

*Full Length Research Paper*

# **The role of red monkeys in the spread of *cactus* seeds, *Opuntia tuna* (L.) Mill., in the Gueumbeul Special Fauna Reserve (Saint-Louis, Senegal)**

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The cactus is a plant that has a great capacity to adapt to global warming and the increasing risks of drought. In Senegal, it belongs to the category of neglected and under-utilized species (NUS). Its introduction as a protective hedge around the perimeter of the Gueumbeul Special Fauna Reserve has led his proliferation in the reserve. This proliferation of the cactus considerably reduces the surface area preferred by animal species. In order to determine the causes of the cactus plants proliferation in the reserve, the objective is to study the role of red monkeys in the seeds dissemination. To this end, a questionnaire and an interview guide were respectively confectioned for the villagers and the reserve agents. The mapping of cactus and red monkey populations and their signs of presence was carried out. Cactus fruits and monkey droppings were collected in the reserve. The droppings as well as the seeds extracted from them were weighed. The results of interview and the percentage of cactus fruits in the monkey alimentation revealed that monkeys are responsible for 78.6% of the spread of the cactus. The mapping also showed that cactus populations are more important in the western zone.

**Key words:** Special Faunal Reserve of Gueumbeul, cactus, neglected species, dissemination, proliferation, red monkey.

## **INTRODUCTION**

The *cactus* or prickly pear is a vascular and flowering plant. It is one of the xerophytic and succulent plants (Diop, 2011). The cactus has a great capacity to adapt to global warming and the increasing risks of drought.

Prickly pear cultivation is also gradually gaining ground in response to the need to strengthen the resilience of populations facing drought, high temperatures or soil degradation (FAO, 2017). In many countries, such as

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Ethiopia, it is the only crop on which the local population can make a profit, when the climatic conditions are not favourable. In Brazil, in the semi-arid north-eastern region, a plantation of more than 400,000 ha plays an important role in livestock development (FAO and IARDA, 2018). The *cactus* also saved many people and cows from starvation following the huge drought in Madagascar in late 2005 (FAO, 2017).

In Senegal, the *cactus* is a species that is very little exploited. According to Sarr et al. (2020), the main use of the *cactus* in Senegal is as a protective hedge for small-scale market gardening plots in the Niayes area. With the exception of this agroforestry technique, the cactus remains stereotyped by its invasive aspect, leaving untapped its enormous potential for multiple uses in several agri-food and silvopastoral sectors.

In Senegal with the deterioration of climatic conditions, the *cactus* occupies an important place in protective hedge around the perimeter of the Special Fauna Reserve of Gueumbeul (RSFG). However, the lack of knowledge about the breeding biology, the way in which the seeds are spread, its uncontrolled proliferation and the lack of local initiative for its transformation, occur as a drastic reduction of the vital areas of the terrestrial fauna; this is causing the progressive disappearance of the fodder reserves and a threat to the Sahelo-Saharan antelopes acclimatized in the Gueumbeul Special Fauna Reserve.

In response to the questions about the spread of *cactus* seeds, preliminary results have shown that red monkeys are responsible for this seeds proliferation according to 79.69% of the populations who live near the reserve (Diop, 2011). Indeed, red monkeys are reported to be major consumers of *cactus* fruits in this protected area. In addition, other animals such as birds have been cited in the dispersal and germination of seeds. Similar studies have shown the positive effect of transit in the digestive tract of pigeons on the germination of olive seeds (Hladik and Hladik, 2011).

With the aim of defining the mode of dissemination of seeds and the part of cactus fruits in the diet of red monkeys, in the Special Fauna Reserve of Gueumbeul, the present study was carried out for a better management of the reserve.

## METHODOLOGY

### Presentation of the study zone

The Special Reserve of Fauna of Gueumbeul is located in the delta of the Senegal River more precisely in the department of Saint-Louis (15°59 North and 16°28 West). This reserve has the same name with the village located at 12 km from the town of Saint-Louis, on the southern axis that links the town to the Gandiolais and the Barbarie land (Figure 1).

The reserve was created by decree No. 83-550 of 30 May 1983 and covers an area of 720 ha. Including the basin of Gueumbeul and its 500 m wide adjacent area, the total perimeter of

the reserve is 12 km.

### Interviews with RSFG agents

It concerns the conservator and the park agents. For this purpose, questions relating to introduction, propagation, vectors and control methods of the seeds dissemination, were asked to the agents (Appendix 1).

