



Water Parameters and Floristic Composition of African Manatee (*Trichechus senegalensis*) Habitat in Pandam Wildlife Park, Nigeria

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ABSTRACT: The study of the physicochemical characteristic and floristic composition of African manatee habitat in Pandam Lake was conducted between 2012 and 2013. The water parameters were tested using standard method while line intercept method was adopted for vegetation survey. Data obtained on the water parameters were analyzed using one-way ANOVA. Plant species diversity index was analyzed using PAST Software. The mean seasonal water surface area increase was 66.12 ± 5.01 . The mean water depth in the dry season was 2.28 ± 1.14 while the wet season value was 4.3 ± 1.15 . Also the mean water transparency for wet and dry seasons were 64.02 ± 4.66 and 111.18 ± 4.26 respectively. The mean pH value was 6.5 ± 0.14 . Water salinity ranges from 0.00mg/l to 0.01mg/l, mean DO was 6.24 ± 1.13 , nitrate was 0.08 ± 0.02 and mean conductivity of 52.65 ± 2.12 . A total of 42 plant species from 23 families were recorded in Pandam Lake. The family Poaceae had the highest number of species (22) (30.56%). The grass species had the highest frequency of 13 while trees recorded the lowest (3). Also there are more perennial species ($n=28$; 66.67%) than annual species ($n=14$; 33.33%). The Shannon diversity index was 3.72. Thirteen species of plants recorded in Pandam Lake during this study were known to provide food for manatees across their range in Africa. All the water parameter values were within the range tolerable by manatee. The Lake have diverse species of plants that manatee can feed on both in the wet and dry seasons. The park management should maintain the integrity of the ecosystem by regulating fishing and other human activities to avoid pollution. The park should be taken over by the Federal government for effective protection of the resources most especially manatee.

DOI: <https://dx.doi.org/10.4314/jasem.v23i10.22>

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Dates: Received: 01 September 2019; Revised: 21 October 2019; 27 October 2019

Keywords: Water quality, vegetation, African manatee, Pandam Lake

In aquatic ecosystems, many factors including radiation, temperature, nutrient availability, physical transport processes, and grazing are known to control the biomass, distribution, and variation of plankton communities (Paerl and Huisman 2008; Lancelot and Muylaert 2011; Saille *et al.* 2015). Paerl *et al.* (2014) opined that human activities (deforestation, land use change, expansion of agriculture and development of industry, urbanization, and increasing wastewater) and global climate change have put remarkable pressure on the ecological conditions and sustainability of many aquatic ecosystems. Human activities have not only increased the quantities of nutrients but also changed forms and proportion of nutrients to the environment which can lead to adverse effects on water quality, such as eutrophication and food web structure (Glibert 2012; Vitousek *et al.* 2012; Duong *et al.* 2012; Isbell *et al.* 2013). Growth, dynamics, distribution, persistence of aquatic species, and the structure of their communities are strongly altered (Paerl *et al.* 2014) as a result of increasing global temperature, changes in precipitation, evaporation, and runoff. The processing and retention of sediment, nutrients, and pollutants in aquatic systems is accelerated by the

presence of aquatic vegetation (Clarke 2002). Numerous studies have shown that macrophytes and algae in marine environments act to reduce ambient concentrations of suspended sediment (Abdelrhman 2003; Moore 2004), nutrients (Moore 2004), and metals (Fritioff and Greger 2003). Macrophytes are important components of the freshwater (aquatic) ecosystem because they enhance the biological complexity and physical structure of habitats which increases biodiversity within the littoral zones (Esteves 1998; Wetzel 2001; Pelicice *et al.* 2008). In addition, both live and dead materials (detritus) from aquatic macrophyte may serve as food resources for aquatic and terrestrial organisms (Lope *et al.* 2007). However, in most rivers and lakes the excessive growth of macrophytes may provoke some negative effects (Bini *et al.* 2005), and it develops into explosively large population only when the environment is altered. Vegetation types and species composition reflect the flooding regime and the chemical quality of the water, whether fresh or saline (Nicole *et al.*, 1994). Species life form categories, prop roots and floating seedlings all help the various plants to survive in such an environment.

