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DIVERSITY AND HABITAT ASSOCIATION OF BIRDS OF DEMBIA PLAIN WETLANDS, LAKE TANA, ETHIOPIA

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ABSTRACT: An ecological investigation on birds was carried out in Dembia plain wetlands, Lake Tana, Ethiopia covering both wet and dry seasons from August 2006 to April 2007. Out of the 49 randomly selected blocks, 10 were from the farmland, 33 from the modified habitat and 6 from Dirma sites. However, at Angara because of the small size of the island, total count was employed. A total of 193 species of birds grouped in 18 orders and 64 families were identified. The species richness of birds in the four habitats ranged from 29–58 and 34–77 during the wet and dry seasons, respectively. The number of species between seasons showed significant difference ($P < 0.01$). The lowest diversity was obtained in Dirma ($H' = 2.753$) and ($H' = 2.647$) during the wet and dry seasons. Among the four habitats, similarity of bird community was less (SI = 0.10). The highest seasonal community similarity was obtained in the farmland (SI = 75.76%). Seasonally, at each site of the study area, there was no significant difference in species number (modified habitat $\chi^2 = 2.674$, $P = 0.102$, Dirma $\chi^2 = 0.061$, $P = 0.806$, Farmland $\chi^2 = 0.011$, $P = 0.918$ and Angara $\chi^2 = 0.397$, $P = 0.529$). There was a significant difference in the use of habitats during both seasons, with high preference for farmland and modified habitats. High diversity and species richness of birds of Dembia plain reinforces the urgency to take conservation measures and minimize activities in the area.

Key words/phrases: Avifauna, Dembia wetlands, habitat association, species richness

INTRODUCTION

Species diversity of an area or a region is determined by the outcome of many contributing factors Associated with almost every pattern of variation in species diversity are patterns of variation in many different biophysical factors as well as anthropogenic processes that could influence biological diversity (Oindo *et al.*, 2001). Food and habitat quality are identified as primary limiting factors that influence avian population distribution. For the majority of birds, deforestation, firewood, commercial logging, subsistence farming, plantations, and mining are the major causes of threat (Fuentes, 1999). Agricultural intensification can cause decline among the wetland birds (Gregory *et al.*, 2004). Accidental and intentional introduction of exotic waterfowl can have negative ecological impacts on native species (Petrie and Francis, 2003). The great input of solar energy in the tropics leads to high productivity accommodating more species in the tropics than at higher latitudes (Pomeroy, 1992).

The central Ethiopian highland Endemic Bird Area (EBA) accounts for over 75% of the birds in the region. In this region, eight species are endemic to Ethiopia and 12 are highland biome species restricted to Ethiopia and Eritrea (EWNHS, 1996). The central plateau and its associated wetlands, particularly the Lake Tana area and the Fogera plains are important wintering areas for Palaearctic migrants such as wattled crane, pallid harrier and lesser kestrel. The avifauna of Ethiopia represents a mixture of East and West African, Palaearctic and some endemic components. Diversity in habitat includes deserts, *Acacia* savannas, wetlands, rift valley lakes, alpine highlands and massifs, each with its own characteristic bird species. Habitats vary greatly in diversity and distribution of birdlife (Williams and Arlott, 1980). The country's diverse habitats contribute to the tremendously diverse avifauna. At present, 69 Important Bird Areas (IBAs) are identified in Ethiopia. These include the already existing protected areas and other additional sites. The birds of Ethiopia are grouped into three biome assemblages. Of these, the Afrotropical Highland Biome assemblage holds about 48 species including seven endemic birds. The Bale Mountains National Park is the richest site for this biome assemblage, representing over 80 per cent of

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the species. The Somali-Massai Biome assemblage is the richest in species variety harbouring over 97 bird species of which six are endemic, and the Sudan-Guinea Savannah Biome assemblage, though the area is poorly known biologically, holds 16 species of birds. Gambella is the richest area on this biome (EWNHS, 1996).

The present study is carried out to identify the species composition and habitat assocoation of birds in Dembia plain wetlands of Lake Tana. The results of this study are expected to contribute to our understanding of the avaian diversity of the area, so as to help in the process of conservation of the biodiversity in the Lake Tana area.

MATERIALS AND METHODS

The study area

The study area is located in the Amhara National Regional State (ANRS), north of Lake Tana, Ethiopia, 827 km northwest of Addis Ababa. The Woreda covers an area of 1490 km² and lies between the coordinates 12° 15′ 30″–12° 18′ 00″ N latitude and 37° 20′ 30″–37° 29′ 00″ E longitude. The identified sites cover an area of 147 ha in the modified habitat, 785 ha at Dirma, 1800 ha at the farmland and 10 ha at the Angara Island (Fig. 1).

The study area lies along the northern shore of Lake Tana with altitude ranging from 1700 to 2500 masl. The minimum temperature is 5.9°C, registered in December and the maximum temperature is 27.4°C, registered in February (Fig. 2).

Binoculars, digital camera, GPS, field guides and topographic maps (1:50000) were used during the study period. Boats were used to travel through the lake and the flooded area during the main rainy season.

