Floral Diversity in the Wetlands of Apete River, Eleyele Lake and Oba Dam in Ibadan, Nigeria: Its Implication for Biodiversity Erosion

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Abstract

Wetlands in Nigeria face constant threat of destruction by urbanization, road construction and agricultural activities, but the floristic compositions of these fragmented communities are unknown. A comparative assessment study of the floral of three wetlands in a forest-savanna transition ecological zone, Ibadan (7°26' N, 3°54' E), Oyo State, Nigeria was conducted in the dry and wet seasons of 2002 to assess their species richness, density, community structure and diversity. Thirty-eight plant species from 19 families were enumerated in the three wetlands in two seasons. Nineteen species from 13 families were enumerated in the dry season, while 14 species belonging to nine families were enumerated in the wet season. Eight families were common to both seasons. Eleyele and Apete wetlands had relatively stable flora for both seasons, while Oba dam exhibited pronounced shift in flora between the dry and wet seasons. Continuous perturbation of the three wetlands encouraged proliferation and dominance of some invasive species at the expense of indigenous species populations, leading to subtle biodiversity erosion.

Introduction

Wetlands are located between drier upland and water bodies. They are usually not found elsewhere because they support a good array of of plants and animals usually not found elsewhere. They are, therefore, very important for their unique floral and faunal composition, as well as for cycling of nutrients, energy and water. It is important to conduct diversity survey of floral components of this ecosystem, since biodiversity is a proven indicator of environmental change. Moreover, individual species in ecosystems relate in little unexplored ways to ecosystem function, stability and resilience (Lovejoy, 1995).

Wetlands are among the most threatened ecosystems of the world. Dixon & Sherman (1990) reported that wetlands are becoming rare because of the need for more agricultural lands, and are being drained for conversion to rice fields or lands for other crops. They are further threatened by erosion from runoff, oil spillage and effluent pollutants. In Nigeria, most wetlands in urban centres (fadama) are cultivated in the dry season to boost the supply of vegetables. In recent times most of these urban wetlands are giving way to estate development for offices. Yet not much is known about the diversity of the plant communities in these wetlands. What would have been stretches of wetlands along contiguous streams and rivers have been and are being fragmented by small dam and road construction, and industrial development. The wetlands in the outlying ecosystems are

not spared the biodiversity erosion, which is loss of biodiversity as a result of dissaperarance of native species from the ecosystem. Wetlands are being fast taken over by invasive exotic plant species, as well as being often overgrazed in the dry season.

Natural relationships that exist among species in an ecosystem may serve as indicators of the state of many resources. Oostermeijer *et al*. (1986) used species relative abundance to assess population viability of *Gentiana pneumonanthe* in the Dutch wet heathlands and hay meadows. Stafford *et al* (2001), in their investigation of relative roles of productivity, species pool, and spatial habitat structure in determination of local species richness, also found that both community biomass and size of the species pool contributed significantly to local species richness. Most of the mechanisms by which plant species coexist are dependent on environmental variation in space or in time or, in the case of disturbance, in both. Temporal variation in the environment may make density dependent population regulation, an infrequent event in many plant communities. Environmental variation can, perhaps, delay the competitive exclusion of species from a community and simul-taneously weaken the action of factors that promote coexistence (O' Connor, 2001).

The study is a comparative assessment of the flora of three wetlandss in Ibadan, Oyo State, Nigeria. The three wetlands occur in the same ecozone and are within 5 km of one another. It was envisaged that there would be marked floristic similarity among them. It was also envisaged that the level of human disturbance could have an influence on the flora of each community. Thus, the objective of the research was to evaluate and compare the flora components of the three wetlands with a view to determining their floristic dis/similarity and effect of anthropogenic disturbances on them. This would help to suggest appropriate management strategies that will ensure thei sustainable utilization.

Materials and methods

Study area

Eleyele lake provides Ibadan megacity dwellers with pipe-borne water. Fishing activities are also carried out on the lake. Oba dam is located within the University of Ibadan, and serves the university community through provision of water for utilities and fishery, as well as being an experimental station to students. Apete river links Eleyele and Oba dam. These wetlands, apart form their socio-economic significance, have invaluable influence on biogeochemical and hydrologic cycles. Apete and Eleyele regularly serve as fadama crop land in every dry season. Oba dam has some farming activities going on in the drier areas of its bank. Therefore, it is in a state of constant perturbation by residents within the university and wildlife, most especially, white cattle Egrets (*Bulbis ibis*) that spend the dry season on the lake banks in large numbers. Unlike the other two wetlands, dry season fadama farming is not permitted in Oba dam, and it is best protected. Eleyele lake came into existence in 1942, while Oba dam was constructed in 1972. Apete river links the two artificial water reservoirs.

