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Ecology and characterization of the habitat of the West African manatee (*Trichechus senegalensis*) in Niger

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Abstract

The study on the ecology of the West African manatee (*Trichechus senegalensis*) was carried out on the Nigerien portion of the Niger River. It aims to overview the manatee's habitat and its feeding habit in order to identify the challenges associated to its conservation. The transect method combined with the phytosociological survey of Braun Blanquet (1928) was used for the data collection on the vegetation using 25 m² (5m × 5m) quadrants arranged on the river bank. In addition, other field parameters like turbidity, PH and water temperature were recorded for a better understanding of species ecology and vegetation's dynamics. During the 224 hours were spent scanning the river with a digital portable sonar and observing manatees' feeding signs, ninety (90) feeding signs were recorded. During the study, twenty six (26) plants species from eleven (11) families were recorded. The overall Shannon index recorded was 4.16 depicting a rich and varied habitat. The study revealed that human activities like rice cultivation, animal husbandry and urbanization heavily impact on the manatees' ecosystem as shown by lower Shannon indexes recorded in "Ayorou-Farié" and "Farié-Niamey" transects with H equal 3.89 and 3.66, respectively. The maximum diversity (Hmax) recorded is 4.70. The perturbations in the physicochemical quality of the river are caused by diverse pollution mainly domestic and industrial wastes that contribute in the increase in the water PH which ranges from 8.2 to 8.7 around Niamey, the Niger's capital. The study revealed that *Echinochloa stagnina* (bourgou) is the most preferred plant species by the manatee.

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Introduction

The West African Manatee (*Trichechus senegalensis*) is a large aquatic mammal found in coastal and inland wetlands of Western Africa between Mauritania and Angola, and inland as far as Mali, Niger and Chad. It occurs in coastal and estuarine habitats, coastal lagoons and the lower reaches of most river systems from the Senegal River of Mauritania/Senegal to the Longa River in Angola. (UNEP/CMS, 2008; Todman *et al.,* 2008). It is classified on the red list of the IUCN and the annex I of the Convention on Illegal Trade of Endangered Species of wildlife and Fauna (CITES, 2016). The manatee is a well known animal species in Niger because in 1901 already, Gratiolet mentioned its presence around Sinder, a village upstream on the river Niger The researches made by Ciofolo and Sadou (1996) enabled to demonstrate the presence of manatee throughout the river Niger from Yassane a village close to the border with Mali up to Dolé, a village on the border with the Federal republic of Nigeria. In Niger, the law n°62-28 of 04 august 1962 placed the manatee in the annex 1 of animal species which benefit from total protection. This law was reinforced by the law n°98-07 of 29 April 1998 regulating hunting and Fauna protection in Niger. Notwithstanding this classification which had given to the species a special status, habitat lost, climate change and human activities, mainly poaching manatee for its meat and its various usages in the traditional medicine, dam's constructions and rice cultivation are the main challenges facing the species' survival. The objective of this work is to assess the manatee's ecology in Niger. Specifically, plants species encountered will be censed and the impact of human activities will be assessed.

Materials and methods

Study area

The study was conducted on the Nigerien portion of the River Niger, the largest river in West Africa. It originates in the Fouta Djallon mounts in Guinea and crosses successively Mali, Niger, Benin and Nigeria. It traverses the Niger territory on about 550 km from Koutougou (region of Tillabéry) to Dolé (Region of Dosso).

The population of the area is estimated at 5,977,951 inhabitants in 2014 with a population density ranging from 13.6 persons/sq km in Ouallam to 35.6 persons/ sq km in Kollo (INS, 2014). The main activities are agriculture and fishing while animal husbandry is conducted on a small scale.

Materials

This study necessitated the elaboration a data collection sheet to conduct a socio-economic survey and personal interviews on manatee's habitat. Interviews focused mainly on (i) manatees' habitat, (ii) plants species eaten by manatee, (iii) the challenges facing its conservation, etc. Field investigations required a motorized canoe equipped with a 45 HP motor, a Garmin 60 GPS, digital portable multifunction sonar, data recording note book, pencil and a digital camera. Desk review provided an overview of the researches conducted on the manatee.

