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Biodiversity conservation: A tool for improving ecotourism potentials of dagona waterfowl sanctuary, Gashua, Nigeria

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Abstract
This study aimed at assessing the biodiversity status of Dagona waterfowl sanctuary with the view of conserving them to boost ecotourism potentials of the site. The line transect method was used to determine animal population density. Two transects of 1000 m were laid systematically at an interval of 500m in the study area. Observation and collection of data was made at 50m along each of the transect. The result revealed that *Papio anubis* as having the highest population density of 0.028/km^2 while the least was *Thryonomys swinderianus* having population density of 0.001/km^2. For the flora species, sample plots of 50m x 50m in size were established at 50 m interval in alternate position along each transect and all flora species were enumerated by direct counting and all other measurements taken. Simpson's diversity index was used to determine plant species diversity. The result showed that transect 2 had the highest plant diversity of 0.969. However, due to some anthropogenic activities such as over exploitation, free grazing, poaching, deforestation, etc. Ongoing in the sanctuary, a lot of flora species like *Mitragyna inermis, Centella astiatica, Acacia sieberitana* etc. have evolved into rare and threatened while the animal population has also reduced drastically due to loss of their habitat hence the need to conserve the biodiversity in the sanctuary been the resource base that would boost ecotourism potentials of the area.

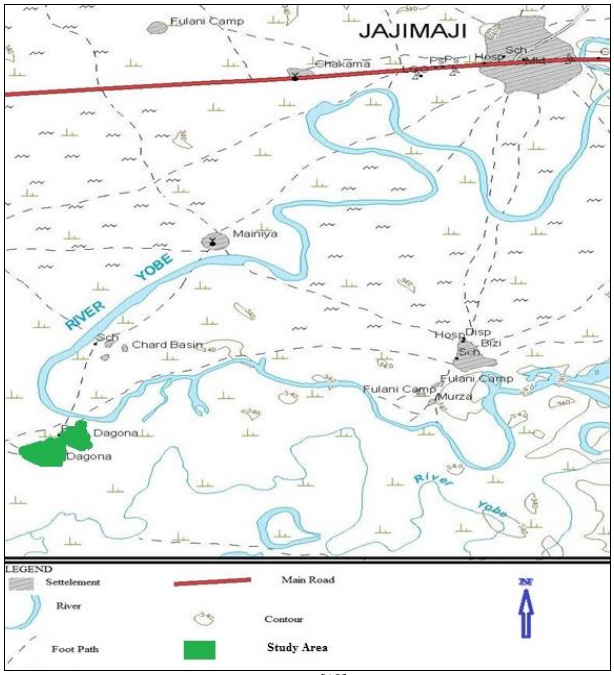
Keywords: Biodiversity conservation, ecotourism potentials

Introduction
Biodiversity is defined as the variability among living organisms from all sources including, interalia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems Millennium Ecosystem Assessment (MEA, 2005) [13]. Biodiversity include all ecosystems (managed or unmanaged ecosystems). It is the foundation of ecosystem services to which human well-being is intimately linked. No feature of the earth is more complex, dynamic, and varied than the layer of living organisms (i.e. biosphere) that occupy its surfaces and its seas. This layer of living organisms the biosphere through the collective metabolic activities of its innumerable plants, animals and microbes physically and chemically unites the atmosphere, geosphere, and hydrosphere into one environmental system within which millions of species have thrived. Breathable air, potable water, fertile soils, productive lands, bountiful seas, the equitable climate of earth's recent history, and other ecosystem services are manifestation of the workings of life (MEA, 2005) [13]. Biodiversity contributes directly (through provisioning, regulating and cultural ecosystem services) and indirectly (through supporting ecosystem services). It present the foundation of ecosystems that through services they provide, affect human well-being. These include provisioning services such as food, water, timber, and fibre; regulating services such as regulation of climate, floods disease, wastes and water quality; cultural services such as recreation, aesthetic enjoyment, and spiritual fulfillment; and supporting such as soil formation, photosynthesis, and nutrient cycling (MEA, 2005) [13]. A lot of benefits such as honey, firewood, poles, medicines, antelopes etc were obtained from Girei forest reserve in Nigeria and the estimated annual monetary value of ecosystem provisioning services from the forest reserve was ₦25,907,400 per anum (Adedotun and Ogunbode, 2023) [1]. Dagona waterfowl sanctuary is a good ecotourism site. Ecotourism includes, but is not limited to nature hiking, wildlife viewing, usually with some attention given to the ecosystem, biodiversity education or sustainability (Buckley, 2009) [5]. Ecotourism in this present era is

