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# Social and Productive Indicators of Forage Palm and the Survival of Livestock Activity in the Semi-arid Region of Northeastern Brazil

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***Authors' contributions***

*This work was done in collaboration. The author HAA conceived, designed, coordinated the study and edited the manuscript. The other authors assisted in the collection and analysis of the data. With the final manuscript, all authors read and approved.*

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## ABSTRACT

The importance of the cultivation of forage palm (*Opuntia fícus indica Mill*) for the agriculturalists of the semi-arid region of Northeast of Brazil, in particular the one of the State of Paraiba, is due to its adaptability to the environmental conditions, especially, in the dry period, since it is the only alternative to feed the herd in most of the localities of this region. The plague of carmine cochineal (*Dactylopius opuntiae*) has been decimating the planting of this important forage in the intermediate geographic region of Campina Grande, Paraiba, Brazil. In view of this, it was necessary to carry out a quantitative and/or qualitative diagnosis of the areas cultivated with the traditional palm (giant cultivar) and its revitalization, with the introduction of new varieties resistant to this pest, in four localities of this region, these determinations being the main objectives. The territorial cut included about fifty farms in the four localities, being geo referenced using GPS and satellite imagery from Google Earth. The diagnosis consisted of the application of structured and

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semi-structured questionnaires, interviews and in loco observations. Data analyzes were performed using statistical distributions of measures of central, dispersion and frequency trends. The main results indicated that forage palm in the semi-arid state of Paraiba, Brazil, is the main or only source of food for ruminants. Carmine cochineal (*Dactylopius opuntiae*) decimated traditional palm varieties and the only alternative was to discard part of the herd and reduce livestock activity. The levels of infestation of carmine cochineal and destruction of palms are of the order of 90%. The program of revitalization of traditional palm cultivation by clams resistant to carmine cochineal has been the alternative for the continuity of livestock activity in this region, although there is a contribution of drought.

*Keywords: Livestock; palm forage; cochineal carmine; livestock sustainability.*

## 1. INTRODUCTION

The forage palm (*Opuntia fícus indica Mill*) originates in Mexico and is scattered on almost all continents. Initially it was used as an ornamental plant and the option of the cultivation of forage species and without thorn and became the main food source for ruminants, especially, in the northeastern semiarid region, due to its adaptation to the type of climate.

The distribution of *Opuntias* species in the world is due to their high genetic variation, which originates from the great ecological diversity of the areas where they are native [1] and by the high degree of genetic diversity due to sexual reproduction and vegetative propagation [2,3].

The semi-arid Northeast occupies about 10.0% of the Brazilian territory and more than half of this geographic cut, the regimes of spatial and temporal distribution of rains are irregular. Even in the short rainy season, there is irregularity in the amount and distribution of rain, lasting from three to five months and there are still chances of not raining [4]. This region has the largest area planted with forage palm in Brazil [5,6,7] and this forage is, on most farms, the only source available to feed the herd of cattle, sheep and goats. As conditions do not favor the formation of native pastures or other forages in the dry season, the livestock activity in this region is dependent on the forage palm.

The search for forage to feed ruminants, especially in periods without rain (dry), the forage palm (*Opuntia fícus indica* L. Mill) stands out for presenting morphological characteristics that make it tolerant to long droughts. Rainfall in the semi-arid region is a decisive factor for the production of palm and livestock activity, in general, because in the short rainy station, which lasts for about two to four months, the totals of rains are extremely irregular in amount and in distribution, when comparing one location to another [8].

The forage palm is an exotic cactus, with more than 1400 species and 120 known genres [9]; [10], native to Mexico, where it is used in cooking, agribusiness, production dyes and cosmetics. In the northeastern semi-arid region, it is used to feed cattle, sheep and goats because it is the only forage that persists, especially, in the dry season.

The forage palm without a thorn (*Opuntia fícus-indica*) is a cactus native to Mexico [9]. In the northeast of Brazil it was introduced around 1880, in Pernambuco, through seeds imported from Texas-United States [11]. There are two species of the genus *Opuntia ficus-indica* (L) Mill, giant palm, and the Nopalea (*cochenillífera Salm-Dyck*), sweet palm, both do not contain spines.