Data collection

Water surface temperature was recorded using digital portable multifunction sonar. This sonar can permit direct reading of water surface temperature, water depth and water PH. The tip of this sonar is sunk vertically into the water column so as that its bottom comes in contact with the water surface. The values were directly read on a lead screen and directly recorded on a field note book. Temperatures were recorded three times in the day (06:00 am, 15:00 pm and 20:00 pm). A total of two hundred and twenty four (224) hours of scanning were carried out during the study. The transect method combined with the phytosociological survey of BRAUNBLANQUET (1928) were used for data collection on the vegetation and the physical characteristics of the river. This method was widely cited in Gounot (1969), Guinochet (1973), Whittaker (1973). The mixed abundance-dominance scale of BRAUNBLANQUET (van der Maarel, 1979, Rivas-Martinez, 1981, Gillet *et al.*, 1991, Gillet, 2000, Dufrêne, 2003, Delpech, 2006) was privileged in the global estimation of number of individual plant or density and recovery surface). This method consisted on the use of 5mx5m quadrants.

Since the manatees never come out completely from water, even for feeding, the quadrants are partially placed in water (2 meters on the river bank and 3 meters in the water). The 25 sq m quadrants are placed along the river bank whenever a manatee feeding sign is observed and the vegetation is totally recorded. In order to assess the impacts of human activities on the manatees' habitat, the study area was divided into three transects: Ayorou-Farié, Farié-Niamey, Niamey-Gaya. A score of abundance-dominance was assigned to each species, taking into account its ground cover rate according to the BRAUNBLANQUET method. At each survey, the following data were collected: site name, survey number, date, geographical coordinates and site characteristics (geomorphology, slope, soil type, etc.), etc. In addition, other field parameters like animal grazing signs and human incursions were also recorded.

Data analysis

Raw data were collected and typewritten using Microsoft Excel Spread sheet. MS Excel statistical tools were used for figures production. Diversity indexes are frequently used in ecology because they are essential parameters for the characterization of a stand (Ramade, 1994). In this study the Shannon index H (1928), maximum diversity (H max) and Pielou's Equitability (E) were calculated for each plant communities. This index takes into account the relative abundance of species and is well suited to the comparative study of the stands because it is relatively independent of the sample size (Ramade, 1994). Diversity indices were calculated for each zone. This index is expressed as:

$$H = ?\ \sum_{i=1}^{s} (P_i * \ln P_i)$$

where:

H = the Shannon diversity index

i : a species

S = numbers of species encountered

∑ = sum from species 1 to species S

P_i = fraction of the entire population made up of species I (ni / N where ni is the number of individuals of the species)

Other parameters like RM and Pi are obtained as follow:

RM (Average Overlay) = Average of all readings

Pi = RM / ΣRM.

Sampling

The sampling, of preferential type, consisted of surveys carried out. Data was collected whenever a manatee feeding sign was observed. This sampling method was used by Guinochet (1954), Gillet (2000) and Bouxin (2008). Data was collected during the dry and rainy seasons.

Results and discussions

PH

The pH plays a great role in the reactions which take place in the water and varies according to seasons, the amount of suspended particles in the water and the water level. Its value depends on the level of the chemical elements present in the water. Fig. 1 shows the PH recorded during the low tide while Fig. 2 shows the PH during the Guinean flood. PH recorded values are relatively stable and fluctuates around the value 7 and this show the neutral PH of the river.

Table 1. Biodiversity richness of the study area.

Index	Global	Ayorou-Farié	Farié-Ny	Ny-Gaya
Specific richness(S)	26	26	25	26
Shannon Index (H')	4.16	3.89	3.66	4.04
Maximuim Diversity (Hmax)	4.70	4.75	4.64	4.70
Pielou's Equitability (E)	0.88	0.84	0.79	0.86

The pH recorded depicted some slight increases on three sites around Niamey.

The PH recorded during the low tide is higher than the one recorded during the local Guinean flood.

In Niger, hydrology and water availability are dependent on the sunshine and solar exposition. This solar exposition lasts all year round but shows its peak from March to June. During this period high temperature recorded cause high level of evaporation. The decrease in water flow begins at the end of January and becomes exacerbated in May when the river is converted into giant water pools separated by sand dunes. This low-flow causes the water level to continue to fall up to from 539 cm to 142 cm at the end of May with a flow speed of 50 m^3/s at Niamey station (NBA, 2017). During the low tide, the increase of the water PH is inversely proportionate to the decrease in the water level.