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Lake water quality is affected by local and regional drivers, including lake physical characteristics, hydrology, landscape position, land cover, land use, geology, and climate (Read *et al.*, 2015). An altered temperature regime can shift species composition from cool water to warm water species (Bednarek 2001). The distribution, community structure, and variation of plankton are clearly influenced by the combination and interactions between physical, chemical, and biological factors presented in a water body (Sabo *et al.* 2008; Cisneros *et al.* 2011; Lancelot and Muylaert 2011) such as rainfall, temperature, light and water discharge (Wehr and Descy 1998; De-Sousa *et al.* 2016; Bussi *et al.* 2016), nutrient enrichment, organic matter (De-Domitrovic *et al.* 2014; Li *et al.* 2016; Paczkowska *et al.* 2017; Hoang *et al.* 2018), and grazing (Mariania *et al.* 2013; Lucas *et al.* 2016).

The West African manatees (*Trichechus senegalensis*) are large herbivorous and totally aquatic mammals that fill a unique ecological niche in tropical lakes, rivers and coastal regions around West and part of Central Africa (Keith, 2015). Manatees tend to aggregate in a clumped distribution pattern in preferred habitats with little or no disturbances or in areas that best meet their biotic and abiotic requirements. Consequently, due to patchy distribution of food resources and variation in habitat characteristics, there is unequal distribution of the species and various habitat usages (Nomura and Higashi, 2000). Similar to the West Indian manatee, West African manatees inhabit practically every aquatic habitat that allows them access and meets their thermoregulation requirements of water temperatures greater than 20°C for *T. manatus* and where the water temperature is above 18°C (64°F) for *T. senegalensis* (Powell 1996, Dodman *et al.* 2008). At 20°C, manatee can function normally. However, at 18-19°C feeding becomes irregular and below 16°C feeding and other activity ceases. *T. senegalensis* require sheltered water with access to food and freshwater (Reep and Bonde 2006, Marsh *et al.* 2012 cited in Keith, 2015). Seasonal movements of African manatees are related to three factors (water current, salinity variation and water level changes), which in-turn is related to dry and rainy seasons in West Africa (Powell, 1996).

The African Manatee is one of the least understood marine mammals in the world, and has recently been shown to be the least studied large mammal in Africa (Trimble and Van Aarde 2010). They are often referred to as the "forgotten" sirenian. Unfortunately, African manatee populations are thought to be small, fragmented, and in continuous decline making the species vulnerable to extinction under IUCN Red list criteria A4cd and C1 (Powell and Akoi, 2006; IUCN, 2016), up-listed from CITES Appendix II to Appendix

I as of the Conference of Parties 16 in March 2013. They are also listed on Appendix I of the Convention on Migratory Species and are protected by national laws in all range states including Nigeria. Pandam Lake was declared a Manatee Sanctuary by Benue-Plateau States because manatees seek refuge during the dry season when water level in Benue River is reduced through Deb River (Powell, 1996). Pandam Wildlife Park may be one of the most important habitats for the global conservation of the African manatees. There were no scientific evidence on the impacts of these human activities on the water parameters and their consequences on aquatic organisms like manatee in Pandam Lake. Therefore this study provides such information in Pandam Wildlife Park through the assessment of the physico-chemical parameters and floristic composition of manatee habitat for an effective manatee conservation in the park.

MATERIALS AND METHODS

Study Area: The study was carried out in Pandam Wildlife Park, Plateaus State located in the middle belt region of Nigeria (Figure 1). It lies between Latitude 8°35'N and longitude 8°55'E and latitude 8°00'E and longitude 10°00'E. It covers an area of 224km² and is located 58km along the Lafia-shendam road to the north of Benue River (Ezealor, 2002) and South of Plateau state (Akosim, 2007) in Quanpan local government area. It is bounded on the East by Namu and Kuagarda, on the west and north by Dep River and in the South by Aningo and Pandam communities (Akosim, 2007). The entire area is drained by Dep and Li Rivers and joins to make a Y-shape before emptying into Benue River. The land slopes gradually south wards and form a basin – “Pandam lake” – wetland complex of approximately 22km. The entire park lies within the guinea savannah eco-zone. Thus the vegetation of the park is typical Sudan-Guinea savannah with gallery forest in riparian areas. Pandam Wildlife Park is managed by the Plateau state Tourism Corporation. The wet season lasts from April to October and annual rainfall is 1,000–1,500 mm.

Determination of Water Parameters: Four sampling stations (One station in each of the two streams that supplies water into the lake (I and II), one in the centre/middle of the lake (III) and one station at the exit point (manatee stream) (IV)) were selected to reflect the lentic and lotic nature of the lake as well as influence of the sources of water entering the lake. The parameters investigated include water; temperature, level (depth), surface area, transparency (turbidity), current/velocity, Dissolve Oxygen, salinity and pH. These parameters were investigated both during the rainy and dry seasons for two years (2012-2013).

