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Environmental determinants influencing seasonal variations of bird diversity and abundance in wetlands, Northern Region (Ghana)

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ABSTRACT

The study assessed major environmental determinants influencing bird community in six wetlands over a 2-year period. A combination of visual and bird sounding techniques under population monitoring survey was used to determine the seasonal variations in bird abundance. A total of 1,169 birds from 25 species and 885 individuals from 23 species were identified in the wet and dry season respectively. The shallow close marshes supported the greatest number of birds ($p < 0.05$) compared to the riparian wetlands. Bird diversity were significantly higher in the wet season than in the dry season ($F = 4.101$, $p < 0.05$). Cattle egret (*Bubulcus ibis*) and Marsh warbler (*Acrocephalus palustris*) were the most abundant. Using the IUCN 'Red List' database guide, we noted that 96.2% of birds identified were least concern (LC), while the Yellow weaver bird (*Ploceous megarhynchus*) was the only vulnerable species (VU) and represented 3.8%. From the three variables tested, bushfire and farming practices were the major threats and cumulatively explained 15.93% (wet season) and 14.06% (dry season) variations in bird diversity and abundance. The findings in this study will help managers of wetlands design conservation measures that will check current threats on birds classified as least concern from becoming vulnerable in the future.

Keywords: environmental assessment, bird population, bird density, canonical correspondence analysis, Habitat preference, IUCN Red list

INTRODUCTION

Birds play a vital role in enriching the biodiversity of wetlands. This explains why wetlands are foremost recognized as a haven for waterfowl by Ramsar International in 1971 [1]. Their sensitivity to habitat perturbation makes them suitable as bio indicators to wetland health, through their population size and composition. Globally, over 150 bird species are reportedly lost since the year 1500 AD [2]. Recent reports have shown that birds have gone extinct at an exceptionally high rate, estimated to be 1,000 to 10,000 times the natural background rate [2]. Today, one in eight bird species is threatened with global extinction, with 190 species critically endangered and particularly alarming are sharp declines in a number of formerly common and widespread species, such as cranes and some waders. The International Union for the Conservation of Nature (IUCN) 'Red List' have shown documented evidence that rate of extinction are getting worse among species confined to small islands to continental scale [2]. This loss is largely due to their increasingly intolerance to the slightest ecosystem disturbance [3] which is linked to pollution [4], habitat type and bird distribution [5, 6], wetland patch size [7], cutting of mangrove vegetation [8], farming practice and urban development within the wetland catchment [9, 10, 11] and habitat fragmentation [12]. These human disturbances at the landscape scale, has structured the population and assemblages of birds because of their highly-specific habitat requirements [13, 14].

Scientific studies on bird ecology, diversity, abundance and spatial distribution is simply absent or poorly investigated in the Northern Savannah wetlands of Ghana. However, unlike the Northern Region, research on birds in the Southern forest belt [15, 16, 17] and coastal wetlands have been considerably extensive [18, 19, 20, 8, 21, 22]. The only notable work previously conducted in one of the wetlands under the current study (Kukobila wetland) was to establish a baseline of the types of birds found in the wetland [23]. Understanding overall bird responses to disturbances will as well require the assessment of the various disturbance scenarios on a seasonal basis, since the impacts of environmental determinants are many and vary along seasonal trends. Ecological changes and land use activities within wetlands catchment in Northern Region of Ghana are seasonally driven and can potentially affect bird assemblage, composition and habitat preference. For instance, it has been observed that in summer, salt marshes, with dominant plant species like *Carex* and *Puccinellia*, are key habitats for raising young goslings, while lake shorelines with fine freshwater grasses and sedges are important for molting birds [24]. Changes in annual water depths affect the breeding and foraging habitat preference for a variety of wetland-dependent bird species [25]. Example of marsh-dependent birds in Great Lakes coastal marshes, affected by long-term changes and annual water level fluctuations include: swamp sparrow (*Melospiza georgiana*), American coot (*Fulica americana*), least bittern (*Ixobrychus exilis*), marsh wren (*Cistothorus palustris*) and pied-billed grebe (*Podilymbus podiceps*) [26].

Of the 728 bird species recorded in Ghana [18, 19, 20] six of them are considered threatened and 12 near threatened [27]. For example the National Biodiversity Strategy for Ghana Report mentioned hornbill, parrots and birds of prey, as the few keystone species under threat [28]. Though these findings were largely from the Southern sector of Ghana (i.e. forest belt and coastal zones), the phenomenon suggests that some birds in the Northern Savannah zone might be under threat or at risk of extinction, giving recent undocumented, but observed environmental disturbances on the wetlands. Therefore, the absence of a scientific investigation makes it impossible to determine the current state of bird population, composition and habitat preference (using their proximate cues), on a seasonal basis among wetlands in the Northern Savannah zone. In this study, we apply multivariate ordination techniques to determine the influence of three environmental factors on the seasonal variation of bird population, diversity and habitat preference among the wetlands. The outcome of this investigation will help equip wetland managers with first-hand information on the types of seasonal disturbance scenarios and how these disturbances could potentially modify bird assemblage in the future and the selection of appropriate conservation approach towards enhancing the sustainability of their population.

MATERIALS AND METHODS

The study was carried out in six wetlands located in the Northern region of Ghana, with their co-ordinates as follows: (i) Wuntori (N09° 08.335' W00° 1 09° .685'); (ii) Kukobila (N10° 08.723' W00° 48.179'); (iii) Tugu (N09° 22.550' W00° 35.004'); (iv) Bunglung (N09° 35.576' W00° 47.443'); (v) Adayili (N09° 41.391' W00° 41.480') and (vi) Nabogo (N09° 49.941' W00° .51.942') (Fig. 1). The six sites lie on the extensive floodplain along the course of the White Volta River, which has overtime become incised and modified through meandering and aligning along various topographic features. This has led to the development of streams that have diverted from the main White Volta [29]. All six wetlands were classified as close shallow marshes (Wuntori and Tugu wetlands), open deep marsh (Kukobila wetland), riparian wetlands (Adayili and Nabogo wetlands) and artificial wetland (Bunglung wetland). The hydrological regimes of the six wetlands under study were typical of permanent wetlands, whose depth at low tide did not exceed 2 m on average. Sizes of the wetlands were as follows: (a) Wuntori = 7.7 ha; (b) Kukobila = 5 ha, Tugu (c) 2.7 ha; (d) Nabogo = 7.9 ha; (e) Adayili = 6.7 ha and (f) Bunglung = 11.5 ha.

