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PROXIMATE AND MINERAL COMPOSITION OF AFRICAN MANATEE FOOD RESOURCES ALONG IPARE RIVER, ONDO STATE, NIGERIA

Odewumi O. S.

Department of Ecotourism and Wildlife Management Federal University of Technology, Akure, Nigeria

Corresponding Author:** ***osodewumi@futa.edu.ng; ORCID ID: https://orcid.org/ 0000-0002-3900-9606

ABSTRACT

This study assessed the African manatee food resources, and their nutritive quality along Ipare river, Ondo State between April and July, 2018 for effective conservation of the animal in the area. Questionnaire administration (A total of 140 Questionnaire distributed to the respondents in seven villages along Ipare River) and Laboratory analysis was adopted. Fourteen plant samples (thirteen food resources and one non-food) were collected for laboratory analysis (Proximate composition using AOAC methods and mineral contents using atomic absorption spectrometry). ANOVA was used to test for significant differences in the mean values. The respondents stated that manatee feed on thirteen plant species. Crude protein content was highest in *Manihot esculenta* leaf (23.95%) and lowest *in Manihot esculenta* tuber (2.28%). Ash content was highest in *Pistia stratiotes* (29.46%) and lowest in *Manihot esculenta* tuber (2.47%). *Phragmites karka* had the highest crude fibre (27.04%) while *Polygonium leptocarpa* had the least (8.60%). Ether extract ranges from 0.44% in *Manihot esculenta* tuber to 11.96% in *Phragmites karka*. Nitrogen free extract (NFE) was highest in *Manihot esculenta* tuber (68.10%) and lowest in *Phragmites karka* (27.33%). Moisture was highest in *Ceratophyllum demersum* (10.04%) and lowest in *Manihot esculenta* tuber (6.48%). The food resources contain both micro and macro minerals needed for healthy living by African manatee. All the nutrient components showed significant difference at $P<0.05$. The study identified soaked *Manihot esculenta* tuber as African manatee food in the study area. The food of African manatee could be dependent on nutritional composition on one hand while other factors (such as availability, taste and other anti-nutritional factors present in plants) may also play a part. This information can contribute to African manatee management during rehabilitation, considering the need to formulate diets similar to that found in nature and with nutritional values useful to develop healthy tissue and fit to fetch its food after release.

Key words: African manatee, food resources, nutritive quality, conservation, Ipare river.

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INTRODUCTION

Manatees and dugong are members of the Sirenia order, also known as sea cows, an ancient and diverse group which dates back to some 50 million years (Reynolds III, 2004). They are large aquatic mammals found mainly in tropical waters (McGraw, 2003). There are two living families that represent the order Sirenia, and they are strictly herbivorous, non-ruminant, which are perfectly adapted to aquatic life and consist of Trichechidae (American manatee, *Trichechus manatus*; African manatee *Trichechus senegalensis*; and Amazonian manatee, *Trichechus inunguis*) and Dugongidae (dugong,

Dugong dugon) (Reeves, 2002, Hines *et al*., 2020). The IUCN Red List of Threatened Species, as well as Annex II of the Convention on International Trade in Endangered Species (CITES) and the Convention on Migratory Species (CMS), classifies all three manatees and dugongs as Vulnerable (IUCN,2006).

Manatees are primarily herbivores and are of a considerable importance in the aquatic ecosystems (Allen, 2014). According to several studies, manatees eat more than 60 different plant species, including turtle grass, manatee grass, shaol grass, mangrove leaves, various algae, water hyacinth, acorns, and hydrilla (Rodrigues *et al.* 2021, Seaworld, 2002, Best, 1985, Borges *et al.* 2008; Rodrigues *et al.* 2016). The African manatee the least studied large mammal in Africa (Trimble and Van Aarde 2010) is of a considerable importance because it contributes to the water quality by grazing on high proliferating floating plant species that prevents light rays from penetrating the water (Allen, 2014). Studies by Akoi, 2004, Iwar, 2003; Daniel and Abdul, 2006; Ofori, 2009; Powell, 1996, Aristide, 2011, Odewumi, 2014 identified 32 food resources consumed by African manatee. Because of these determinants, manatees could be used to curb the growth of invasive aquatic plants (Allen, 2015). However, the nutritional composition of aquatic plants may vary with the frequency of consumption by herbivores (Castelblanco-Mart´inez *et al.*, 2012, D'Souza *et al.*, 2015).