The floristic survey was carried out in three wetlands in Ibadan ($7^{o}26^{'}$ N, $3^{o}54^{'}$ E), a forest-savanna transition ecological transition zone (Fig. 1). Sampling of the floral components of the wetlands was conducted in the dry season between

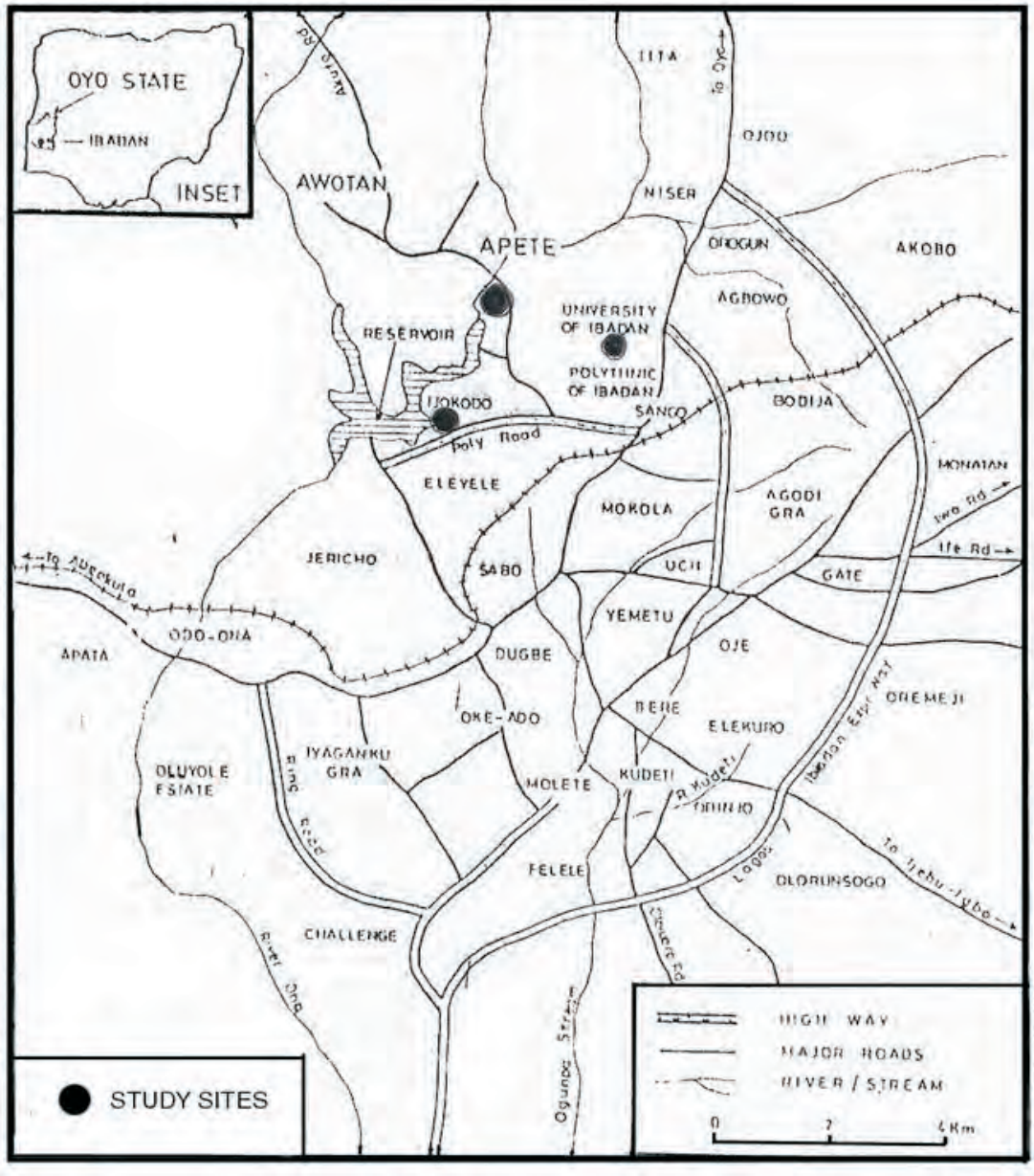

Fig. 1. Map of Ibadan metropolis showing the study sites

February and March, 2002, and in the wet season between April and July of the same year.

