

Social and productive indicators of forage palm and the survival of livestock activity in the semi-arid region of north-eastern 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

ABSTRACT

The importance of the cultivation of forage palm (*Opuntia ficus 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 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

35 revitalization of traditional palm cultivation by clams resistant to carmine cochineal has been the
36 alternative for the continuity of livestock activity in this region, although there is a contribution of drought.

37 Keywords: livestock; palm forage; cochineal carmine, livestock sustainability;

38 1. INTRODUCTION

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

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

46 The semi-arid Northeast occupies about 10.0% of the Brazilian territory and more than half is
47 characterized by irregular rainfall and frequent droughts. The rainy season is irregular, lasts three to five
48 months and there are still chances of being dry [4]. It has the largest herd of ruminants in the country and
49 forage palm is, on most farms, the only forage available to feed the herd of cattle, sheep and goats,
50 therefore, the success of livestock activity in this region has a strong relationship with the rainfall regime,
51 conditions that do not favor the formation of native pastures and/or the cultivation of other forages

52 In the Brazilian northeast, it has the largest herd of ruminants in the country, and the forage palm
53 (*Opuntia ficus indica* L. Mill) is the only forage available to feed cattle, sheep and goats. However, the
54 success of livestock activity in this region has a strong relationship with the rainfall model, conditions that
55 do not favor the cultivation of other forages.

56 The search for forage to feed ruminants, especially in periods without rain (dry), the forage palm stands
57 out for presenting morphological characteristics that make it tolerant to long droughts. Rainfall in the
58 semi-arid region is a decisive factor for the production of palm and livestock activity, in general, because
59 in the short rainy station, which lasts for about two to four months, the totals of rains are extremely
60 irregular in amount and in distribution, when comparing one location to another [5].

61 The forage palm is an exotic cactus, with more than 1400 species and 120 known genres ([6]; [7]), native
62 to Mexico, where it is used in cooking, agribusiness, production dyes and cosmetics. In the northeastern
63 semi-arid region, it is used to feed cattle, sheep and goats because it is the only forage that persists,
64 especially, in the dry season.

65 The forage palm without a thorn (*Opuntia ficus-indica*) is a cactus native to Mexico ([6]. In the northeast
66 of Brazil it was introduced around 1880, in Pernambuco, through seeds imported from Texas-United
67 States [8]. There are two species of the genus *Opuntia ficus-indica* (L) Mill, giant palm, and the *Nopalea*
68 (*cochenillifera* Salm-Dyck), sweet palm, both do not contain spines.

69 The giant and the *Nopalea* palm têm as genetic characteristics of rusticity, drought-resistant and high
70 water use efficiency provide the adaptability to the semi-arid environment, which are associated with
71 good acceptability of consumption by cattle [9].

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

75 The agronomic characteristics of resistance to drought caused the forage palm to incorporate the
76 livestock of Paraíba and other areas of the northeastern semi-arid region, because it is the only one that
77 perseveres and remains nourishing during the long periods of drought and, therefore, guarantees the
78 maintenance of the herd ([10], [11]) and can also be used in the form of bran [12], in addition to providing
79 environmental conservation [13].

80 **Moreover**, in the Northeast of Brazil, the genus *Opuntia* and *Nopalea* are spineless cactus without spines
81 and the most used as fodder, standing out the giant palm, the round and the small one, for having fast
82 growth and moisture content superior to the other cactus. It is not known how a destructive pest known
83 as carmine cochineal (*Dactylopius opuntiae*) was introduced in the State of Paraíba, Brazil, whose origin
84 is Mexican, detected in traditional palm plantations, especially in the giant variety, between mid 2009 and
85 2010 [5].

86 **Generally**, The emergence of this pest in the semi-arid region of Brazil occurred unexpectedly, since the
87 original purpose of carmine was to produce a natural dye for use in the food and cosmetics industry.
88 However, there is strong evidence that this introduction was erroneously done on the *Dactylopius*
89 *opuntiae*, rather than the correct one, *Dactylopius coccus*, for the production of the "carmine cochineal"
90 dye on an experimental scale [14]. Encouraging the cultivation of forage palm is a strategy that aims not
91 only the development of livestock in the Northeast, but the survival of this activity.