Annual rainfall is in the range of 1000-1,300 mm/p.a and the wet season lasts from June to early October, while the dry season last from November to May. Average temperature varies between 14°C and 40°C [29]. Altitude ranges between 108 – 138 meters above mean sea level. The vegetation cover is a mixture of grassland dominated by *Lersia hexandra* and woodland dominated by Mahogany (*Khayasenegalensis*) and shea tree (*Vitellaria paradoxa*) interspersed with shrubby communities of *Mitragynainermis* and *Ziziphus abissynica*. The trees are relatively short with thick bark and occlusions, signifying their adaptation to the cyclical dry season bush fires. Crop farming, livestock rearing and fishing are the main stay of activities among the inhabitants.

2.1: Sampling procedure for bird species

Population monitoring type of survey was used to determine the seasonal variations in bird population, using transects line approach [30]. Ten plots in each of the six wetlands of 60 m x 10 m dimension were laid. The distance between one sampling plot and the other was 5 m. Birds were counted each of the ten plots with increasing five class distance scale (1-10, 10–20, 20–40, 40 - 50 and 50 – 60 m) from the base of the transect line, using visual approach and vocally through bird sounding technique developed by the Royal Society for the Protection of Birds [31]. Bird sounding technique is software of recorded sounds of different birds, accompanying their names and photos. This

vocal technique was only used to count birds that were hidden in dense vegetation and difficult to visualize. This was made possible after observing and listening to the same bird screech, chirps or tweet in the open vegetation in previous sampling. Repeated and careful listening of the bird sound in the thick vegetation for 5 minutes was followed by playing the composed sound in order to identify the right bird. Also, birds that were hidden in the thicket vegetation were counted through a deliberate agitation of the vegetation. This was done, by carefully throwing a stone inside the dense vegetation, in order to force the hidden bird(s) to fly out. They were counted after settling on the open vegetation. Counting of birds was done from 0700 – 01100 GMT when most of the birds were feeding. Counting was done once a week and hence four times in month. Birds were counted in the dry (absence of rain or harmattan season) and wet seasons (rainy season). The total number of birds recorded was compiled on a monthly basis. Bird nest were not counted, since it was impossible to establish the type and number of birds co-habiting a nest. A pair of Bushnell Falconbinoculars with a 10 x 50 mm dimension was used to observe birds located beyond 20 m distance for morphological features like colour and structure of the beak, colour of tail feather, colour of feathers around the neck, colour of the head feathers and the presence of comb-like feathers (See Birds of Ghana Galleries [32]).

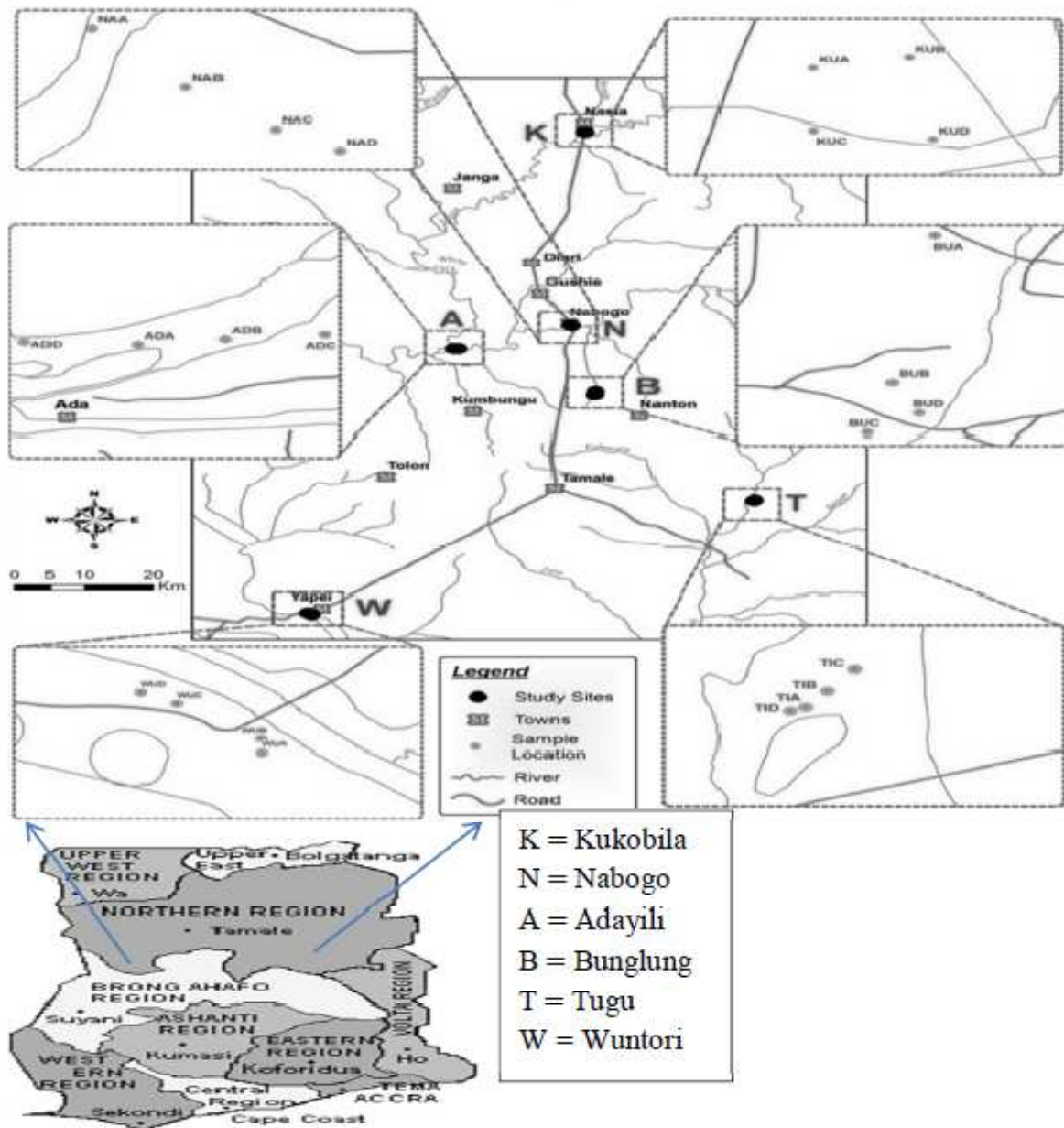


Fig.1: Map of the study areas, showing the location of the wetlands in the floodplains of the White Volta River catchment, Northern Region

2.2: Environmental assessment

Four environmental drivers of change were assessed and included: bushfire, erosion intensity, grazing intensity and farming activities. A land disturbance index score (LDI) was used to estimate the intensity of impact of these environmental drivers of change on the wetlands (farming activities, grazing intensity, erosion and bush fire) [33]. Assessment of the area disturbed was carried out within 1.2 km radius starting from the hydric delineated zone of the wetland. This is because all land use activities assessed were observed within this radius following a preliminary survey of the wetlands. The LDI is computed as Land area of wetland disturbed over the total area of the Whittaker plot (1000 m²) multiplied by 100% as shown below:

$$LDI = \frac{L_d}{T_w} \times 100$$

where

LDI is land disturbance index, L_d is land area disturbed by farming activities, grazing intensity, erosion and bush fire
 T_w = Total area of the Whittaker plot. LDI scores were assigned as follows: 1-20% = 1, 21-40% = 2, 41-60% = 3, 61-80 = 4 and 81-100% = 5. A score of 1 is interpreted as less disturbed, 2-3 as moderately disturbed and 4-5 as highly disturbed.