Twenty five square quadrats were used at each site in each season. Systematic sampling technique was used according to Dalby (1987). Species identification and enumeration were done along transects laid parallel to the water bodies with twenty five 0.25 m^2-quadrats being used at Apete and Eleyele; and twenty five 0.125 m^2-quadrats used at Oba dam. The number of quadrats used was chosen on the basis of a preliminary survey to determine the minimal area and species area curve (Kent & Coker, 1992). All the species occurring in each quadrat and their densities were recorded in quadrat-by-species raw data matrices. All numerical data were standardized to 1 m^2 quadrat for all stands.

Nomenclature followed Hutchinson & Dalziel (1946), Akobundu & Agyakwa (1998), Johnson (1997) and Obot & Ayeni (1987). Species that could not be identified on site were preserved and identified at the Forestry Herbarium (FHI) of the Forestry Research Institute of Nigeria (FRIN). The diversity indices of the communities were calculated following Kent & Coker (1992). Detrended correspondence ordination analysis was used to summarize the floristic data. Bulked soil samples, replicated three times, from each site were analysed in the Department of Agronomy, University of Ibadan, Nigeria, following Udo & Ogunwale (1986). Data were analysed using ANOVA for completely randomized design.

Results

Species composition of the wetlands

A total of 38 plant species, belonging to 19 plant families was encountered in the floristic survey of the three wetlands. The three wetlands differ in floristic composition. At Apete, 12 species were enumerated in the dry season, while 10 were found in the wet season (Table 1). At Eleyele, 19 species were enumerated in the dry season and 14 in the wet season (Table 2). Oba dam had three and eight species in the dry and wet seasons respectively. (Table 3). The alpha diversity of Eleyele lake was the highest. The greatest numbers of species were recorded in both seasons at Eleyele lake. Nineteen species from 13 families were enumerated in the dry season, while 14 species belonging to nine families were enumerated in the wet season. Eight families were common to both seasons. The wetland of Apete river followed in alpha diversity with 12 species belonging to nine families enumerated in the dry season. In the wet season, 10 species of six families were enumerated. The wetland of Oba dam had the least alpha diversity with three species of three families enumerated in the dry season. In the wet season, the alpha diversity increased to eight species from seven families.

Each wetland exhibited some seasonal shift in flora. This was more pronounced in Oba dam than in the other two communities. The beta diversities of Eleyele and Apete wetlands were 7 and 4 in the dry and wet seasons, respectively. The beta diversities of Eleyele lake and Oba dam wetlands were 16 and six in the dry and wet season, respectively; that of Apete and Oba dam were nine and two in the dry and wet seasons, respectively. The differences in the floristic composition of the stands from the three wetlands in the two seasons are summarized in ordination diagrams (Fig. 2 and 3). The

TABLE 1

Floristic composition and density of the flora of Apete wetland in the dry and wet seasons of 2002 (Density values are mean ± SE)

Season	*Species*	*Family*	*Density (plant/m²)*
Dry	*Leersia hexandra*	Poaceae	896 ± 4.352
	Vossia cuspidata	Poaceae	4 ± 0.000
	Paspalum conjugatum	Poaceae	16 ± 0.000
	Ipomoea aquatica	Convolvulaceae	44 ± 0.588
	Triumfetta rhomboidea	Tiliaceae	8 ± 0.000
	Marsilea minuta	Marsileaceae	48 ± 4.619
	Pentodon petandrus	Rubiaceae	28 ± 0.980
	Spermcocea latifolia	Rubiaceae	4 ± 0.000
	Commelina diffusa	Commelinaceae	8 ± 0.000
	Scleria verrucosa	Cyperaceae	4 ± 0.000
	Waltheria indica	Sterculiaceae	12 ± 0.200
	Aniseia martinicensis	Convolvulaceae	28 ± 0.667
Wet	*Leersia hexandra*	Poaceae	280 ± 1.165
	Oplismenus burmannii	Poaceae	8 ± 0.000
	Cenchrus biflorus	Poaceae	92 ± 2.872
	Acroceras zizanoides	Poaceae	16 ± 1.333
	Ipomoea aquatica	Convolvulaceae	76 ± 0.900
	Marsilea minuta	Marsileaceae	8 ± 0.000
	Pentodon petandrus	Rubiaceae	5 2± 1.052
	Commelina diffusa	Commelinaceae	8 ± 0.000
	Momordica charantia	Cucurbitaceae	16 ± 1.333
	Aniseia martinicensis	Convolvulaceae	40 ± 0.655