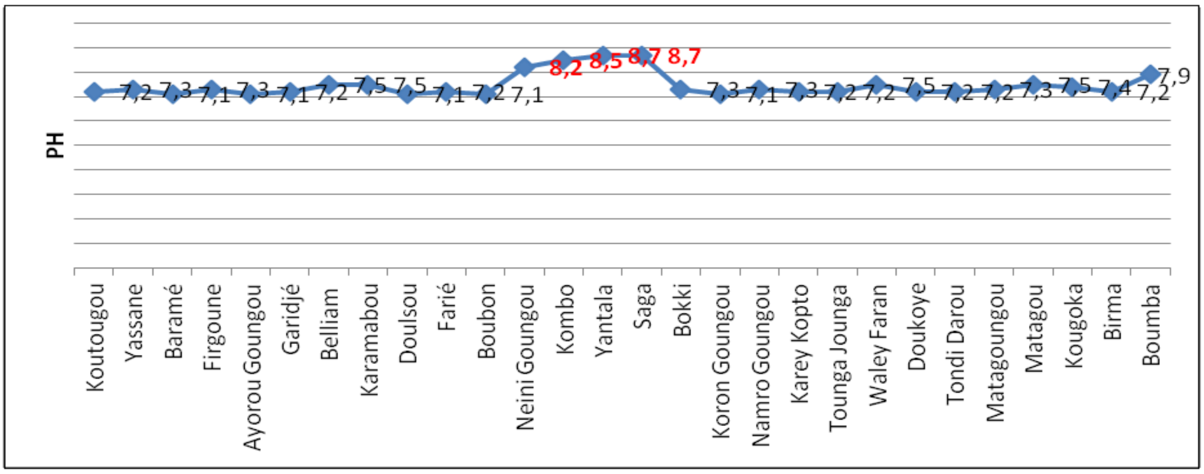

Fig. 1. PH at water surface during low tide.

The PH recorded is 8.2 at Neini Goungou site, 8.7 at Saga site and 8.7 at Yantala site, respectively. On the other hand, the Guinean flood begins from mid-October and lasts until January ending. This flood comes from the upper Niger and passes to the entrance of Niger to spread downstream towards Malanville in Benin republic. The maximum water level recorded during this period is 539 cm at Niamey station with a flow rate of 1773 m^3/s. During this period the water level rises to its peak.

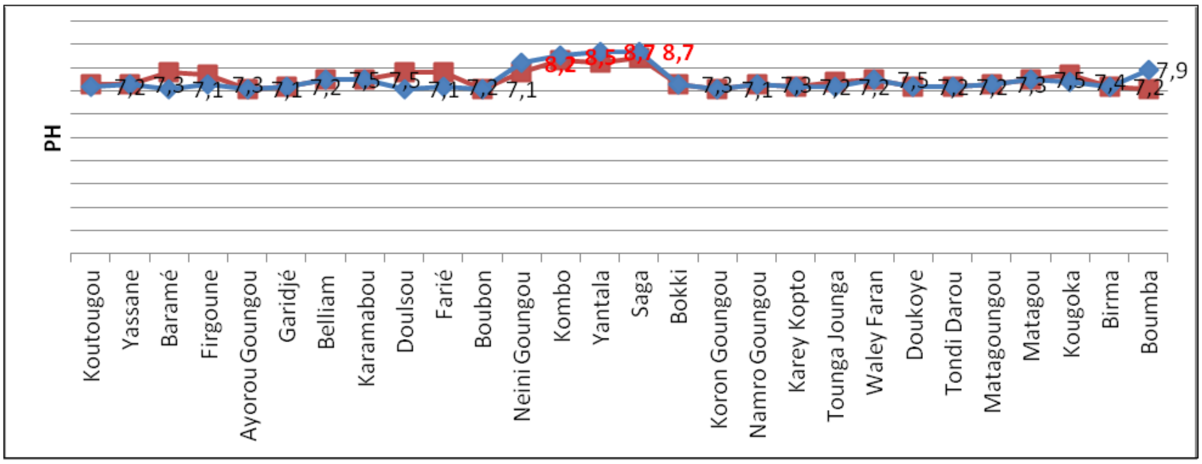

Fig. 2. PH at water surface during Guinean flood.

The large amount of water in the river dilutes the pollution and lowers the level of PH recorded. PH recorded during this period is 7.2 at Neini Goungou site, 8.4 at Saga site and to 8.3 at Yantala site respectively. This shows a significant pollution of the river waters around Niamey. This pollution is unfortunately due to human activities like domestic and industrial sewages. Indeed, Niamey, the Niger's capital city is home to major health centers such as the National Hospital, Issaka Gazobi Maternity Home, an industrial zone where many factories use chemicals in the manufacture of their goods, the Gamkallé tannery where animal skins are treated with chemicals and the refrigerated slaughterhouse. All facilities discharge their sewages without prior treatment directly into the river. This reflects the impact of the city on the quality of the river. River pollution has several origins, 38.4% of stakeholders stated that the use of pesticides in irrigated agriculture is responsible for the pollution, while 31.5% stated that domestic and industrial sewages are the main causes, 27.5% of the respondents suspected the fertilizers while 2.6% are unanimous that the canoes engine oils contribute more to the pollution of the river (Fig 3).

