INTRODUCTION

Birds are the best known vertebrate group (Lentino, 2003); however, the development of the ornithological knowledge in most African countries is still in its early stages, particularly for raptors. Analyses of the status of 557 birds of prey showed that 18% of these birds are threatened with extinction and 52% have declining global populations, making them more threatened than all birds as a whole (BirdLife International, 2019).

The population status and distribution of raptor species can be difficult to estimate because they are often dispersed and/or secretive species that nest in low densities (with large individual area needs), and their population can fluctuate cyclically in relation to prey abundance (Kirk, Hyslop, 1998). This can make raptors studies challenging, and many species remain poorly known around the world (Bildstein et al., 1998; Bierregaard, 1998; Watson, 1998). In the recent decades, raptors have become gradually more protected, and several species have become significant “flagships” for increasing public interest and support of conservation programs around the world, but their decline often persists, because of pollution, habitat alteration, and fragmentation or direct/indirect human disturbance (Virani, Watson, 1998; Brambilla et al., 2004). Their declining numbers and economic relationships warrant additional interest, and studies of total raptor populations are needed as a means by which we may elucidate their responses to changing pressures and environmental conditions (Smith, Murphy, 1973).

Most species of raptor are conspicuous and they feed on a broad array of invertebrates and vertebrates across all natural and artificial habitats (Thiollay 2006). Today, the dramatic increase in human pressure, deforestation and general decrease in tree cover, overgrazing and erosion, pesticide use, over-hunting and fishing, land degradation and sometimes direct persecution of predators, all impact negatively on raptor population (Thiollay, 2006). For example in West Africa an estimate of the mean abundance index of raptors between protected and unprotected areas has shown a 30% decline of raptors in protected areas compared with a 67% decline in unprotected areas (Thiollay 2006, 2007b). In the savannas of West Africa, 40 breeding raptor species and 19 Palaearctic migrant species have been recorded (Borrow and Demey 2001, Thiollay 2007a). Thiollay (2006) observed that little is known about the actual numbers of the various species, and without knowing this it is difficult to determine the real effect of conservation effort.

Studies indicate that raptors are more imperiled than birds in general, with 52% of raptor species in decline and 18% currently classified as threatened with extinction. Whereas across all bird species, 44% are declining and 13% are threatened. Among raptor species listed as Least Concern, 38% are declining, further supporting assertions that the biodiversity crisis should be viewed not only regarding...
species extinction, but also population decline (Hughes et al., 1997; Ceballos et al., 2017). The global loss of raptors per se is worrying, not just because of their charisma and flagship role (Sergio et al., 2008), but also because reduced abundance of raptors can have cascading effects on ecosystem functioning through changes in the numbers and behavior of their prey (Terborgh et al., 2001; Şekercioğlu, 2006). Raptor decline may also lead to loss of ecosystem services (Gaston et al., 2018; Bryan et al., 2018), sometimes acutely impacting human well-being (Markandya et al., 2008). Therefore, population declines, range contractions, and extinctions of raptors demand investigation into their causes and potential conservation interventions.

A survey in Yankari Game Reserve, Bauchi State, Nigeria, revealed a decline in the population of vultures (Tende & Ottosson 2008). However, data on the population status of other raptor species is lacking. In Hadejia Nguru wetlands, birds have been intensively studied but the focus often was on water-related birds, passeriformes and doves (Ringim et al., 2017; Sulaiman et al., 2014; Sabo, 2016; Lameed, 2011). Hence, there have been no attempts to describe their population distribution and diversity in detail comparable to those of raptor researchers around the world (Thiollay 1977a, b, 1989; Piana, Marsden, 2012; Zilio et al., 2013). This research aimed at filling this gaps of knowledge by examining the raptor population distribution and diversity in Hadejia Nguru Wetlands, in terms of species richness in order to establish a live data observatory that can help build the local expertise needed to monitor these emblematic species in the future and implement a sound strategy for their effective safeguarding.

