranged from 16.7 to 50.7 species per km and 27.9 to 172.0 birds per km respectively. The Upper Wassaw Forest Reserve had the lowest species and bird encounter rates while the Pra-Sushien and the Nsuensa Reserves had the highest species and bird encounter rates respectively. A total of 1 786 birds comprising 67 species were captured in mist-nets from all reserves over the survey period and capture rates ranged from 1.2 birds per 100 mnh at the Upper Wassaw Reserve to 3.9 birds per 100 mnh at the Bowiye and Ayum Reserves (Table 1).

The relative abundance of bird species recorded in the survey in terms of presence and absence and in terms of frequency of sighting during the transect surveys are presented in Appendix 1. 68 species out of the total of 227 were recorded in 20 or more reserves. On the other hand, 75 species occurred in only one or two reserves with total sightings of less than 10 individuals. In terms of frequency of observations, the most abundant species out of the 146 recorded in the transect surveys was the Green Hylia (5.4% of observations, scientific names listed in Appendix 1), followed by the Yellow-whiskered Greenbul (4.6%) and Green Pigeon (4.0%). Three species, Olive Sunbird, Yellow-whiskered Greenbul and Fire-crested Alethe accounted for 43.7% of the birds caught in mist-nets. The 20 most abundant bird species sighted in transect surveys and captured in mist-nets in the Ghanaian forests are listed in Table 2.

Comparison of bird communities in different forest categories and vegetation types

The total number of bird species recorded in Condition II forests was 183 while the Condition III forests contributed 167 species. The mean number of species for the Condition II and III forests were 103 and 99 respectively. In terms of the vegetation types, the total number of species recorded in the different types were Moist semi-Deciduous forest, 165 species; Moist Evergreen, 162; Upland Evergreen, 147 and Wet Evergreen, 107. When tested by Analysis of Variance, the effects of forest condition and vegetation types on the total number of species recorded explains 18% of the variation, but neither of these effects were significant (Forest Condition: F-Ratio = 0.416, P = 0.527; Vegetation type: F-Ratio =1.052, P = 0.394).

Of the 227 species recorded in the survey, 57 occurred only in Condition II forests while 41 were recorded only in Condition III forest with 126 occurring in both forest categories. This gives a similarity index for the bird communities in the two forest categories as 0.72 (Sorenson Index, Maguran 1988). Figure 1 shows the similarity indices for the bird communities within the different forest categories and vegetation types.

Table 3 summarises the overall species composition of birds recorded in the different forest categories and vegetation types in terms of habitat associations. Of the species recorded only in Condition II forest, 33 were species associated with primary and matured secondary forests while 22 were secondary forest/forest clearings species. The proportion of the two groups in the case of species recorded only in Condition III was 6:18. 29 of forest associated species recorded in the survey are classified as rare, 30 as uncommon and 145 as common or not uncommon by Grimes (1987). 53 of the rare and uncommon species occurred in Condition II forests while the Condition III forests contributed only 30 of the rare/uncommon species.

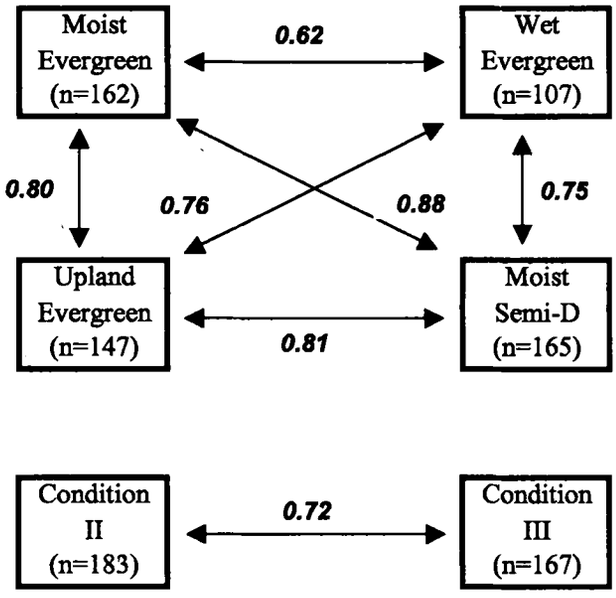

Figure 1. Similarly between bird communities in the different vegetation types and forest categories.