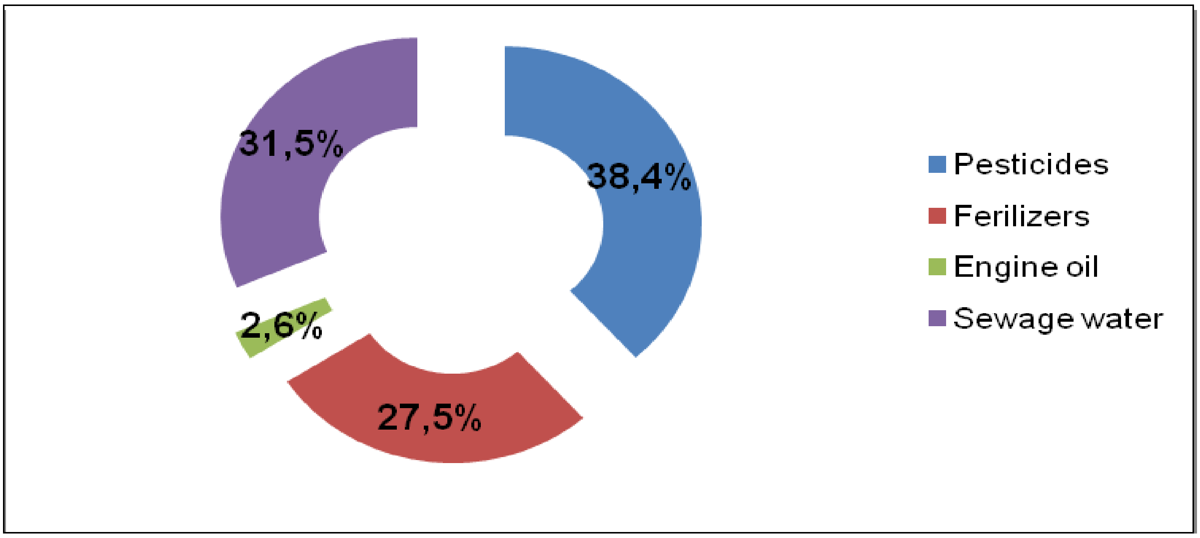

Fig. 3. Different causes of water pollution in river Niger.

These values are close to those recorded by Rabani (2015), who recorded PH values between ranging between 6 and 8.5 on the same sites. The PH recorded in Boki, a site about 25 km downstream of Niamey show a decrease in the PH and shows the river's ability to self-purify, thus maintaining the physicochemical properties of the river and creating a suitable environment for the development of aquatic fauna.

Temperature

The Guinean flood corresponds to a period when the river is filled with water and the temperatures are relatively low because of the harmattan that blows in Niger. According 17.3% of the respondents stated that they sighted the manatee during the Guinean flood when the river is filled with water and the vegetation is abundant (Fig. 4).

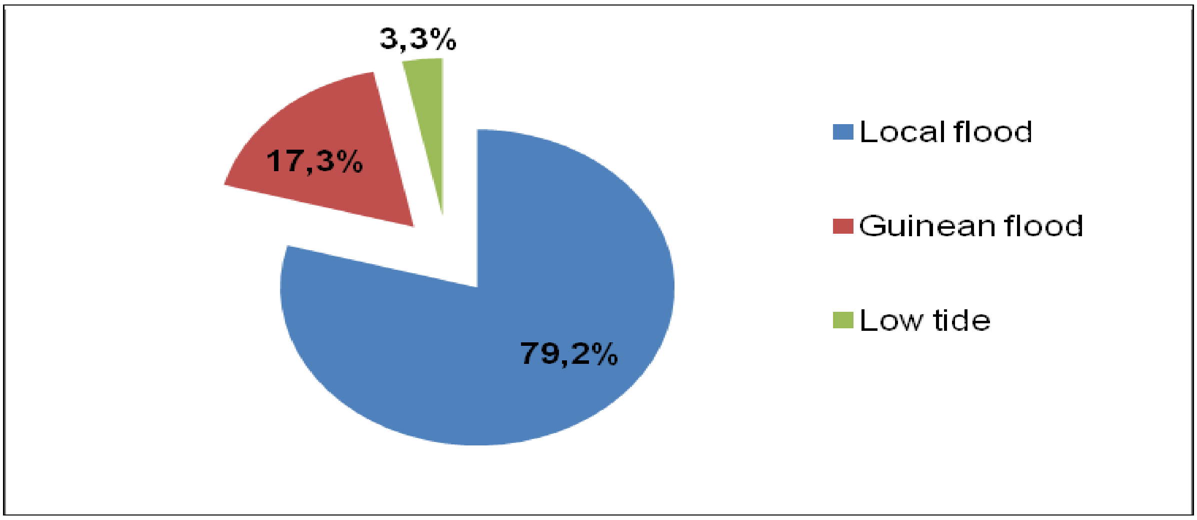

Fig. 4. Manatee sighting period.