Water level was measured using a wooden pole graduated in cm/m at three points for each of the four stations. The wooden pole was lowered from a canoe into the water until it rest on the floor of the lake. The depth was then read off the calibrated rope. Water transparency (Turbidity) was measured using a standard Secchi disc having a diameter of 20cm with black and white quarters. The Secchi disc was lowered into the water and the depth at which the disc becomes invisible was recorded. It was also gradually withdrawn from the water and the depth at which it becomes visible recorded. The transparency of the water at that point was calculated as the mean of the two readings for each point sampled. Water Temperature (T°C) and pH were determined using a high accuracy pen type pH meter with Temperature display (pH-009 model) (battery operated). The pH meter was dipped into the water to a graduated level and the pH and Temperature values displayed were recorded. Water Temperature was measured at 9.00hr once in a month. Dissolve oxygen was measured using modified Winkler azide method. Conductivity/salinity was determined by Hanna multirange conductivity/salinity meter model H18033 while nitrate and phosphate was determined using Hach Spectrophotometer model DREL5. Three points each were used at the four locations for all the measurements. The samples collected were chemically fixed in the field itself for measuring dissolved oxygen and analysed on the same day in the laboratory. All the parameters were collected in the morning hours. Seasonal change in water surface area was determined by noting the area covered by water during the peak of the wet season and the peak of the dry season. Then the average distance value (from the dry season point and rainy season point) obtained was recorded. Water velocity was determined by recording the time it took a float to cover a predetermined distance (30m) using a stopwatch. This was done five times at each of the four locations.

Vegetation Sampling: A line intercept sampling method was used, following Kent and Coker (1996). A rope (nylon type), that is 100m long and calibrated at 1m interval was used and all species intercepting or touching the tape were recorded. Plant species that are emergent, submerged, floating, and at the bank of the river along the established transect lines were identified and recorded. Any plant species present but not counted were identified and recorded to get the actual species composition of the Pandam Lake. A 1m x 1m quadrat was then laid at 5m interval to facilitate a complete littoral and open water plant species data collection. Herbaceous and woody species within each transect were also identified to species level according

to Hutchinson and Dalziel (1954-1972). Also, morphological and biological types (grass, tree, herb, shrub and others (fern, creeper, submerged, free floating etc.) and their percentages estimated relative to the total amount of all vegetation forms (Lathourder *et al*, 2009). Specimens of unknown plants were collected, labelled, photograph taken and then later used a hand book of West Africa weeds for identification.

Plant species diversity index was calculated using Shannon-Weiner Diversity Index written as:

$$H' = -\sum_{i=1}^S (P_i \ln P_i) \quad 1$$

Where H¹= index; P_i= the proportion of plants; ln= natural logarithms; \sum = summation.

Statistical Analysis: Data obtained were described using graphs, charts, tables, percentages and frequencies. Data on the physicochemical parameters in the four stations were analyzed using one way ANOVA to test for significant difference. Plant species diversity indices were determined using PAST ((Paleontological statistics software package for education and data analysis) statistical software [v. 16].

RESULTS AND DISCUSSION

Physicochemical characteristics of Pandam Lake: The mean physico- chemical characteristics of Pandam Lake collected during the field survey (Table 1) put the mean water surface increase at 66.12±5.01m², water depth (4.3±1.15m and 2.28±0.41m) for wet and dry seasons respectively, Transparency (64.02±4.66cm and 111.18±4.26cm) in the wet and dry seasons respectively, pH was 6.57±0.14, Temperature (27.38±1.05°C), Dissolve Oxygen (6.24±1.13), nitrate (0.08±0.02), conductivity (52.65±2.12) and salinity (0.0001). The result further showed that station IV had the highest mean seasonal water surface area increase (72.79m±7.47) followed by station III with a mean of 67.10m ± 16.70 while the lowest mean seasonal increase in water surface area was recorded in station I (61.79m± 13.34). However, there was no significant difference (p=0.98002) in the mean seasonal water surface area increase within the four locations. Station III was the deepest with a depth of 2.87m±0.34 and 6.01m±0.01 in the dry and wet seasons respectively while station IV was shallower than others (1.94m±0.4 – 3.54m±0.12 for dry and wet seasons respectively). Test of homogeneity showed no significant difference (p>0.05) in the water temperature recorded for the four locations.