### Surveys with surrounding populations

An investigation has been established to obtain information on the origin, evolution and vectors responsible for the proliferation of the *cactus*. For having responses on these dissemination factors, a questionnaire consisting of two parts, was drawn: the identification of the person under investigation; the interview guide (Appendix 1). For this study, the villages were chosen according to two criteria: the presence of the *cactus*; the proximity of the villages to the reserve.

The survey was conducted in 6 villages (Gueumbeul, Ndaikher, Ndiawsir, Ngayna lébou, Diama thiaguel and Tougou peulh). In each village, we interviewed only one person per house whose age was 40 years or above.

### Collection of geographical coordinates

They were taken using a GPS type (GARMIN MAP 64). With the GPS, the geographical coordinates of the *cactus* clumps were taken. The use of GPS also enabled assess to the spatial distribution of red monkeys (direct observation) and their droppings (indirect observation). The tufts are *cactus* plants which are quite distant from each other and whose diameters are equal to 8 m. A *cactus* stand consists of a group of tufts which are fairly close together. The following parameters have been calculated for showing the uncontrolled proliferation of the *cactus* in the reserve:

(1) The percentage of the area occupied by the *cactus* in relation to the total extent of the reserve (720 ha).

Area occupied by the *cactus* (%) = (total *cactus* area) / (total surface area of the reserve) × 100

(2) The percentage of the area occupied by the *cactus* in relation to the land surface (380 ha)

Area occupied by *cactus* (%) = (total *cactus* area) / (land area) × 100

The surface area of the earth is equal to the surface area of the reserve without that of the bowl.

(3) The surface of a tuft: Area of a tuft =  $(d/2)^2 \times 3.14$  D = tuft diameter

### Monkey watching

The observation consists of following the red monkeys with binoculars throughout the reserve or noting their presence index (droppings). The geographical coordinates of the monkeys and droppings were taken (Figure 2).