TABLE 2

Floristic composition and density of the flora of Eleyele wetland in the dry and wet seasons of 2002 (Density values are mean ± SE)

Season	*Species*	*Family*	*Density (plant/m²)*
Dry	*Cynodon nlemfuensis*	Poaceae	60 ± 0.000
	Imperata cylindrica	Poaceae	64 ± 3.266
	Perotis indica	Poaceae	68 ± 0.980
	Panicum maximum	Poaceae	120 ± 6.450
	Eleusine indica	Poaceae	52 ± 11.392
	Pentodon petandrus	Rubiaceae	82 ± 2.313
	Commelina diffusa	Commelinaceae	4 ± 0.000
	Scleria verrucosa	Cyperaceae	72 ± 2.876
	Cyperus esculentus	Cyperaceae	108 ± 13.796
	Ludwigia abyssinica	Onagraceae	64 ± 4.454
	Polygonum saliefolium	Polygonaceae	16 ± 1.333

	Calopogonum mucunoides	Leguminosae	108 ± 2.379
	Tithonia diversifolia	Asteraceae	104 ± 3.232
	Tridax procumbens	Asteraceae	4 ± 0.000
	Sida garckeana	Malvaceae	16 ± 0.000
	Phyllanthus amarus	Euphorbiaceae	4 ± 0.000
	Combretum hispidum	Combretaceae	8 ± 0.000
	Aniseia martinicensis	Convolvulaceae	60 ± 1.180
	Cissus arguta	Vivataceae	28 ± 5.333
Wet	*Cynodon nlemfuensis*	Poaceae	36 ± 4.000
	Imperata cylindrica	Poaceae	184 ± 1.476
	Panicum maximum	Poaceae	332 ± 1.145
	Eichinochloa stagnina	Poaceae	196 ± 2.666
	Oplismenus burmannii	Poaceae	76 ± 3.112
	Oryza longistaminata	Poaceae	40 ± 3.464
	Pentodon petandrus	Rubiaceae	32 ± 1.333
	Commelina diffusa	Commelinaceae	28 ± 0.980
	Ludwigia abyssinica	Onagraceae	12 ± 2.000
	Calopogonum mucunoides	Leguminosae	88 ± 0.661
	Tithonia diversifolia	Asteraceae	80 ± 1.054
	Phyllanthus amarus	Euphorbiaceae	36 ± 3.200
	Passiflora foetida	Passifloraceae	52 ± 4.490
	Aniseia martinicensis	Convolvulaceae	24 ± 0.800

TABLE 3

Floristic composition and density of the flora of Oba dam wetland in the dry and wet seasons of 2002 (Density values are mean ± SE)

Season	*Species*	*Family*	*Density (plant/m²)*
Dry	*Cyperus rotundus*	Cyperaceae	9480 ± 56.155
	Polygonum lanigerum	Polygonaceae	1868 ± 12.736
	Ludwigia abyssinica	Onagraceae	3902 ± 74.125
Wet	*Acroceras zizanoides*	Poaceae	312 ± 1.639
	Oplismenus burmannii	Poaceae	4 ± 0.000
	Marsilea minuta	Marsileaceae	168 ± 5.542
	Ageratum conyzoides	Asteraceae	100 ± 6.066
	Ludwigia abyssinica	Onagraceae	188 ± 5.813
	Polygonum lanigerum	Polygonaceae	72 ± 3.464
	Pentodon petandrus	Rubiaceae	40 ± 2.000
	Peperomia pellucida	Piperaceae	20 ± 6.000