one of the fastest growing sector of the economy in many parts of Africa. It involves travel to relatively remote and undisturbed natural settings where flora and fauna are seen as main attractions. Besides conservation of biodiversity, it involves empowerment and participation of the local communities as important beneficiaries of the tourist activities. Earnings from visitors are generally ploughed back into preserving and conserving the natural environment and if properly managed can have a substantial impact on rural economy by improving the living standard of the people. Ecotourism has the potential to improve public education on cultural and biological diversity, conserve wild habitats and improve conditions for host nations (Buckley, 2009) [5]. However, despite the tremendous benefits of ecotourism and biodiversity as a resource base, threats such as over exploitation, free grazing, agriculture, poaching, deforestation, etc has continued to destroy the resources in the sanctuary and this has impacted negatively on the ecotourism potential of Dagona waterfowl sanctuary. Therefore, this study aim at collection and documentation of information on the biodiversity status of the sanctuary with the view of conserving them while also boosting the ecotourism potentials of the site.

Materials and Methods

Dagona waterfowl sanctuary is located on 12° N, 10° 45'E (Nigeria 1.50.000 Gogaram NW sheet 40 NW) (Figure 1). The sanctuary is situated 7km off the Gashua-Nguru high way from Tashan-Kalgo village within the Bade Native Authority, Zurgum Badderi forest reserve established in 1966 under the Bade Native Authority. Dagona waterfowl sanctuary falls within the Sudan Savannah. The area is characterized by seasonally flooded areas with woody vegetation. The forest on the peninsula has virtually disappeared due to excessive tree cutting and over grazing. Lameed (2012) [11] reported that within the sanctuary stands fewer trees, many of which are typical of desert trees such as *Acacia albida, Adansonia digitata, Zizipus spp* etc. During the rainy season the sanctuary has good vegetation cover mostly grasses. There is a scrub savanna, which consist of upland farmland areas and Acacia woodlands. The second include the higher areas which are inundated with tree species of *Acacia spp, Ziziphus spp, Balanites aegyptiaca, Tamarindus indica* and *Adansonia digitata* while common grasses include *Cenchrus biflorus, Andropogon spp* and *Vitileria nigritana*. In addition, pockets of riparian forests and woodlands, comprise species of *Khaya senegalensis, Mitragyna inermis* and *Diospyros mespiliformis*. In some parts, the wetland has been replaced with orchards of *Mangifera indica* and *Psidium guajava* (Ezealor, 2001) [9]. The third vegetation type consist of the seasonal flooded marshes in which the tree *Acacia nilotica* is common while Dum palms (*Hyphaene thebaica*) grow on small raised islands (Ezealor, 2001) [9]. Aquatic grasses include *Echinochloa Oryza spp* while in drier parts are *Dactylocteniuma egyptium, Setaria spp* and *Cyperus spp*. The floodplain at one time supports over 423,000 birds of 68 different species, including significant number of Ferruginous duck (*Aythya nyroca*), Blacktailed godwit (*Limosa limosa*) and Ruff (*Philomachus pugnax*) (Birdlife international, 2010) [4]. Other wildlife species found include species of Gazella (*Gazella sp.*), Duiker (*Cephalophus spp*), Jackal (*Cani sp*) and Hyena (*Crocuta crocuta*) (Chiroma *et al*., 2007; Ogunkoya and Dani, 2007) [6, 15]. In total, there are about 378 bird species listed, 103 fish species, 250 species of flowering plants and more than 136 species of aquatic flora and fauna (Oduntan *et al*., 2010) [14].