MATERIALS AND METHODS

The Hadejia-Nguru Wetlands being an Internationally recognized Ramsar site lie on the southern edge of the Sahel savanna in northeastern Nigeria with coordinates 10° 33.00’ East 12° 39.00’ North (Figure 1), an altitude of 152-305 m, and depth of about 1.5-7 m with a size of about 350,000 hectares (Birdlife International, 2015). It is a Ramsar site and an Important Bird Area (IBA) being recognized nationally and internationally as an ecological area for resident, inter-African and Palearctic migrant bird species in sub-Sahara region, Nigeria. However, biological invasion due to Typha grass is threatening the rich avifauna of the wetlands in particular water birds. The wetlands are found in Yobe, Jigawa and Bauchi states, located in the northern part of Nigeria. The catchment area of the wetlands covers an area of about 3,500 km2, which includes two rivers, the Hadejia and the Jama’are, which flow and converge into the Chad Lake. Hadejia-Nguru Wetland (HNW) supports a total of 378 wetland bird species and the highest total numbers of water birds recorded during were 259,769 in 1995; 201,133 in 1996 and 324,510 in 1997 (Birdlife International, 2006). Also the wetland supports at least 250 species of flowering plants, over 136 types of aquatic flora and fauna and more than 103 species of fishes. All these wild plants and animals depend on one another and the flood for survival and so many people depend on them for their livelihood.

Figure 1: Study Area Map showing Sample Location (Source: Sabo, 2016)
Birds Transect method was used for the bird survey. This method proved most efficient in terms of data collection per unit effort (Yallop et al., 2003). This census involves an observer moving slowly along the routes and recording all birds detected on either side of the route. A Field survey was carried out in Hadejia Nguru wetlands from March to August, 2021. The census to count raptors was conducted by observations along 5km transect line in each wetland using binoculars, telescopes and field guide to West African Birds by Borrow and Demey, (2014). The observations were conducted by long watches along the transect line. The number of the raptors seen flying around and perching was recorded. The coordinates of each observation point was recorded. Surveys were carried out in the morning around 8am to 10am and in the evening (15h00–18h00) when the temperature was relatively cool and bird’s activities are high (Bibby et al., 2000). Garmin 760CSx Global Positioning System (GPS) was used to collect coordinates of the sampling locations.

RESULTS AND DISCUSSIONS
The results presented in table 1 below showed the outcome of transect survey of birds of prey species population distribution in Hadejia-Nguru wetlands from March to August, 2021. Transect line survey method detected a total of 1,562 individual birds of prey that belong to twenty four (24) species of 2 families during this study indicating that the Hadejia-Nguru wetlands area is an important breeding, roosting, and feeding habitat for several raptors (Table 1).

The most abundant species, Yellow billed kite, black shouldered kite and gabor goshawk comprised 68.5% of all individuals seen in all wetlands in all seasons. This finding is in akin with the study conducted by Adewumi, et al., (2020) who also reported black shouldered kite as one of the abundant specie in Akure metropolis. Out of the 24 species recorded 16 are resident, 5 Palearctic migrant and 3 intra-African migrant. Four species of global conservation concern were also recorded; the Vulnerable Tawny eagle (Aquila rapax) was recorded in both protected and unprotected areas during dry season. The Near threatened Red-necked falcon (Falco chicquera) and Pallid harrier (Circus macrourus) were also recorded in both protected and unprotected areas in dry and wet seasons in protected and unprotected areas during dry season respectively. The Endangered Martial eagle (Polemaetus bellicosus) was seen in dry season in both protected and unprotected areas of Hadejia Nguru Wetlands.