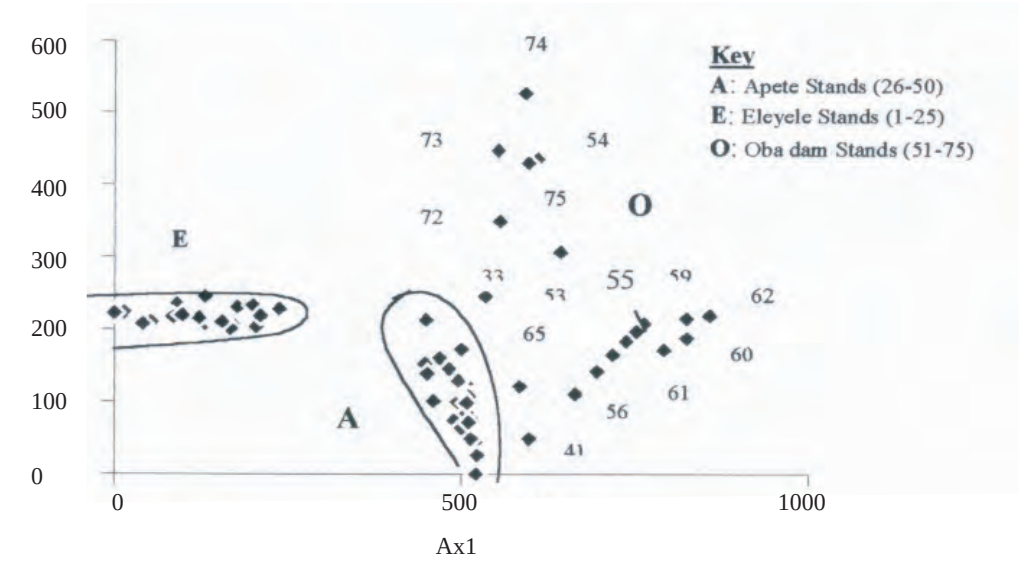

Fig.2. DCA biplot showing the distribution of stands from the three wetlands on the 1st two ordination axes (dry season data)

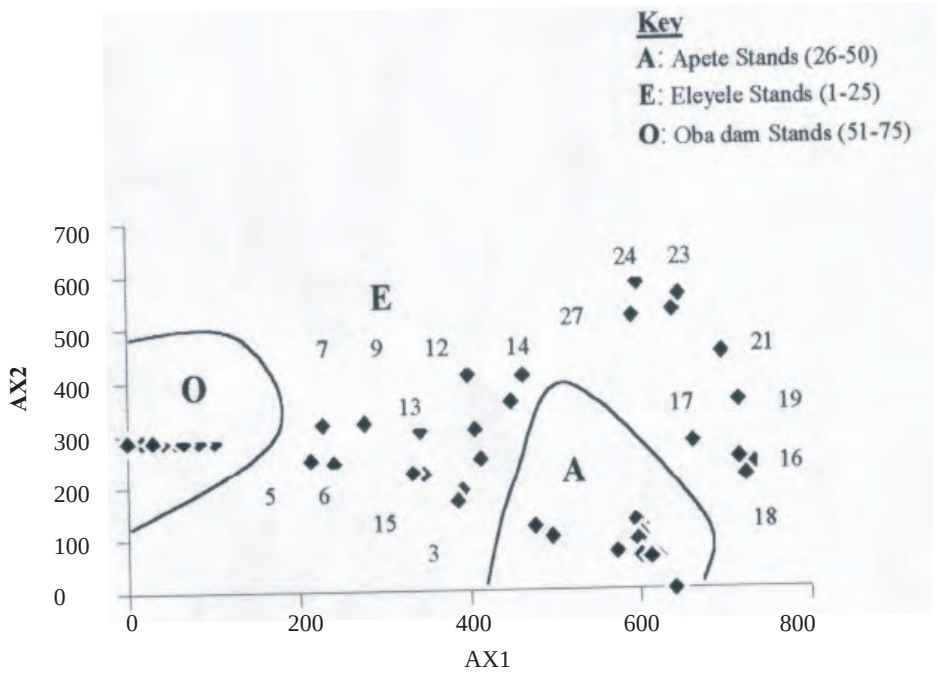

Fig. 3. DCA biplot showing the distribution of stands from the three wetlands on the 1st two ordination axes (wet season data).

stands from each community aggregated on the ordination facet. Stand ordination was based on species composition of each stand. The wet season flora tended to be richer than the dry season, especially in Oba dam wetland, and, thus, subdued the differences observed in the dry season. The order of floristic richness in the dry season was Eleyele lake > Apete river > Oba dam.