The giant and the Nopalea palm têm as genetic characteristics of rusticity, drought-resistant and high water use efficiency provide the adaptability to the semi-arid environment, which are associated with good acceptability of consumption by cattle [12].

In recent years, encouraging the planting of this fodder is not due to its importance as the main source of feed for ruminants, but for the environmental conservation of the Caatinga biodiversity, especially in the climate change scenario.

The agronomic characteristics of resistance to drought caused the forage palm to incorporate the livestock of Paraiba and other areas of the northeastern semi-arid region, because it is the only one that perseveres and remains nourishing during the long periods of drought and, therefore, guarantees the maintenance of the herd [13],

[14] and can also be used in the form of bran [15], in addition to providing environmental conservation [16].

Moreover, In the Northeast of Brazil, the genus *Opuntia* and *Nopalea* are spineless cactus without spines and the most used as fodder, standing out the giant palm, the round and the small one, for having fast growth and moisture content superior to the other cactus. It is not known how a destructive pest known as carmine cochineal (*Dactylopius opuntiae*) was introduced in the State of Paraíba, Brazil, whose origin is Mexican, detected in traditional palm plantations, especially in the giant variety, between mid 2009 and 2010 [8].

Generally, the emergence of this pest in the semi-arid region of Brazil occurred unexpectedly, since the original purpose of carmine was to produce a natural dye for use in the food and cosmetics industry. However, there is strong evidence that this introduction was erroneously done on the *Dactylopius opuntiae*, rather than the correct one, *Dactylopius coccus*, for the production of the "carmine cochineal" dye on an experimental scale [17].

Encouraging the cultivation of forage palm is a strategy that aims not only the development of livestock in the Northeast, but the survival of this activity. However, with the emergence of carmine cochineal (*Dactylopius opuntiae*), palms with traditional varieties were practically decimated.

The carmine cochineal arose in the traditional forage palm plantations, mainly in the state of Paraiba in an unexpected way, since the original objective was to produce a natural dye, the carmine, to be used in the food and cosmetics industry. Nevertheless, there is strong evidence that this introduction was erroneously done in the *Dactylopius opuntiae*, rather than the correct one, *Dactylopius coccus*, for the production of the "carmine cochineal" dye on an experimental scale [17].

This species of pest is considered the most damaging to the crop and the dispersion / decimation occurs very quickly. Thus, the advance of carmine cochineal on forage palm crop in the intermediate geographic region of Campina Grande, Paraiba, Brazil, which includes 72 municipalities in this stat the State, and in other locations. The damages caused by the decimation of the palms are high and without the palm there is no way to feed the ruminants, besides being used as a bargaining chip during the dry season, when its price reaches three times [18].

Cochineals are insects that suck the rackets of this forage by inoculating toxins. This process results in the weakening of the plants, causes the yellowing and the fall of the cladodes. When the infestation rate is high and if a control measure is not adopted, the infested area is practically decimated [19].

The name of carmine cochineal is due to the production of the natural red dye (carmine), from the synthesis of carminic acid, which has great commercial importance in the production of cosmetic and, therefore, an income generating activity.

In the northeastern semi-arid region, this pest was observed around 2001 in the states of Pernambuco and Paraíba and currently occupies the status that previously belonged to scale cochineal [5]. Their recognition is relatively easy, because on the surface of the cladodes appear small white circles similar to cotton threads and when they are crushed, it releases a reddish substance, which is carmine [20].

The failure to produce carmine dye in Brazil may have been motivated by the introduction of the "false" cochineal (*Dactylopius opuntiae*l), because this pest has a high destructive power [21].

In the other side, the advance of carmine cochineal in the state of Paraiba occurred in the plantations of the giant variety, the one most cultivated, especially, in the intermediate geographic region of Campina Grande [6,22]. As a result of this pest, the extermination of this variety is inseparable; therefore, the carmine cochineal has directly affected the follow-up of livestock, an activity that is the main generator of employment and income in this geographic cut.