Methods

A total of 49 blocks, 10 in the farmland, 33 in the modified habitat and 6 in Dirma were identified. As the Angara island is small in size (10 ha), total count method was carried out (Urfi *et al.*, 2005). At the farmland, 10 blocks were randomly taken each consisting of 1x1 km with a total area of 10 km². Dirma habitat had six blocks each 1x1 km with a total area of 6 km². The distance between blocks ranged from 250 to 300 m. Reverse counting census at the far end of the counting route was adopted at the farmland (Crozier and Gawlik, 2002). In the modified habitat, a total of 33 points with 25 m radius were laid along transects. Points were at a distance of 150–200 m depending on the density of the vegetation and accessibility of the area (Bibby *et al.*, 1992).

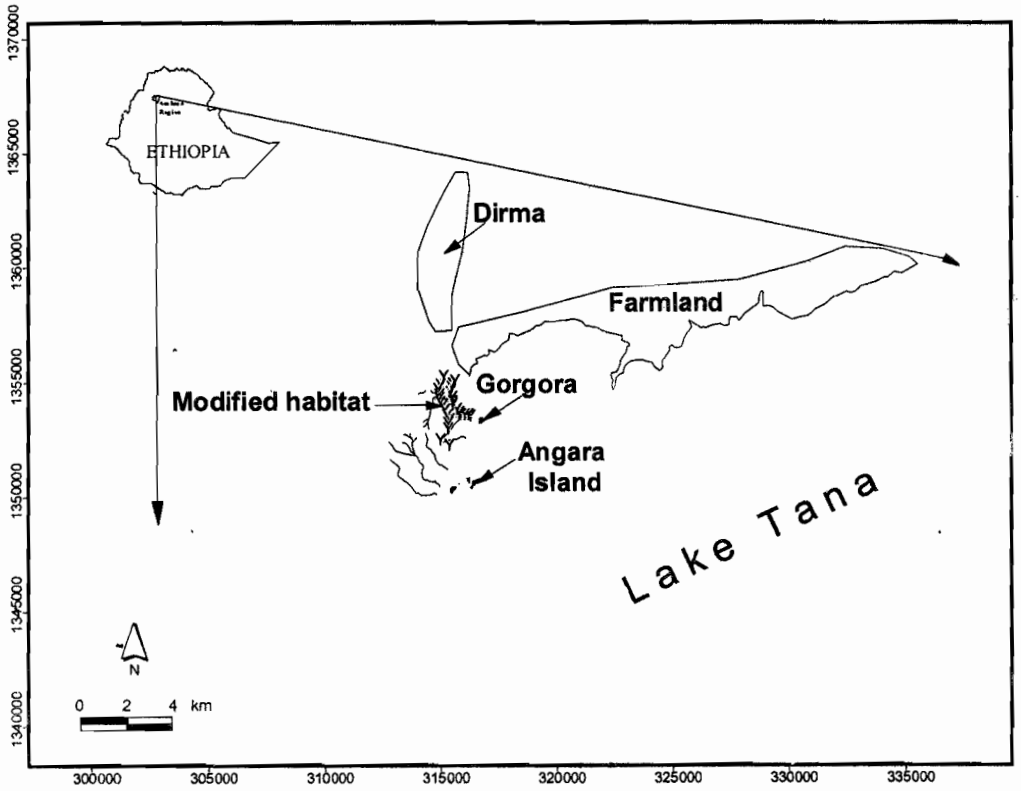

Fig. 1. Map of the study area.

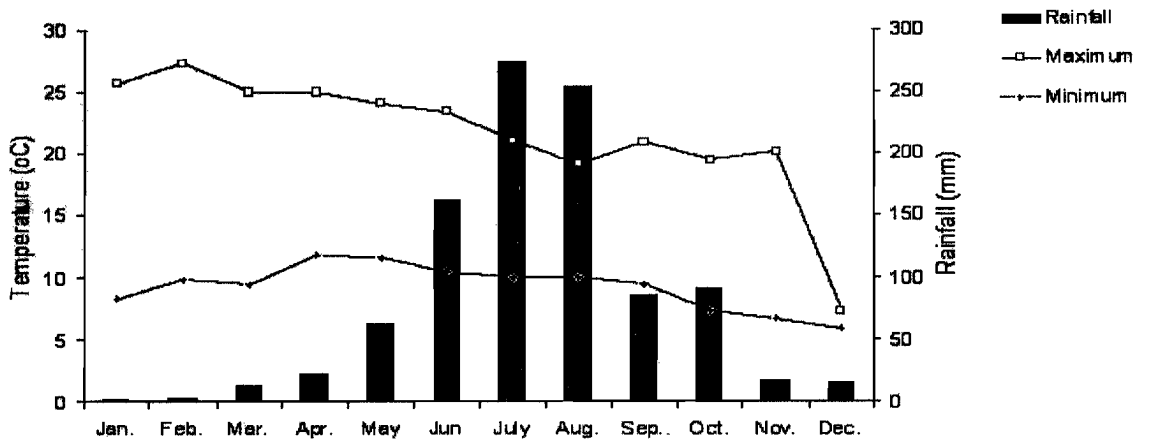

Fig. 2. Monthly variation in temperature and rainfall in the study area (1998–2007).

Data collection and analyses

Observation was carried out using naked eye, supplemented with binoculars. Survey of the avian species in the blocks and points of the survey zones were conducted in the morning from 6:00–10:00 a.m. and in the afternoon 3:00–6:00 p.m., when most of the avian species were active under calm weather conditions. Indirect observation of birds using their calls was made in modified habitats (O' Reilly *et al.*, 2006). For some colonial forms, flushing all birds from the colony using loud noise and then counting repeatedly while they were flying was practiced (Pomeroy, 1992). Bird community structure of each habitat was expressed in terms of diversity (Shannon-Wiener Index). Simpson's Similarity Index (SI) was adopted to compare the similarity of different habitat types in terms of avian species diversity. Data obtained during the survey were analyzed using SPSS software. Chi-square test was employed to check the significance of habitats with seasons and the abundance of birds.