92 However, with the emergence of carmine cochineal (*Dactylopius opuntiae*), palms with traditional
93 varieties were practically decimated. The carmine cochineal arose in the traditional forage palm
94 plantations, mainly in the state of Paraíba in an unexpected way, since the original objective was to
95 produce a natural dye, the carmine, to be used in the food and cosmetics industry. **Nevertheless**, there is
96 strong evidence that this introduction was erroneously done in the *Dactylopius opuntiae*, rather than the
97 correct one, *Dactylopius coccus*, for the production of the "carmine cochineal" dye on an experimental
98 scale [14].

99 This species of pest is considered the most damaging to the crop and the dispersion / decimation occurs
100 very quickly, the advance of carmine cochineal on forage palm crop in the intermediate geographic region
101 of Campina Grande, Paraíba, Brazil, which includes 72 municipalities in this state the State, and in other
102 locations. The damages caused by the decimation of the palms are high and without the palm there is no
103 way to feed the ruminants, besides being used as a bargaining chip during the dry season, when its price
104 reaches three times [15].

105 Cochineals are insects that suck the rackets of this forage by inoculating toxins, this process results in the
106 weakening of the plants, causes the yellowing and the fall of the cladodes, when the infestation rate is
107 high and if a control measure is not adopted, the infested area is practically decimated [16].

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

111 In the north-eastern semi-arid region, this pest was observed around 2001 in the states of Pernambuco
112 and Paraíba and currently occupies the status that previously belonged to scale cochineal [17]. Their
113 recognition is relatively easy, because on the surface of the cladodes appear small white circles similar to
114 cotton threads and when they are crushed, it releases a reddish substance, which is carmine [18], the
115 failure to produce carmine dye in Brazil may have been motivated by the introduction of the "false"
116 cochineal (*Dactylopius opuntiae*), because this pest has a high destructive power [19].

117 **In the other side**, The advance of carmine cochineal in the state of Paraíba occurred in the plantations of
118 the giant variety, the one most cultivated, especially, in the intermediate geographic region of Campina
119 Grande [20; 22]. As a result of this pest, the extermination of this variety is inseparable; therefore, the
120 carmine cochineal has directly affected the follow-up of livestock, an activity that is the main generator of
121 employment and income in this geographic cut.

122 The devastation of forage palm cultivation in Paraíba, due to this pest, is very worrisome even because
123 the level of infestation comes to decimate the entire planting. If there is no food such as maintaining cattle
124 ranching, especially in the main dairy, in the basin of the municipalities of Caturité and Boqueirão, for
125 example, whose social and economic losses compromise even the small and medium-farmer's patrimony
126 [20].

127 In most locations states of Paraíba and Pernambuco were the most affected by carmine cochineal where
128 the infestation has already decimated about 90% of the traditional planting, with the advent of carmine
129 cochineal, the option of planting is with varieties resistant to this pest [20], this condition led to the
130 establishment of a forage palm revitalization program, which consists of replacing more productive palm
131 clones with higher nutritional value and, in particular, being resistant to carmine cochineal, such as small
132 and elephant ear varieties [21].

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

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

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142 **2 MATERIAL AND METHODS**

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144 **2.1 Location of the Study**

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

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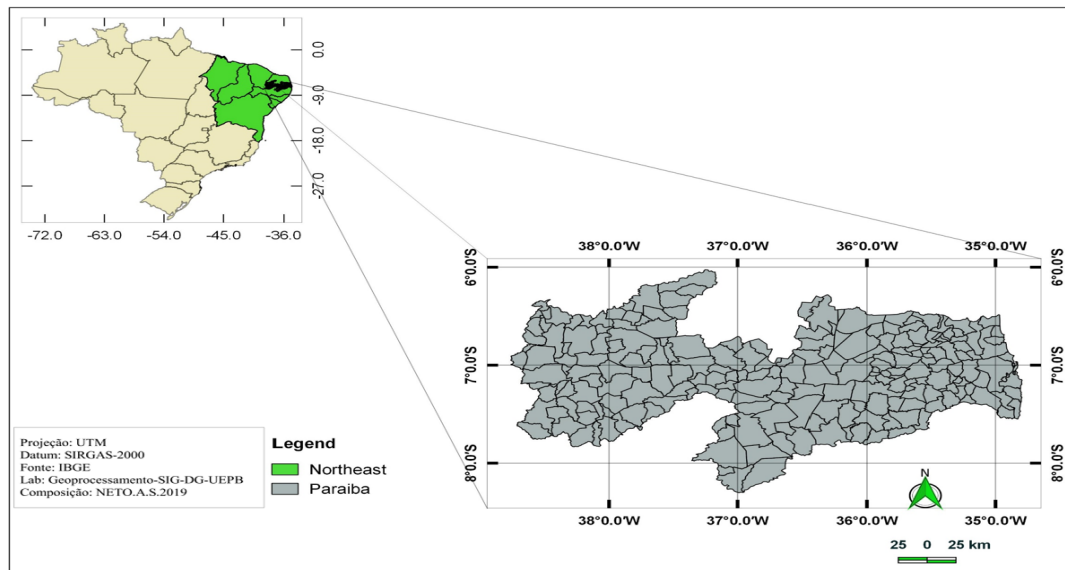