2.3: Statistical analysis

A Canonical correspondence analysis (CCA) was performed to determine the influence of environmental drivers of change on variations on bird diversity, abundance and spatial distribution [34], using two analytical packages- Environmental community analysis version 1.4 (ECOM.exe) [35]. Shannon-Weiner index was performed to determine the current status of bird community composition. Shannon-Weiner index equation expressed as:

$$H' = -\sum_{i=1}^s p_i (\ln p_i) \quad [36].$$

Where s is the number of species and P_i is the proportion of individuals or the abundance of the i th species expressed as a proportion of the total cover and \ln is a natural logarithm [36]. Species evenness distribution was evaluated using Pielou evenness index (J) expressed as:

$$J = H' / \ln S$$

Where H' is the diversity index, S is species number and \ln is natural logarithm [37]. Species richness was quantified using Margalef's index (D) for species richness expressed as:

$D = (S-1) / \ln N$ [38]. A one-way ANOVA was applied to test whether bird diversity, evenness and species richness differed significantly from one wetland to the other, using SPSS version 16.0. Kruskal-Wallis test was applied to test the differences in the mean of the diversity index.

RESULTS

A total of 1, 169 individual birds from 25 species were identified and counted during the wet season, while 885 individuals from 23 species were observed in the dry season (Fig.2, Table 1). Of the 25 species counted, 24 species (96.2%) were classified as List concern (LC), using the IUCN 'Red List' database guide (Table 1). The Yellow weaver bird (*Ploceousmegarhynchus*) was only the species classified as vulnerable (VU) and represented 3.8%. This species was restricted to thorny tree (*Ziziphusabyssinica*) and some tufted and rough edge grasses such as *Deplachnefusca* along the banks of Nabogo forested and the Bunglung man-made wetlands. All bird species were classified into 21 bird group, of which waders, finches and pigeon and doves, had two species each classified under them (Table 1). Cattle egret (*Bubulcus ibis*) was the single most abundant species in the wet season while Marsh warbler (*Acrocephaluspalustris*) was the single most abundant species in the dry season (Table 1). Comparing all the four wetland classes in both seasons, the shallow close marshes of Wuntori and Tugu supported the greatest number of birds followed by the riparian wetlands (Adayili and Nabogo) (Fig. 2). Birds population in the three marshes (Tugu, Wuntori and Kukobila wetlands) and the two riparian wetlands substantially differed in both seasons ($p < 0.05$) whereas species in artificial wetland (Bunglung) did not vary significantly ($p > 0.05$).

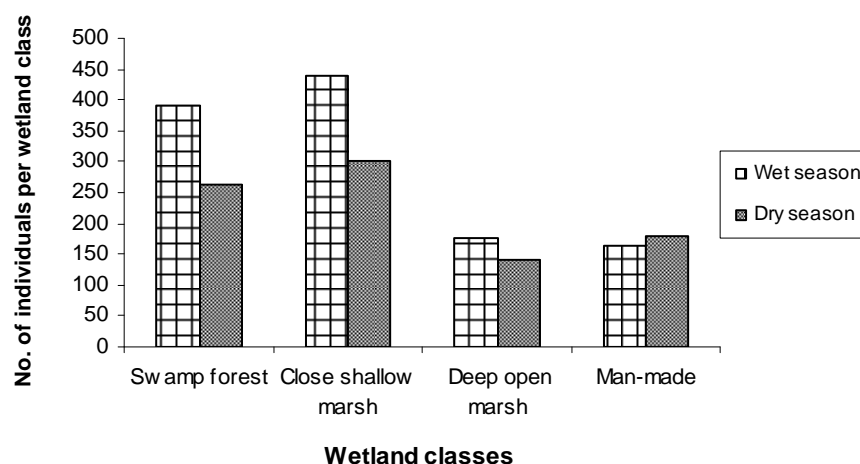
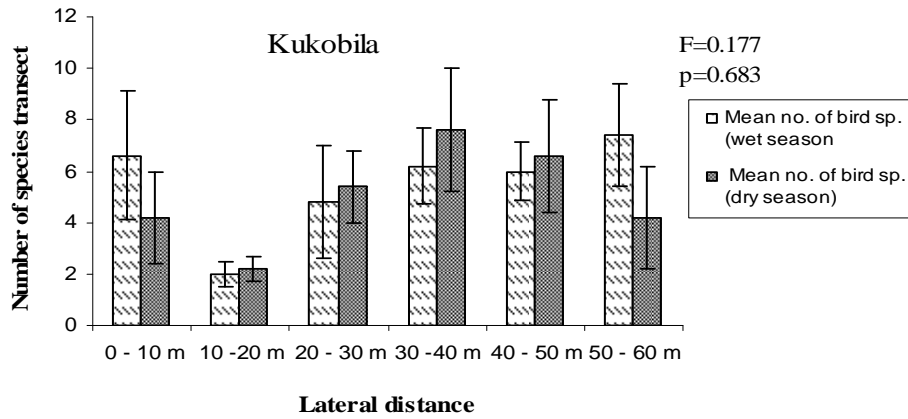


Fig.2: Comparison of bird population and distribution pattern among the different wetland classes in both wet and dry seasons

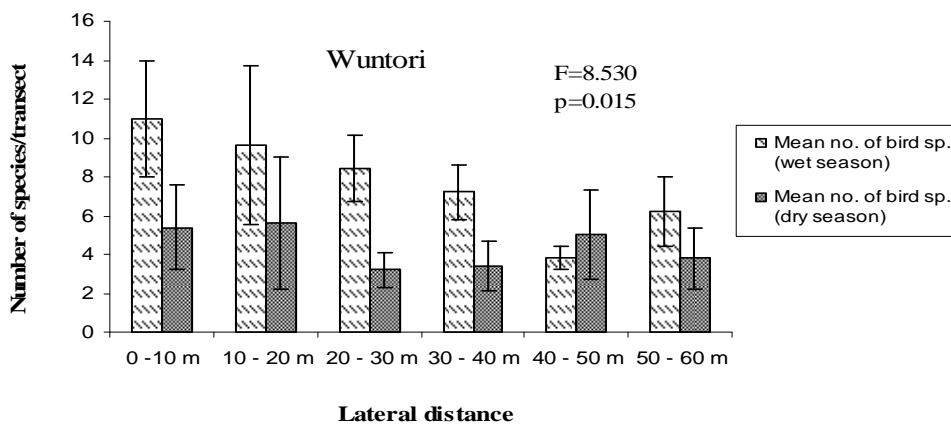
Table 1: List of bird species detected and their status, with respect to the IUCN global 'Red list' database. The status abbreviations are as follows: Least concern (LC); Vulnerable (VU); Threatened (T); Near threatened (NT); Critical (CR); Extinct (EX)