The devastation of forage palm cultivation in Paraíba, due to this pest, is very worrisome even because the level of infestation comes to decimate the entire planting. If there is no food such as maintaining cattle ranching, especially in the main dairy, in the basin of the municipalities of Caturité and Boqueirão, for example, whose social and economic losses compromise even the small and medium-farmer's patrimony [6].

In most locations states of Paraiba and Pernambuco were the most affected by carmine

cochineal where the infestation has already decimated about 90% of the traditional planting. With the advent of carmine cochineal, the option of planting is with varieties resistant to this pest [6].

This condition led to the establishment of a forage palm revitalization program, which consists of replacing more productive palm clones with higher nutritional value and, in particular, being resistant to carmine cochineal, such as small and elephant ear varieties [23].

The alternative to not extinguish livestock activity in the northeastern semi-arid region is to revitalize the planting of the traditional forage palm decimated by tolerant varieties of carmine cochineal. Also, without the palm, there is no way to continue this important activity, which is the basis for sustainable rural development in the semi-arid region of Paraiba.

In view of this, there was a need for a study on forage palm, before and after the incidence of carmine cochineal, in the geographic cut of the State of Paraiba, Brazil, because the livestock activity is inductive of the local sustainable development, being these determinations the main objectives.

## 2 MATERIALS AND METHODS

### 2.1 Location of the Study

The experimental area of this work included about 20 farms, located in the dairy basins of the intermediate geographic region of Campina Grande, Paraiba, Brazil [22], which includes 72 municipalities of which the municipalities of Boa Vista (7°15'58" S, 36°14" W), Boqueirão (7°29'15" S, 36°07'17" W), Caturité (7°25'20" S, 36°01'41" W) and Pedra Lavrada (6°45'14" S, 36°28'13" W), according to the geographic map of the State of Paraíba Fig. 1.

The experimental unit consisted of about 50 farms, in the four localities mentioned above, where the predominant climate type belongs to the tropical domain, by the Koppen climatic classification, is hot semiarid (BSh), characterized by an annual average of lower rainfall to 600 mm and average temperature of the coldest month exceeding 18ºC.

The methodological procedures adopted consisted in the application of semi-structured questionnaires, with questions related to the social and productive indicators of traditional forage palm cultivation and the tolerance to carmine cochineal and the follow-up that involves livestock activity.

This diagnosis included the sizes of cultivated and decimated areas, the use of forage palm, among others. In order to establish the pluvial regime, the rainfall data of the four localities were used, which are arranged chronologically. Due to the asymmetry in the annual distribution model, the annual medians were adopted as a measure of central tendency and the anomalies of the relative annual deviations of rainfall, in mm, were calculated by the difference between the rain value observed in the year and the expected median.

Data from the four localities and 50 farms were statistically analyzed using measures of central tendency and dispersion. The model presented was symmetrical. Carmine cochineal is a devastating pest, so the percentages of areas depleted with forage palm were similar. This condition allowed only one place instead of the four. The choice of the locality of Boa Vista is due to its tradition in the production of cheese in the state of Paraiba, almost a century.

Calculations and analysis of data, preparation of tables and drawing of figures were done using the Excel worksheet.

## 3. RESULTS AND DISCUSSION

The cactus species Opuntia fícus-indica and Nopalea cochenillifera are native to Mexico and are currently cultivated in the Brazilian semi-arid and other countries. They have various uses, from human and animal food, medicine, the pharmaceutical industry, production of dyes to soil conservation. In the semi-arid region of Paraiba, northeastern Brazil, forage palm is used exclusively as ruminant in nature feed, wasting part of its production potential.

The forage palm has high productivity and is consumed in nature by several animal species. Because it is a drought-tolerant plant, the conditions of the semiarid have been very well adapted. In addition to these characteristics, it has the metabolism of crassulaceae, which differentiates it by opening the stomata essentially at night, when the ambient temperature is reduced, reducing water losses by evapotranspiration.