***Table 2.** The twenty most abundant bird species recorded in transect counts and mist nets in the Ghanaian forests (Scientific names of species are given in Appendix 1).*

	Transect Counts			Mist net captures	
Species	**No. recorded**	**% total**	**Species**	**No. captured**	**% total**
Green Hylia	473	5.4	Olive Sunbird	393	22.0
Yellow-whiskered Greenbul	404	4.6	Yellow-whiskered Greenbul	255	14.3
Green Pigeon	348	4.0	Fire-crested Alethe	132	7.4
Naked-faced Barbet	341	3.9	Grey-headed Bristle-bill	115	6.4
Black-headed Oriole	322	3.7	Icterine Greenbul	94	5.3
Olive Sunbird	298	3.4	Red-bellied Paradise Flycatcher	83	4.6
Allied Hornbill	273	3.1	Green Hylia	82	4.6
Tambourine Dove	269	3.1	Little Greenbul	73	4.1
Grey-headed Bristle-bill	262	3.0	Bearded Greenbul	53	3.0
Red-bellied Paradise Flycatcher	256	2.9	Green-tailed Bristle-bill	43	2.4
Glossy-backed Drongo	255	2.9	Black-capped Illadopsis	41	2.3
Green-crested Touraco	249	2.8	Forest Robin	39	2.2
Little Greenbul	248	2.8	Bristle-bill	38	2.1
Yellow-throated Tinker-bird	214	2.4	Cameroon sombre Greenbul	38	2.1
Speckled Tinker-bird	152	1.7	White-tailed Ant-thrush	34	1.9
Fraser's Rusty Thrush	148	1.7	Brown Illadopsis	22	1.2
West African Nicator	147	1.7	Olive Longbill	22	1.2
Grey-crowned Negro-finch	145	1.7	White-bellied Kingfisher	18	1.0
Yellow-browed Camaroptera	131	1.5	Blue-bill	16	0.9
Sharpe's Apalis	129	1.5	Blue-billed Malimbe	15	0.8

Table 3. Habitat association of bird species recorded in the different forest categories and vegetation types.

Species associated with	No. recorded in						
	All sites	Cond. II	Cond. III	WE	ME	UE	MSD
Primary forest	13	13	6	8	9	8	6
Primary and matured secondary forest	72	68	43	32	45	45	46
Secondary forest, forest edge and clearings	123	99	90	62	98	85	102
Others	19	5	18	5	10	8	11
Total	**227**	**183**	**157**	**107**	**162**	**147**	**165**

DISCUSSION

Species richness and relative abundance of forest birds in Ghana

Avifaunal species lists for any particular site are influenced by extent and intensity of surveys as well as experience of observers; and it is acknowledged that in tropical forests, complete lists of sites require several years of survey effort. Gartshore *et al.* (1995), however, reckon from species count curves that 20 counts were necessary before the accumulation of species slowed to a level characteristic of the area. Recent bird surveys in sites within the Upper Guinea rainforests include those of Colston & Curry-Lindahl (1986) and Kofron & Chapman (1995) in Liberia; Allport *et al.* (1989) in Gola Forest, Sierra Leone; Dutson & Branscombe (1990); Holbech (1992, 1995) and Moyer (1994) in Ghana and Gartshore *et al.* (1995) in Tai National Park, Cote d'Ivoire. The survey efforts vary from one study to the other and it is therefore not possible to make any conclusive comparative statements regarding species richness of the sites. Gola forest holds 222 species of forest birds as compared with 237 from Tai National Park and 160 from Kakum National Park. The total number of forest birds recorded from all sites in this survey was 206 while the lists for individual sites ranged from 70–110. The individual site species counts are comparable to the 67–117 species recorded by Holbech for 15 forest sites in southern Ghana during two-week survey periods in each reserve. While the checklists for Tai, Kakum and Gola are based on several surveys, for most of the reserves covered in this study and that of Holbech, these are the first and only bird surveys carried out in the sites. The species lists reported are therefore far from complete, being limited by the short duration of the surveys and poorer coverage; and further, more intensive surveys over longer periods of time are required to provide complete species lists for all the sites.