Family	Scientific name	Bird group	Common name	IUNC Status
Jacaniidae	<i>Actophilornis Africana</i>	Coots	African jacana	LC
Anatidae	<i>Nettastauritis</i>	Bitterns and herons	African pygme-goose	LC
Lybiidae	<i>Lybiusdubius</i>	Woodpeckers	Bearded barbet	LC
Columbidae	<i>Turturabyssinicus</i>	Pigeons and doves	Black-billed dove	LC
Malaconotidae	<i>Tchagraaustralis</i>	Shrikes	Black-crown tchagra	LC
Charadriidae	<i>Vanellustectus</i>	Plovers and lampings	Black headed plover	LC
Ardeidae	<i>Bubulcus ibis</i>	Bitterns and heron	Cattle egret	LC
Nectariniidae	<i>Anthreptescollaris</i>	Tree creepers	Collared sunbird	LC
Phasianidae	<i>Pternistisbicalcaratus</i>	Pheasants and partridges	Double spurred francolin	LC
Muscicapidae	<i>Muscicapagambagae</i>	Flycatchers	Gambaga flycatcher	LC
Falconidae	<i>Falco biarmicus</i>	Falcons	Lanner falcon	LC
Meropidae	<i>Meropsusillus</i>	Bee eaters	Little bee eater	LC
Acrocephalidae	<i>Acrocephaluspalustris</i>	Warblers	Marsh warbler	LC
Ploceidae	<i>Euplectesfranciscanus</i>	Finches	Northern red bishop	LC
Bucerotidae	<i>Tockuserythrorhynchus</i>	Hornbills	Northern red hornbill	LC
Alcedinidae	<i>Cerylerudis</i>	Kingfishers	Pied kingfisher	LC
Ploceidae	<i>Queleaquelea</i>	Weavers	Red-billed quelea	LC
Certhiidae	<i>Salpormisspilonotus</i>	Tree creepers	Spotted creeper	LC
Ardeidae	<i>Areodeolarolloides</i>	Waders	Squacco heron	LC
Columbidae	<i>Streptopeliavinacea</i>	Pigeons and doves	Vineaceous dove	LC
Sturnidae	<i>Cinnyricinclusleucogaster</i>	Terns	Violet backed stirling	LC
Musophagidae	<i>Criniferpiscator</i>	Touracos	Western gray plantain eater	LC
Ciconiidae	<i>Ciconiaepiscopus</i>	Waders	Wooly necked stock	LC
Accipitridae	<i>Milvusaegyptius</i>	Swallows	Yellow-billed kite	LC
Ploceidae	<i>Ploceousmegarhynchus</i>	Finches	Yellow weaver bird	VU

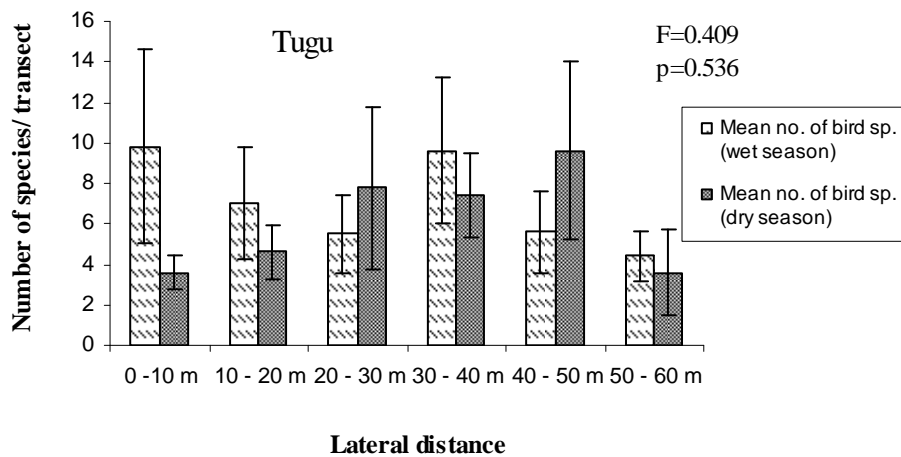
Mean number of birds in each line transect per plot, ranged between 2.0 ± 0.5 to 11.6 ± 2.8 in the wet season and 2.2 ± 0.5 to 9.6 ± 4.4 in the dry season (Fig. 3). Nabogo wetland registered the highest mean number of birds per plot while Bunglung artificial wetland was the least recorded in the wet season. Overall, mean bird diversity in the wet season ($H' = 1.361 \pm 0.14$ and 1.75 ± 0.13) was significantly higher than that of the dry season ($H' = 1.24 \pm 0.14$ and 1.56 ± 0.07) ($F = 4.101$; $p < 0.05$) (Fig. 3). Bird diversity generally followed their evenness distribution among the wetlands, with some slight variations (Kruskal-Wallis test, $p = 0.297$) (Figs.4&5). Comparatively, the marshes (Wuntori and Kukobila) were more diverse in the wet ($H' = 1.75 \pm 0.13$) and dry ($H' = 1.56 \pm 0.07$) seasons respectively than the riparian wetlands (Nabogo- $H' = 1.67 \pm 0.08$ wet; $H' = 1.52 \pm 0.04$ dry) (Figure 4). However, the riparian wetlands (e.g., Nabogo) were more species rich ($D = 1.96 \pm 0.25$) than the marshes (e.g., Wuntori- $D = 1.87 \pm 0.29$). The artificial wetland (Bunglung) was the least in diversity ($H' = 1.57 \pm 0.09$ wet, $H' = 1.36 \pm 0.14$ dry) and species rich (1.36 ± 0.18) (Figs.4 &6).