However, in the semi-arid region of Paraiba, forage palm is the main or only source of food of the herd (cattle, goats and sheep), mainly during the long dry season. Even in the short rainy season, which lasts, on average, about three months, native pasture needs to be supplemented with corn or cottonseed meal in the herd. In addition to these characteristics, forage palm has high biomass productivity and water use efficiency, which also meets the growing demands of renewable energy sources in the semi-arid.

With the advent of the carmine cochineal plague, plantings of the traditional varieties, especially the giant variety, being the most cultivated, were almost all decimated. Anywise the research has been researching varieties tolerant to this pest. This is, without a doubt, the alternative capable of avoiding not only the rural exodus, but the sustainable development and the cattle-raising activity, in the northeastern semi-arid region. There are other challenges in livestock farming; the dependence of the local pluvial regime, being characterized by the high irregularity in the amount and distribution of rainfall.

In this context, the great challenge of livestock breeding in this territorial court is influenced by the rainfall distribution model, summarized in Fig. 2.

This figure summarizes the medians of the annual rainfall anomalies of the four semi-arid Paraiba (Boa Vista, Boqueirão, Caturité and Pedra Lavrada) plains located in the intermediate geographic region of Campina Grande, Paraiba, Brazil, since these localities coincide with the main milk basins and, consequently, with activities of the follow-up of livestock.

As a rule, the method of analysis of the rainfall anomaly, instead of using only the total amount of rain observed, is more effective than using the value of rain observed annually, which results corroborate with those found for semiarid Northeastern by Almeida [4]. This rainfall deficit contributes to the absence of native pasture. Even in this adverse environmental condition, the forage palm resists and is productive. If there is no pasture, the palm becomes the main or only alternative to feed the herd in the semi -arid region of Paraiba, that is, the food available in this geographical section and in the other semi-arid localities during the dry season, results that agree with those found by Adli et al. [3], Souza and Lorenzi [10] and Raújo et al. [12].

Moreover, the territorial cut of Boa Vista, Paraiba, Brazil, is recognized for its main cattle activity which is famous artisanal rennet cheese. The area cultivated with forage palm is around 33 thousand hectares, distributed in 532 rural properties. Since it is a reference municipality in the State of Paraiba, of this cattle activity, the majority of the results refer to this locality, avoiding, therefore, the repetition of the social and productive indicators of the forage palm for each place.