Source: (Eaton and Sarah 1997) [10]

Fig 1: Map of Dagona Waterfowl Sanctuary

Sampling and Survey Technique

The line transect methods as described by (Lameed, 2012) [11], was employed to determine population density. Two transect lines were laid systematically at an interval of 500 meters and each transect was 1000 meters long subdivided into 50 meters subsection to aid data collection. At each site, animal observation was carried out twice daily. Morning between 6:00am and 11am and evening between 4:00pm and 6:00pm by walking slowly along the transects and making observations. For the floral species sample plots of 50m x 50m in size were established at 50m interval in alternate position along each transect and all flora species were enumerated by direct counting. Measurements and a checklist of floral species (trees, shrubs etc.) was made as adopted by (Adedotun and Ogunbode, 2023) [1].

Data Analysis

The king's census model was used to analyze animal population density while Simpson's diversity was used to determine plant species diversity.

King's census model $D = \frac{n}{2L\bar{r}}$ as adopted by (Mamman and Yusuf, 2019) [12]

Where;
D = density
L = total length of transects cut
n = number/animals sited
$\bar{r}$ = average sighting distances

Simpson's index $D = 1 - \frac{n(n-1)}{N(N-1)}$ as adopted by (Saka *et al.*, 2022) [16]

Where;
n = total number of plant of a particular species
N = total number of plant of all species

Results and Discussion

Checklist of animal species and population density in dagona waterfowl sanctuary

The checklist of animal species in Dagona waterfowl sanctuary showed a total of 11 animal species where *Papio anubis, Xerus resticus, Thryonomys swinderianus, Vivera cevitta, Sylvicapra grimmia, Cephatophus rufilatus, Hysterix cristata, Kobus ellipsiprymnus* were all directly sighted in the sanctuary. Animals such as *Erythrocebus patas, Apis mellifera* were identified through interviews while *Lepus spp* was identified at the bush market processing and selling centre (Table 1).

This result showed a serious decline of animal species and population in the sanctuary. This is in contrast with the findings of (Oduntan *et al.*, 2010) [14]. The decline in animal species and population may be attributed to constant disturbance in the sanctuary as a result of grazing been carried out by the fulani nomads where the animals became scared and eventually migrated out of the area. The downward trend in animal population could also be as a result hunting pressure on the animals by the locals which is a wildlife crime. Anadu (2015) [2] reported that grazing and poaching as the highest crime committed in old Oyo National Park. Results of animal population density (Table 2) revealed that the animal with the highest population density of 0.028/km^2 was *Papio anubis*, followed by *Xerus rusticus* 0.027/km^2, *Cephalophus rufilatus* was 0.007/ km^2, *Sylvicapra grimmia and Hysterix cristata* were 0.005/ km^2, *Viverra cevitta* was 0.003/ km^2 while *Kobus ellipsiprymnus* and *Thryonomys swinderianus* has 0.002/ km^2 and 0.001/ km^2 respectively (Table 2). The implication of these result in the study area shows a downward trend in animal population. This could be due to hunting pressure. Estrada *et al.*, (2017) [8] reported that monkeys of the family's *Cycotopida* are facing most of the threat of poaching. Ayeni *et al.*, (1982) [3] also reported that immediate effect of poaching is reduce in animal number.

Table 1: Animal species checklist in dagona waterfowl sanctuary

Wildlife species	Methods of identification		
	DS	INT	BM
Papio anubis	√		
Xerus rusticus	√		
Thryonomys swinderianus	√		
Viverra cevitta	√		
Sylvicapra grimmia	√		
Cephalophus rufilatus	√		
Hysterix cristata	√		
Kobus ellipsiprymnus	√		
Apis mellifera		√	
Lepus spp			√
Erythrocebus patas		√	

Key: DS- Direct sighting, INT- Interview, BM- Bush meat processing and selling centre

Table 2: Wild animal's population density in Dagona waterfowl sanctuary

Wildlife species	Frequency	Density N/km
Papio anubis	28	0.028
Xerus rusticus	27	0.027
Thryonomys swinderianus	1	0.001
Viverra cevitta	3	0.003
Sylvicapra grimmia	5	0.005
Cephalophus rufilatus	7	0.007
Hysterix cristata	5	0.005
Kobus ellipsiprymnus	2	0.002