Fig. 1. Geographic map of northeastern Brazil, with emphasis on the State of Paraíba.

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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 18 °C.

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.

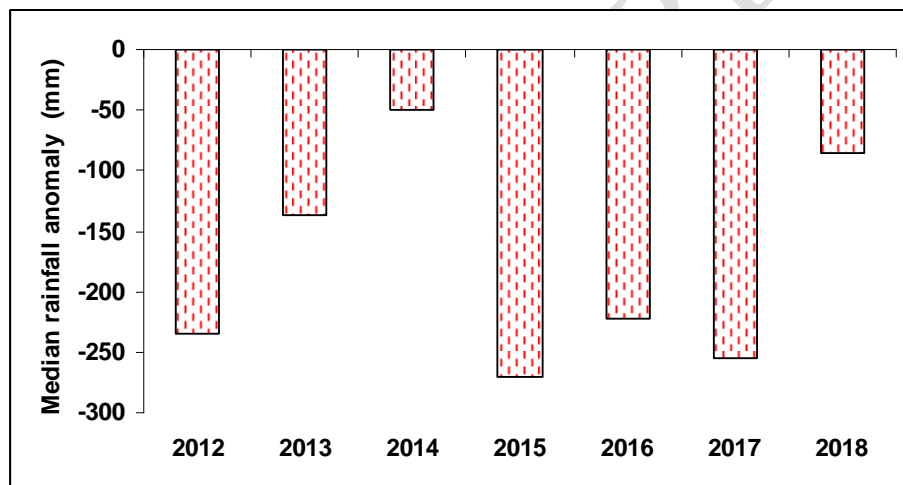
The technical criteria of analysis were made through the use of descriptive statistics, using the specific tools and necessary for determinations of averages, relative frequency, percentage and other descriptive techniques. Due to the large amount of data (questionnaire responses and on-site visits on 50 farms) and because the spatial data (farms) were homogeneous, it was decided not to present individualized data for each locality, but rather from one or another site, and we analyzed and calculated of data, preparation of tables and drawing of figures were done using the Excel worksheet.

3. RESULTS AND DISCUSSION

The cactus species *Opuntia ficus-indica* L. 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 Paraíba, 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