The three wetlands also differ in some soil characteristics, especially clay content (Table 4). The clay content in the soil of Oba dam (26.8%) was significantly higher than the clay contents of the other two wetlands. Clay content of Eleyele lake (12.8%) was close to that of Apete (14.8%). The soil of the two wetlands belonged to the same textural class (sandy loam), while the soil of the wetland of Oba dam was clay loam. Soil *p*H was relatively similar (neutral – slightly basic) in all the wetlands. These are 6.07, 7.07 and 7.17 for the soils of the wetlands of Apete river, Eleyele lake and Oba dam, respectively (Table 4). While Apete and Eleyele had C.E.C. values of 0.29 me100g^{-1}, Oba dam, which was significantly higher in clay content, had a C.E.C. of 0.23 me100g^{-1} (Table 4).

Some threat is posed to biodiversity sustainability by the occurrence of invasive species. The following exotic species: *Tithonia diversifolia, Polygonum lanigerum, Ludwigia abyssinica, Passiflora foetida, Calopogonum mucunoides,* and *Cynodon nlemfluensis* occurred in Eleyele wetland as 26.3% and 35.7% of all species enumerated in the dry and wet seasons, respectively, while *Cenchrus biflorus* and *Spermacocea latifolia* were enumerated in Apete as 18.3% and 1.0% of all species enumerated in the dry and wet seasons, respectively. *Ludwigia abyssinica* and *Polygonum lanigerum,* enumerated as 66.7% and 25.0%, were encountered at Oba dam.

TABLE 4

Soil physical and chemical properties (n=3 ±SE) in the rooting layers of plants in the wetlands of Apete river, Eleyele lake and Oba dam in Ibadan, Nigeria

Soil parameters	*Apete river*	*Eleyele lake*	*Oba dam*
*p*H/H$_2$O	6.97 ± 0.02	7.07 ± 0.04	7.17 ± 0.10
Org. C (%)	1.39 ± 0.08	1.52 ± 0.01	2.75 ± 0.09
Total N (%)	0.20 ± 0.01	0.27 ± 0.33	0.39 ± 0.01
Av. P (p.p.m.)	6.78 ± 2.10	3.65 ± 0.56	3.10 ± 0.58
Ca	0.06 ± 0.00	0.07 ± 0.00	0.06 ± 0.00
Mg	0.07 ± 0.00	0.06 ± 0.00	0.06 ± 0.00
Na	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00
K	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
Ex. Ac.	0.13 ± 0.02	0.11 ± 0.02	0.13 ± 0.03
C.E.C.	0.29 ± 0.02	0.29 ± 0.02	0.23 ± 0.01
% Sand	67.13 ± 0.39	69.80 ± 0.67	62.47 ± 1.02
% Silt	18.07 ± 0.39	17.40 ± 1.16	10.73 ± 0.39
% Clay	9.41 ± 0.67	12.80 ± 0.67	26.8 ± 0.67
Textural class	Sandy loam	Sandy loam	Sandy clay loam

All species were enumerated in the dry and wet seasons, respectively (Fig. 4).

Discussion

The results of the survey indicated that there is no typical wetland flora in the south-western ecozone investigated. Clear variation in species composition and population density of each species exists among the three wetlands, despite their nearness. It seems the flora of different wetlands was brought about by edaphic and anthropogenic factors in the areas. The differences in species composition could have been due to differences in edaphic factors. Farming and fishing activities which were being actively carried out around the three wetlands are indicative of the influence of man-related disturbances on the flora of the study sites.

Ogunyemi (1977) reported that the weed flora of different cropping systems in south-western Nigeria depended more on edaphic factors than on climate or crop type. Soil clay content and, consequently, water retention capacity of the soil could have contributed to the occurrence of species. Oba dam soil was more clayey than the other two soils, and may have tended to be water logged for most part of the year. Only plants adapted to water logging would occur in such soils. The drastic reduction in species richness in the dry season suggests that only ephemeral water-loving species appear in Oba dam every wet season. The more persistent species are few. The highest floristic richness observed at Eleyele could be due to its potential as a nutrient and organic matter sink, because of its larger size than either of the other wetlands.