Plant composition, diversity and status

The checklist of plant species in Dagona waterfowl sanctuary showed a total of 1000 individual species belonging to 30 families and 59 different species (Table 3 and 4). A total of 34 species were enumerated in transect 1 (Table 3). The specie that had the highest population was *Balanite aegyptiaca* having a frequency of 143 and relative frequency of 22.2% while the least are *Centella astiatica, Ipomea carneat* and *Feretia apodenthera* each having a frequency of 2 and relative frequency of 0.31%. The diversity index stood at 0.0891. The result further showed that *Acacia nilotica, Dichrostachys cinerea, Mucuna Prurient, Tamarindus indica, Hyphaene thebatica, Chrozophora senegalensis* and *Balanite aegyptiaca* were abundant. *Acacia ataxacantha* and *Detarium macrocarpum* were frequent. *Acacia sieberitana, Mimosa pigra, Senna occidentalis, Azadiractha indica* and *Pennisetum purpureum* were occasional. *Saba florida, Eclipta prostratara, Capparis polymtorpha, Acacia albida, Bauchinia rufestcens, Chaemacrista rotundifolia, Desmodium scorpiurus, Onchoba spinosta, Urena lobata, Mollugo nuddicatolis, Jussiea ervicosta, Pennisetum recticulum, Bambusa vulgaris, Ziziphus abyssinica and Striga hermonthica* were rare. *Centella astiatica, Ipomoea carneat, Uzoroa insignits, Feretia apodenthera* and *Mitragyna inermis* were threatened (Table 3). In transect 2 a total of 42 species were enumerated (Table 4). The species that had the highest population were *Hyphaene thebatica* and *Feretia apodenthera* each having a frequency of 21 and relative frequency of 5.89% while the least were *Alternantha nodiflora, Maerua angolensis, Ipomea involucrate, Gradenia aqualla, Phyllanthus muellerianus* and *Strychnos*

spinosa each having a frequency of 2 and relative frequency of 0.56%. The plants diversity index was 0.969. The result further showed that *Acacia albida*, *Bauhinia rufestcens*, *Hyphaene thebatica* and *Feretia apodenthera* were abundant. *Cyperus difformis* is frequent, *Strophanthus gratus*, *Newbouldia laevis*, *Grewia mollis*, *Tamarindus indica*, *Mimosa pigra*, *Mucuna prurient*, *Senna occidentalis*, *Ochna afzelia*, *Ziziphus spinachristi* and *Lemna trisulca* were occasional. *Cyathhula prostrate*, *Anona senegalensis*, *Casrissa edulis*, *Plumeria rubra*, *Rauvolfia caffra*, *Saba florida*, *Anogeisus leiocarpus*, *Acacia ataxacantha*, *Acacia nilotica*, *Chaemacrista rotundifolia*, *Desmodium scorpiurus*, *Detarium macrocarpum*, *Dichrostachys cinerea*, *Moringa oleifera*, *Mitragyna africanus* and *Mitragyna inermis* were rare while *Alternantha nodiflora*, *Stereospermum kunthianum*, *Maerua angolensis*, *Guiera senegalensis*, *Ipomea* involucrate, *Acacia sieberitana*, *Psidium guajava*, *Gradenia aqualla*, *Pavetta corymbosa*, *Phyllanthus muellerianus* and *Strychnos spinosa* were threatened (Table 4).