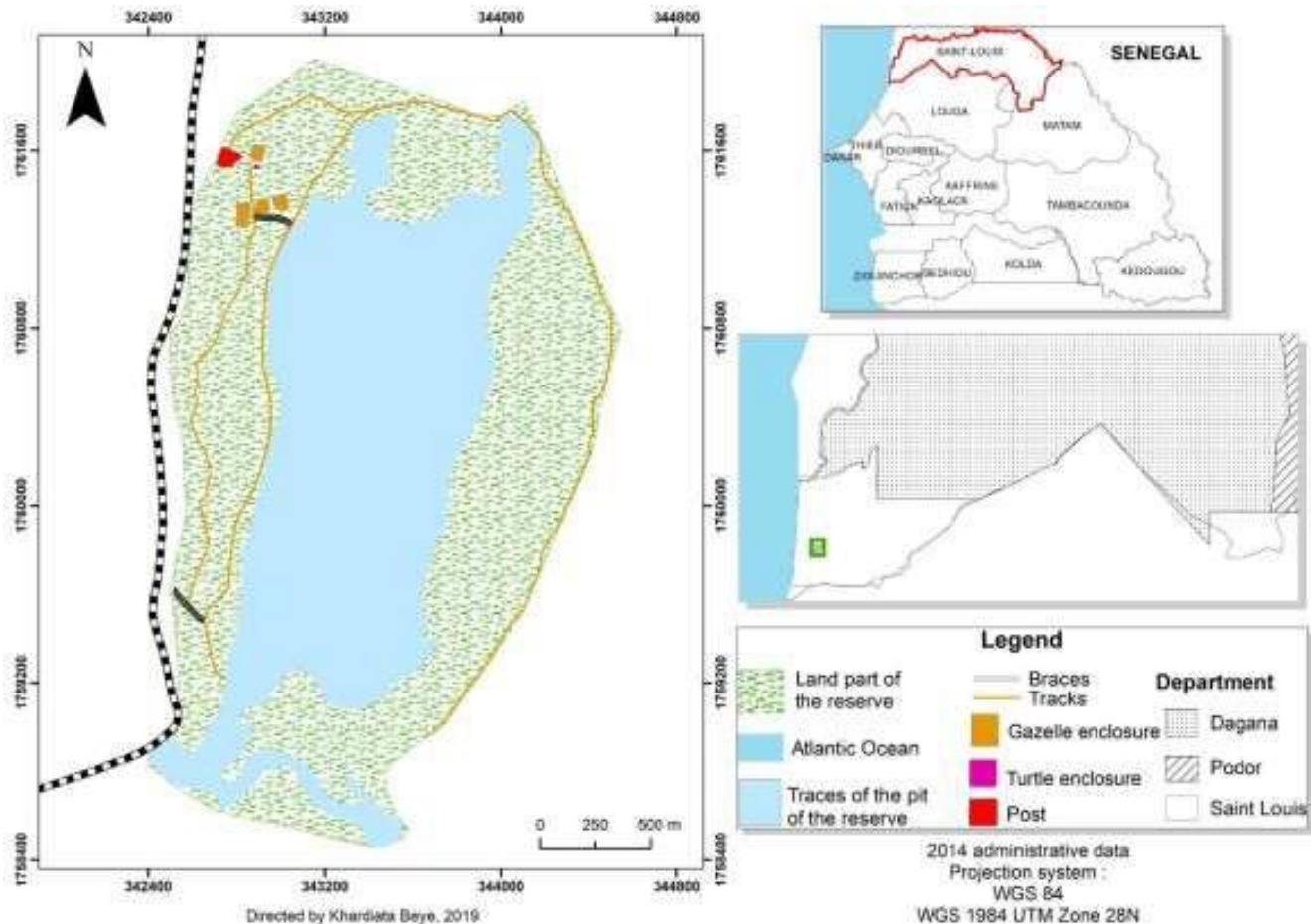


Figure 1. Location of the Gueumbeul reserve.

### Evaluation of the part of fruit in the diet of monkeys

To determine the part of fruits in the diet of the monkeys, a sample of 10 droppings was considered with a number of repetitions of 08. The total weight of the 10 droppings was calculated using an electronic balance type HCB 302 with a maximum weight of 300 g, with an accuracy of 0.01 g. After weighing, the droppings were crushed and the *cactus* seeds were extracted. The seeds extracted from the 10 crushed droppings were weighed.

In order to assess the proportion of *cactus* fruits in the monkeys' diet, the percentage of the weight of the seeds in the droppings was calculated.

Percentage of seeds (%) = (weight of seeds extracted from droppings) / (total weight of droppings) × 100.

## RESULTS

### Evolution and origin of *cactus* proliferation

According to the results of the surveys, the proliferation of *Opuntia tuna* is linked to vectors. These different vectors, which are responsible for the rapid evolution of the area

occupied by the *cactus* in the reserve, are illustrated in Figures 3, 4 and 5.

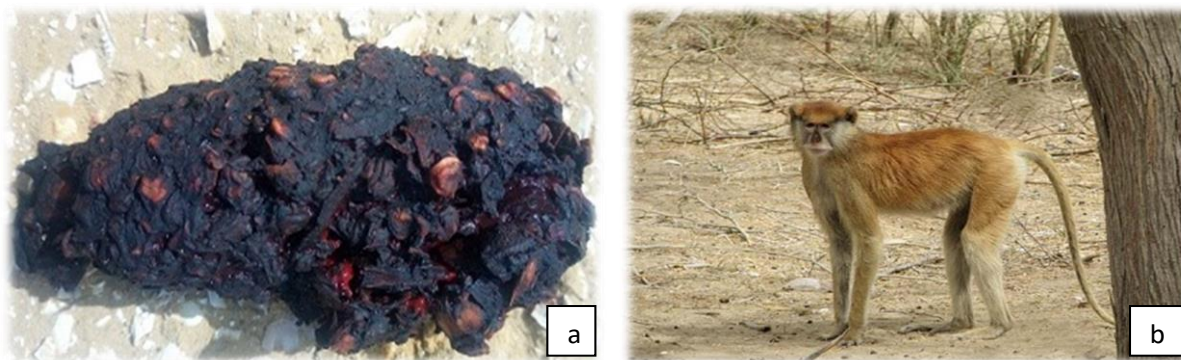
### Evolution of the species since its introduction into the reserve

Figure 3 shows the responses of the people surveyed on the evolution of the *cactus* populations since their introduction as a live hedge around the perimeter of the reserve.