Less than 15% of the species occurring in the Ghanaian forests can be said to be relatively abundant (accounting for 1% or more of total number of observations) and only about 40% can be said to be widespread (occurring in 20 or more sites). Over 40% of the species were recorded in less than ten sightings and a significant number occurred in only one or two sites. The most abundant species included the Yellow-whiskered Greenbul, the Green Hylia, Olive Sunbird and the Green Pigeon. The Yellow-whiskered Greenbul and the Green Pigeon were the two species heard most frequently in the south-west Ghana forests studied by Dutson & Branscombe (1990); while Yellow-whiskered Greenbul and Olive Sunbird were among the most abundant species recorded by Holbech (1995). Three species (Verreaux's Turaco, Bronze-naped Pigeon and Blue-headed Dove), reported among the most abundant species in the Dutson & Branscombe study were not observed with any degree of abundance in the present study. The Verreaux's Turaco was among the least abundant species with only ten sightings in three reserves on the transect counts. In the Tai national Park, Blue-headed Dove and Verreaux's Turaco ranked first and second in daily logged frequencies, with the Bronze-naped Pigeon, Green Pigeon and Yellow-whiskered Greenbul recorded at over 70% frequency. A number of species recorded very frequently in Tai, including the Black-casqued Hornbill, Yellow-casqued Hornbill, Copper-tailed Glossy Starling and Finsch's Rufous Flycatcher were either not recorded or recorded very rarely in the Ghanaian forests.

The three dominant avian families found in the survey, Muscicapidae, Pcynonotidae and Cuculidae, typically dominate the undergrowth of African rainforest (Karr 1989; Kofron & Chapman 1995). Capture rates in mist nets averaged 1.2 to 3.9 and were similar to rates reported for other forest sites in Africa (e.g. Bowden 1986; Allport *et al.* 1989; Gartshore *et al.* 1995). The Ghanaian forests support a number of bird species of conservation interest although most of them occurred in relatively low numbers. Of the nine species of hornbills recorded, the most abundant were the Allied Hornbill, White-crested Hornbill, Piping Hornbill and Black-casqued Hornbill. Of the ten forest species of birds of prey recorded, only the Long-tailed Hawk, West African Goshawk and Palmnut Vulture occurred with any degree of abundance. The Grey Parrot was the only parrot species encountered frequently (1% of transect counts records), while the Senegal Parrot was the most rare.

Only six of the 13 threatened forest species reported from Ghana were recorded in the survey. The Yellow-throated Olive Greenbul, Copper-tailed Glossy Starling, Yellow-casqued Hornbill and Brown-cheeked Hornbill were sighted infrequently; while the Green-tailed Bristle-bill and Rufous-winged Illadopsis were widespread and relatively common. The Green-tailed Bristle-bill was the tenth most common species in mist-net catches, although the bulk of the catch came from the two Upland Evergreen forest reserves. The restricted range species, Sharpe's Apalis *Apalis sharpii* was among the 20 most abundant species; it was recorded in all the 28 forest sites studied and accounted for 1.5% of the transect count observations.

Effects of forest degradation on avifauna

Hawthorne & Abu-Juam (1995) define Condition II forests as good forest with < 10% disturbed, logging damage restricted or light and well dispersed with fire damage peripheral while Condition III forests are slightly degraded forest, obviously disturbed or degraded and usually patchy, but with good forest predominant. Thus all the forest sites studied had suffered varying degrees of disturbance, mainly from logging, encroachment by farms, damage from bush-fires and in a few cases mining activities. The five Condition II reserves covering a total area of 547 km^2 yielded more species than the 23 Condition III reserves (total area 3 730 km^2). In terms of vegetation type, the species counts was highest in Moist semi-Deciduous forest type, followed by Moist Evergreen and Upland Evergreen, with the Wet evergreen forest type contributing the least number of species. However, the ANOVA test showed that neither forest Condition nor vegetation type explained the variation in the numbers of species recorded at the individual sites. In their study of the avifauna of the Tai National Park, Gartshore *et al.* found the avifauna of two natural forests and one logged forest to be similar; a PCA performed on the covariance of species matrix data showed observer variability to be the most important factor in explaining the variations in species counts. In studies of forests in Malawi and Zambia, Dowsett (1982) found that forest structure (as measured by numbers of tree species) was by far the most important factor, which accounted for some 90% of the variation observed.