This low percentage of respondents shows the difficulty in sighting the animal during this period of the year when the temperatures are relatively low when recorded. Theses temperatures fluctuate between from 16.1°C in the morning and 34.4°C in the afternoon. However, these temperatures remain usually low early in the morning and late in the night (Fig. 6).

According to these respondents, the manatees are very sensitive to low temperatures and they reported hearing the manatee cough early in the morning or late in the night, which explains the difficulty in sighting the animal during the Guinean flood when the temperatures fall below 18°C. Low temperatures would reduce the manatees' activities (feeding and migration) and may cause pneumonia like disease which makes the animal to cough.

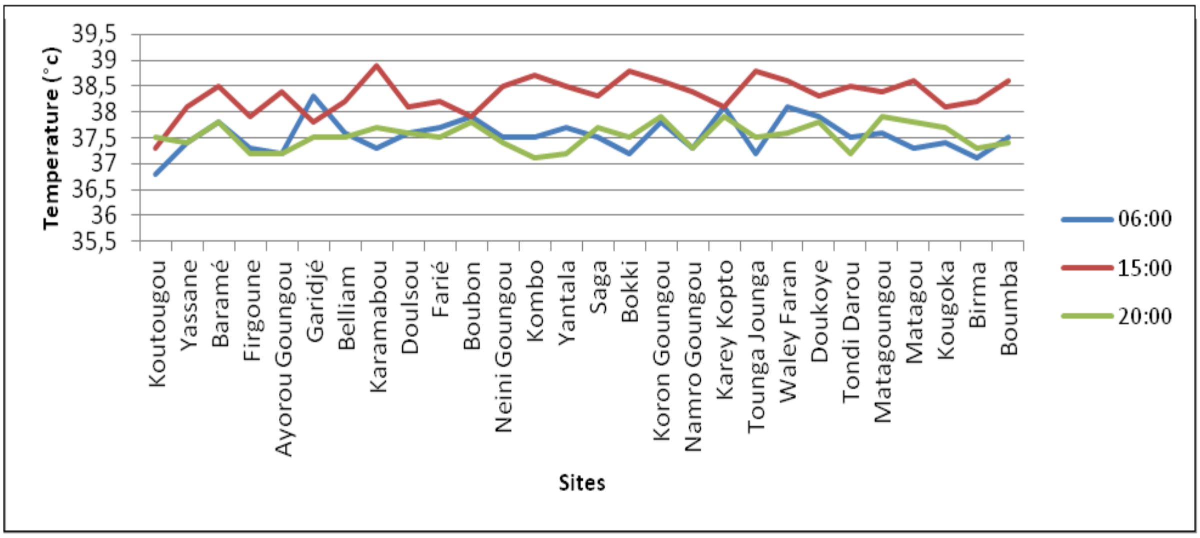

Fig. 5. Temperatures at water surface during local flood.

This could lead to cold stress syndrome as reported by fishermen who stated that hearing the manatee "cough" early morning and late evening when the temperatures drop. These results are confirmed by the findings made by many researchers. According to Brown (1975), temperature is a key factor which influences life in ecosystems. Reynolds III and Powell (2002) who stated that acute or chronic exposure to temperatures below 17 ° C may cause thermal stress, resulting in many clinical signs that can lead to death of the manatee. Bossart (2001) also stated that early symptoms of cold stress syndrome may appear as early as the first few days of exposure to temperatures below 20 ° C. Low temperatures can lead to acute manifestations, with lethargy, anorexia and terminal hypothermia. Chronic exposure to low temperatures causes a cascade of physiological upheavals that predispose the animal to lung, skin or digestive infections caused by opportunistic bacteria such as *Staphylococcus aureus, Morganella morganii, Edwardsiella tarda, Aeromonas hydrophila*, and many species of *Pseudomonas, Vibrio,* and *Clostridium*. He also added that lderly individuals appear to be more resistant to low temperatures than juveniles and calves, which can be explained by the difference in "surface to body volume" ratio and a different nutritional pattern resulting in lower production capacities. The limited capacity of the manatee to maintain heat would thus be another factor affecting its distribution (Powell and Rathbun, 1984, Lefebvre *et al.*, 1989, Reid *et al.*, 1991). According to Bréheret (2007) a maximum temperature of 30°C is recommended for manatees in captivity.