RESULTS

Species richness and composition

A total of 193 species of birds grouped under 18 orders and 64 families were recorded (Table 1). Species richness of birds in the four habitats ranged from 29 to 58 during the wet season and from 34 to 77 during the dry season. Among the recorded species, 63 were residents, 11 were African migrants, 30 were northern migrants, six were both African and northern migrants and 83 species were uncategorized ones. The highest number of species (S = 12) was recorded for the family Anatidae and the least (S = 1) was for 22 families, each with a single species. Highest density was obtained in the modified habitat during both wet and dry seasons (Table 2).

Table 1. Species of birds recorded during the wet and dry seasons (* wet season, ♦ dry season, ♥ Endemics, + African Migrants, Δ Northern Migrants, ⊥ African and Northern Migrants; species without symbols are ,residents).

Family	Common Name	Scientific Name
Coraciidae	Abyssinian Roller ♦+	*Coracias abyssinica*
Muscicapidae	Abyssinian Slaty flycatcher ♦	*Melaenornis chocolatina*
Anatidae	African Black Duck *	*Anas sparsa*
Fringillidae	African Citril ♦	*Serinus citrinelloides*
Cuculidae	African Cuckoo* +	*Cuculus gularis*
Anhingidae	African Darter	*Anhinga rufa*
Muscicapidae	African Dusky Flycatcher ♦	*Muscicapa adusta*
Esterildidae	African Firefinch	*Lagonosticta rubricata*
Accipitridae	African Fish Eagle *	*Haliaeetus vocifer*
Oriolidae	African Golden Oriole *+	*Oriolus auratus*
Bucerotidae	African Grey Hornbill	*Tockus nasutus*
Pandionidae	African Harrier-Hawk ♦	*Polyboroides typus*

Family	Common Name	Scientific Name
Pandionidae	African Hawk Eagle ♦	*Hieraatus spilogaster*
Upupidae	African Hoopoe ⊥	*Upopa africana*
Jacanidae	African Jacana	*Actophilornis africanus*
Apodidae	African Palm Swift *	*Cypsiurus parvus*
Muscicapidae	African Paradise Monarch +	*Terpsiphone virids*
Motacillidae	African Pied Wagtail	*Motacilla aguimp*
Alcedinidae	African Pygmy Kingfisher ♦	*Ispidina picta*
Corvidae	African Rook	*Corvus capensis*
Threskiornithida	African Spoonbill	*Platalea alba*
Rallidae	African Water Rail *	*Rallus caerulescens*
Charadriidae	African Wattled Lapwing ♦	*Vanellus senegallus*
Accipitridae	African White Backed Vulture *	*Gyps africanus*
Apodidae	Alpine Swift Δ	*Tachymarptis melba*
Ploceidae	Baglafecht Weaver *	*Ploceus baglafecht*
Platysteiridae	Banded Wattle Eye ♦	*Platysteira cyanea*
Picidae	Bearded Woodpecker *	*Dendropicos namaquus*
Nectarinidae	Beautiful Sunbird	*Cinnyris pulchellus*
Otididae	Black Bellied Bustard *	*Eupodotis melanogaster*
Capitonidae	Black Billed Barbet	*Lybius guifsobalito*
Columbidae	Black Billed Wood Dove	*Turtur abyssinicus*
Phoeniculidae	Black Billed Wood Hoopoe ♦	*Phoeniculus somaliensis*
Ploceidae	Black Bishop *	*Euplectes gierowii*
Gruidae	Black Crowned Crane	*Balearica pavonina*
Malaconotidae	Black Crowned Tchagra ♦	*Tchagra senegala*
Oriolidae	Black Headed Forest Oriole ♦ ♥	*Oriolus monacha*
Ardeidae	Black Headed Heron	*Ardea melanocephala*
Ploceidae	Black headed Weaver *	*Ploceus melanocephalus*
Strigidae	Black kite Δ	*Milvus migrans*
Psittacidae	Black winged Love Bird ♥	*Agapornis taranta*
Meropidae	Blue Breasted Bee eater *	*Merops variegatus*
Picidae	Brown backed woodpecker *	*Picoides obsoletus*
Columbidae	Bruce's Green Pigeon	*Treron waalia*
Sylvidae	Buff-Bellied Warbler	*Phyllolais pulchella*
Meropidae	Carmine Bee eater	*Merops nubicus*
Sternidae	Caspian Tern ♦ ⊥	*Sterna caspia*
Ardeidae	Cattle Egret +	*Bubulcus ibis*
Estrildidae	Chestnut Breasted Black Finch *	*Nigrita bicolor*
Emberizidae	Cinnamon Breasted Rock Bunting *	*Emberiza tahapisi*
Laridae	Common Blockheaded Gull ♦	*Larus ridibundus*
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*
Cisticolidae	Common Camaroptera	*Camaroptera rachyuran*
Gruidae	Common Crane Δ	*Grus grus*
Laniidae	Common Fiscal Δ	*Lanius collaris*
Glareolidae	Common Pratincole ♦ Δ	*Glareola pratincola*
Phasianidae	Common Quail ♦ +	*Coturnix coturnix*
Scolopacidae	Common Sandpiper Δ	*Actitis hypoleucos*
Recurvirostridae	Common Stilt	*Himantopus himantopus*
Phasianidae	Crested Francolin *	*Francolinus sephaena*
Cisticolidae	Croaking Cisticola *	*Cisticola natalensis*
Scolopacidae	Curlew Sandpiper Δ	*Calidris ferruginea*
Capitonidae	Double Toothed Barbet	*Lybius bidentatus*
Musophagidae	Eastern Grey Plantain Eater	*Crinifer zonurus*
Anatidae	Egyptian Goose	*Alopochen aegyptiacus*
Hirundinidae	Ethiopian Swallow ♦	*Hirundo aethopica*
Recurvirostridae	Eurasian Avocet ♦ ⊥	*Recurvirostra avosetta*
Cuculidae	Eurasian Cuckoo * Δ	*Cuculus canorus*
Muscicapidae	Eurasian Reed Warbler Δ	*Acrocephalus scirpaceus*
Corvidae	Fan-tailed Raven	*Corvus rhipidurus*
Ploceidae	Fawn Breasted Waxbill	*Estrilda paludicola*
Alaudidae	Flappet Lark	*Mirafra rufocinnamomea*
Anatidae	Fulvous Whistling Duck *	*Dendrocygna bicolor*
Pandionidae	Gabar Goshawk ♦	*Micronosus gabar*
Anatidae	Gadwall ♦ Δ	*Anas strepera*
Anatidae	Garganey ♦ Δ	*Anas querquedula*
Alcedinidae	Giant Kingfisher	*Megaceryle maximus*
Threskiornithida	Glossy Ibis ⊥	*Plegadis falcinellus*
Picidae	Golden Tailed Woodpecker *	*Campethera abingoni*
Ardeidae	Goliath Heron	*Ardea goliath*