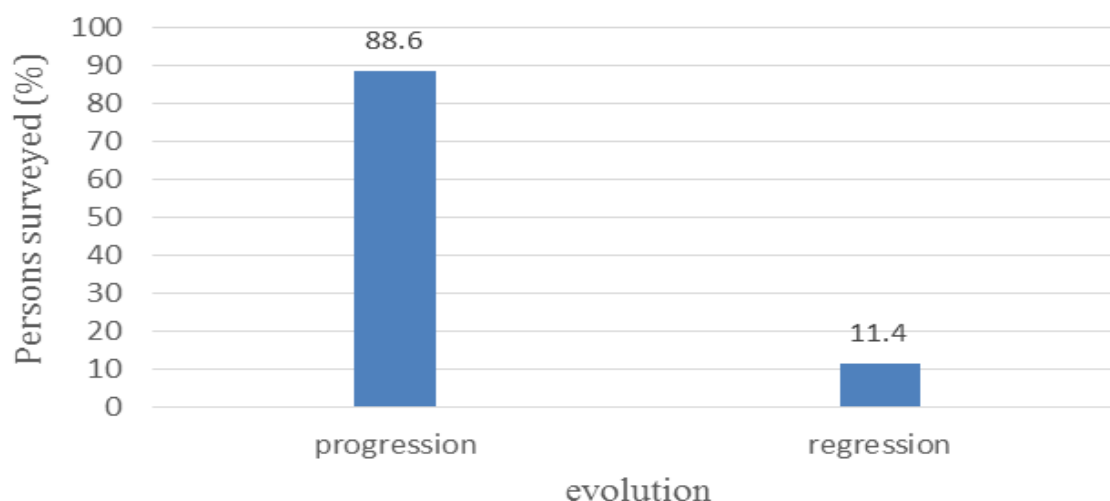
The development of the *cactus* in this area has progressed according to 88.6% of the persons surveyed (Figure 3). 88.6% of the people surveyed said that the *cactus* population had increased strongly and the consequence is that the areas preferred by the animals were occupied.

### Origin of *cactus* proliferation

In Figure 4, the responses of the persons surveyed



**Figure 2.** Red monkey droppings (a), red monkeys (b).



**Figure 3.** Opinions of the persons surveyed on the evolution of *Opuntia tuna* plants in the reserve.

about the animals that are vectors for the spread of *cactus* seeds are recorded.

The exploitation of the responses, revealed the role of different vectors in the proliferation of the *cactus*. Among these vectors, monkeys occupy the first place with 78.6% of the people surveyed. It is followed by monkeys-birds with 11.4%, monkey-human with 2.9%, goats with 2.9% and finally camels, birds and non-users with 1.4% each (Figure 4).

#### The *cactus* in the diet of the animals in the reserve

Figure 5 illustrates the responses of the persons surveyed on the consumption of the *cactus* fruits by the animals in the reserve.

Among the responses collected on the animal species that consume the *cactus*, the monkey comes in first place with 85.7% of the people surveyed. Birds came second

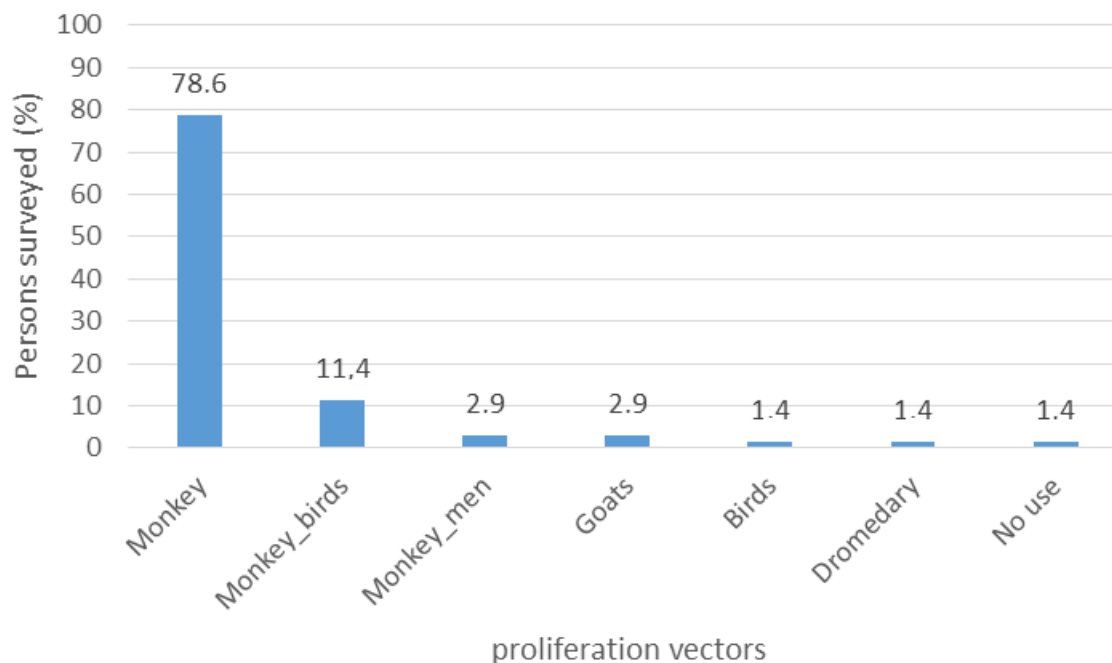
with 8.6%. Goats and dromedaries come in last place with 2.9 and 1.4%, respectively (Figure 5). These results obtained on the diet of animals in the reserve confirm the role of monkeys in the dissemination of *cactus* seeds.