Table 1: Mean water parameters of Pandam Lake recorded during the survey

Water Characteristics	Mean	I	II	III	IV
Seasonal increase in water surface area (m ²)	66.12 ±5.01	61.79±13.34	62.79±12.64	67.10±16.70	72.79±7.47
Water depth (m) (wet)	4.30 ±1.15	3.72±0.01	3.94 ±0.19	6.01±0.01	3.54 ±0.12
Water depth (m) (dry)	2.28 ±0.41	2.1±0.1	2.19±0.06	2.87 ±0.34	1.94 ±0.40
Water transparency (cm) (wet)	64.02 ±4.66	60.82±0.41	64.81 ±2.36	70.29±2.14	60.14±0.02
Water transparency (cm) (dry)	111.18±4.26	109.17±11.02	110.18±9.97	117.41±5.04	107.94±8.52
Water acidity (pH)	6.57±0.14	6.74±0.01	6.51±0.01	6.60±0.02	6.42±0.01
Salinity (mg/l)	0.0001	0.01	0.01	0	0
Water Temperature (°C)	28.4±1.05	28.73±1.57	28.75±1.36	29.25 ±0.46	26.87±1.35
Nitrate (mg/l)	0.08±0.02	0.069	0.072	0.101	0.072
Dissolved Oxygen (mg/l)	6.24±1.13	6.68	6.75	6.98	4.55
Conductivity (um/cm)	52.65 ±2.12	52.4	51.6	50.9	55.7

In general, West African manatees seemed to prefer those areas that had deep pools for refuge during the dry season (Powell, 1996). The mean water depth values which range from 1.94±0.4m to 6.01±0.01m in the dry and wet seasons were within the tolerable mean depth for manatees activities (resting and non-resting) as reported by Bacchus *et al.*, (2009) that the mean water depth for *Trichechus manatus manatus* in the Drawned Cayne at Belize was 3.5 ± 0.30m (resting holes) 2.0 ± 0.12 m (non-resting hole areas). This explains why manatees were seen utilizing all the four locations in the Lake according to Odewumi, *et al.*, (2017). Water transparency values which ranged from 62.12cm±2.14, to 125.23cm±9.97 for wet and dry seasons was not too low for manatee survival which could be attributed to the extent of vegetation cover along the shoreline thereby filter sediments before entering the Lake. Apart from the fact that this factor increased the visibility of manatees while in the water, it also allowed high contrast with the mud cloud generated by manatees as they moved. The pH range (6.42 – 6.74) recorded were within the range reported by Egwali *et al.* (2018) (5.95±0.24 - 7.23±0.05). This indicated that the water was not acidic (i.e it is tending towards being alkaline) (Esenowo *et al.*, 2014) which was not harmful to manatee and other aquatic organisms in the Lake. Water salinity values which ranged from 0mg/l – 0.01mg/l fell within the value obtained by Akoi (2004). High level of nitrites can cause serious illness to both wildlife and humans, The nitrate values between 0.069mg/l and 0.101mg/l obtained in this study is within the acceptable level in surface water for aquatic organisms and plant growth as reported by Marschner, (1995); Bruning-Fann and Kaneene, (1993) that acceptable nitrate levels for drinking water have been established as 10 mg/l. and that unpolluted water generally has a nitrate reading of less than 1.0 mg/l. This is due to the fact that farming activities and waste that can increase the nitrate level is prohibited in the area. The DO level recorded was also within the range recorded by Egwali *et al.* (2018) (6.52±0.22- 7.77±2.41) for African manatee in

Nigeria. This is also related to the normal nitrate level recorded in the water. However, the low level of DO recorded in the MS was as a result of the high level of floating aquatic plants such as *Nymphaea lotus*, *Salvinia nymhellula* and *Azolla africana* presence in the area. The mean water temperature obtained in Pandam Lake was within the stipulated range as recommended safe for aquatic fauna generally (Esenowo *et al.*, 2014) and .water temperature that can be tolerated by manatee as reported by Powell (1996); Perrin (2001); Akoi (2004) that West African manatees inhabit practically every aquatic habitat that allows them access and meets their thermoregulation requirements of water temperatures greater than 20 degrees Celsius.