Family	Common Name	Scientific Name
Laridae	Great Black Headed Gull ♦ Δ	*Larus ichthyaetus*
Phalacrocoracid	Great Cormorants	*Phalacrocorax carbo*
Laniidae	Great Grey Shrike Δ	*Lanius excubitor*
Pelecanidae	Great White Pelican	*Pelecanus onocrotalus*
Sturnidae	Greater Blue Eared Glossy Starling	*Lamprotornis chalybaeus*
Nectarinidae	Green Headed Sunbird *	*Nectarinia verticalis*
Scolopacidae	Green Sand Piper *	*Tringa ochropus*
Phoeniculidae	Green Wood Hoopoe ♦	*Phoeniculus purpureus*
Scolopacidae	Greenshank Δ	*Tringa nebularia*
Platysteiridae	Grey Headed Batis ♦	*Batis orientalis*
Laridae	Grey Headed Gull *	*Larus cirrocephalus*
Alcedinidae	Grey Headed Kingfisher ♦ +	*Halcyon leucocephala*
Passeridae	Grey Headed Sparrow	*Passer griseus*
Ardeidae	Grey Heron Δ	*Ardea cinerea*
Falconidae	Grey Kestrel *	*Falco ardosiaceus*
Picidae	Grey Woodpecker	*Dendropicos geortae*
Sternidae	Gull Billed Tern * Δ	*Gelocheliden nilotica*
Threskiornithida	Hadada ibis	*Bostrychia hagedash*
Scopidae	Hammerkop *	*Scopus umbretta*
Numididae	Helmented Guineafowl ♦	*Numida meleagris*
Laridae	Herring Gull Δ	*Larus argentatus*
Muscicapidae	Heuglin's Wheateater ♦	*Oenanthe heuglini*
Aegypiidae	Hooded Vulture *	*Necrosyrtes monachus*
Nectarinidae	Hunter's Sunbird ♦	*Nectarinia hunteri*
Muscicapidae	Isabelline Wheat-eater ♦ Δ	*Oenanthe isabellina*
Cuculidae	Klaa's Cuckoo	*Chrysococcyx klaas*
Anatidae	Knob Billed Duck	*Sarkidiornis melanotos*
Columbidae	Laughing Dove	*Streptopelia senegalensis*
Falconidae	Lesser Kestrel ♦ Δ	*Falco naumanni*
Meropidae	Little Bee-eater	*Merops pusillus*
Ardeidae	Little Egret ♦	*Egretta garzetta*
Scolopacidae	Little Stint Δ	*Calidris minuta*
Sternidae	Little Tern ♦ ⊥	*Sterna albifrons*
Ploceidae	Little Weaver *	*Ploceus luteolus*
Accipitridae	Long Crested Eagle *	*Lophaetus occipitalis*
Phalacrocoracid	Long Tailed Cormorant	*Phalacrocorax africanus*
Alcedinidae	Malachite Kingfisher	*Alcedo cristata*
Scolopacidae	Marsh Sandpiper Δ	*Tringa stagnatilis*
Nectarinidae	Mouse Colored Sunbird	*Nectarinia veroxii*
Columbidae	Namaqua Dove ♦	*Oena capensis*
Muscicapidae	Northern Black Flycatcher	*Melaenornis edolioides*
Anatidae	Northern Pintail ♦ Δ	*Anas acuta*
Anatidae	Northern Shovler ♦ Δ	*Anas clypeata*
Picidae	Nubian Woodpecker *	*Campethera nubica*
Apodidae	Nyanza Swift *	*Apus niansae*
Turdidae	Olive Thrush	*Turdus olivaceus*
Pandionidae	Osprey ⊥	*Pandion haliaetus*
Ploceidae	Parasitic Weaver	*Anomalospiza imberbis*
Corvidae	Pied Crow	*Corvus albus*
Alcedinidae	Pied Kingfisher	*Ceryle rudis*
Motacillidae	Pied Wagtail * Δ	*Motacilla alba*
Muscicapidae	Pied Wheat-eater ♦ Δ	*Oenanthe pleschanka*
Viduidae	Pin Tailed Whydah *	*Vidua macroura*
Pelecanidae	Pink Backed Pelican	*Pelecanus rufescens*
Ardeidae	Purple Heron	*Ardea purpurea*
Esterildidae	Red Billed Firefinch	*Lagonosticta senegala*
Sturnidae	Red Billed Oxpecker *	*Buphagus erythrorhynchus*
Esterildidae	Red Cheeked Cordon Bleu	*Uraeginthus bengalus*
Columbidae	Red eyed Dove	*Streptopelia semitorquata*
Sturnidae	Red Winged Starling ♦	*Onychognathus morio*
Columbidae	Ring necked Dove	*Streptopelia capicola*
Charadriidae	Ringed Plover * Δ	*Charadrius hiaticula*
Sturnidae	Rueppell's Long Tailed Starling *	*Lamprotornis purpuropterus*
Muscicapidae	Rueppell's Robin Chat	*Cossypha semirufa*
Scolopacidae	Ruff Δ	*Philomachus pugnax*
Threskiornithida	Sacred Ibis	*Threskiornis aethiopicus*
Nectarinidae	Scarlet Chested Sunbird	*Chalcomitra senegalensis*
Pandionidae	Scissor-tailed Kite ♦ +	*Chelictinia rioccourii*