During the local flood, the temperatures recorded range from 36.8°C and 38.9°C with the lowest recorded around 6:00 am and the highest recorded during the afternoon around 15:00 pm (Fig. 5). According to 79.2% of the interviewees, the manatee is more sighted during the local flood. (Fig. 4).

Temperatures are relatively high during this period, creating favorable conditions for photosynthesis which enhances plant growth, zooplankton and phytoplankton development. These temperatures are ideal for the manatee to feed and to reproduce. These findings are confirmed by the work of Paaijmans (2008), who stated that water temperature is an important determinant in many aquatic biological processes, including the growth and development of immature aquatic wildlife, plant photosynthesis and dissolved oxygen. According to Bengston (1981), seasonal fluctuations in temperature would explain why the manatees hibernate in the relatively warm refuges during low temperatures.

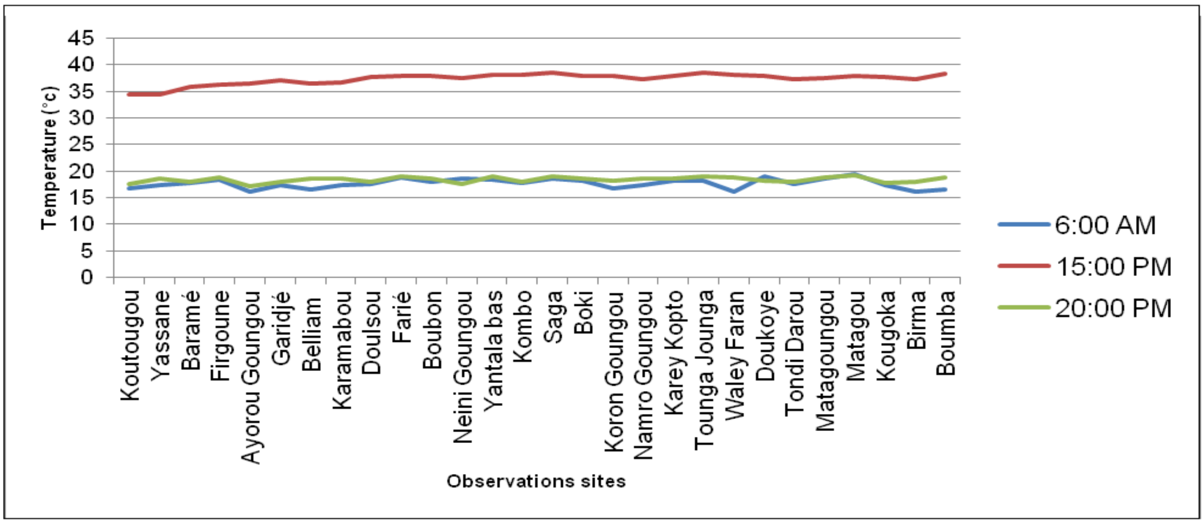

Fig. 6. Temperature at water surface during Guinean flood.

Feeding habit of the manatee

According to 79.2% of the respondents the manatees spend long time feeding and they are usually very active in search of food early morning and late in the night. They reported that the manatee could spend the whole night feeding.

These findings are confirmed by results obtained by Hartman (1979) who stated that the manatee devotes between 6 to 8 hours a day to feeding. Bengston (1981) stated that the manatee spent an average of 5.1 hours per day eating and could consume between 4 and 9% of its body weight while, on the other hand, Etheridge *et al.* (1985) noted that manatees spent between 5 and 6 hours feeding on aquatic plants and would consume about 7.1% of body weight.

According to Smith (1993), an adult manatee weighting 700 kg can consume between 30 and 65 kg of vegetation per day; According to Ripple (1999), nearly 8 hours a day are devoted by the manatee in feeding, so it could swallow nearly 50 kg of aquatic vegetation.

During 224 hours of field observation (4 hours/site), ninety (90) feeding signs were recorded. *Echinochloa stagnina, Cyperus bulbosus, Polygonum senegalense, Echinochloa stagnina, Nymphaea lotus*, *Pista stratiotes, Glinus lotoides, Sphenoclea zeilanica, Cynodon dactylon* were among the most grazed plant species recorded. According to 33.4% of the respondents, the manatees show a feeding preference for *Echinochloa stagnina* (bourgou) from which it consumes the tender leaves and young shoots by cutting them at irregular intervals over a long distance (Fig. 7). 11.8% of the respondents stated that in low tide, when water level is very low in the river and that food is scarce, the manatees usually graze on *Cyperus bulbosus* which forms the grassy carpet in the river bed (Fig. 7). This plant contains hard tubers which are very rich in sugars and starch and is edible for man. It could be used as a dietary supplement to the manatee during the dry season when the other plants which they feed on are no longer available.