Table 3: Family, species composition, diversity and status of transect 1

S. No	Family	Scientific name	Frequency	Density N/km^2	Relative density (%)	Diversity n(n-1)	Status
1	Apiaceae	*Centella astiatica*	2	0.002	0.56	2	Threatened
2	Apocynaceae	*Saba florida*	6	0.006	1.69	30	Rare
3	Asteraceae	*Eclipta prostratara*	7	0.007	2.00	42	Rare
4	Capparidaceae	*Capparis polymtorpha*	4	0.004	1.12	12	Rare
5	Convolvulaceae	*Ipomoea carneat*	2	0.002	0.56	2	Threatened
6	Euphorbiaceae	*Uzoroa insignits*	3	0.003	0.84	6	Threatened
7	Fabaceae	*Acacia nilotica*	130	0.13	36.51	16770	Abundant
		Acacia albida	5	0.005	1.40	20	Rare
		Acacia ataxacantha	17	0.017	4.77	272	Frequent
		Acacia sieberitana	12	0.012	3.37	132	Occasional
		Bauhinia rufestcens	6	0.006	1.69	30	Rare
		Chaemacrista rotundifolia	4	0.004	1.12	12	Rare
		Desmodium scorpiurus	5	0.005	1.40	20	Rare
		Detarium macrocaroum	15	0.015	4.21	210	Frequent
		Dichrostachys cinera	21	0.021	5.89	420	Abundant
		Mimosa pigra	12	0.012	3.37	132	Occasional
		Mucuna prurient	43	0.043	12.07	1806	Abundant
		Senna occidenttalis	12	0.012	3.37	132	Occasional
		Tamarindus indica	21	0.021	5.89	420	Abundant
8.	Flacourtiaceae	*Occhoba spinosta*	9	0.009	2.52	72	Rare
9	Maliaceae	*Urena lobata*	8	0.008	2.24	56	Rare
		Azadiractha indica	13	0.013	3.65	156	Occasional
10	Molluginaceae	*Mollugo nuddicatulis*	8	0.008	2.24	56	Rare
11	Onagraceae	*Jussiea ervicosta*	6	0.006	1.68	30	Rare
13	Palmae	*Hyphaeane thiebatica*	50	0.05	14.04	2450	Abundant
14	Phyllanthaceae	*Pennisetum recticulum*	5	0.005	1.40	20	Rare
15	Poaceae	*Bambusa vulgaris*	10	0.010	2.80	90	Rare
		Pennisetum purtpureum	14	0.014	3.93	182	Occasional
16	Rhamnaceae	*Ziziphus abyssinica*	10	0.010	2.80	90	Rare
17	Rubiaceae	*Feretia apodenthera*	2	0.002	0.56	2	Threatened
		Mitragyna inermis	3	0.003	0.84	6	Threatened
18	Scrophulariaceae	*Striga hermonthica*	6	0.006	1.69	30	Rare
19	Suphulariaceae	*Chrozophora senegalensis*	30	0.030	8.42	870	Abundant
20	Zygophyllaceae	*Balanite agyptiaca*	143	0.143	40.16	20306	Abundant
	Total		644			44886	
	Diversity index					0.891	

Table 4: Family, species composition, density and status of transect 2

S. No	Family	Scientific name	Frequency	Density N/km^2	Relative density (%)	diversity n(n-1)	Status
1	Amaranthaceae	*Althanantha nodiflora*	2	0.002	0.56	2	Threatened
		Cynthula prostrate	6	0.006	1.69	30	Rare
2	Annonaceae	*Annona senegalensis*	4	0.004	1.12	12	Rare
3	Apocynaceae	*Casrissa edulis*	6	0.006	1.69	30	Rare
		Plumeria rubra	8	0.008	2.24	56	Rare
		Rauvolfia caffra	9	0.009	2.52	72	Rare
		Saba florida	7	0.007	1.96	42	Rare
		Strophanthus gratus	12	0.012	3.37	132	Occasional
4	Bignoniaceae	*Newbouldia laevis*	12	0.012	3.37	132	Occasional
		Stereospermum kunthianum	3	0.003	0.84	6	Threatened
5	Capparidaceae	*Maerua angolensis*	2	0.002	0.56	2	Threatened
6	Combretaceae	*Anogeisus leiocarpus*	4	0.004	1.12	12	Rare
		Grewia mollis	13	0.013	3.65	156	Occasional