There was high similarity in the bird communities in sites within three vegetation types, Moist Evergreen, Upland Evergreen and Moist semi-Deciduous (Similarity Index > 0.8). The bird community within the Wet Evergreen forest type was the most

different (Similarity Index 0.6–0.75). Differences were also observed in bird communities in Condition II and III forests (Similarity Index of 0.72) and in species composition. All the 13 species associated with primary forest species recorded in the survey occurred in Condition II forests but seven of these were absent in Condition III forests. These were the Yellow-casqued Hornbill, Yellow-throated Green Cuckoo, Shining Drongo, Grey-throated Tit Flycatcher, Yellow-throated Olive Greenbul, Red-chested Owlet and Narina's Trogon. 40% of the species associated with primary and matured forest were also absent from the Condition III forests. The degraded state of the Condition III forest was further shown by the presence of a higher number of savannah species and species associated with open habitats. The differences observed in our study in species composition and bird communities in forests of varying degrees of disturbance is similar to the findings of Allport *et al.* (1989), Holbech (1992) and Gartshore *et al.* (1995)

Implications for conservation of the Upper Guinea rainforest

Although the Ghanaian section of the Upper Guinea rainforest has been fragmented, a number of forest reserves managed by the Ghana Forestry Department cover significant tracts of forest. Of the 28 sites studied, two sites (Tano-Offin and Krokosua Hills Forest Reserves) cover >400 km^2; Sui River Forest Reserve is 334 km^2 while 19 other reserves are >100 km^2. Thiollay (1985) advocates that conservation of primary forest species can only be achieved in large areas of undisturbed forest without modern logging exploitation or cultivation and with the complete microhabitat mosaic needed by specialised species. Regarding territorial species, however, Dowsett, (1982) reckons that a larger and more viable population of some species may be preserved in a collection of smaller forest patches than one large forest of the same area. The current system of forest reserves within the south-eastern part of Ghana provide a matrix of patches of forest embedded in secondary forests and other modified habitats. This mosaic of habitat types offers greater chance of food availability all year round, thus the secondary forest and modified habitats would act as critical buffer zones to provide foraging opportunities in times of food shortage in the forests. This would mean that although the fragmented nature of the Ghanaian forest has resulted in species loss and population decline of certain primary forest specialists, the existing system still offers high potential for conservation of avifauna of the Upper Guinea rainforest. All the 28 sites studied potentially qualify as Globally Important Bird Areas under the BirdLife Criteria based on occurrence of Threatened species, Restricted Range species and Biome Restricted species (Fishpool 1996).

In the face of rapid human population increases, increasing demand for land for agricultural development and current expansion of the mining industry in the forest areas of Ghana, it would be wishful thinking to expect that any new large areas of forest will remain and can be added to the list of protected areas in the country. The reality is that the existing forest reserves will continue to come under serious pressure for deforestation. Although the timber production is a key objective in the management of most of the Ghanaian forest reserves, the management practices provide some measure of biodiversity conservation and it should be possible to develop management systems that incorporate faunal conservation. Thus, instead of advocating for total protection of the forest reserves for wildlife, a more feasible approach to the maintenance of avifaunal diversity and stability in the Ghanaian forest would be, as Loiselle & Blake (1992) advocate, identification and manipulation of those factors that contribute to the survival and hence persistence of forest birds in the altered ecosystem. This would involve a multiple-purpose approach to forest conservation in.Ghana, targeting particularly, Condition I, II and III Reserves which still contain relatively undisturbed, sizeable tracts of forest.

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Appendix 1. Relative abundance of species recorded based on number of sites species occurred in and frequency of sighting in transect counts.