#### Location of the *cactus*

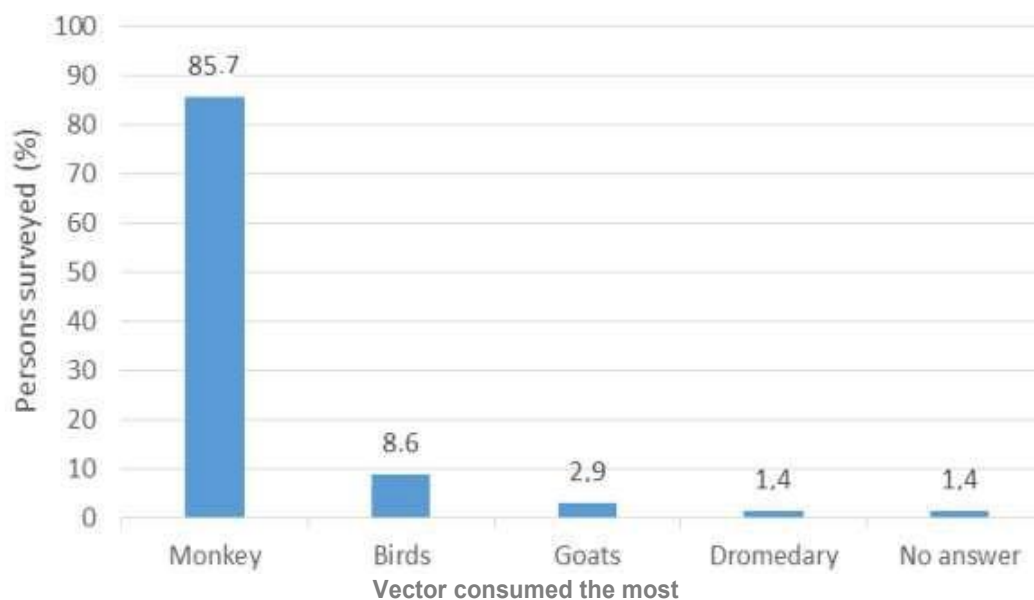
The exploitation of the results shows a total of 298 mapped *cactus* tufts; these tufts, which are close to each other according to the mode of aggregation, form stands of different sizes (Figure 6). The north-western zone is characterized by tufts that are scattered, allowing more or less easy movement of the animals.

In the south-western zone, many *cactus* individuals form denser stands. However, despite the high density of *cactus*, there are corridors for the movement of some animals.