		Guiera senegalensis	3	0.003	0.84	6	Threatened
7	Convulaceae	*Ipomea involucrate*	2	0.002	0.56	2	Threatened
8	Cyperaceae	*Cyperus difformis*	16	0.016	4.49	240	Frequent
9	Fabaceae	*Acacia ataxacantha*	10	0.010	2.80	90	Rare
		Acaca nilotica	8	0.008	2.24	56	Rare
		Acacia albida	18	0.018	5.05	306	Abundant
		Tamarindus indica	13	0.013	3.65	156	Occasional
		Acacia sieberitana	2	0.002	0.56	2	Threatened
		Bauhinia rufestcens	19	0.019	5.33	342	Abundant
		Chaemacrista rotundifolia	6	0.006	1.68	30	Rare
		Desmodium scorpiurus	8	0.008	2.24	56	Rare
		Detarium macrocarpum	9	0.009	2.52	72	Rare
		Dichrostachys cinerea	10	0.010	2.80	90	Rare
		Mimosa pigra	12	0.012	3.37	132	Occasional
		Mucuna prurient	13	0.013	3.65	156	Occasional
		Senna occidenttalis	13	0.013	3.65	156	0ccasional
10	Moringaceae	*Moringa oleifera*	5	0.005	1.40	20	Rare
11	Myrtaceae	*Psidium guajava*	3	0.003	0.84	6	Threatened
12	Ochaceae	*Ochna afzelia*	13	0.013	3.65	156	Occasional
13	Palmae	*Hyphaene thebatica*	21	0.021	5.89	420	Abundant
14	Rubiaceae	*Feretia apodenthera*	21	0.021	5.89	420	Abundant
		Gradenia aqualla	2	0.002	0.56	2	Threatened
		Mimosa pigra	6	0.006	1.68	30	Rare
		Mitragyna inermis	4	0.004	1.12	12	Rare
		Pavetta corymbosa	3	0.003	0.84	6	Threatened
15	Rhanaceae	*Ziziphus spinachristi*	12	0.012	3.37	132	Occasional
16	Phyllanthaceae	*Phyllanthus muellerianus*	2	0.002	0.56	2	Threatened
17	Loganiaceae	*Strychnos spinosa*	2	0.002	0.56	2	Threatened
18	Lemnaceae	*Lemna trisulca*	12	0.012	3.37	132	Occasional
	Total		356			3916	
	Diversity index					0.969	

The slight high population of *Balanite aegyptiaca*, *Acacia nilotica*, *Hyphame thebatica*, *Mucuna prurient* in both transects 1 and 2 in the study area may be attributed to favorable microclimate within the sanctuary or viable seeds of trees to sustain regeneration. The abundance of the above mentioned species may also be attributed to the species efficiency in seed dispersal mechanism as reported by (Udo *et al.,* 2007) [17] while the low species representation could be due to poor regeneration abilities and/or anthropogenic activities (Zhigilla *et al.,* 2016) [18]. The low plants population may also be due to high incidence of grazing and pastoralism where lopping of plants like *Moringa oleifera*, *Anogeisus leocarpus*, *Pennisetum recticulum* etc by nomadic herds men has set a downward trend on the floral resources of the sanctuary. Fire is observed to be used in the sanctuary by grazers and poachers as a tool in their various activities, however a combination of all these uses has resulted in changed habitat composition in many areas (Dunn, 1993b) [7]. The high plants species diversity recorded in transect 2 is an indicator of a healthy sanctuary particularly in the area and lesser or no anthropogenic activities while the slight lower diversity index of plant species in transect 1 may be as a result of higher anthropogenic activities such as fuel wood collection/harvested in the area. The dependence of rural population (80% of the total population) on fuelwood for their energy needs and inefficient utilization of fuel wood have contributed to the serious resource depletion which is more noticeable in the arid zone of the country (Dunn, 1993b) [7]. The high energy needs of the people may be responsible for a number of these plant species like *centella astiatica, Mitragyna inermis, Alternantha nodiflora* etc in the sanctuary evolve into rare and threatened. If forests are over exploited, the different usage and functions connected with them including ecotourism can be lost with them as there would be no or decline in plant and animals species and population for the tourist to explore.

Conclusion

Dagona waterfowl sanctuary at one time was an ecosystem of exceptionally high biodiversity. However, from the results obtained from this study the sanctuary is facing a serious downward trend in species and population. This is as a result of anthropogenic activities such as over exploitation, free grazing, poaching deforestation, agriculture, etc on-going in the area. Hence there is need to intensify conservation efforts particularly on those plant species that are rared or threatened. When this is done and poaching minimized, animal species and population may increase thereby boosting the ecotourism potentials of the sanctuary.

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