Humans have altered the habitat in which wild animals live, including the quantity and quality of food available to them, affecting animal health, reproduction, and survival. (Acevedo-Whitehouse and Duffus, 2009; Birnie-Gauvin, *et al.*, 2017). Two fields of nutrition have experienced tremendous growth. (Frost *et al.*, 2014). Nutritional ecology investigates the relationships among diet, digestive physiology and feeding behaviour (Raubenheimer *et al.*, 2009), while nutritional physiology focuses on the subset of relationships related to the intake and assimilation of food items. The amount of vegetation consumed varies depending on the size and activity level of the animal, the nutritious content of the plants consumed, body function needs, and the availability of food plants. (Allen *et al.*, 2018). Mastering a species' nutritional ecology is essential for good ex situ husbandry and is a crucial component of any conservation management plan. Nutritive quality varies significantly among and within forage crops. Therefore, analyzing plant samples for nutrient content is used to determine the nutritional requirement of the animal that depend on them for food. Food selectivity, measures why certain foods are not consumed by comparing the nutritional contents of foods eaten with those not eaten.

Though several studies have been able to identify wide variety of plants species consumed by the African manatee but the proximate and mineral contents of these plants have not been extensively studied in relation to the nutritional needs of the animal. There are relatively few data regarding energy assimilation from the various types of forage they consume, and understanding their nutritional needs has been identified as critical to enhancing their long-term viability in the wild (USFWS 2001). Thus, the objective of this study was to analyze the nutritional composition (proximate and mineral composition) of foods consumed by African manatee (*T. senegalensis*) along Ipare River, Ondo State, Nigeria, to provide preliminary information on nutritional requirements of African manatees, and assist in the development of basic maintenance diets for captive animals.

MATERIALS AND METHODS

Study Area

This study was carried out in Ipare River in Ilaje Local Government Area of Ondo State, Nigeria. This area, which is less than fifteen meters above the sea level, lies between latitude $7^0$10'N $5^0$05'E and 7.167N 5.083^{0}E with an area of 1,318 km² and a population of 290,615 at the 2006 census (Kamuruddin *et al.*, 2019). Ilaje land is bordered on the west by the Ijebus, on the north by the Ikale, on the east by the Itsekiri, on the north by the Apoi and Arogbo Ijaw, and on the south by the Atlantic Ocean. The town of Igbokoda is home to its headquarters. Fishing is the major occupation.

The vegetation of the area is predominantly mangrove swamp, with low grasses covering expanse of undulating lowland of mud and silt deposit in the south. There is abundant raffia palm in the northern part of the local government. According to coastal news, 2013, the Ilaje local government area is dominated by a maze of creeks and estuaries. The tropical climate of the area is broadly of two seasons: rainy season (April –October) and dry season (November – March). The temperature throughout the year ranges from 21% to 29% and humidity is very high (Olagbegi, 2010).

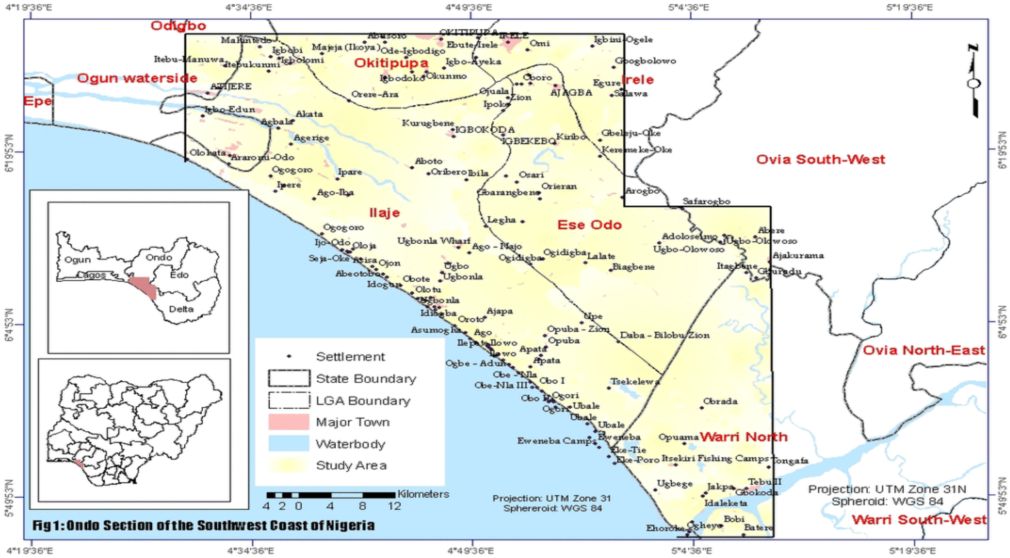

Figure 1: Map showing the delta region of Ondo state. (Source: Kamuruddin *et al.*, 2019)