	Species		Sighting freq. (transect cts.)
Species recorded in >20 sites			
1	Green Hylia	*Hylia prasina*	473
2	Yellow-whiskered Greenbul	*Andropadus latirostris*	404
3	Green Pigeon	*Treron australis*	348
4	Naked-faced Barbet	*Gymnobucco calvus*	341
5	Black-headed Oriole	*Oriolus brachyrhynchus*	322
6	Olive Sunbird	*Nectarinia olivacea*	298
7	Allied Hornbill	*Tockus fasciatus semifasciatus*	273
8	Tambourine Dove	*Turtur tympanistra*	269
9	Grey-headed Bristle-bill	*Bleda canicapilla*	262
10	Red-bellied Paradise Flycatcher	*Terpsiphone rufiventer*	256
11	Glossy-backed Drongo	*Dicrurus adsimilis*	255
12	Green-crested Touraco	*Tauraco persa*	249
13	Little Greenbul	*Andropadus virens*	248
14	Yellow-throated Tinker-bird	*Pogoniulus subsulphureus*	214
15	Speckled Tinker-bird	*Pogoniulus scolopaceus*	152
16	Fraser's Rusty Thrush	*Stizorhina fraseri*	148
17	West African Nicator	*Nicator chloris*	147
18	Grey-crowned Negro-finch	*Nigrita canicapilla*	145
19	Yellow-browed Camaroptera	*Camaroptera superciliaris*	131
20	Sharpe's Apalis	*Apalis sharpii*	129
21	Hairy-breasted Barbet	*Lybius hirsutus*	126
22	Honey-guide Greenbul	*Baeopogon indicator*	122
23	Forest Robin	*Stiphrornis erythrothorax*	114
24	Yellow-bill	*Ceuthmochares aereus*	114
25	Fire-crested Alethe	*Alethe diademata*	107
26	Yellow-billed Barbet	*Thrachyphonus purpuratus*	107
27	Olive Longbill	*Macrosphenus concolor*	105
28	Blue-headed-crested Flycatcher	*Trochocerus nitens*	105
29	Brown Illadopsis	*Trichastoma fulvescens*	99
30	Chestnut Wattle-eye	*Platysteira castanea*	98
31	Red-billed Shrike	*Prionops caniceps*	92
32	Fire-bellied Woodpecker	*Mesopicos pyrrhogaster*	87
33	Grey Parrot	*Psittacus erithacus*	87
34	Buff-throated Sunbird	*Nectarinia adelberti*	82
35	Swamp Palm Bulbul	*Thescelocichla leocopleurus*	79
36	Bearded Greenbul	*Criniger barbatus*	73
37	Blue-headed Dove	*Turtur brehmeri*	73
38	Square-tailed Drongo	*Dicrurus ludwigii*	73
39	Icterine Greenbul	*Phyllastrephus icterinus*	70
40	White-crested Hornbill	*Tropicranus albocristatus*	70
41	Cameroon Sombre Greenbul	*Andropadus curvirostris*	70
42	White-bearded Greenbul	*Criniger calurus*	69
43	Collared Sunbird	*Anthreptes collaris*	66
44	Chocolate-backed Kingfisher	*Halcyon badia*	56
45	Red-rumped Tinker-bird	*Pogoniulus atroflavus*	53
46	Black-throated Coucal	*Centropus leucogaster*	52
47	Black-cap Illadopsis	*Trichastoma cleaveri*	51