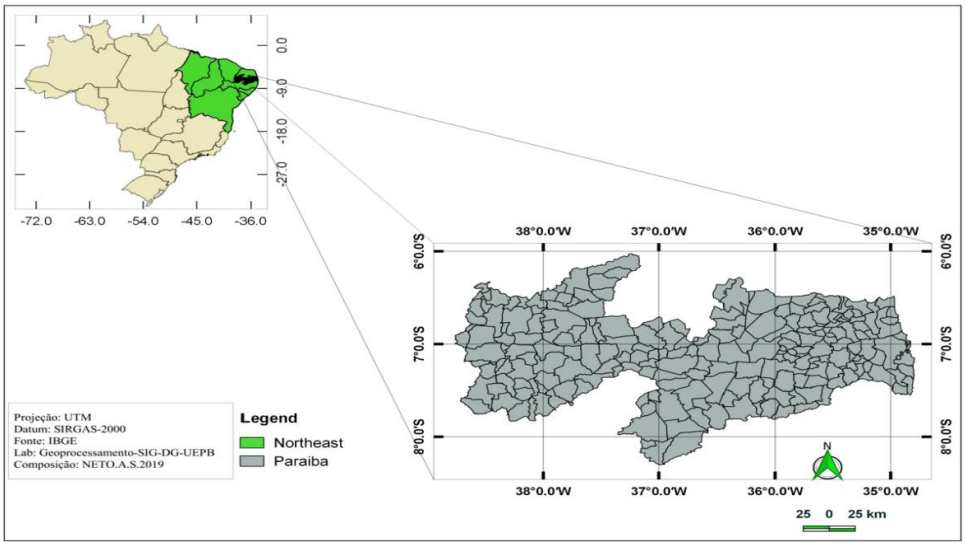


**Fig. 1. Geographic map of northeastern Brazil, with emphasis on the State of Paraiba**

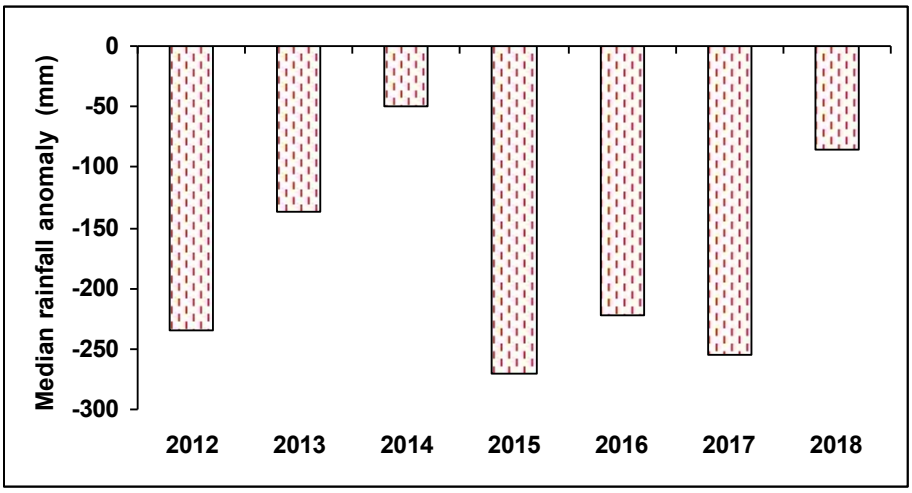


**Fig. 2. Annual rainfall anomaly medians from four localities of the intermediate geographic region of Campina Grande, Paraiba, Brazil**

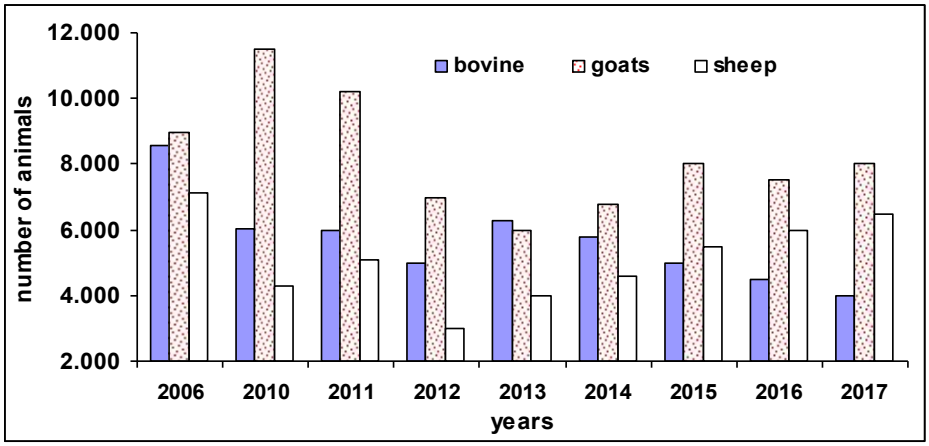


**Fig. 3. Number of animals (cattle, goats and sheep) in the municipality of Boa Vista, Paraiba, Brazil**

Fig. 3 shows the numbers of animals (cattle, goats and sheep) between 2006 and 2017 for this municipality, similar to those of other localities.

In the general context, it is believed that the reduction of the herd (bovine, sheep and goat) can be explained by the difficulty of feeding it by demanding a lot of fodder, industrialized ration and water. As the cost of goats and sheep is lower and a little easier to cope with the droughts, it justifies in part the smaller reductions when compared to cattle.

The gradual reduction of the herd (Fig. 3), as of 2011, can be explained by the rainfall deficit and lack of forage palm to feed the herd, given the incidence of carmine cochineal, which has been decimating drastically, the traditional palm plantations in the semi-arid region of northeastern Brazil, reached the palm plantations of these four locations. Without palm and with drought, the alternative was to dispose of the herd. These results are not restricted to these sites, but are confirmed for other sites in the semi-arid state of Bahia, for example, by Mendonça [24].