In the eastern part, the *cactus* tufts are more or less



**Figure 4.** Opinions of the persons surveyed on dissemination vectors seeds of *Opuntia tuna* in the reserve.



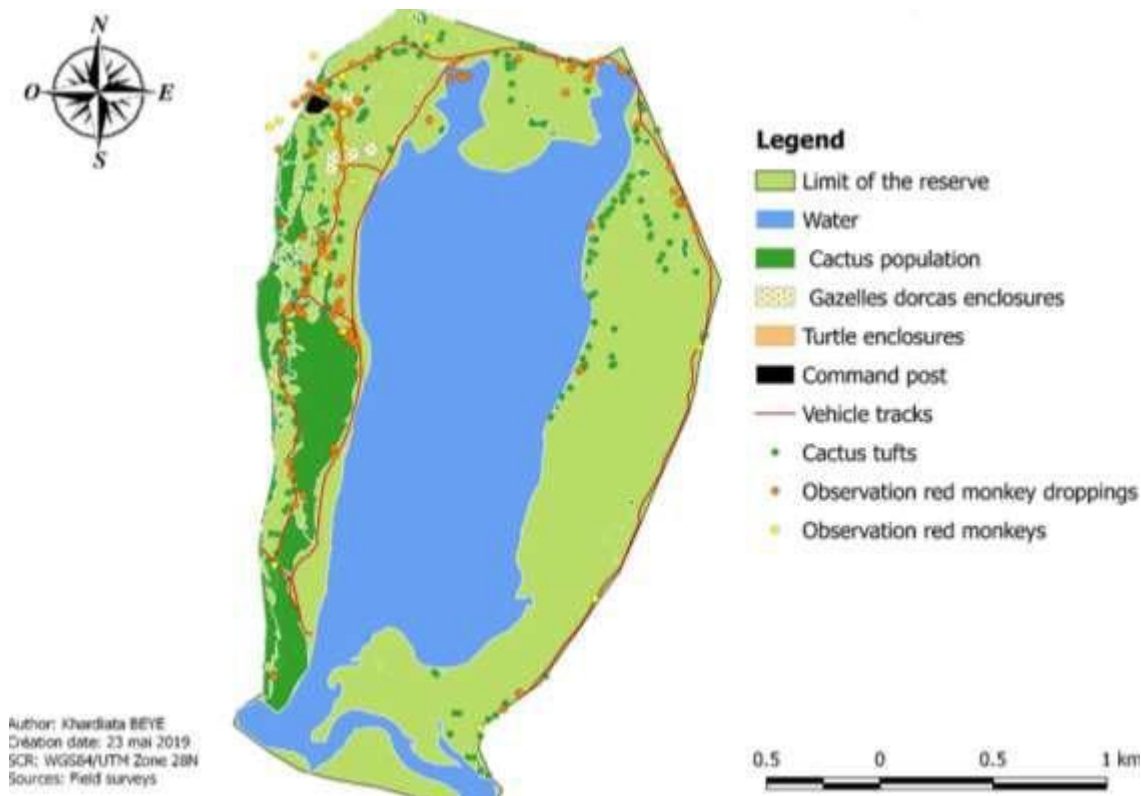
**Figure 5.** Opinions of respondents on the place of *Opuntia tuna* in the diet of the animals in the reserve.

evenly spread over the whole area. The estimate of the total area occupied by *cactus*, according to the calculation method mentioned earlier, is 47.26 hectares. Consequently, the *cactus* occupies 12.43% of the land surface of the reserve; this drastically reduces the grazing area and the mobility of the animals in the reserve.

### Spatial distribution of red monkeys and their signs of presence

Figure 6 shows the geographical coordinates of the monkeys and their signs of presence in the reserve.

Reading the results shows the predilection zones of the monkeys in the reserve. The green dots show the



**Figure 6.** Mapping of *cactus* populations and monkey displacements in the reserve.

presence of monkeys in these areas by direct observation during the various prospections in the reserve. The red dots indicate their passage by observation of the droppings found in these zones.

A final reading shows that the concentration of *cactus* populations is higher in the north-western zone where the presence of monkeys is much more noted. The north-eastern zone also contains less dense *cactus* stands.

### Proportion of cactus fruits in the diet of red monkeys

Figure 7 illustrates the importance of the *O. tuna* fruits in the diet of red monkeys. The *cactus* fruits occupy more than 50% of the weight of the droppings collected in the reserve; this percentage concerns 87.5% of the batches of droppings weighed. On average, 5.25 g of the average weight of a turd (16.92 g), is occupied by *cactus* seeds.

To conclude this study, it can be said, that *cactus* fruits occupy a predominant place in the diet of red monkeys.