Plant species composition, richness and diversity of Pandam Lake: A total of 42 plant species from 23 families were recorded in Pandam Lake (Table 2) during the period of study. The family Poaceae had the highest number of species (22) (30.56%) followed by the families Mimosaceae and Rubiaceae with 5 (6.94%) species each. The family Poaceae had the highest number of species (n=7), Cyperaceae had 4 (10.53%) species, Mimosaceae had 3 (7.89%) species, while Rubiaceae had one (2.635) species (Figure 1). The vegetation recorded along the banks and on the water surface of the lake were water dependent and commonly found in wetland areas. Majority of these plants were also recorded by Akosim *et al.*, (2007) in Pandam Lake while authors like Adesina *et al.*, (2011) and Obot and Mbagwu (1988) also recorded most of these plants in Jebba and Kainji Lakes. There were also tree species, like *Crataeva adansonii*, *Pterocarpus santalinoides* and *Morelia senegalensis* along the banks of ZU and GU arms of Pandam Lake that were typically riparian forest species, which served as watershed for the Lake and which may also provide resting place for manatee in the afternoon. Moreover, the diverse plant species (38 species from 23 families) were dominated by the Poaceae family.

Table 2: Plant species composition of Pandam Lake

Family	Botanical name	Biological Type
Nymphaeaceae	<i>Nymphaea lotus</i> L.	P
	<i>Nymphaea maculata</i> L.	P
Poaceae	<i>Echinochloa stagnina</i> Retz. P.Beauv	P
	<i>Echinochloa pyramidalis</i> (L.) Hitchc. & Chase	P
	<i>Vossia cuspidata</i> Griff.	P
	<i>Phragmites spp</i> (Retz.) Steud.	P
	<i>Digitaria horizontalis</i> (Retz.) Pers.	A
	<i>Vitiveria flavibarbis</i> (Benth.) Stapf	P
	<i>Leersia hexandra</i> Swartz	P
Azollaceae	<i>Azolla Africana</i> (Desv.)	A
	<i>Azolla pinnata</i>	A
Onagraceae	<i>Ludwigia leptocarpa</i> (G.Don)Excell	A
	<i>Ludwigia hyssopifolia</i> (G.Don) Excell	A
	<i>Ludwigia decurrens</i> Walt. Syn.	A
	<i>Jussiaea repens</i> L.	A
Polygonaceae	<i>Polygonum lanigerium</i> R.Br.	P
	<i>Polygonum salicifilium</i>	P
Convolvulaceae	<i>Ipomea aquatica</i> Forsk.	P
	<i>Ipomea asarifolia</i> (Desr.) Roem. & Schult	P
Najadaceae/ hydrocharitaceae	<i>Najas pectinata</i> Parl.	P
Lemnaceae	<i>Lemna aequinoctialis</i> Welwitsch	P
Ceratophyllaceae	<i>Ceratophyllum demersum</i> L.	P
Alteranthaceae	<i>Alternanthera sessilis</i> (L.) R. Br. ex DC	A
Jussicaceae	<i>Jussica repens</i>	A
Salviniaceae	<i>Salvinia nymphellula</i> Desv.	P
Typhaceae	<i>Typha australis</i> Schum & Thorn	P
Menyanthaceae	<i>Nymphoides indica</i> Water-snowflake	P
	<i>Neptunia oleracea</i> water mimosa or sensitive neptunia	P
Mimosaceae	<i>Schrankia leptocarpa</i>	P
Fabeceae	<i>Mimosa pigra</i> L.	P
Lentibulariaceae	<i>Utricularia charoidea</i>	P
	<i>Diplazium sammatii</i>	P
Capparaceae	<i>Crataeva adansonii</i>	P
Malvaceae	<i>Melochia corchorifolia</i>	P
Papilionaceae	<i>Pterocarpus santalinoides</i>	P
Rubiaceae	<i>Morelia senegalensis</i> Hepper	A
Cyperaceae	<i>Cyperus difformis</i>	A
	<i>Pycurus lanceolatus</i>	A
	<i>Fimristylis feruginea</i>	P
	<i>Scleria verrucosa</i>	A
Sapindaceae	<i>Cardiaspermum halicacabum</i>	A
Icacinaceae	<i>Icacinia trichanta</i>	P

Note: A means Annual; P means Perennial

This was in agreement with previous studies by Bini *et al.* (1999); Daddy *et al.* 1993; Ikenweibe 2005; Olopade and Eyina, 2017; Diénye 2015) which reported that Poaceae and Cyperaceae are among the best represented families, and are also the most important families in other freshwater ecosystems.