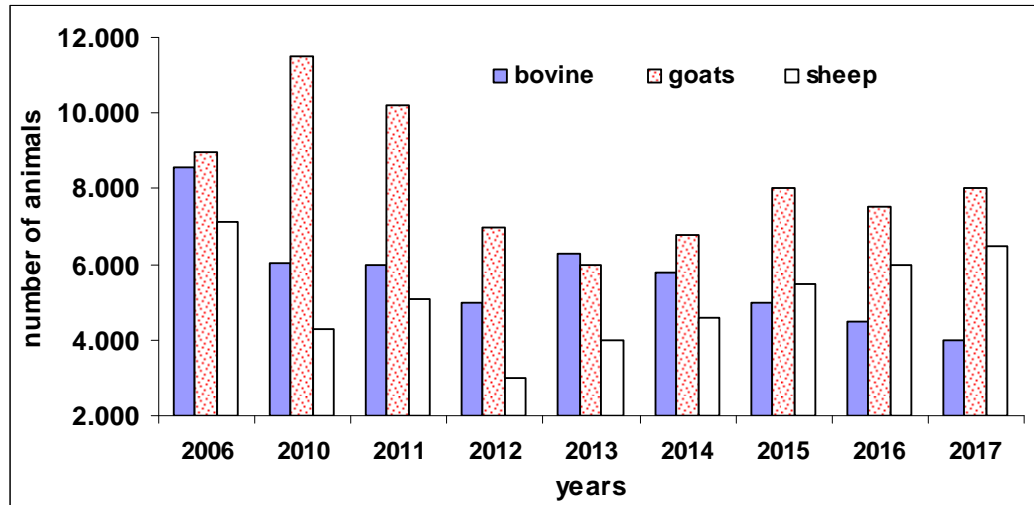
180 characteristics, it has the metabolism of crassulaceae, which differentiates it by opening the stomata
181 essentially at night, when the ambient temperature is reduced, reducing water losses by
182 evapotranspiration.
183 **However**, in the semi-arid region of Paraiba, forage palm is the main or only source of food of the herd
184 (cattle, goats and sheep), mainly during the long dry season. Even in the short rainy season, which lasts,
185 on average, about three months, native pasture needs to be supplemented with corn or cottonseed meal
186 in the herd. In addition to these characteristics, forage palm has high biomass productivity and water use
187 efficiency, which also meets the growing demands of renewable energy sources in the semi-arid.
188 With the advent of the carmine cochineal plague, plantings of the traditional varieties, especially the giant
189 variety, being the most cultivated, were almost all decimated. **Anywise**, the research has been
190 researching varieties tolerant to this pest, this is, without a doubt, the alternative capable of avoiding not
191 only the rural exodus, but the sustainable development and the cattle-raising activity, in the northeastern
192 semi-arid region. There are other challenges in livestock farming; the dependence of the local pluvial
193 regime, being characterized by the high irregularity in the amount and distribution of rainfall, in this
194 context, the great challenge of livestock breeding in this territorial court is influenced by the rainfall
195 distribution model, summarized in Fig. 2.
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198 Fig. 2. Annual rainfall anomaly medians from four localities of the intermediate geographic region
199 of Campina Grande, Paraiba, Brazil.
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201 This figure summarizes the medians of the annual rainfall anomalies of the four semi-arid Paraiba (Boa
202 Vista, Boqueirão, Caturité and Pedra Lavrada) plains located in the intermediate geographic region of
203 Campina Grande, Paraiba, Brazil, since these localities coincide with the main milk basins and,
204 consequently, with activities of the follow-up of livestock. **As a rule**, the method of analysis of the rainfall
205 anomaly, instead of using only the total amount of rain observed, is more effective than using the value of
206 rain observed annually, which results corroborate with those found for semiarid Northeastern by [4].
207 Rainfall deficit contributes to the absence of native pasture, even in this adverse environmental condition,
208 the forage palm resists and is productive. If there is no pasture, the palm becomes the main or only
209 alternative to feed the herd in the semi-arid region of Paraiba, that is, the food available in this
210 geographical section and in the other semi-arid localities during the dry season, results that agree with

211 those found by [3], [7] and [9]. **Moreover**, the territorial cut of Boa Vista, Paraíba, Brazil, is recognized for
 212 its main cattle activity which is famous artisanal rennet cheese. The area cultivated with forage palm is
 213 around 33 thousand hectares, distributed in 532 rural properties. Since it is a reference municipality in the
 214 State of Paraíba, of this cattle activity, the majority of the results refer to this locality, avoiding, therefore,
 215 the repetition of the social and productive indicators of the forage palm for each place.
 216 Fig. 3 shows the numbers of animals (cattle, goats and sheep) between 2006 and 2017 for this
 217 municipality, similar to those of other localities.



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 219 Fig. 3. Number of animals (cattle, goats and sheep) in the municipality of Boa Vista, Paraíba, Brazil.
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221 In the general context, it is believed that the reduction of the herd (bovine, sheep and goat) can be
 222 explained by the difficulty of feeding it by demanding a lot of fodder, industrialized ration and water. As
 223 the cost of goats and sheep is lower and a little easier to cope with the droughts, it justifies in part the
 224 smaller reductions when compared to cattle.