## DISCUSSION

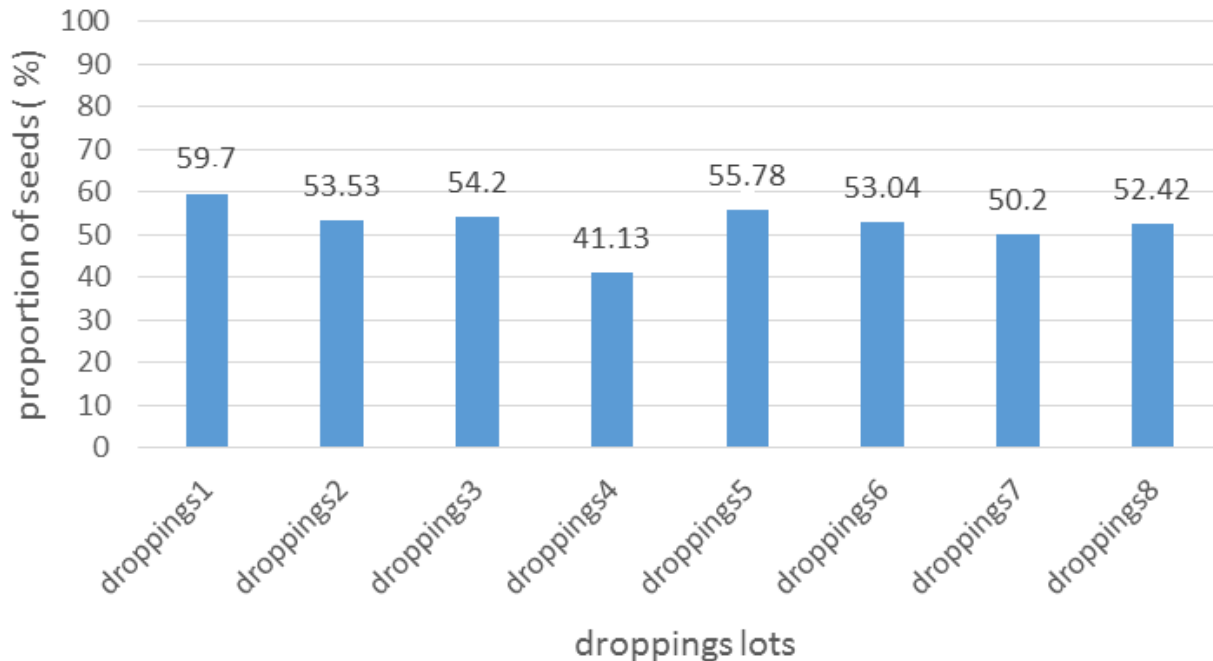
### Proliferation of the *cactus*

The *cactus* has proliferated exponentially and is a real problem for the reserve's ecosystems (RSFG, 2010).

Numerous ethological studies have shown that animals climb the trees with the sweetest fruits, consume them and the seeds are widespread (Krief and Hladik, 2010). The observations made on the proliferation of *cactus* during the present work, noticed a real progression of *cactus* plants in the reserve.

On the basis of the results obtained for *cactus* proliferation, it appears that monkeys are large consumers of cactus fruits. Indeed, the *O. tuna* plant produces a lot of red-coloured fruits that attract monkeys. In his research, Hladik (2002) reported that fruit is the main source of food for most primates. The monkeys have a very large population and are uncontrollable in the reserve. They consume the *cactus* fruits and disperse the seeds to sites more or less favourable for germination. This is confirmed by the villagers who maintain that the monkey is the animal that consumes the most *cactus*. Other species or factors are responsible for the proliferation of the cactus. Among these species and factors, we can mention that:

1. Birds also consume the fruit and the seeds are regurgitated or defecated;
2. The populations use the *cactus* plant as hedges in the fields;
3. Children also eat the fruit (fruit, juice) and throw away the seeds;
4. Other animals such as goats and camels eat the



**Figure 7.** Proportion of *cactus* fruits in the diet of red monkeys.

snowshoe and the fruit;

5. The lack of fruits processing initiatives (non-use) has a positive impact on the proliferation of the *cactus*.

These observations are similar to the results of Faye (2010) and Diop (2011) which noted that animals have a considerable role in the proliferation of the *cactus*.

#### Location of the *cactus*, monkeys and their signs of presence

At the reserve, two stands of *O. tuna* are noted:

1. The first stand is located in the western part of the basin with a high concentration of tufts;
2. The second stand is located at east of the basin with a low presence (Faye, 2010; Cissé, 2017).

In effect, the observations made on the map, show that the western zone contains more *cactus* stands with a much denser concentration in the south-west.

This density means that *Oryx* are rarely present; only monkeys and warthogs frequent this south-western zone. In this zone, fodder areas and corridors for the animals are limited. The eastern part is dotted with tufts far from each other. The low presence of *cactus* tufts and the availability of fodder in quantity explain the presence of *Oryx* and *Dama Mhorr* gazelles. In addition, the eastern zone contains very diverse vegetation with wider traffic corridors. These results are similar to those of Diop

(2011). In addition, we note that the *cactus* develops better in the western zone than in the eastern zone; this could be related to soil types (yellowish soil in the western part and reddish soil in the eastern part).

The area occupied by *cactus* stands is 47.26 ha. Thus, the proportion of the area occupied by the *cactus* in relation to the total land area is 12.43%. Diop (2011) found an area occupied by *cactus* that was 26.51% of the total land area. This decrease in surface area could be linked to the *cactus* tussock removal activities initiated by the park conservator in conjunction with the local population. It could also be explained by the DIOP method, which takes into account a lot of space not occupied by the *cactus*.

This map also shows the distribution of the monkeys and their presence index. Each yellow dot represents a band of monkeys (about 60 individuals) and the orange dots represent the presence index (droppings) of the monkeys. Indeed, a large number of *O. tuna* seeds occupy on average 5.2 g of the weight of a monkey dropping. In conclusion, the monkeys are the potential agents of dissemination of *cactus* seeds in the reserve. Transit of the seeds through the digestive tract of the monkeys would facilitate the germination of the defecated seeds.