Livestock farms in the semi-arid region of Paraiba are primarily activities carried out within the household, that is, small producers. Fig. 4 summarizes the relative frequency of farm size in hectares.

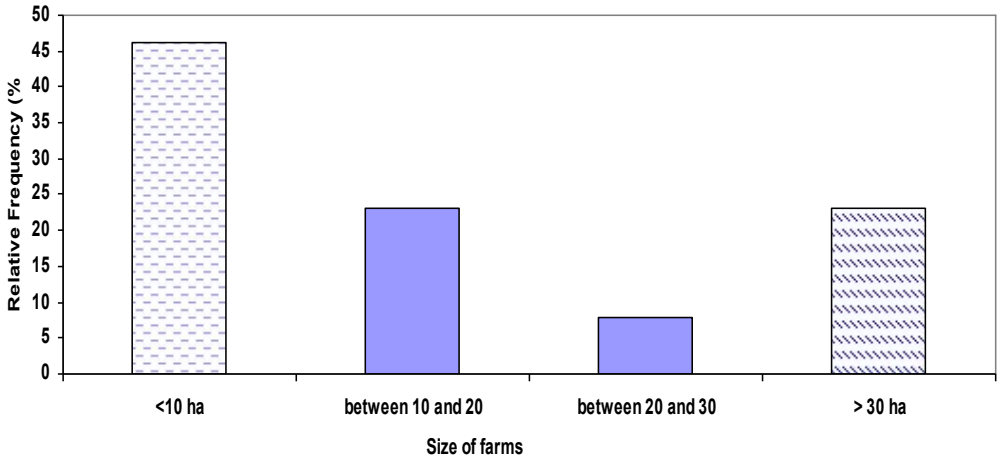


**Fig. 4. Relative frequency of the size of farms with forage palm. Boa Vista, Paraíba, Brazil**

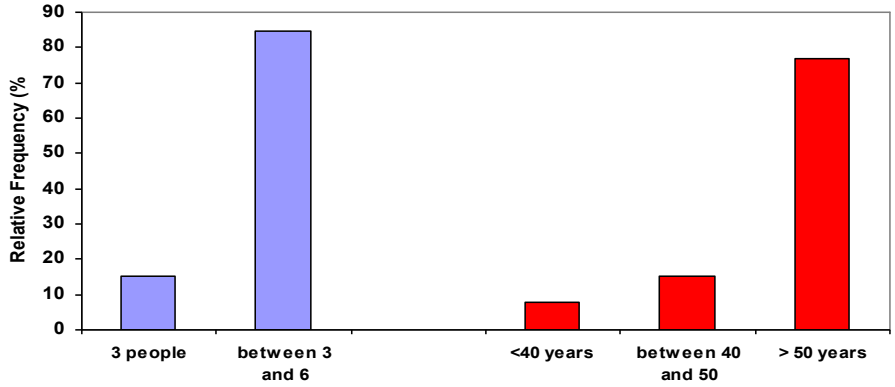


**Fig. 5. Relative frequency of family size and age group. Boa Vista, Paraíba, Brazil**

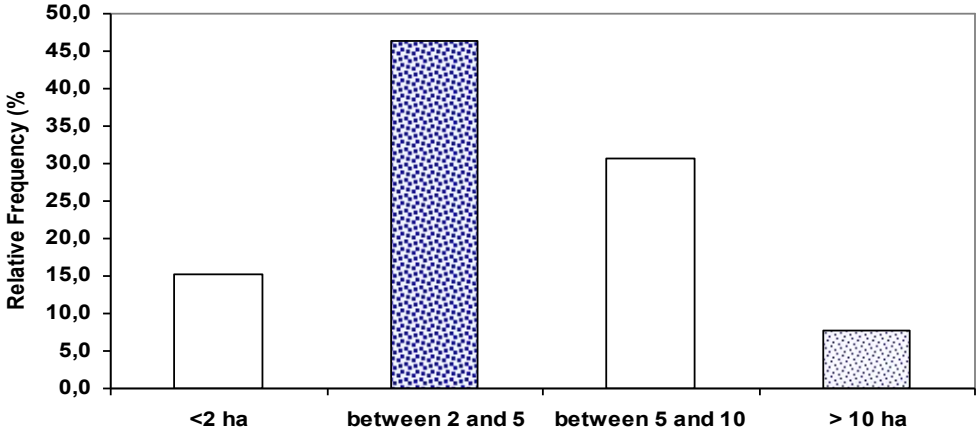


**Fig. 6. Relative frequency of the traditional forage palm area (giant cultivar), before the carmine cochineal. Boa Vista, Paraiba, Brazil**


**Fig. 7. Relative frequency of the producers that still have the traditional palm (giant cultivar). Boa Vista, Paraiba, Brazil**

**Fig. 8. View of forested palm rackets attacked with cochineal carmine**

Fig. 4 summarizes the relative frequency of farm size in hectares. The extract from farm areas shows that 46.2% of the rural properties are less than 10 hectares and about 70.0% do not exceed 20 hectares. It is an activity predominantly of small producers. The sizes of the properties agree with those found by Almeida et al. [8] for other locations in the semi-arid region of Paraiba, such as those in the Boqueirão and Caturité dairy basins.

With regard to the rural exodus, it seems that there is a rapid reduction of traditional family participation (parents with children), as well as the average size of Brazilian families. Rural young people continue to migrate and it is an important part, numerically, socially and economically, as shown in Fig. 5.

As illustrated in Fig. 4, the size of the families in 86.4% is from three to six people and only 13.6% of the farms are made up of up to three people. Regarding the age group, the age of the head of the family with more than 50 years old was predominant and less than 40 years was less than 8.0% and demonstrates, therefore, that this

rural activity (livestock) is being developed, preferably, by older people and rural youths do not seem to identify with the profession of farmer and therefore migrate to cities.