The result further shows that grasses had the highest percentage of 30.95 (n=13) followed by herbaceous species with 26.19% (n=11) while trees had the least percentage of 7.14 (n=3) (Figure 2). The perennial species were more abundant (n=28; 66.67%) than the annual plants (n=14; 33.33%). The plant species diversity index (Shannon) was 3.72.

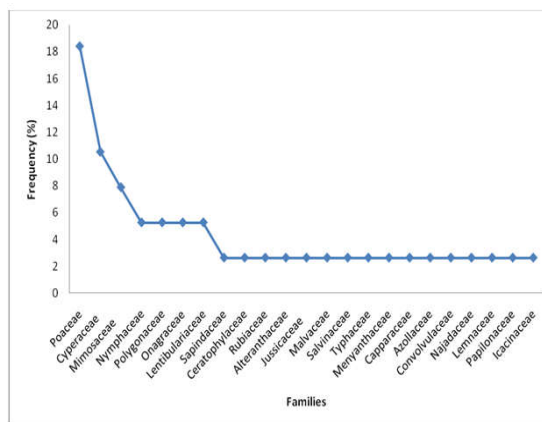


Figure 1: The frequency and percentage of plant species in each family in Pandam Lake

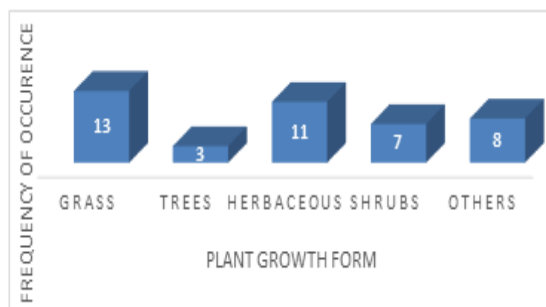


Fig 2: Frequency and percentge frequency of the morphological growth form of plant species recorded in Pandam Lake

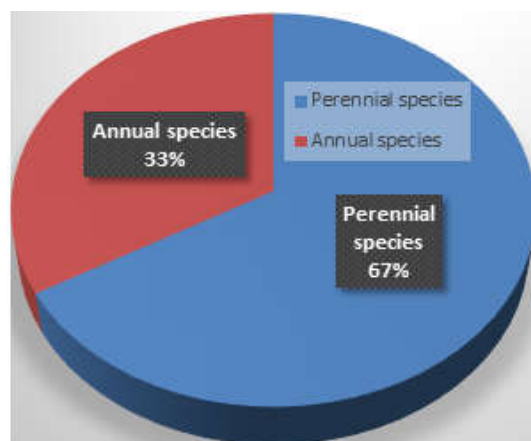


Fig 3: Biological types of plants recorded in Pandam Lake

The diversity index (3.72) of identified aquatic macrophyte species on the lake was within the rang recorded by (Adesina *et al.*, 2007) in Jebba Lake (3.8) which may be due to the flooding of the shoreline areas leading to the increase in biodiversity and also could be as a result of the dungs of manatee, Hippo and many aquatic water birds especially white faced whistling duck that enrich the water and thereby encourage plant growth.. The presence of aquatic macrophytes such as *Nymphaea* species that had their growth apparatus such as rhizomes buried in the soil or seeds dropped on soil surface probably emerged due to the favourable soil condition. This is in agreement with the statement by Obot, (1984) as recorded in Kainji Lake.

Thirteen species of plants recorded in Pandan Lake during this study were known to provide food for manatees across their range in Africa as reported by Powell (1996) and Ofori- Danson (2009); Egwali *et al.*, (2018). However, manatee feed more on *Echinocloa stagnina*, *Nymphaea lotus*, *Polygonum lanigerium* and *Echinocloa pyramidalis* in that order. This was evidenced in the colour and texture of dungs collected. However, the banks of ZU and GU arms of the Lake were dominated by *Echinocloa stagnina*, *Polygonum lanigerium* and sedges, which explained why manatee feeding activities were more concentrated in these areas. Also the dominance of

Nymphaea lotus, *Salvinia nymphellula*, and *azolla spp* in MS area made it another important feeding area for manatee.

Conclusion: It can be concluded that Pandam Lake in Pandam Wildlife Park can be an ideal habitat or refuge for manatee in the dry and wet seasons as the water parameters in all the three arms of the lake are within tolerable range for manatee to survive while there were diverse plant species that manatee can feed upon in both seasons. Therefore, for effective and sustainable conservation of manatees in Pandam Lake, human activities within and outside the Park should be regulated and monitored regularly.

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