Table 1: Birds of Prey Species in Hadejia Nguru Wetlands

| S/No | Local Name     | Scientific Name        | Family  |
|------|----------------|------------------------|---------|
| 1    | Shahe          | Falco chicquera        | Falconida|
| 2    | Tayani Goyo    | Micronisus gabar       | Accipitridae|
| 3    | Karambita      | Falco naumanni         | Falconida|
| 4    | Shirwa         | Milvus aegyptius       | Accipitridae|
| 5    | Dan tukuliji   | Elanus caeruleus       | Accipitridae|
| 6    | Shirwa         | Chelictinia riocourii  | Accipitridae|
| 7    | Shirwa         | Circus runivorus       | Accipitridae|
| 8    | Farin Shabo    | Circus pygargus        | Accipitridae|
| 9    | Shirwa         | Circus macrourus       | Accipitridae|
| 10   | Shoan/Biha     | Butastur rapijennis    | Accipitridae|
| 11   | Duk’i          | Hieraaetus Wahlberg    | Accipitridae|
| 12   | Mekriya/Gagafa | Aquila rapax           | Accipitridae|
| 13   | Jihirmah       | Polemaetus bellicosus  | Accipitridae|
| 14   | Farin Komo     | Melierax metabates     | Accipitridae|
| 15   | Ci Kadarangura | Kaupifalco monogrammicus | Accipitridae|
| 16   | Shaho ya baraza | Bat Hawk              | Accipitridae|
| 17   | Shaho Madauki  | Accipiter tachiro      | Accipitridae|
| 18   | Bakin Shaho    | Milvus migrans        | Accipitridae|
| 19   | Surau          | Falco alopec          | Falconida|
| 20   | Mairi Shaho    | Accipiter ovampensis   | Accipitridae|
| 21   | Surau          | Falco arsoiacus       | Falconida|
| 22   | Kakkore        | Haliaetua vocifer      | Accipitridae|
| 23   | Jan Shaho      | Buteo auguralis       | Accipitridae|
| 24   | Hura Kogo      | Circus aeroginus      | Accipitridae|

Source: Field Survey, 2021

The findings of this study suggested more species of birds of prey. This is not in agreement with the Lameed (2011), Ringim et al., (2017) and Odewumi et al., (2020). Lameed (2011) recorded nine (9) birds of prey species in his research on Species diversity and abundance of wild birds in Dagona Waterfowl Sanctuary. Although his studies was not on birds of prey species but on general birds species diversity. Ringim et al., (2017) also recorded 8 birds of prey species in his studies on species diversity of migrant birds between protected and unprotected areas of the Hadejia-Nguru wetlands, his research is also on the general bird’s species diversity not birds of prey. Odewumi et al., (2020) identified 11 birds of prey species in similar research in Akure metropolis, Ondo State. Sangdon (2013) recorded 16 species...
of birds of prey of 2 families in Korean Peninsula. Also, this result is not in agreement with Wickramasinghe et al., (2021) who recorded 9 birds of prey species of 2 families (accipitridae and falconidae) in Bolgoda Lake, Sri Lanka in his study on spatial ecology of raptors in an urban wetland. Moreover, the findings of this research is not agreement with Grzegorz (2018) who recorded only 5 birds of prey in the city Wroclaw in Europe during 2002/2010 with the common kestrel and common buzzard as the commonest species, while gobar gashawk, Eurasian sparrowhawk as the rarest species. It is also not in akin with Zillo et al., (2013) recorded a total of 1,890 individuals’ birds of prey of 18 species in Southern Brazil, Onoja et al., (2014) recorded 886 individuals of 37 species in Yankari game reserve with the grasshopper buzzard, dark chanting goshawk, African fish eagle, grey kestrel, lizard buzzard and black kite as the commonest species, Okosodo et al., (2016) recorded 39 birds of prey species and owls belonging to 3 families in South western Nigeria with black kite as the commonest species while hooded vulture and tawny eagle have the lowest number of individuals and Tinajero et al., (2017) recorded 332 individuals’ birds of prey belonging to 14 species in Scrubland of Northern Central Mexican Dryland environment.