These results are similar to those found by Almeida et al. [8], in other places in Paraiba, where 60% of respondents were over 50 years of age or even in the State of Parana, in southern Brazil, by [22] shows that 13, 4% of young people aged 15-29 reside in rural areas, that is, the demographic dynamics of rural emptying. This dynamic, in other Brazilian states, is not only associated with the advance of mechanized agriculture, but with the consolidation of family agriculture.

The educational levels of the rural population tend to be lower than those of the cities and the illiteracy rate is much higher. It agrees with the results found by Maia and Buainain [25] the level of schooling is an important determinant of the rural exodus and education is essential for the formation of human and social capital.

### 3.1 The Importance of Forage Palm in Feeding Ruminants and Carmine Cochineal

Mostly, the ranchers of the farms studied have the forage palm as the main or only source to feed the herd. Most breeders use palms to feed the herd, but as they cut the palms, they replant, maintaining almost the same area planted over the years, that is, withdrawal cycles followed by planting.

Livestock farming is done by smallholders, with a maximum income of around $ 250, and therefore they have financial difficulty to expand and/or even maintain their property. In the current scenario, Fig. 6 summarizes the situation of the traditional cultivation of the palm tree (giant cultivar), that is, before the appearance of carmine cochineal around 2010/2011.

It is observed (Fig. 6) that 61.6% of the sizes of the areas planted with palm are equal to or less than 5 hectares; 30.8% are between 5 and 10 ha and only 7.8% exceed 10 ha. It should be noted, however, that these areas existed traditional forage palm plantations, but were totally or partially decimated by carmine cochineal. These results are fully in agreement with those found in most of the other northeastern states by Almeida et al. [8] and Almeida et al. [18].

As most farms are small producers and low-income farmers, they do not have the economic conditions to replace traditional planting with varieties tolerant to this pest. The sequence of years with drought (Fig. 2) does not contribute to the formation of native pasture and, therefore, the alternative to feed the herd is the forage palm, combined with industrialized rations of cotton and corn.