Methods of Data Collection

The data collection procedure was carried out in two phases: Field work and Laboratory work

Field work: An oral interview was purposively conducted on a total of 140 respondents (fishermen, farmers and cassava processors) from seven adjoining villages of Ipare River (Ilefunfun, Agerige, Olopemeji, Oke-Ipare, Alake, Oke- Alafia and Opokiti), in order to collect information and identify the plant species consumed by manatees in the area. Information on parts of the plants consumed, season of consumption and preference was collected. The plant species fed upon by manatee were observed on the field and samples of such plants were collected in a polythene bag for analysis in the Department of Fisheries and Aquaculture Technology (FAT) laboratory, Federal University of Technology, Akure.

Laboratory work: Samples of 14 plant species, (Table 2) comprising of 13 food items and one non-food item collected from the field were analysed for proximate (crude protein, ether extract, ash content, crude fiber, moisture content, dry matter and nitrogen-free extract) and mineral (calcium, sodium, iron, zinc and potassium) composition as follows;

Proximate Analysis

Plant Samples were finely grounded using a standard blender, and thoroughly mixed. Portions were taken quickly for analysis in order to avoid a significant change in water content. The remaining samples were labeled and kept in desiccators prior to analysis. Following the AOAC (2003) procedures for moisture, protein, fat, ash, fiber, and nitrogen free extract analysis, the samples were uniformly sized and analyzed for moisture, protein, fat, ash, fiber, and nitrogen free extract which was carried out in the Graduate Lab of the Federal University of Technology, Akure's Department of Fisheries and Aquaculture Technology (FAT). The moisture was measured according to AOCS. According to the Association of Official Analytical Chemists, the protein level was evaluated using the Kjeldahl method (AOAC). Calcination at 550°C was used to determine the ash, according to the American Oil Chemists Society's Official Methods and

Recommended Practices (AOCS). Lipids were extracted in Soxhlet apparatus with petroleum ether at 40– 60°C. Total fibers were determined according to the method of proposed by AOAC.

Mineral determination: The sample's mineral content was determined by atomic absorption spectrometry, flame photometry, and spectrophotometry, as recommended by the AOAC (2003).

Data Analysis

Data obtained were analysed using both descriptive statistics such as tables, bar chart, pie chart and analytical method. Data on proximate and mineral compositions of the food resources of African manatee were analysed using One-way ANOVA to test for significant difference. Chi square was used to test for level of relationship between occupation and ability to know manatee food resources as well as preference.

RESULTS

Local communities' knowledge of African manatee food resources along Ipare River

The local communities were aware of thirteen different plant resources consumed by African manatees in the area. This includes, *Ceratophyllum demersum, Echinocloa spp, Vossia cuspidata, Polygonium leptocarpa, Manihot esculenta leaf, Manihot esculenta tuber, Brachiaria ramosa, Najas pectinate, Phragmites karka, Pistia stratiotes, Avicennia germinans,Eichhornia crassipes,* and *Nymphea lotus*

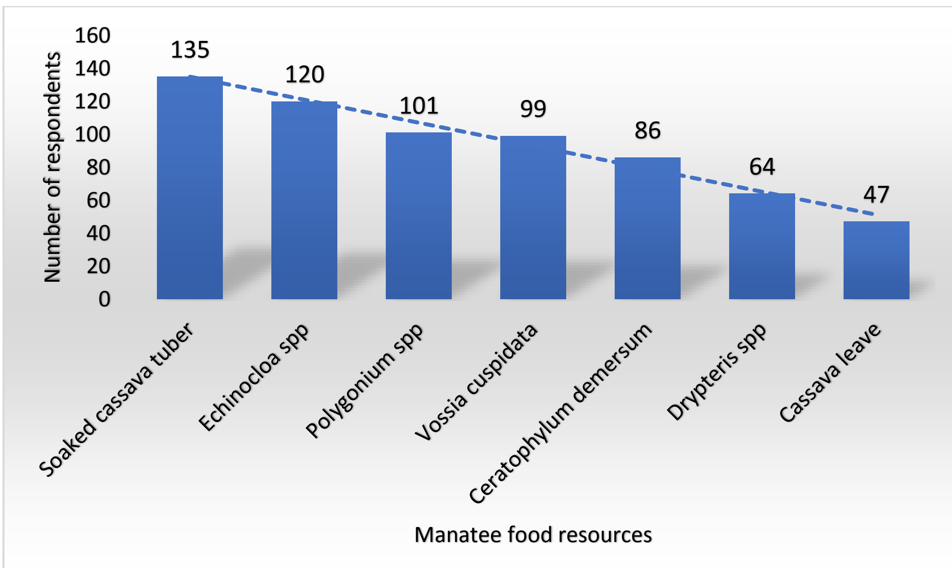

Figure 2: Frequency of mention/occurrence of manatee food resources along Ipare River by the respondents