Family	Common Name	Scientific Name
Cuculidae	Senegal Coucal*	*Centropus senegalensis*
Charadriidae	Senegal Lapwing	*Vanellus lugubris*
Nectarinidae	Shining Sunbird *	*Cinnyris habessinicus*
Accipitridae	Short Toed Snake Eagle ♦	*Circaetus gallicus*
Bucerotidae	Silvery Cheeked Hornbill *	*Ceratogymna brevis*
Anatidae	Southern Pochard ♦ +	*Netta erythrophthalma*
Collidae	Speckled Mousebird	*Colius striatus*
Columbidae	Speckled Pigeon	*Columba guinea*
Ploceidae	Speke's Weaver	*Ploceus spekei*
Muscicapidae	Spotted Flycatcher *	*Muscicapa striata*
Scolopacidae	Spotted Sandpiper ♦	*Actitis maculara*
Burhinidae	Spotted Thick-knee Δ	*Burhinus capensis*
Charadriidae	Spur Winged Lapwing	*Vanellus spinosus*
Anatidae	Spurwinged Goose	*Plectropterus gambensis*
Ardeidae	Squacco Heron	*Ardeola ralloides*
Caprimulgidae	Standard Winged Nightjar * +	*Macrodipteryx longipennis*
Cisticolidae	Stout Cisticola *	*Cisticola robustus*
Alcedinidae	Striped Kingfisher	*Halcyon chelicuti*
Cisticolidae	Tawny Flanked Prinia	*Prinia subflava*
Scolopacidae	Temminck's Stint Δ	*Calidris temminckii*
Corvidae	Thick Billed Raven * ♥	*Corvus crassirostris*
Nectariniidae	Variable Sunbird	*Nectarinia venustus*
Falconidae	Verreaux's Eagle *	*Aquila verreauxii*
Strigidae	Verreaux's Eagle Owl	*Bubo lacteus*
		Contd
Viduidae	Village Indigo Bird	*Vidua chalybeata*
Sturnidae	Violet Backed Starling +	*Cinnyricinclus leucogaster*
Threskiornithida	Wattled Ibis * ♥	*Bostrychia carunculata*
Indicatoridae	Western Green Backed Honey bird *	*Prodotiscus insignis*
Sturnidae	White Billed Starling ♦ ♥	*Onychognathus albirostris*
Musophagidae	White Cheeked Turaco ♦	*Tauraco leucotis*
Strigidae	White Faced Scops-Owl *	*Otus leucotis*
Anatidae	White faced Whistling Duck	*Dendrocygna viduata*
Accipitridae	White Headed Vulture	*Aegypius occipitalis*
Fringillidae	White Rumped Serin *	*Serinus leucopygius*
Apodidae	White Rumped Swift	*Apus caffer*
Anatidae	Yellow Billed Duck	*Anas undulata*
Sturnidae	Yellow Billed Oxpecker ♦	*Buphagus africanus*
Ciconiidae	Yellow Billed Stork *	*Mycteria ibis*
Ploceidae	Yellow Crowned Bishop *	*Euplectes afer*
Fringillidae	Yellow Fronted Serin *	*Serinus mozambicus*
Capitonidae	Yellow Fronted Tinkerbird ♦	*Pogoniulus chrysoconus*
Ploceidae	Yellow Mantled Widow Bird *	*Euplectes macrourus*
Motacillidae	Yellow Wagtail Δ	*Motacilla flava*
Zosteropidae	Yellow White Eye *	*Zosterops senegalensis*
Cisticolidae *	Zitting Cisticola	*Cisticola juncidis*

Table 2. Species diversity of birds during wet and dry seasons.