48	Pale-breasted Illadopsis	*Trichastoma rufipennis*	51
49	Rufous-sided Broadbill	*Smithornis rufolateralis*	49
50	Bristle-bill	*Bleda syndactyla*	48
51	Senegal Kingfisher	*Halcyon senegalensis*	47
52	Emerald Cuckoo	*Chrysococcyx cupreus*	43
53	Sabines's Puff-back	*Dryoscopus sabini*	43
54	Blue-breasted Kingfisher	*Halcyon malimbica*	42
55	Olive Long-tailed Cuckoo	*Cercococcyx olivinus*	40
56	Buff-spotted Woodpecker	*Campethera nivosa*	39
57	Black Cuckoo	*Cuculius clamosus gabonensis*	33
58	Klass Cuckoo	*Chrysococcyx klaas*	32
59	White-spotted Pigmy Rail	*Sarothura pulchra*	29
60	Rufous-winged Illadopsis	*Trichastoma rufescens*	24
61	White-tailed Ant-thrush	*Neocossyphus poensis*	20
62	West African Goshawk	*Accipiter toussenelii*	17
63	Grey-backed Camaroptera	*Camaroptera brachyura*	14
Species recorded in 10–20 sites			
1	Crested Malimbe	*Malimbus malimbicus*	58
2	Kemp's Longbill	*Macrosphenus flavicans kempi*	46
3	Piping Hornbill	*Bycanistes fistulator*	38
4	Red-headed Malimbe	*Malimbus rubricollis*	38
5	Red-chested Cuckoo	*Cuculus solitarius*	36
6	Black-casqued Hornbill	*Ceratogymna natrata*	34
7	Red-billed Dwarf Hornbill	*Tockus camurus*	31
8	Afeps' Pigeon	*Columba unicinta*	30
9	Blue-billed Malimbe	*Malimbus nitens*	28
10	Blue Plantain-eater	*Corytheola cristata*	26
11	Bronze-naped Pigeon	*Columba malherbii*	21
12	Brown-necked Parrot	*Poicephalus robustus*	19
13	Ahanta Francolin	*Francolinus ahantensis*	18
14	Long-tailed Hawk	*Urotriochis macrourus*	18
15	Common Garden Bulbul	*Pycnonotus barbatus*	16
16	Blue Cuckoo-shrike	*Coracina azurea*	14
17	Dusky Long-tailed Cuckoo	*Cercococcyx mechowi*	13
18	Pied Crow	*Corvus alba*	13
19	Forest Wood-hoopoe	*Phoeniculus castaneiceps*	13
20	Red-winged Warbler	*Prinia erythroptera*	12
21	Harrier Hawk	*Polyboroides radiatus*	11
22	Lemon-rumped Tinker-bird	*Pogoniulus bilineatus*	10
23	Senegal Coucal	*Centropus senegalensis*	9
24	Blue-throated Roller	*Eurystomus gularis*	9
25	Green Crombec	*Sylvietta virens*	7
26	Dusky-crested Flycatcher	*Trochocerus nigromitratus*	7
27	Pale-breasted Negro-finch	*Nigrita fusconota*	6
28	White-bellied Kingfisher	*Alcedo leucogaster*	6
29	Yellow-mantled Weaver	*Ploceus tricolor*	6
30	Black-capped Apalis	*Apalis nigriceps*	5
31	Superb Sunbird	*Nectarinia superba*	5
32	Forest Francolin	*Francolinus lathami*	5
33	Orange-cheeked Waxbill	*Estrilda melpoda*	4