A



B



C

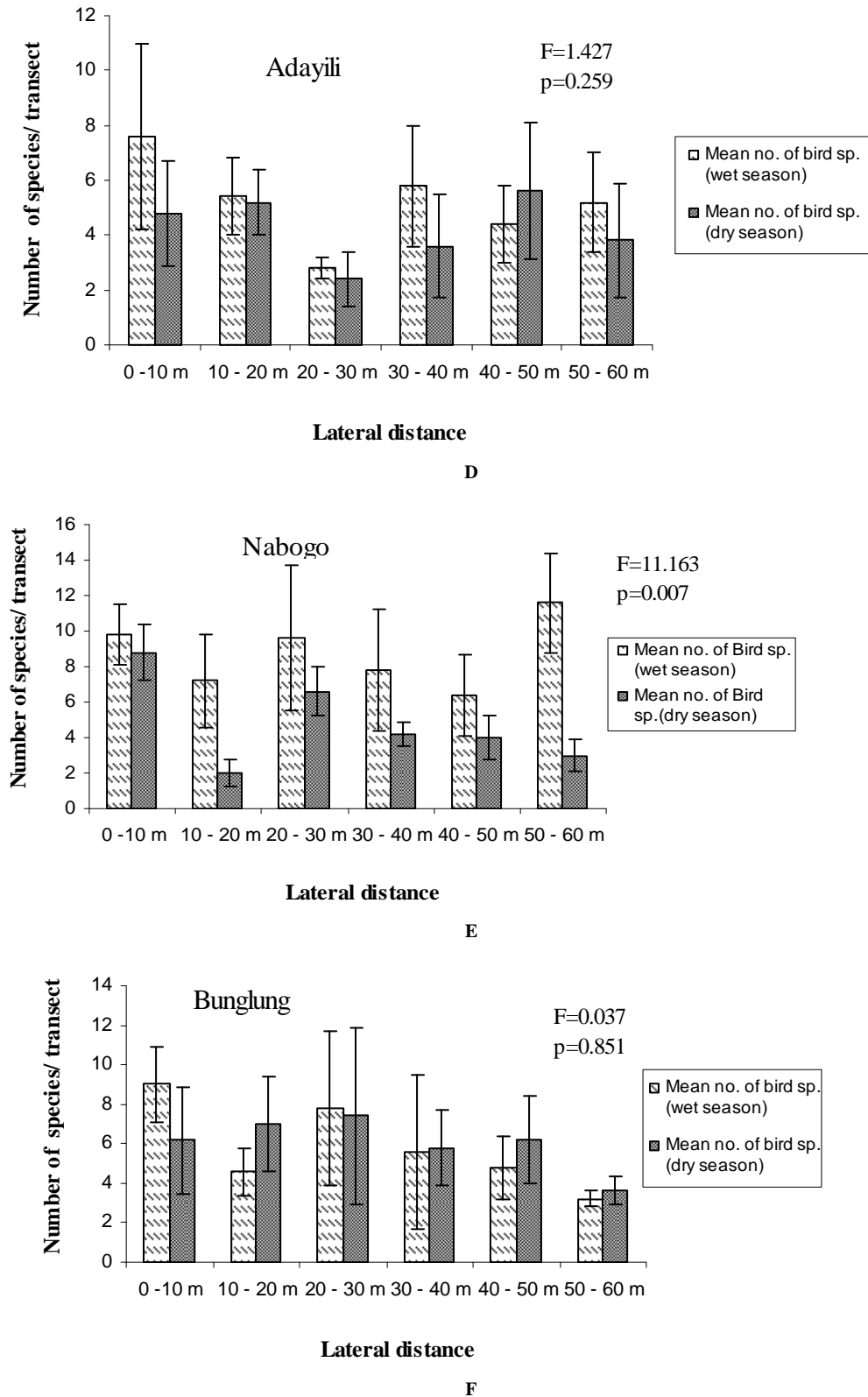


Fig. 3: Mean number of birds counted on different plots across the six wetlands (A-F) for wet and dry seasons