Sites	Season	Species Richness	Abundance	H	H_{max}	H/H_{Ma}	$D' = 1-\Sigma P_i^2 1/D$	
M. Habitat	Wet	58	1874	3.573	4.060	0.880	0.964	27.78
	Dry	77	2057	3.869	4.344	.891	.972	35.71
Dirma	Wet	32	11250	2.753	3.466	.795	.897	9.71
	Dry	34	6215	2.647	3.526	.751	.883	8.55
Farmland	Wet	48	27931	3.404	3.871	.879	.959	24.39
	Dry	47	44255	3.153	3.850	.819	.946	18.52
Angara	Wet	29	830	2.934	3.367	.871	.933	14.93
	Dry	34	570	3.203	3.526	.908	.948	19.23

H′ = Shannon-Wiener Diversity Index, $H_{max} = \ln S = \ln$ (total number of Species), H'/H_{Max} = Evenness, D = Simpson's Index, D′ =Simpson's Index of diversity.

Species similarity

During the wet season, the similarity of bird species observed between the farmland and Dirma (SI = 0.70) was high. However, less similarity was obtained between species of both modified habitat and the farmland, and modified habitat and Dirma (SI = 0.13). Similarity of bird species among the habitats was very low (SI = 0,10) (Fig. 3).

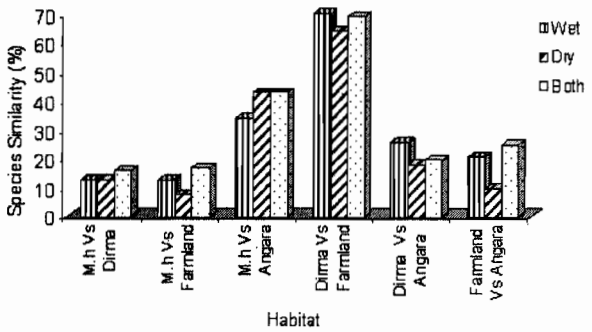

Fig. 3. Species similarity between the four habitats in the study area.

During the dry season, species similarity was high between farmland and Dirma (SI=0.64) followed by modified habitat and Angara (SI=0.43). During both seasons, highest similarity of bird species was obtained at the farmland (SI=75.76%), followed by the modified habitat (SI=59.25%).

Abundance of birds showed a significant change from wet to dry season; an increase from 1,874 to 2,057 and 27,931 to 44,255 in the modified habitat and farmland and a decline from 11,250 to 6,215, and 830 to 570 at Dirma and Angara, respectively. This was statistically significant at the level of 0.001, P = 0.00. There was no significant difference in species number in different habitat types during wet and dry seasons (Modified habitat χ^2=2.674, P=0.102, Dirma χ^2=0.061, P=0.806, Farmland χ^2=0.011, P=0.918 and Angara χ^2 = 0.397, P=0.529), however, there were differences in the abundance of individuals in different habitats. There was a significant difference in habitat association of birds (χ^2_{64}=877.518, P<0.01) during the wet season (Table 3). Highest positive association was obtained in a patch of vegetation dominated by fruiting plants.

Table 3. Habitat association of birds during the wet and dry seasons in the modified habitat.

		Fruit and flower	Trees	Fruits
Chi-square	Wet	186.966	314.759	375.793
	Dry	399.299	214.974	529.273
df	Wet	23	22	19
	Dry	24	17	18
Sig.	Wet	0.00	0.00	0.00
	Dry	0.00	0.00	0.00

The dry season data showed a high significant difference compared with the wet season (χ^2_{59} = 1143.55, P < 0.01). Highest positive interaction was obtained in the area where fruits were dominant. The modified habitat with varieties of fruits was favoured by different species of birds. At Dirma, the wet season data showed significant difference compared to the dry season (χ^2_{79} = 235.63, P < 0.01) showing the existence of interaction between birds and the use of croplands. During the dry season, significant difference between the bird species and habitat usage was obtained compared to the wet season (χ^2_{72} = 164.77, P < 0.05) (Table 4). There was more preference of birds to the riverine area than to other habitats.

Table 4. Habitat association of birds during the wet and dry seasons at Dirma.

		Riverine	Barely	Sorghum	Millet
Chi-square	Wet	46.00	64.750	75.625	49.250
	Dry	56.882	41.765	35.294	30.824
df	Wet	23	17	20	19
	Dry	14	22	18	18
Sig.	Wet	0.003	0.000	0.000	0.000
	Dry	0.000	0.007	0.009	0.03

During the wet season, significant difference was obtained in the farmland compared to the dry season (χ^2_{152} = 750.25 P < 0.01), showing the existence of interaction between bird species and usage of farmland (Table 5). During the dry season, significant difference was obtained in the farmland (χ^2_{141} = 595.85 P < 0.01). High positive association of birds was obtained in the mudflat associated with grassy area.

Table 5. Habitat association of birds during the wet and dry seasons in the Farmland.