In the dry season, water level recedes and some terrestrial species and facultative hydrophytes can survive. The soil in Oba dam wetland is poorly drained and the terrestrial species surviving in Eleyele and Apete may not survive there. With the drying up of water in the dry season, oxgyen level in the soil increases with deposition of dissolved nutrients, the soil becoming more fertile to support a higher species diversity. Ojo (1990) has linked amount of rainfall with nutrient and organic matter status of rain forest soils in western Nigeria. He implied that low rainfall is correlated with high nutrients and organic matter status. Since the dry season offers the possibility of high nutrients and organic matter, more plant species are, thus, expected to be encountered in the dry season.

Also, Eleyele and Apete wetlands are much disturbed by the dry season vegetable farming communities. Though the two wetlands are within the areas supposed to be protected by the Oyo State Forestry Department, the legislation against farming could not be enforced. Oba dam is less disturbed as the University is still able to enforce legislation against farming in the wetland. Also, domestic animals do not have free access to the wetland, so there is less trampling. This phenomenon was found to occur at Eleyele and Apete, which had more alpha diversities than Oba dam in the dry season.

What was observed at the wetland of Oba dam could be due to what Schemeske *et al.* (1994) referred to as immediate threats to continued existence of many rare vascular plant species. These threats are anthropogenic, with species losses occurring as a result of habitat loss and fragmentation of ecosystem from continued land development, as well as because of direct human activities, including trampling and collecting. Unregulated fishing and

associated trampling could be responsible for the lower number of plant types (diversities) encountered at the wetland in the dry season since only hardy species would survive such activities.

Species have been observed to be influenced by those changes in the environment that occur over a time interval equal to or greater than their response time (Hollander *et al*., 1994).Thus, sudden marked fluctuations in the water level, occasioned by intermittent flooding of Oba dam wetland in the seasons would permit only adapted species to survive the micro-climate. The few adapted species occurred in very large numbers because of reduced inter-specific competition for available nutrients. The dynamic relationships which the scattergrams of stand ordination of Oba dam and Apete river wetlands depicted could mean that the wetlands were still in their juvenile stages. This may be so, considering their small sizes and exposure to continuous perturbation from human activities.

The study showed that it is necessary that the wetlands be given adequate and effective protection from anthropogenic disturbances, such as farming, fishing and unrestricted trespassing. Apete river and Oba dam are being lost due to poor management. In view of the potentials that a wetland holds for enhancing the quality of the environment, in terms of environment clean up, protection of adjoining water bodies, biodiversity enrichment and sustainable development, it is recommended that the wetlands be conserved and human activities in the area be well regulated.

The most abundant species in the three wetlands differ but the phyto-sociologically dominant species are exotics. These alien species have become adapted to the environmental conditions of the wetlands, and have probably ousted the original native species. Those species that are suspected to be indigenous to the communities occur in small numbers (low relative densities), resulting in their being outcompeted as invasives spread in the wetlands. *Tithonia diversifolia* found at Eleyele has been a very aggressive weed of farmlands and roadsides. It has replaced *Chromolaena odorata* (another invasive alien) in south-western Nigeria. Agbato (2009) reported that *Tithonia diversifolia* was more agressive than *Chromolaena odorata* such that the former usually replaces the latter when they share same ecology. It was brought into the country as maize contaminants in the Oyo State Agricultural Development Programme. *Tithonia diversifolia* is now prevalent in the farm settlements where the imported maize variety was adopted for planting.

Cynodon nlemfluensis and *Calopogo-num mucunoides* were brought into Nigeria as components of fodder to improve the diet of domestic ruminants. These species are now problems in tree crop plantations. Their presence in the wetlands would not be unconnected with the regular fadama cultivation of the lands. Seeds of weedy species now come into, hitherto, clean areas in association with farming implements and planting materials. The presence and persistence of such invasive aliens may pose serious threats to biodiversity sustenance in these wetlands.

People carrying out farming and fishing activities there could be relocated with adequate compensation, if necessary. Also, fishing activities should be well regulated. For a more feasible protection, the natives

should be enlightened on the need to safeguard the wetlands, and possibly integrate them in the protection activities. Areas adjoining the wetlands should be reforested to serve as watershed and stabilize the soil, thus, regulating runoff and erosive action. Illegal and unregulated arable cropping and felling of trees in Eleyele and Apete watershed areas should be checked, and incursion of invasive plants into the area prevennted.

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