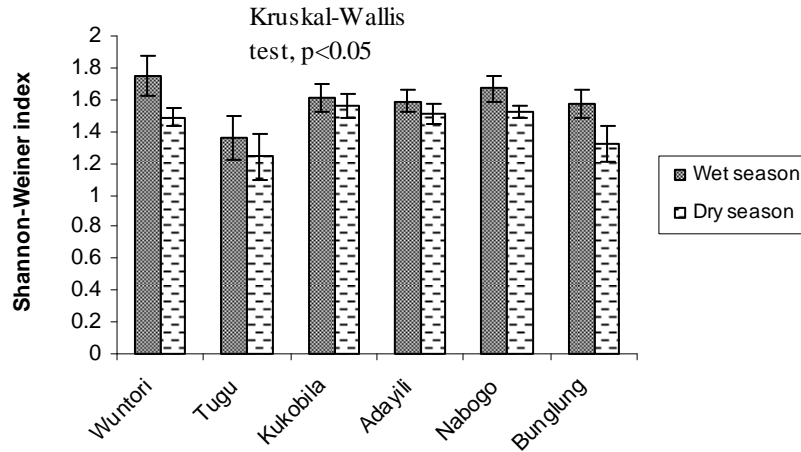


Fig.4: Variations in mean diversity in the wet and dry season

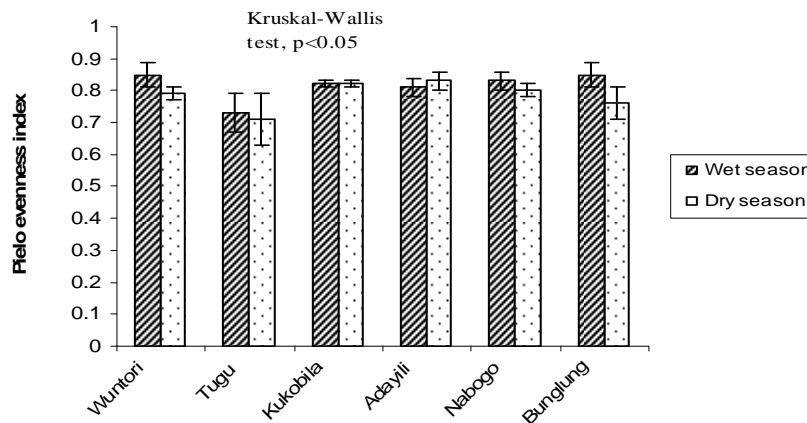


Fig. 5: Bird evenness distribution of birds in the wet and dry seasons

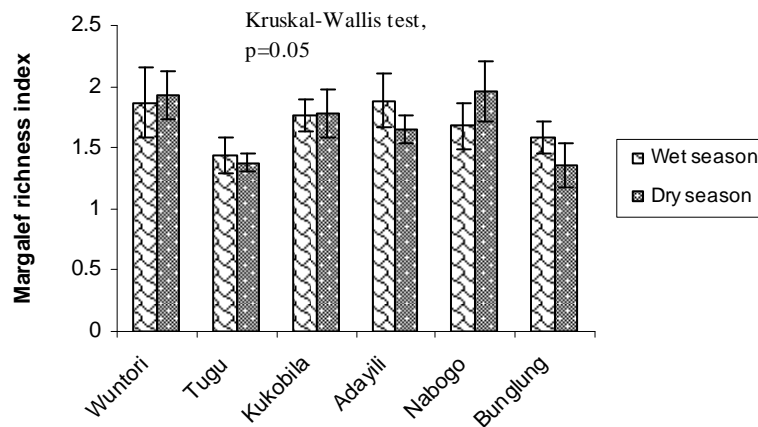


Fig. 6: Comparison of bird richness in the six wetlands in wet and dry seasons

Relationship between environmental factors and bird assemblage

Canonical correspondence analysis (CCA) diagram showed that bird diversity and abundance were generally influenced by farming practices, bushfires and grazing intensity although the level of impact varied between the wet and dry seasons (Figs. 7 and 8). Although farming practices was a common activity within the catchment of the wetlands in the wet season, the situation was more severe and widespread within 100 m radius in the artificial wetland, with almost 90% of the fertile lands cultivated. Birds that were identified in these farmed plots were less diverse, low in abundance and sensitive to disturbances. Examples included: black-billed dove (*Turturabyssinicus*),

marsh warbler (*Acrocephaluspalustris*) and the yellow weaver bird (*Ploceousmegarhynchus*) compared with birds found in the remaining five wetlands. Heavily grazed plots in Wuntori and Tugu shallow marshes, with severe animal trampling, supported high abundance of birds like the African pygme-goose (*Nettapusauritus*), collard sunbird (*Anthreptescollaris*), African jacana (*Actophilornisafricanus*), Pied kingfisher (*Ceryle rudis*) and the Squacco heron (*Areodeola rolloides*) (Fig. 7).

Bushfire was the key human-led factor that consistently influenced bird population and diversity in the two riparian wetlands in the dry and wet seasons, and a few plots in the Tugu shallow marsh. Observed patchy conditions brought about by previously and recent burnt areas (for the purposes of farm clearing and charcoal production) were more extensive in Adayili and Nabogo forested wetlands than tin Tugu wetland. This disturbance scenario rather attracted diverse birds such as Little bee eater (*Meropspusillus*), Yellow weaver bird (*Ploceousmegarhynchus*), Spotted creeper (*Salpornisspilonotus*), Northern red hornbill (*Tockuserythrorhynchus*) and Western gray plantain eater (*Criniferpiscator*) to these wetlands, in spite of the narrow ranges that were created (Fig. 7). Majority of species not captured in the ordination diagrams, were detected in habitats with average conditions of the environmental factors evaluated. Cumulative percentage variance of the species–environment relationship (axis I = 5.54 and axis II = 10.39) explained 15.93% of the variation in the weighted averages of the 25 species in relation to three environmental variables in the wet season (Table 2a). The rather weak correlation between species–environmental factors in the first three axes ($r = 0.430$, $r = 0.523$ and $r = 0.320$) reflected in the high diversity registered in the wet season (Table 2a).

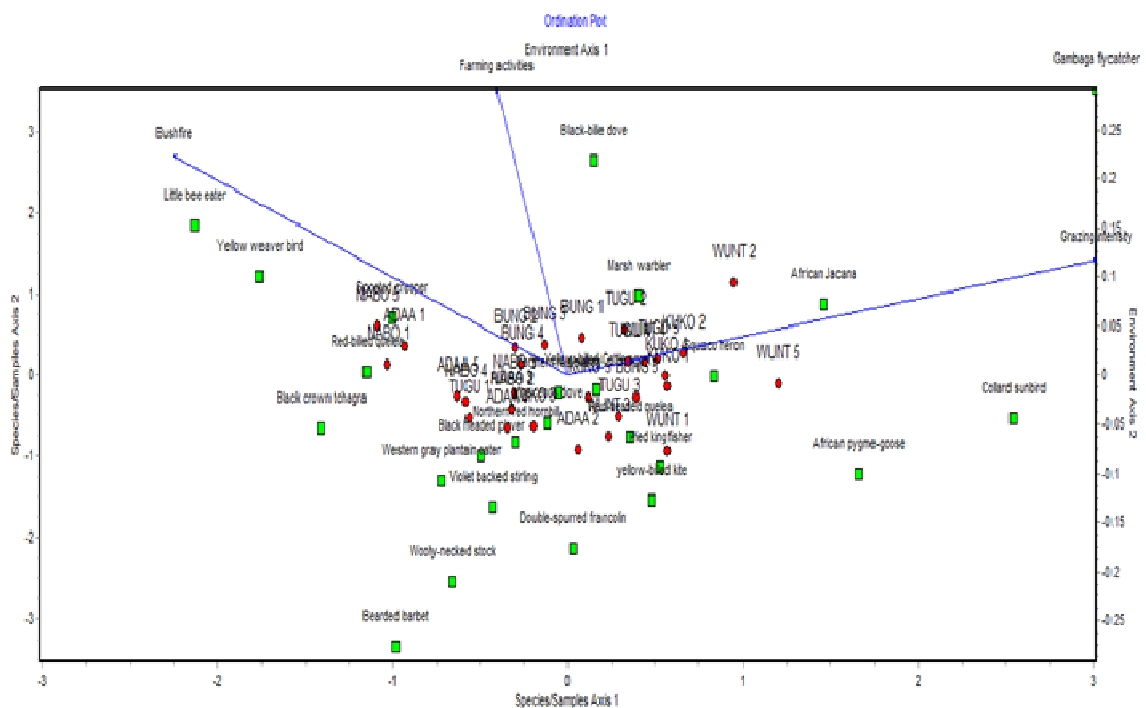


Fig. 7: Canonical correspondence analysis (CCA) ordination diagram, showing the relationship between environmental variables and bird species across the six wetlands, in the wet season. The red circles represent sample plots, the green squares represent bird species and the arrows represent each of the environmental variables plotted pointing in the direction of maximum change of explanatory variables across the six wetlands

The dry season saw water from the three marshes (Kukobila, Wuntori and Tugu) and Bunglung were drained to irrigate nearby farms. Consequently, birds such as African jacana (*Actophilornisafricanus*), Lanner falcon (*Falco biarmicus*), Marsh warbler (*Acrocephaluspalustris*) and Black billed dove (*Turturabyssinicus*), were confined to the central part of the wetlands that had isolated pools of water and vegetation (Fig. 8). Although birds were spatially diverse in these wetlands, they were less abundant. However, the population of Yellow billed kite increased in the first 0 – 10 m and 10 – 20 m transect lines, where incidences of bushfire was observed. All the three wetlands with inherent human-led disturbances (grazing intensity and farming activities) were spatially auto correlated in the dry season (Fig. 8).