	Season	Mud with grasss	Chickpea	Sorghum	Fenugreek	Vetch
Chi-square	Wet	143.617	128.745	137.213	92.787	93.489
	dry	188.883	64.125	154.500	168.29	174.500
df	Wet	30	27	25	29	30
	Dry	28	38	29	28	29
Sig.	Wet	0.00	0.00	0.00	0.00	0.00
	Dry	0.00	0.005	0.00	0.00	0.00

DISCUSSION

The study sites have high number of avian species. Diversity may be measured in number of species and can be expressed as an index that incorporates the species richness and evenness of a given community (Plotkin and Muller-Landau, 2002). Thus, species count of birds alone may provide a fairly good prediction of bird species diversity at any time of the year (Austin and Tomoff, 1978). An area is said to be important if it accommodates diversified species and this in turn indicates the heterogeneity of the area (Pomeroy, 1992). Most terrestrial environments undergo seasonal changes in habitat structure and food abundance and these changes are likely to influence diversity (Stephens *et al.*, 2003). During the wet season, the highest index of diversity was recorded from the modified habitat followed by the farmland. This high diversity may be due to the availability of food items and cover. During the dry season, the richest and more diversified sites (modified habitat and the farmland) showed high measure of Shannon-Wiener index. When the availability of favoured food declines, foragers switch to a different food source or forage in different localities (Stephens *et al.*, 2003).

During the wet season, Angara habitat harboured different species because of the presence of flowers, grasses and dense trees. This is in consistent with other studies that showed increase in species diversity with foliage diversity (MacArthur and MacArthur, 1961). However, during the dry season, with a change in vegetation structure, the number of bird species declined as a result of local migration to the neighbouring sites in search of food and cover. These birds migrated to the natural forest and the modified habitat near Angara.

The low number of species recorded at each site might be due to the less conspicuous nature of some species. It is often impossible to list all of the species in a natural community (Krebs, 1999). The species richness in the habitats showed variation, during both seasons. Forests within agriculturally disturbed landscapes have high species richness (Rodewald and Yahner, 2001). In the modified habitat, agricultural activities may provide food (fruits and flowers) for birds. In addition to this, some species such as kingfishers were using the edge of the lake near the modified habitat to fish. Therefore, edge effect also contributed to an increase in the number of species at this site as suggested by Baker *et al.* (2002).

During the wet season, the presence of high diversity of species can be measured as number of species and expressed as an index that incorporates the species richness and evenness of a given community (Plotkin and Muller-Landau, 2002). High community similarity between the farmland and Dirma signifies the presence of water bodies, croplands, and grassy areas in the two sites. This might be related to the increase in food resources that may increase the species composition of the avian community (Crozier and Gawlik, 2002). However, there was less similarity between the modified habitat and Dirma. This is because birds using the modified habitat are mostly forest dwellers and those in Dirma are wetland forms. Low overlap in species between two or more habitats emphasizes that such habitats are dissimilar (Johns, 1991).

The dependence of species habitat relationship on factors ranging from local vegetation structure to landscape features suggests that several processes operate simultaneously at different scales of influence. The present study showed the presence of strong interaction between the habitat type and specific bird species. This indicates that certain habitats are very important for the survival of birds. The presence of fruits, seeds and nectar in different patches attracts different species of birds (MacArthur *et al.*, 1962; Brooke and Birkhead, 1991).

The patches with high foliage serve food and cover for many bird species. This is because most of the insects are in the forested wetlands and uplands associated with flowers and fruits (Jaensch, 1994). During the dry season, the same patch that was dominated by fruits was highly preferred by birds. This is because throughout the year fruits were available in the irrigated modified habitat.

At Dirma where barley, sorghum and millet were cultivated, the wet season data showed preference to sorghum cultivated area. The availability of swamps in the sorghum area, which may provide good habitat for invertebrates, may provide additional food for birds. Some birds such as geese need to feed on weeds and grasses grown in between the crops (Fletcher, 2003; Jaensch, 1994). Availability of alternative food sources may also attract birds to any of the habitats (Brooke and Birkhead, 1991).

During the dry season, the river bank with some riparian vegetation was preferred by birds (Wang and Finch, 2002). This is because the area was marshy and might be suitable for the invertebrate

prey (Borghesio, 2004). Piscivorous birds were using the shallow area in order to get fish and worms (Wires and Cuthbert, 2000). However, during this season, there was a decline in bird number. This might be due to the requirement of permanent and healthy coastal marsh habitats. In the farmland, during the wet season, most of the area was flooded to an average depth of 50 cm. The mudflat with grass was relatively favoured by birds than the other croplands of the site as during and after searching for food, birds congregate on the mudflat.

During the dry season, cranes, geese and other wetland species were observed in the croplands, feeding on the seedlings and seeds. This coincides with the finding that farmland birds benefit from the seeds sown and the sowing practice that increases the availability of seeds to feed on. The availability of open water and marshes in the farmland was another factor for the presence of different species of wetland birds. This agrees with Brown *et al.* (2001) that species show a tendency to be confined to the habitat where they get their feeding, perching and nesting sites.

Farmland, where mostly cattle are observed grazing, was frequented by a large number of yellow wagtails, cattle egrets, starlings and crows. This might be due to the presence of cattle dung and ticks on the animals. The preference of birds to feed on short grasses with cattle and sheep increases the number of subsurface invertebrates as a result of the dung and disturbances. On this site, compared to the other species of birds, African spoonbills were few in number because of the destruction of shore plants due to farming activity. Disappearance of invertebrate feeding birds like African spoonbills can be caused by the decrease in the macrophytes and other aquatic plants that serve as food and shelter for the invertebrates (Borghesio, 2004). Reduction of natural marshy habitat and loss of certain habitat components have marked effects on wetland dependent species diversity and number.