However, the results in agreement with Prakash (1989) who recorded 30 species of birds of prey in Keoladeo National Park, India with 26 species belonging to Accipitridae and 4 to falconidae and Elfari et al., (2020) who recorded 936 individual birds of prey representing 14 species belonging 3 families with accipitridae 9 species as the richest family followed by falconidae (4 species) and pandionidae with only 1 specie. The most abundant species are the black kite, common kestrel and Egyptian vulture and Buij & Barbara (2013) who recorded 36 birds of prey belonging to 2 families in lake Chad basin with black kite as the most abundant species. Also, this is in conformity with the findings of Renzo (2013) who recorded 19 birds of prey species in northwestern Peru. Moreover, Jensen et al., (2005) recorded 28 species of birds of prey in Llanos wetlands, Venezuela.

**Birds of Prey Species Richness**

A good understanding of the state of communities and ecosystems is vital for devising effective regimes for their conservation (Sutherland 1996, 2000; Gaston 2000, Margules and Pressey 2000, Krebs 2000). This mainly involves an assessment of the state of collective attributes of species in communities and appraising the manner by which environmental changes may affect their future. The commonest approach is an assessment of species richness of a given community. The species richness of birds of prey within the Hadejia-Nguru wetlands differs between protected and unprotected areas and with seasons. The highest richness index was registered in Dagona wetlands (3.011). Dabar Magini, Nguru Barrack and Baturiya have richness index of 2.683, 2.611 and 2.308 respectively (Table 2). The highest species richness index in the Dagona wetlands of the study area was due to dense vegetation cover of the area (Figure 2) which provides favorite breeding sites, availability of food in microhabitats which favored certain varieties of bird species, cover from predators, and less disturbance compared to other areas. This corroborate with the findings of Sethy et al., (2015) and Takele and Afeework (2018) who conducted research in North Orissa University and Choke Mountains, East Gojjam, Ethiopia respectively. Both identified favorite breeding site and availability of food as the main factors influencing birds’ higher species diversity index.

The present study shows that Dagona wetlands habitats have dense vegetation cover to serve as a foraging site for a substantial number of bird species. The large size of the area, as compared to the other sites, might contribute to the highest richness and abundance of bird species. As reported by Nabaneeta and Gupta (2010), bird species richness and abundance are influenced by the size of habitat patches, local resource availability and vegetation composition. This is because of the availability of multiple, and varied, alternative feed sources for the birds; moreover, a large area is inaccessible for people contributing to a favorable condition for breeding, feeding and nesting sites (Aynalem and Bekele, 2008). It was also pointed out by Prakash and Manasvini (2013) that a higher abundance of birds in a habitat might be brought by the vegetation composition that forms the main element of their habitat, or it may be influenced by landscape, floral diversity, anthropogenic activities, as well as predation. Various workers have reported significant changes in species richness of avian communities along gradient of vegetation (Krebs 2000) and the effect on raptors is indirect by limiting the availability of their herbivorous prey.

Baturiya wetlands have the lowest species richness index because of sparse vegetation cover consisting mainly of Acacia trees (Figure 2) and is also located on higher altitude. The area is dominated by acacia tree which have smaller leaves and easily shade their leaves, hence does not provide cover from predators, and less disturbance compared to other microhabitats which favored certain varieties of bird species, which provides favorite breeding areas was due to dense vegetation cover of the area (Figure 2) and unprotected areas and with seasons. The highest richness index was registered in Dagona wetlands (3.011). Dabar Magini, Nguru Barrack and Baturiya have richness index of 2.683, 2.611 and 2.308 respectively (Table 2). The highest species richness index in the Dagona wetlands of the study area was due to dense vegetation cover of the area (Figure 2) which provides favorite breeding sites, availability of food in microhabitats which favored certain varieties of bird species, cover from predators, and less disturbance compared to other areas. This corroborate with the findings of Sethy et al., (2015) and Takele and Afeework (2018) who conducted research in North Orissa University and Choke Mountains, East Gojjam, Ethiopia respectively. Both identified favorite breeding site and availability of food as the main factors influencing birds’ higher species diversity index.