This could also explain the "croc-croc" sound reported by the respondents when the manatees are eating. According to 19.8% of the respondents *Polygonium senegalensis* is also highly valued by the manatee. These results are confirmed by the work carried out by Harouna (2004) on manatees' feces analyze which revealed that *Echinochloa stagnina* is the most consumed herbaceous species. The roots and bark of *Ipomoea aïtoni* and *Polygonium senegalensis* are also highly valued by the manatee. Other aquatic plants species such as water lettuce *(Pista stratiotes) and Echinochloa colona, Ipomea aquatica, Sacciolepsis africana, Nymphea lotus, Oryza glaberrima, Eichhornia crassipes* are part of the plants that make up the manatee's diet (Fig. 7). 15.7% of the respondents reported that the manatees feed on shellfish. This result confirms the findings of Hartman (1979) who reported that manatees also feed on invertebrates (eg. insect larvae, amphipods, mollusks and shrimps) which would provide additional supplemental protein and mineral salts to an essentially vegetarian diet. A total of 90 feeding signs were recorded at different sites, however, some plants had already begun to grow again, and no estimation was made for the time required for these plants to develop new leaves.

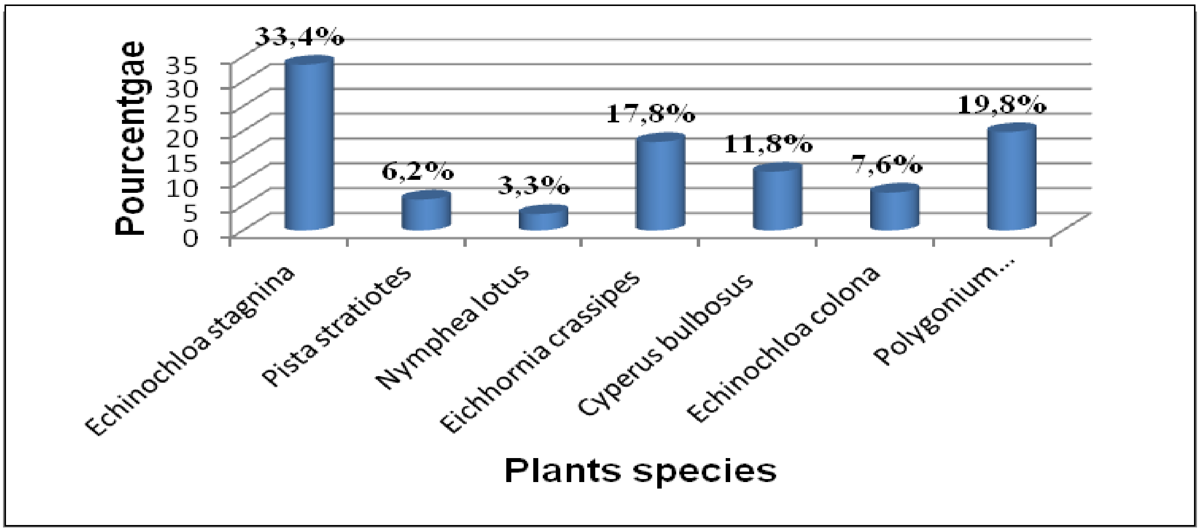

Fig. 7. Manatee most preferred plants species.

Diversity index

The Shannon diversity index (H) is an index that is commonly used to characterize species diversity in a community. A diversity index is a quantitative measure that reflects how many different types (such as species) there are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types. The global Pielou's Equitability (E), which is the mode of distribution of the species within a sample, E = 0.88, which shows all species have the same number of individuals within the same sample, no species is dominant (table 1).

The overall diversity index of the study area was determined by the calculation of the Shannon index. The Shannon's index of the study area "H" is 4.16.

This index recorded is fluctuating and it ranges between 3.89 in Ayorou-Farié transect, 3.66 in Farié-Niamey Transect and 4.04 in Niamey-Gaya Transect. In the first two transects, manatees' habitat is exposed to human pressures like habitations, rice fields and industries. These infrastructures contribute to the degradation of the river's ecosystem and the reduction aquatic plants which the manatees rely on for their feeding. The Ayorou-Niamey transect where low index were recorded depict the impacts of human activities on the ecosystem. Indeed, this transect is home to more than three million people with Niamey, the city capital housing around two million people (INS, 2014). This transect is covered by huge rice fields like the ones in Tillabéry, Dai Kaina, Koutoukalé, Karma, Namardé Goungoun, Namaro, Lamordé and Saga. These rice fields contributed to the alteration and destruction of the manatees' habitat.