34	Red-billed Wood Dove	*Turtur afer*	4
35	West African Prinia	*Prinia subflava*	4
36	Palmnut Vulture	*Gypohierax angolensis*	3
37	White-throated Bee-eater	*Merops albicollis*	3
38	Black Kite	*Milvus migrans*	2
39	Red-tailed Buzzard	*Buteo auguralis*	2
40	Green-tailed Bristle-bill	*Bleda eximia*	1
41	Didric Cuckoo	*Chrysococcyx caprius*	1
42	Scarlet-tufted Sunbird	*Anthreptes fraseri*	-

Species recorded in 2–9 sites

1	Red-headed Parrot	*Poicephalus guliemi*	18
2	Black Coucal	*Centropus toulou*	17
3	Forest Flycatcher	*Fraseria ocreata*	16
4	Black and White Mannikin	*Lonchura bicolor*	15
5	Brown-cheeked Hornbill	*Bycanistes cylindricus*	15
6	Red-rumped Swallow	*Hirundo daurica*	13
7	Verreaux's Touraco	*Tauraco macrorhynchus*	10
8	Broad-billed Roller	*Eurystomus glaucurus*	9
9	Lesser-stripped Swallow	*Hirundo abyssinica*	9
10	Gambian Puff-back	*Dryoscopus gambensis*	5
11	Red-eyed Dove	*Streptopelia semitorquata*	5
12	Square-tailed rough-winged Swallow	*Psalidoprocne nitens*	5
13	Splendid Glossy Starling	*Lamprotornis splendidus*	3
14	Blue-bill	*Spermophaga haematina*	3
15	Dusky-blue Flycatcher	*Muscicapa comitata*	3
16	Chestnut-capped Flycatcher	*Erythrocerus mccali*	3
17	Bristle-nosed Barbet	*Gymnobucco peli*	3
18	Fire-crowned Bishop	*Euplectes hordeaceus*	3
19	Fanti Rough-winged Swallow	*Psalidoprocne obscura*	2
20	Olive-bellied Sunbird	*Nectarinia chloropygia*	2
21	Chestnut -breasted Negro-finch	*Nigrita bicolor*	2
22	Leaf-love	*Phyllastrephus scandens*	2
23	Scarlet-breasted Sunbird	*Nectarinia senegalensis*	2
24	Black-billed Dwarf Hornbill	*Tockus hartlaubi*	2
25	Cassin's Grey Flycatcher	*Muscicapa cassini*	2
26	Yellow-spotted Barbet	*Buccanodon duchaillui*	2
27	Black and White-casqued Hornbill	*Bycanistes subcylindricus*	2
28	Blue-bellied Roller	*Coracias cyanogaster*	2
29	Red-vented Malimbe	*Malimbus scutatus*	2
30	African Sand Martin	*Riparia paludicola*	1
31	Black and white Flycatcher	*Bias musicus*	1
32	Chestnut-winged Starling	*Onychognathus fulgidus*	1
33	Crowned Hawk-eagle	*Stephanoaetus coronatus*	1
34	Shining Drongo	*Dicrurus atripennis*	1
35	Ussher's Dusky Flycatcher	*Artomyias ussheri*	1
36	Lesser Honeyguide	*Indicator minor*	-
37	Palm Swift	*Cypsiurus parvus*	-
38	Mosque Swallow	*Hirundo senegalensis*	-
39	Nkulengu Rail	*Himantornis haematopus*	-
40	Village Weaver	*Ploceus cucullatus*	-
41	Black and chestnut Weaver	*Ploceus nigerrimus*	-
42	Green-backed twin spot	*Hypargos nitidulus*	-
43	Hooded Vulture	*Neophron monachus*	-
44	White-throated Greenbul	*Phyllastrephus albigularis*	-
45	Pygmy Kingfisher	*Ceyx picta*	-
46	Spotted Honeyguide	*Indicator maculatus*	-
47	White-naped Weaver	*Ploceus albinucha*	-
48	Pied Wagtail	*Motacilla alba*	-
49	Least Honey-guide	*Indicator exilis*	-
50	Lizard Buzzard	*Kaupifalco monogrammmicus*	-
51	European Swallow	*Hirundo rustica*	-
52	Wilcock's Honey guide	*Indicator wilcocksi*	-
53	Wire-tailed Swallow	*Hirundo smithii*	-
54	Blue-throated Brown Sunbird	*Nectarinia cyanolaema*	-
55	Crested Guinea-fowl	*Guttera edouardii*	-
56	Sabine's Spine-tailed Swift	*Chaetura sabini*	-
57	Little Swift	*Apus affinis*	-
58	Red Bishop	*Euplectes orix*	-
59	Sooty Boubou	*Laniarius leucorhynchus*	-
60	Yellow-throated Olive Greenbul	*Criniger olivaceus*	-
61	Yellow White-eye	*Zosterops senegalensis*	-
62	Brown-eared Woodpecker	*Campethera caroli*	-
63	Buff-headed Wood-hoopoe	*Phoeniculus bollei*	-
64	Narina's Trogon	*Apaloderma narina*	-
65	Spotted Greenbul	*Ixonotus guttatus*	-
66	Bell Shrike	*Laniarius ferrugineus*	-
67	Black Bee-eater	*Merops gularis*	-
68	Equatorial Akalat	*Sheppardia equatorialis*	-
69	Flower-pecker Weaver-finch	*Parmoptila woodhousei*	-
70	Long-tailed Nightjar	*Caprimulgus climacurus*	-
71	Purple Glossy Starling	*Lamprotornis purpureus*	-
72	Spectacled Weaver	*Ploceus nigricolis*	-
73	Vitelline-masked Weaver	*Ploceus velatus*	-
74	Yellow-bellied Greenbul	*Phyallstrephus flavostriatus*	-
75	Serine Greenbul	*Calyptocichla serina*	-
76	Grey Ground –thrush	*Turdus princei*	-
77	Narrow-tailed Starling	*Poeoptera lugubris*	-