The high percentages of devastation of the traditional forage palm (Fig. 7), in a geographic cut, in Boa Vista, Paraiba, Brazil, after the arrival of the carmine cochineal, are similar to the other areas of the Brazilian northeast, where the forage palm is the main food of the herd.

It is important to note that, before the arrival of the carmine cochineal, around 2001, the northeastern semi-arid region had the largest cultivated area of forage palm in Brazil (about 500 thousand hectares). With the incidence of this pest, this area was reduced to less than half. As the forage palm is the main or only source of food, especially during the dry season, it will be very difficult to feed the whole herd. These results coincide with those found elsewhere in the same micro region or northeast region by other authors [8,11,12,6] who claim that carmine cochineal is a potentially devastating pest.

Scalps are insects that feed on the sap of plants. Usually they associate by forming groups of several individuals that are called colonies, and carmine cochineal is thus named because it is the raw material of the carmine dye that is produced from female cochineal of that species.

The pest has been decimating the palms in several places in the northeastern semi-arid region, and especially those in the semiarid dairy basins of Paraiba, one of the driest micro regions in this state, where the palm is the main and/or only alternative to feed the herd and , therefore, responsible for the development of livestock.

The carmine cochineal is one of several species of the genus Dactylopius that produce the carmine dye. In the feeding process, the mealy bugs suck the palm racquets inoculating toxins, which results in the weakening of the plants, causing the yellowing and the fall of the cladodes (Fig. 8).

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Scallops also excrete a sugary substance that favors the attack of fungi and also attracts ants. Attacked rackets turn yellow and then die. Therefore, production losses can be total, making livestock in the affected regions unfeasible, which agrees with the results of [24].

Without the traditional forage palm, the solution was the partial or total sale of the herd. The cattle ranchers who persist in continuing the livestock activity, the alternative is to revitalize areas decimated by carmine cochineal, with clones resistant to this pest.

The program has contributed gradually and slowly, revitalizing with more productive cultivars and those of better nutritive value, such as the varieties Miúda (*Nopalea cochinillifera*) and Ear of Elephant (*Opuntia sp*.), have been the most promising. This alternative technology has been the only hope for the maintenance of livestock, goat breeding and sheep farming that are the basis for the sustainable development of the semi-arid Paraíba.

As small producers have low purchasing power, the replacements of areas decimated by carmine cochineal by varieties tolerant to this parakeet have been occurring slowly.

The other major challenge of livestock activity in the studied geographic area and in the northeastern semi-arid region is irregularities in the quantity and distribution of rainfall. With this pluvial regime it does not favor the formation of native pasture or other forage. Therefore, forage palm will continue being the main or only alternative of the cattle activity in this geographic micro region.

## 4. CONCLUSION

The irregularity in the rainfall regime in the semi-arid state of Paraiba, Brazil, does not favor the formation of native pasture, especially during the long dry season. For this condition, forage palm (*Opuntia fícus indica Mill*) is the main or only source of food for cattle, goats and sheep**.**

Forage palm is an important alternative to for the cultivation and animal feed in semi-arid conditions due to its high dry matter, good dry matter yield and to good nutritional value. However, with the incidence of carmine cochineal (*Dactylopius opuntiae*), in this geographic cut, the alternative is revitalization with resistant cultivars of carmine cochineal.

In the northeastern semi-arid, the carmine cochineal has already decimated almost all the plantations of the traditional forage palm (giant variety). If it does not have this forage, the only alternative of the producer is to reduce the herd and, consequently, the cattle activity.

At all events**,** under the conditions of the Paraiba semi-arid, the palm is the only forage that resists and produces great amount of dry matter, even during the dry period.

The program of revitalization of the traditional palm cultivation, by varieties resistant to carmine cochineal, has been made slowly, the option and by clones of the varieties Miúda and Ear of Mexican Elephant. The acceptance and the animal digestibility are very good.

The cattlemen are convinced that the solution is to revitalize with carmine-resistant cochineal material. However, there is a need for studies on the production of this fodder and the water needs, in order to guarantee the continuity of the cattle raising activity.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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