The respondents noted also that there is a reduction in the richness and diversity of biodiversity in these transect could be explained by climate change, silting up of the river due to desertification and human pressures, invasive plant species, which prevent the development of the "bourgou" which constitutes the feeding, breeding, spawning and nesting grounds for several aquatic species, increased construction of large irrigated agricultural farms and urbanization.

The Niamey-Gaya transect shows a relatively higher index due to the presence of the W national Park which is the last refuge for about 80% of the national biodiversity (CNEDD, 2014). On the ecological level, the river constitutes Northern natural bouandary of the W National Park which includes the last important biotopes of the biodiversity of Niger. According to Seyni (1996) its peripheral zones harbors more than 80% of national biodiversity from the point of view of species and ecosystems. The presence of Park W, a site of international importance, which received several labels such as the Ramsar site in 1987, the UNESCO World Heritage site in 2002 and the Transboundary Biosphere Reserve in 2002. This international recognition has made it possible to mobilize resources for continuous protection and conservation of the biodiversity of this part of the Niger River. The biodiversity of the park is fully protected and no human pressure is recorded. In some areas the river banks are sloppy especially around the W park where the river valley is narrow. In other areas around Karey Kopto, the valley is a large flooding area and the river bank's slope is softer (Kandadji, 2014). The plant species are characterized by both their frequency and their abundance, and form the vegetation's nucleus of the manatees' habitat. The presence of *Echinochloa stagnina, Polygonum senegalensis, Nymphaea lotus, Cyperus maculatus, Aeschynomene afraspera, Oryza longistamina* and *Vetiveria nigritana* is mainly noted. These species are distributed in particular niches. Thus, *Nymphaea lotus* occupies the calm and deep waters; *Echinochloa stagnina*, the deep water banks while the *Cyperus maculatus* colonize the sand and gravel banks. This justifies a high rate of the Shannon index which recorded H = 4.04.

A total of twenty six (26) plant species from eleven (11) families were recorded in the study area. These species are: *Aeschynomene afraspera, Coldenia procumbens, Cynodon dactylon, Cyperus bulbosus, Cyperus maculatus, Echinochloa colona, Echinochloa stagnina, Eichhornia crassipes, Glinus lotoides, Glinus raddiatus, Heteranthera callifolia, Ipomea aïtoni, Ipomea aquatica, Ipomea coscinosperma, Mimosa pigra, Nymphaea lotus, Nymphaea maculata, Oryza barthii, Oryza glaberrima, Oryza longistaminata, Pista stratiotes, Polygonum senegalense, Sacciolepsis africana, Sphenoclea zeilanica, Stachytarphetta angustifolia, Tristicha trifaria*. These results are close to those obtained by Kandadji (2014) which recorded twenty nine (29) plant species.

LEEW (1985) wondered "What if the Niger river disappeared in its middle course? Indeed, there is a persistent decrease of the annual contribution of the river tributaries. Of the 30 billion m^3 traditionally recorded in the past years, it only drains about 18 billion m3 during the last ten years (NBA, 2016). In this zone, climate change effects conjugated with deforestation created two main valleys which drain water and sand into the river. The Bougoum and Saga Gourma valleys drain billions of tons of sand into the river contributing to its silting up. Large sand dunes which block water channels could be observed around Niamey. These sand dunes in the river conjugated with the destruction of river banks for rice cultivation contributed to the disappearance of vegetation in this zone.

Conclusion

This work aimed to assess the ecology of the West African manatee (*Trichechus senegalensis)* and the impact of human activities on its habitat in Niger. The study revealed that the disturbances in the physicochemical properties of the river caused by various types of pollution from human, agricultural and industrial sewages and silting up of the river bed contributed to an increase of the PH of the river in three sites around Niamey with a PH ranging between 8.2 to 8.7.

The study also revealed also that human activities coupled with climate change contributed to the modification of the river's ecosystem leading to a decrease of biodiversity index in the densely populated areas with an index ranging from 3.66 to 3.9. This study showed that protection efforts in and around the "W" national park contributed to conservation of biodiversity in the study zone with H equal 4.04. The study revealed also that the *Echinochloa stagnina* (bourgou) is the most appreciated plant species by the manatee. Therefore in order to sustainably protect and conserve the manatees, existing "bourgou" fields should be identified and protected while the creation of new bourgou fields and the control of their carrying capacity must be listed as a priority for Wildlife and Forestry services.

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