Cumulative percentage variance was explained by the first two axes (axis I = 8.963 and axis II = 5.092) and accounted for 14.06% of the variation in the weighted averages of the 23 species diversity and abundance (Table

2b). The low bird diversity recorded in the dry season, was further reflected in the strong correlation with the environmental factors on the first three axes of the of the ordination diagram ($r = 0.581$, $r = 0.644$ and $r = 0.629$) (Fig. 8).

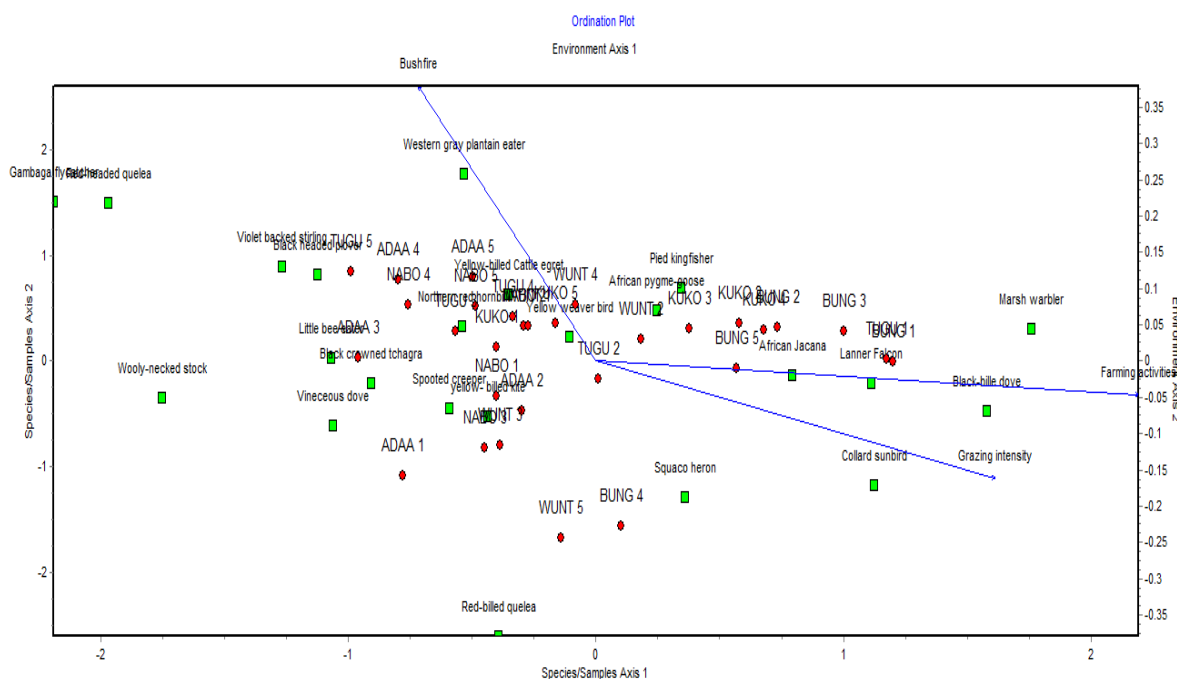


Fig. 8: Canonical correspondence analysis (CCA) ordination diagram showing the relationship between environmental factors and bird assemblage in the six wetlands in the dry season. Diagram description is the same as in Figure 7

Table 2a: Summary of CCA axis lengths for birds, showing the levels of correlation between axes and environmental gradients, percentage variance of species and species-environment relationships

Wet season			
	Axis1	Axis 2	Axis 3
Canonical eigenvalues for bird sp.	0.163	0.143	0.078
Pearson correlation sp-env'tal scores	0.722	0.795	0.558
Kendall rank correlation sp-env'tal scores	0.430	0.523	0.320
Cumulative percentage variance	5.54	10.39	13.05
% variance explained	5.54	4.85	2.66
Number of sites	=30		
Number of species (response variables)	= 25		
Number of environmental variables	= 3		

Table 2b: Summary of CCA axis lengths for birds, showing the levels of correlation between axes and environmental gradients, percentage variance of species and Species-environment relationships

Dry season			
	Axis1	Axis2	Axis 3
Canonical eigenvalues for bird species	0.29	0.16	0.10
Pearson correlation sp-environmental scores	0.86	0.65	0.61
Kendall rank correlation for sp-env'tal scores	0.58	0.64	0.63
Cumulative percentage variance	8.97	14.1	17.2
% variance explained	8.96	5.09	3.14
Number of sites	=30		
Number of species (response variables)	=25		
Number of environmental variables	= 3		

DISCUSSION

There have been reported declines in the global diversity of habitat-specific birds and shorebird populations, since 1980 – 2007 [39]. This decline has been linked to a number of anthropogenic factors, including pollution [4], cutting of mangrove vegetation [8] and water fluctuations [25, 26). In this study, however, bird population was influenced by farming practices, grazing intensity and bushfires. Although farming activities had intensified especially in the wet season, bird diversity was fairly high in the wet season than in the dry season, thus suggesting the presence of food availability, stable hydrological regime, dense vegetation (serving as secured nesting sites against hunting) and the near absence of inflammable litter that could cause bushfire. In their study on the seasonal changes and the

influence of land cover on breeding birds, [40] revealed that mean values of Margalef richness, Shannon diversity, and β -diversity of birds were higher in winter than summer periods. The authors concluded that the high mean values of richness and diversity could be due to 'intermediate disturbance hypothesis' leading to seasonal changes in habitat heterogeneity. It has also been observed that resident bird species diversity was higher during winter, both in terms of species richness and evenness in their distribution number than in summer, in the Comana Lake - Romanian Plains [41]. The present study also observed the surge of African Jacana (*Actophilornis africanus*) and Cattle egrets (*Bubulcus ibis*) abundance in some of the wetlands that farming was widespread in the wet season. The patchy condition created during farming activities and previously burnt areas, could have contributed in the increase in bird numbers.

Pre-agricultural loss of bird numbers as against an increase in global bird populations, in the advent of agricultural activities has been documented, with the conclusion that poor agricultural practices rather than destroy bird habitats, contributed in increased bird population [42]. An example is the Greenland white-fronted goose (*Albifrons flavirostris*) whose population has increased in preferred intensive agricultural land than in natural and semi natural habitats [43].