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### Table 2: Species Richness Index in four Study Area

| Study Site          | Species Richness Index |
|---------------------|------------------------|
| Baturiya            | 2.308                  |
| Dagona              | 3.011                  |
| Nguru Barrack       | 2.611                  |
| Dabar Magini        | 2.683                  |

Source: Field Survey, 2021
We attribute the differences in species richness among wetlands to the environmental heterogeneity. At regional scale of analysis, different biomes would be represented with their own levels of species richness, therefore, the highest levels of species richness occur in highly heterogeneous biomes (Rahbek, 1997). Although, at a larger scale, landscape heterogeneity did not affect species richness of carnivore birds in North America (Carnicer & Díaz-Delgado 2008).

Rahbek and Graves (2001) found it to be an important predictor of birds’ species richness in South America. Environmental heterogeneity has been described as a determinant of species diversity of Neotropical raptor (Jullien & Thiollay 1996; Anderson 2001; Diniz-Filho et al., 2002). Since p value (0.000) is less than alpha value (0.05) level of significant, hence there is significant difference in species richness index between the study sites.

Table 3: Seasonal Species Richness Index in the four study sites.

| Study Site  | Species Richness Index | Species Richness Index |
|-------------|------------------------|------------------------|
|             | Dry Season             | Wet Season             |
| Baturiya    | 2.693                  | 1.572                  |
| Dagona      | 2.805                  | 1.801                  |
| Nguru Barrack | 2.702              | 1.906                  |
| Dabar Magini | 2.502                | 2.001                  |

Source: Field Survey, 2021
Table 3 above shows seasonal species richness index in the four study sites. Dagona has the highest species richness index in the dry season (2.805), followed by Nguru barrack (2.702), Baturiya wetlands (2.693) and Dabar Magini has the lowest species richness index in the dry season (2.502). Whereas, Dabar Magini has the highest species richness in the wet season (2.001), followed in descending order by Nguru barrack (1.906), Dagona (1.801) and Baturiya wetlands (1.572).

Table 4: Species Richness Index during Dry and Wet Seasons

| Season  | Species Richness Index |
|---------|------------------------|
| Dry     | 3.066                  |
| Wet     | 2.284                  |

Source: Field Survey, 2021

According to Mehra et al., (2017), bird species richness, distribution and abundances are directly or indirectly affected by seasonal variations and rate of anthropogenic activities. Anthropogenic activities such as over grazing and deforestation, which are the main causes of habitat loss, fragmentation, degradation, and climate change can ultimately cause migration and extinction of bird species that are present in that habitat (Gibbs et al., 2010).

Since p value (0.008) is less than alpha value (0.05) level of significant, hence there is significant difference in species richness index between dry and wet season

CONCLUSION

The species richness of birds of prey in Hadejia-Nguru wetlands shows there were 24 species of birds of prey belonging to two families directly during the study period. Out of the 24 species, 16 are resident, 5 Palearctic migrant and 3 intra-African migrant.

The highest number of birds of prey species was recorded in dry season, showing seasonal variation in species richness. Factors such as food availability and foraging ground are responsible. Habitat destruction via logging of trees especially in protected wetlands was the major threat to birds community in Hadejia-Nguru wetlands.

RECOMMENDATIONS

The HNWs harbor many birds of prey species, including globally threatened species. However, in order to maintain the bird community and other biodiversity of the HNWs, the management needs to increase conservation measures that will ensure the protection of the wetlands. This can be done through training and re-training of more forest guards to ensure protection of the wetlands. Public awareness should be raised to inform the local populace about the importance of these species to the environment vis-à-vis protecting the infrastructures used by the birds. More studies on birds of prey species diversity and abundance during migration period (winter season) are needed to provide a complete checklist on the wetlands birds of prey community including Palearctic, resident and the intra African migrant.

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Mundava et al., (2012) identified seasonal weather changes as a factor that influence the ecology of species, hence the birds of prey species abundance. This study at Hadejia-Nguru wetlands recorded higher number of raptors species in dry season (20 species) as compared to the wet season (17 species). However, in terms of abundance, wet season has higher number of relative abundance than the dry season.
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