The Proximate Composition of the Food Resources of African Manatee along Ipare River

The results of the proximate analysis indicated that crude protein content was highest in *Manihot esculenta* leaf (23.95%), followed *Najas pectinata* (19.84±0.06) while *Manihot esculenta* tuber had the lowest (2.28%). However, the crude protein content varies significantly (P<0.05) (Table 2). Ash content was highest in *Pistia stratiotes* (29.46%) followed by *Avicennia germinans* (18.62%) and lowest in *Manihot esculenta* tuber (2.47%). The ash content also varies significantly (P<0.05). Furthermore, *Phragmites karka* had the highest crude fibre (27.04%) while *Polygonium leptocarpa* had the least (8.60%). Ether extract percentage ranges from 0.44% in *Manihot esculenta* tuber to 11.96% in *Phragmites karka*. Nitrogen free extract (NFE) was highest in *Manihot esculenta* tuber (68.10%) and lowest in *Phragmites karka* (27.33%). Moisture content was highest in *Ceratophyllum demersum* (10.04%) and lowest in cassava tuber (6.48%). All the nutrient components showed significant difference at P<0.05.

Table 2: Proximate composition of plant species consumed by manatee along Ipare River

Plant samples	Crude Protein	Ash Content	Crude Fibre	Ether Estract	Nitrogen Free Extract	Moisture	Total Carbohydrate
CL	23.95±0.25a	8.00±0.10g	10.24±0.20e	4.40±0.30c	45.85±0.03c	7.56±0.03b	56.09±0.12^{cd}
CT	2.28±0.20f	2.47±0.11h	20.23±0.04b	0.44±0.60e	68.10±0.02a	6.48±0.02c	88.33±0.03a
DS	17.02±0.20bc	17.92±0.29b	15.98±0.13c	3.26±0.15cd	38.48±0.05d	7.35±0.05b	54.46±0.09d
CD	18.42±0.12b	10.32±0.38f	11.20±0.38^{de}	2.69±0.13d	47.33±0.03c	10.04±0.03a	58.53±0.25c
ES	12.65±0.76d	9.59±0.46^{fg}	13.00±0.26d	3.56±0.29cd	54.21±0.01b	6.99±0.04c	67.21±0.14b
VC	13.46±0.03d	14.02±0.06d	15.24±0.16c	2.12±0.09d	47.93±0.01c	7.23±0.04bc	63.17±0.09b
PL	16.16±0.25bc	12.23±1.49e	8.60±0.19f	3.61±0.12cd	51.28±0.03b	8.12±0.01b	59.88±0.11c
EC	17.52±0.05bc	16.89±0.05c	20.75±.0.05b	2.19±0.04d	34.79±0.07e	7.86±0.02b	55.54±0.06d
BR	14.50±0.05d	12.92±0.05	23.85±0.07b	8.27±0.04b	32.53±0.07e	7.93±0.02b	56.38±0.07^{cd}
NP	19.84±0.06b	18.20±0.06b	16.57±0.06c	3.62±0.02cd	33.49±0.07e	8.28±0.04b	50.06±0.07e
PK	9.79±0.04e	16.55±0.06c	27.04±0.07a	11.96±0.03s	27.33±0.06f	7.33±0.03bc	54.37±0.07d
AG	14.02±0.04d	18.62±0.06b	21.10±0.05b	3.74±0.03cd	37.99±0.07d	8.48±0.03b	59.09±0.06c
PS	13.18±0.03d	29.46±0.07a	16.29±0.05c	4.25±0.01c	33.10±0.06e	7.06±0.03bc	49.39±0.06e
NL	14.00±0.05d	13.93±0.04^{de}	17.11±0.06c	4.09±0.02c	37.93±0.08d	8.57±0.01b	55.04±0.07d