#### The part of the *cactus* fruits in the diet of red monkeys

Each plant species is visited by a greater or lesser

number of fruit-eaters during its fruiting period (Charles-Dominique, 2003). When they are present in normal densities, primates play an important role in this dispersal; in the Gabonese rainforest, of 51 plant species for which the role of *Cercopithecus* could be precisely defined, 80% had their seeds dispersed by these animals (Gauthier-Hion, 1984).

The observations made on the proportion of seeds extracted from the droppings show that *cactus* fruits occupy more than 50% of the weight of the droppings collected in the reserve; this percentage concerns 87.5% of the batches of droppings weighed. The same observations were made by Hladik and Hladik (1969), who noticed that in the Barro Colorado forest, the fruits always constitute the largest part of the dietary intake (60-80%) in primates. In fact, the *cactus* produces a large quantity of red fruits which attracts disseminating vectors, the main one being the red monkey. Consequently, the number of monkeys being important, the seeds are scattered all over the reserve. On this subject, Hladik and Hladik (2011, 1988), Hladik (1996) and Julliot (1992), have shown in their work that monkeys contribute significantly to the propagation of plants that are necessary for their diet.

## Conclusion

The objective of this research was to study the role of red monkeys in the proliferation of the *cactus* in the Gueumbeul Special Fauna Reserve. Indeed, the survey showed an evolution of the species since its introduction into the zone. It also emerged from the survey that the monkeys are large consumers of *cactus* fruits; the proportion of seeds extracted from the droppings of red monkeys revealed the importance of the *cactus*, *O. tuna*, in their diet. Therefore, with their large numbers, they are present throughout the reserve and spread the *cactus* seeds present in their droppings. A mapping of *cactus* populations has shown that the western zone, where the monkeys are more present, concentrates the largest *cactus* populations than the eastern zone. Based on the results, if an effective control method against the proliferation of the *cactus*, is not done, the animals habitats are in danger of disappearing. Local and national initiatives for the processing and cultivation of *cactus* in reserved areas would help to better develop them and manage their propagation.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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**Appendix 1****FACT SHEET ON THE ORIGIN OF CACTUS PROLIFERATION****Identification**

Date:...../...../.....

File number:.....

Name of the village:.....

First names:.....Name :.....

Sex:..... Age:..... Profession:.....

**Maintenance Guide*****Origin and history of the species***a. Do you know a species called *Opuntia tuna*?

Yes:.....

No:.....

b. How long have you known this species?

Recently:.....

For a long time now :.....

c. Was it present before in your terroir?

Yes:.....

No :.....

d. How is it introduced?

Voluntarily:.....

Involuntarily:.....

e. Were the areas occupied by the company

Unimportant:.....

Moderately important :.....

Very important :.....

***Propagation of the species***

a. What promotes the development of the species?

Richness of the soil:.....

Others :.....

b. Has the species regressed or progressed since its introduction into the environment?

Regression:.....

Progression:.....

c. What is at the origin of this regression or progression?

Man:.....

Monkey:.....

Birds:.....

Others:.....

d. Did you see them consuming the species?

Yes:.....

No:.....

e. Where are they located?

In the reserve:.....

Inside as well as outside the reserve:.....

f. Does the development of the species cause problems in your terroir?

Yes:.....

No:.....

g. If Yes, what types of problems?

.....

.....

### **Control**

a. Have you tried to control this species?

Yes :.....

No:.....

b. What methods did you use?

Manual:..... Mechanical :..... Chemical:..... Organic:.....

c. Are these methods effective?

Yes :.....

No:.....

### **Uses**

a. Do you use the cactus?

Yes:.....

No:.....

b. If yes, what are these uses?

Food use:..... Fodder:..... Protection:..... Others:.....

### **INTERVIEW GUIDE WITH THE CONSERVATOR AND RSFG AGENTS**

1. How long have you been recruited from this pool?
2. Did you find the cactus in the reserve when you arrived?
3. How was the Cactus introduced into the reserve?
4. Tell us about the spread of the cactus in the RSFG?
5. What are the vectors of propagation?
6. Do you see them consuming the cactus?
7. Are they located only in the reserve?
8. Have you tried to control the proliferation of the species?
9. What method did you use to control it? Is it effective?
10. Do you know of other methods to control the proliferation of the cactus?
11. Do you know any uses of the cactus?
12. What recommendations would you like to propose to curb the proliferation of the cactus in the reserve?