Bird diversity indices across the six wetlands were fairly high ($H' = 1.24 - 1.75$), compared to similar findings in the Abirw sacred grove in the Eastern Region of Ghana ($H' = 0.011 - 0.012$) [12]. This points to the fact that bird species may appear to be on a steady decline. It has been revealed that between 1600 and present, bird species evolutionary history has been lost at similar rates and concluded that the relative rate of history loss in the future may continue at a rate not less than 80% [44]. Bushfires were a common phenomenon in Northern Region and mostly occur as a result of land clearing, hunting and charcoal processing. Bushfire affected the population of some birds detected in the dry season, such as bearded barbet (*Lybius dubius*) and Spotted creeper (*Salpornis ptilinopus*). The presence of fewer bearded barbet in Wuntori wetland in the wet season, probably showed their sensitivity to dry season disturbances and habitat preference for marshy conditions. The abundance of the Spotted creeper in the two riparian wetlands during the dry season, where bushfires were more widespread and severe, suggests their gradual shift from food scarce areas to places where there is readily availability of carcass from burnt rodents and insectivores, by the use of their proximate cues. Research have indicated the population decline of honeyeaters, through post mortality of bushfires, predation and food scarcity in Australian wetlands; agree with similar findings in this study on the low number of Bearded barbet (*Lybius dubius*) and Northern Red hornbill (*Tockus erythrorhynchus*) recorded in severely burnt wetlands [45]. However, the numbers of some birds such as Yellow-billed cattle egret (*Bubulcus ibis*) had increased in the burnt wetlands, as they were attracted to sites that were burnt. The surge in their abundance was probably due to the development of response cues to the availability of burnt and decomposed carcass after bush burn. [46] found out that only five out of 35 species observed, were seen in unburned sites in a Florida wetland and concluded that the bird species encountered, showed no fear of fire and were rather attracted to the smoking landscape. [47] also detected an increase in the abundance of Upland Sandpipers (*Bartramia longicauda*) following burning and grazing activities. Mean bird richness were higher in Wuntori and Kukobila wetlands as a result of less disturbance, whereas Tugu was least rich in wet and dry seasons because of severe impacts of grazing pressure. Grazing pressure and animal trampling has the tendency of destroying bird nest through vegetation removal.

The increase in bird density in the wet season, with a corresponding increase in area of lateral distance, in Nabogo and Wuntori wetlands could be due to the adaptation of most birds to the inherent spatial habitat heterogeneity conditions brought about by human-led activities. Furthermore, the corresponding increase in birds per unit area, suggests the importance of plot size effect on bird abundance. The findings in this study, agree with similar observation documented by [5]. The authors reported that higher densities of bird species were recorded in semi-permanent wetlands in North Dakota, which they believe was partly due to the effects of wetland size in the respective study areas.

With reference to the IUCN 'Red List' database (2011), it was observed that the Yellow weaver bird was considered vulnerable (VU), thus indicating that a large number of birds in Northern Savannah wetlands may not be under threat. This may be attributed to the fact that about 96% of the birds encountered, were well adapted to the patchy habitat conditions due to disturbances as was observed during the study. The VU status of the Yellow weaver bird was confirmed by their presence on the narrow range habitat especially along the banks of Nabogo and Bunglung wetlands, where *Deplachnefusca* and *Ziziphus abyssinica* plants were predominant. It is thought that the habitation of the Yellow weaver bird on the rough serrated surface of *Deplachnefusca* and thorny nature of *Ziziphus abyssinica* plants (which are unpleasant when in contact with the human body), served as the only source of safe haven for the birds against hunting.

In order to confirm the general habitat range size of the Yellow weaver bird from the rest of the ecological zones of Ghana, an extensive survey was conducted along the forest and coastal zones where the birds were found nesting on

similar narrow range habitat, predominated by fewer economic tree species like Bamboo plant (*Bambusa vulgaris*), Kassod tree (*Casiasiamea*), coconut tree (*Cocosnucifera* L.) and Oil palm tree (*Elaeisguineensis*). Some identified birds like Woolly-necked stork, African pygme-goose and squacco heron, indicates the importance of Northern wetlands as possible waterfowl habitats. But there is the likelihood giving the current trends of human-led activities, that future scenarios could see some of the birds categorized as LC, becoming vulnerable and the Yellow weaver bird, completely extinct. Other evidence of possible risk in the future of birds reaching the critical level of vulnerability, is the relatively low number of species (26 species) encountered in this study, compared to 48 species of water birds detected in four Coastal wetlands of Ghana [22].

Birds and wetland habitat preference

While [5] reported that Seasonal and semi-permanent wetlands provided habitat for the largest proportion of the population of all species, the current study however, found that the close shallow marshes supported the highest number of resident birds like African Jacana and Squacco heron in both seasons. Whereas the Spotted creeper and the Northern hornbill for instance, were confined to the swamp forested wetlands. The pied Kingfisher and Cattle egret were found in all the wetland classes, suggesting the tolerance to a wide range of habitats. Bird-habitat association may in part explain habitat preferences on the basis of the type of food they feed and the ease with which they can have access to food resources and the hydrological regime of wetlands. [48-48] explained that wetland-dependent birds used the availability of water in the whole of spring, as proximate cues to assist in their broad scale selection of habitat preference. The marsh warbler preferred areas with grasses and herbaceous cover intersperse with shrubs, which are suitable nesting sites compared to riparian wetlands.

The Northern Red bishop (*Euplectesfranciscanus*) was not only associated marshy habitats but was only common during wet season. This probably indicates that environmental conditions in the wet season were favourable for their survival than the dry season. The Black headed plover (*Vanellustectus*) a typical wader, was among the largest number of species that was found in more than half of the six wetland classes. [50] reported that 85% of waders were being supported in majority of Ghana's Coast wetlands. Thus the findings in this study showed that the Black headed plover were adapted to a broad range of habitats; from the Savannah to Coastal ecosystems. Tolerance to habitat alteration is species-specific and varies in line with the resilience level of wetlands to disturbances. Different wetland types such as permanent seasonal and temporal marshes exhibit varied stress tolerance to disturbed scenarios in different seasons. Thus the long term transformation of permanent wetland to a semi-permanent or seasonal wetland, could potentially affect the abundance of both resident and migratory birds. This phenomenon may be linked to simultaneous changes in hydrological regime, reduction in food availability and destruction of nesting sites.

CONCLUSION

Generally, bird diversity and abundance were largely influenced farming activities and bushfire, and the impacts varied according to the season and the type of wetland. Although farming activities and bushfire encouraged the presence of some bird species, the overall impacts of these environmental determinants, negated the role of the disturbance scenario and hence may not be entirely recommended as conservation measure to increase bird population and diversity. Furthermore, considering the fact that the Yellow weaver bird was identified as a vulnerable species (VU) gives an indication that the current environmental disturbances observed during the study, could in the near future affect the population of the remaining 96.2% of birds classified presently as least concern (LC).

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