Key: *CD: Ceratophyllum demersum, ES: Echinocloa spp, VC: Vossia cuspidata, P: Polygonium leptocarpa, CL: Manihot esculenta leaf, CT: Manihot esculenta tuber, DS: Drypteris spp, BR: Brachiaria ramosa, NP: Najas pectinata, PK: Phragmites karka, PS: Pistia stratiotes, AG: Avicennia germinans,EC: Eichhornia crassipes, NL: Nymphea lotus*

Note: No significant differences between values with the same alphabet; the plant highlighted in green is non-food item of African manatee in the area

Mineral composition of plant species consumed by manatee along Ipare River

From the result of the mineral composition analysis of the plant samples collected, it was observed that the concentration of Sodium (Na) ranges from 0.12 to 10.19 recorded for *Drypteris spp* and *Nymphea lotus* respectively (Table 3). Potassium (K) was highest in *Nymphea lotus* (6.67) and lowest in *Eichhornia crassipes (*0.49). Calcium concentration was highest in *Drypteris spp* (5.23) and lowest in *Echinocloa spp (*0.35*)*. Also, Phosphorus content was highest in *Eichhornia crassipes* (0.86) and lowest in *Echinocloa spp (*0.19*)*. Iron (Fe) was highest in *Manihot esculenta* tuber (7.5) and lowest in *Echinocloa spp*, (0.04). Furthermore, zinc concentrations in the plant samples also varies ranging from 0.13 to 0.13 recorded for *Nymphea lotus* and *Ceratophyllum demersum* respectively. These mineral composition values varied significantly (p<0.05) among all the collected plant samples.

Table 3: Mineral composition (Mg/g) of plant species consumed by manatee along Ipare River

Plant samples	Na	K	Ca	P	Fe	Zn
CD	3.46±0.18b	1.81±0.06d	0.99±0.01d	0.60±0.03a	1.7±0.01bc	3.50±0.24a
ES	0.16±0.03d	0.78±0.09e	0.35±0.02e	0.19±0.01d	0.04±0.01e	2.25±0.11a
VC	0.24±0.03d	1.06±0.03d	0.41±0.02e	0.39±0.02b	0.7±0.02d	1.24±0.29b
PL	1.85±0.08c	3.11±0.07c	1.33±0.04d	0.73±0.02a	1.1±0.02c	0.32±0.02c
CL	0.22±0.01d	1.36±0.01d	1.10±0.03d	0.39±0.02b	1.7±0.01bc	0.22±0.01c
CT	0.36±0.02d	0.84±0.17e	2.86±0.15c	0.24±0.03cd	7.5±0.02a	1.15±0.02b
DS	0.12±0.01d	4.17±0.16b	5.23±4.46a	0.27±0.04c	1.2±0.01c	0.45±0.04c
EC	2.60±0.06b	0.49±0.03e	3.28±0.03bc	0.86±0.03a	0.60±0.05d	1.71±0.13b
BR	0.42±0.11d	4.69±0.17b	2.91±0.69c	0.65±0.06a	2.26±0.12b	1.26±0.29b
NP	0.26±0.06d	3.45±0.03c	4.23±0.03ab	0.23±0.06cd	1.25±0.05c	0.13±0.02c
PK	3.40±0.17b	5.55±0.55a	4.18±0.06ab	0.43±0.02b	2.08±0.30b	0.15±0.08c
AG	2.35±0.06bc	3.56±0.03c	2.86±0.05c	0.31±0.06c	1.23±0.02c	0.15±0.03c
PS	3.64±0.10b	3.21±0.07c	2.36±0.07c	0.54±0.01b	0.61±0.05d	1.23±0.02b
NL	10.19±0.32a	6.67±0.42a	4.24±0.10ab	0.38±0.06b	2.59±0.06b	0.49±0.09c

Key: *CD: Ceratophyllum demersum, ES: Echinocloa spp, VC: Vossia cuspidate, Pl: Polygonium leptocarpa, CL: Manihot esculenta leaf, CT: Manihot esculenta tuber, DS: Drypteris spp, BR: Brachiaria ramosa, NP: Najas pectinata, PK: Phragmites karka, PS: Pistia stratiotes, AG: Avicennia germinans,EC: Eichhornia crassipes, NL: Nymphea lotus*

Note: Values with the same alphabet are not significantly different (p<0.05); the plant highlighted in green is non-food item of African manatee in the area

DISCUSSION

Adequate animal nutrition is essential for growth and efficient reproduction. However, nutritive quality varies significantly among and within forage crops and nutritional needs vary among and within animal species and classes. All the thirteen (13) plant species reported by authors such as Allen, (2014). Akoi, (2004), Iwar, (2003), Daniel and Abdul, (2006); Ofori, (2009), Powell, (1996), Aristide, (2011), Odewumi, (2014) to be consumed by African manatee along Ipare River are among the known food items of African manatee except soaked *Manihot esculenta* tuber which is been recorded for the first time. This first record of consumption of soaked cassava tubers agrees with the statement by Powell (1996) that the African manatees can be extremely opportunistic in their dietary choices. For this reason, cassava (*Manihot esculenta)* tuber could be one of such.