At the same time, in the farmland and modified habitats, the diversity of avian species is high. Many bird species were attracted as a result of ample supply of resources. The high anthropogenic effect in these areas has indirectly contributed to the significance in the biodiversity and conservation value of these disturbed habitats. However, this does not mean that modified habitats should be expanded. The original habitat when altered can affect the survival of certain species of birds whereas others might be attracted by the modification of the habitat resulting in different faunal composition.

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REFERENCES

1. Austin, G.. T. and Tomoff, C.S. (1978). Relative abundance in bird populations. *Am. Nat.* **112**:695–699.
2. Baker, J., French, K. and Whelan, R.J. (2002). The edge effect and ecotonal species: Bird communities across a natural edge in southeastern Australia. *Ecology* **83**:3048–3059.
3. Bibby, C.J., Burgess, N.D. and Hill, D.A. (1992). *Bird Census Techniques*. Academic Press, Harcourt Brace, London, 239 pp.
4. Borghesio, L. (2004). Variation in water bird populations of two freshwater lakes in Marsabit National Park, northern Kenya. *Scopus* **24**:1–10.
5. Brown, J.D. Robinson, S.K. and Thompson, F.R. (2001). The role of disturbance in the ecology and conservation of birds. *Ann. Rev. Ecol. Syst.* **32**:251–276.
6. Brooke, M. and Birkhead, T. (1991). *The Cambridge Encyclopedia of Ornithology*. Cambridge University Press, Cambridge, 362 pp.
7. Crozier, G.E. and Gawlik, D.E. (2002). Avian response to nutrient enrichment in an oligotrophic wetland, the Florida Everglades. *The Condor* **104**:631–642.
8. EWNHS (Ethiopian Wildlife and Natural History Society) (1996). *Important Bird Areas of Ethiopia: a first Inventory*. Ethiopian Wildlife and Natural History Society, Addis Ababa, 300 pp.
9. Fletcher, R. (2003). *Loss of wetlands: How are bird communities affected?* BioScience Magazine. American Institute of Biological Sciences, Missoula, 24 pp.
10. Fuentes, E.R. (1999). The Role of Restoration in Sustainable Bio-resources Management. *Natu. Resour. Forum* **23**:79–80.
11. Gregory, R.D., Noble, D. G. and Custance, J. (2004). The state of play of farmland birds: population trend and conservation status of lowland farmland birds in the United Kingdom. *Ibis* **146**:1–13.
12. Jaensch, R.P. (1994). An inventory of wetlands of the sub-humid tropics of the Northern Territory. A

report to the Australian Nature Conservation Agency. *Wetl. Arid* 1:105–117.

13. Johns, A.D. (1991). Responses of Amazonian rain forest birds to habitat modification. *J. Trop. Ecol.* 7:417–437.
14. Krebs, C. J. (1999). *Ecological Methodology.* 2nd ed. Addison-Wesley Longman, Menlo Park, California, 1–620.
15. MacArthur, R. and MacArthur, J. (1961). On bird species diversity. *Ecology* **42**:594–598.
16. MacArthur, R., MacArthur, J. and Preer, J. (1962). On bird species diversity II. Prediction of bird census from habitat measurements. *Am. Nat.* **96**:167–174.
17. Oindo, B.O., Deby, R.A. and Skidmore, A. (2001). Environmental factors influencing bird species diversity in Kenya. *Afr. J. Ecol.* **39**:295–302.
18. O'Reilly, L., Ogada, D., Palmer, T.M. and Keesing, F. (2006). Effects of fire on bird diversity and abundance in an East African savanna. *Afr. J. Ecol.* **449**:165–170.
19. Petrie, S.A. and Francis, C.M. (2003). Rapid increase in the Lower Great Lakes population of feral mute swans: a review and a recommendation. *Wildl. Soc. Bull.* **31**:407–416.
20. Plotkin, J.B. and Muller-Landau, H.C. (2002). Sampling the species composition of a landscape. *Ecology* **83**:3344–3356.
21. Pomeroy, D. (1992). Counting Birds, A guide to Assessing Numbers, Biomass and Diversity of Afrotropical Birds. African Wildlife Foundation, Nairobi, Kenya. 48pp.
22. Rodewald, A.D. and Yahner, R.H. (2001). Influence of landscape composition on avian community structure and associated mechanisms. *Ecology* **82**:3493–3504.
23. Stephens, P.A., Freckleton, R.P., Watkinson, A.R. and Sutherland, W.J. (2003). Predicting the response of farmland bird populations to changing food supplies. *J. Appl. Ecol.* **40**:970–983.
24. Urfi, A.J., Sen, M., Kalam, A. and Meganathan, T. (2005). Counting birds in India: methodologies and trends. *Current Sci.* **89**:1–10.
25. Wang, Y. and Finch, D.M. (2002). Consistency of mist netting and point counts in assessing land bird species richness and relative abundance during migration. *The Condor* **104**:59–72.
26. Williams, J.G.. and Arlott, N. (1980). *Collins Field Guide to Birds of East Africa.* Harper Collins Publishers, Hong Kong, 376 pp.
27. Wires, L.R. and Cuthbert, F.J. (2000). Trends in Caspian Tern numbers and distribution in North America. *Water Birds* **23**:388–402.