Species recorded in only one site

1	Grey-breasted Guinea-fowl	*Numida meleagris*	10
2	White-throated blue Swallow	*Hirundo nigrita*	9
3	Bronze Mannikin	*Lonchura cucullata*	2
4	Heuglins's Masked Weaver	*Ploceus heuglini*	2
5	Yellow-casqued Hornbill	*Ceratogymna elata*	2
6	Singing Cisticola	*Cisticola cantana*	1
7	Yellow-billed Shrike	*Corvinella corvina*	1
3	Senegal Parrot	*Poicephalus senegalus*	-
4	Shining Blue Kingfisher	*Alcedo quadribrachys*	-
5	Slender-billed Greenbul	*Andropadus gracilirostris*	-
6	Whistling Cisticola	*Cisticola lateralis*	-
7	African Broadbill	*Smithornis capensis*	-
8	African Goshawk	*Accipiter tachiro*	-
9	African Wood-owl	*Ciccaba woodfordii*	-
10	Blissett's Wattle-eye	*Platysteira blissetti*	-
11	Brown-chested Alethe	*Alethe poicephala*	-
12	Brown-crowned Eremomela	*Eremomela badiceps*	-
13	Cassin's Honey-guide	*Prodotiscus insignis*	-
14	Copper-tailed Glossy Starling	*Lamprotornis cupreocauda*	-
15	Double-spurred Francolin	*Francolinus bicalcaratus*	-
16	Fiery-breasted Bush-shrike	*Malaconotus cruentus*	-
17	Finfoot	*Podica senegalensis*	-
18	Forest Scrub-robin	*Cercotrichas leucosticta*	-
19	Gabon Woodpecker	*Dendropicos gabonensis*	-
20	Grey-throated Tit-flycatcher	*Myioparus griseigularis*	-
21	Laughing Dove	*Streptopelia senegalensis*	-
22	Little Grey Flycatcher	*Muscicapa epulata*	-
23	Lyre-tailed Honey-guide	*Melichneutes robustus*	-
24	Magpie Mannikin	*Lonchura fringilloides*	-
25	Mottled Swift	*Apus aequatorialis*	-
26	Olivaceous Flycatcher	*Muscicapa olivascens*	-
27	Pygmy Woodpecker	*Verreauxia africana*	-
28	Plain-backed Pipit	*Anthus leocophrys*	-
29	Senegal Wood-hoopoe	*Phoeniculus purpureus*	-
30	Tree pipit	*Anthus trivialis*	-
31	Ussher's Spine-tailed Swift	*Chaetura ussheri*	-
32	Western Little Sparrow-hawk	*Accipiter erythropus*	-
33	African Pitta	*Pitta angolensis*	-
34	Black-bellied Seed-cracker	*Pirenestes ostrinus*	-
35	Blue-headed Bee-eater	*Merops muelleri*	-
36	Chattering Cisticola	*Cisticola anonyma*	-
37	Dwarf Kingfisher	*Ceyx lecontei*	-
38	Golden -backed Weaver	*Ploceus preussi*	-
39	Little Grey Greenbul	*Andropadus gracilis*	-
40	Yellow-throated Green Cuckoo	*Chrysococcyx flavigularis*	-

[1] Genetic Heat Index shows the relative richness of the forest in terms of rarity of the species both nationally and internationally. Thus a high GHI would signify an area relatively rich in species such that loss or degradation of the area would represent a highly significant erosion of genetic resources from the world and Ghana in particular.

[2] Threat categories according to Collar *et al.*, 1994