The food resources of African manatee in Ipare River is high in nutrients (proximate composition). It is somewhat similar to the concentration of each nutrient in the diet of captive manatees reported by Harshaw (2012) (15.8-18.1% CP, 6.3-8.7% CF, 8.2-9.0% ash, and 48.5-52.0% NSC) and the nutrients of the aquatic vegetation reported by Siegal-Williot, *et al.* (2010) and Rodrigues et al. (2021) for *Trichechus manatus manatus* (5.35-21.93% CP, 5.35-68.52%NDF, 4.75-70.40%ADF and 10.67-63.11MM). It is also in tandem with the statement by Chinelo and Jega **(**2019**)** that the presence of these compounds of nutritive value, as well as high energy value suggests that *Nymphaea lotus* rhizome could be used as a livestock and human dietary supplement. Several authors (Preen 1992; Lanyon and March 1995; Aragones 1996; Aragones and Marsh 2000; Lanyon and Sanson 2006) have also suggested that to optimize nutritional intake, dugongs like manatees must ingest highly digested (Halophila) and nutrient-rich (Halodule) plant species. The fibre and NFE contents of the food resources is in line with the statement by Schmidt *et al.* (2001) that herbivores, including hindgut fermenters like manatees require adequate amounts of plant fiber.

Protein is required by the micro-organisms inside the stomach of herbivores to digest forages. Therefore, inadequate protein will lead to reduced intake of food. However, the crude protein content of the non-food sample (*Drypteris spp*) falls within the range of the documented food samples. From the result of the proximate analysis of these plant samples, it can deduce that West African manatee diet selection is not only based on their proximate composition of the plants which implies that there are other determinants for the west African manatee choice of diet. The moisture content in all the samples were significantly high. This is because the plants are in the aquatic environment and are therefore able to store water in their tissues. This strongly suggests that the African manatee can derive most of its water requirement from their food by eating the succulent parts of these grasses. This agrees with the statement by Dashak, and Fali, (1993) that the high moisture content of the rhizome implies that it is likely to have a short storage capability. It is also in agreement with the statement by Castelblanco-Mart´inez *et al.* (2009) and Allen *et al.* (2018) that different parts of mangroves are consumed by the American manatee, which is able to supplement its need for water by eating the leaves rich in fresh water

Minerals can be broadly divided into macro (major) and micro (trace) components. The third category is the ultra-trace elements. Calcium, phosphorus, salt, and chloride are macro-minerals, whereas iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium, and sulfur are micro-minerals (Eruvbetine, 2003). Minerals are essential for the proper functioning of tissues and act as second messengers in some biochemical mechanisms (Anita, *et al.*, 2006). The food resources of African manatee along Ipare River contain both the mico and macro minerals. These minerals are adequate for proper functioning of manatee body tissues which help in maintaining healthy living preventing them from having diseases. This is in agreement with the statements by Chinelo and Jega **(**2019**)** that the presence of these compounds of nutritive value, suggests that *Nymphaea lotus* rhizome could be used as a livestock and human dietary supplement. Also, the bromatological composition of food items varies according to the part of the plant ingested (Werner, 1993), as well as the species, age, time of year and soil fertility (Siegal-Willott *et al.,* 2010;).

CONCLUSSION AND RECOMMENDATION

This study shows that there are diverse food resources with high nutrients composition for African manatee along Ipare River. Protein and fiber are important to African manatees, but that they do not need to specifically seek it out owing to its high availability in diverse plants in the study area. However, it is difficult to point out through proximate and mineral composition alone the reason why manatees feed on some plants and not on others. This indicates that the African manatee choice of diet may be determined by some other factors such as anti-nutrient factors which is not within the scope of this study. It is therefore recommended that further study should be conducted to cover a wider area and plants while the digestibility of the food resources and antinutritional analysis be conducted to actually determine the reason for the preference of some food items to other.

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