225 The gradual reduction of the herd (Fig. 3), as of 2011, can be explained by the rainfall deficit and lack of
 226 forage palm to feed the herd, given the incidence of carmine cochineal, which has been decimating
 227 drastically, the traditional palm plantations in the semi-arid region of northeastern Brazil, reached the
 228 palm plantations of these four locations. Without palm and with drought, the alternative was to dispose of
 229 the herd. These results are not restricted to these sites, but are confirmed for other sites in the semi-arid
 230 state of Bahia, for example, by [23].

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

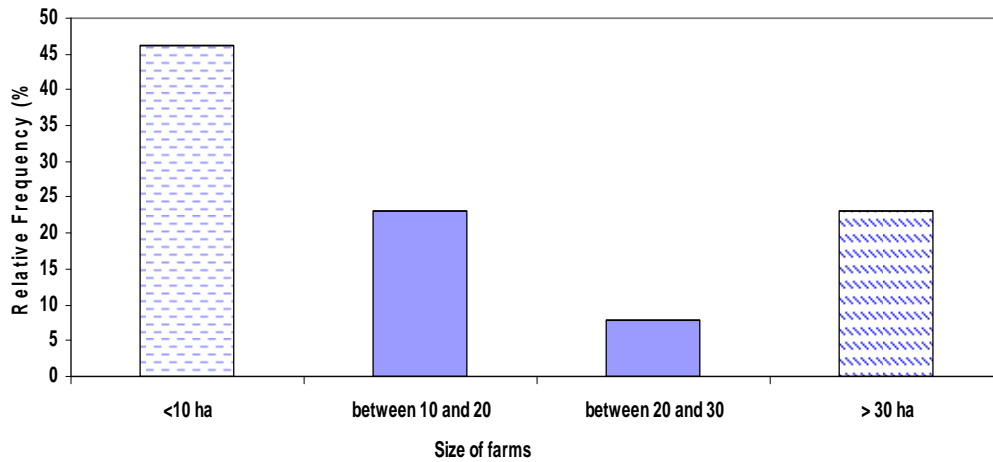


Fig. 4. Relative frequency of the size of farms with forage palm. Boa Vista, Paraíba, Brazil

Fig. 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 [5] for other locations in the semi-arid region of Paraíba, 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.

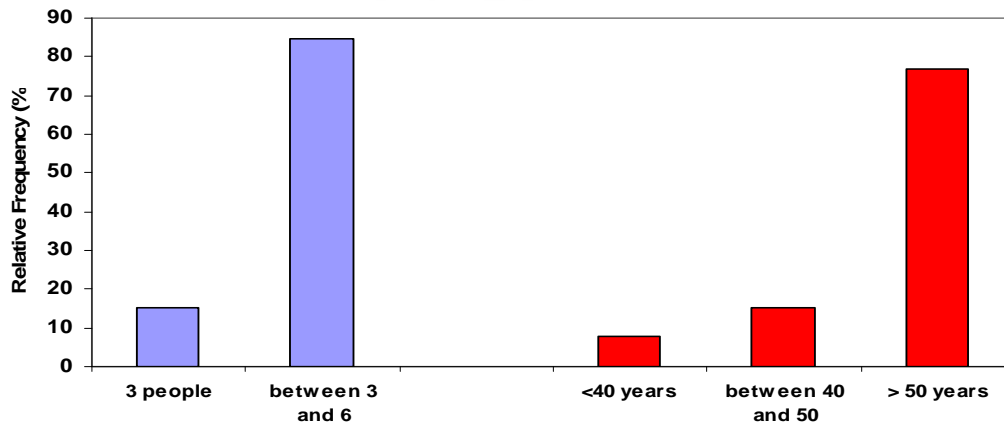


Fig. 5. Relative frequency of family size and age group. Boa Vista, Paraíba, Brazil

As illustrated in figure 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.

253 These results are similar to those found by [5], in other places in Paraiba, where 60% of respondents
254 were over 50 years of age or even in the State of Parana, in southern Brazil, by [22] shows that 13, 4% of
255 young people aged 15-29 reside in rural areas, that is, the demographic dynamics of rural emptying. This
256 dynamic, in other Brazilian states, is not only associated with the advance of mechanized agriculture, but
257 with the consolidation of family agriculture. The educational levels of the rural population tend to be lower
258 than those of the cities and the illiteracy rate is much higher. It agrees with the results found by [24] the
259 level of schooling is an important determinant of the rural exodus and education is essential for the
260 formation of human and social capital.

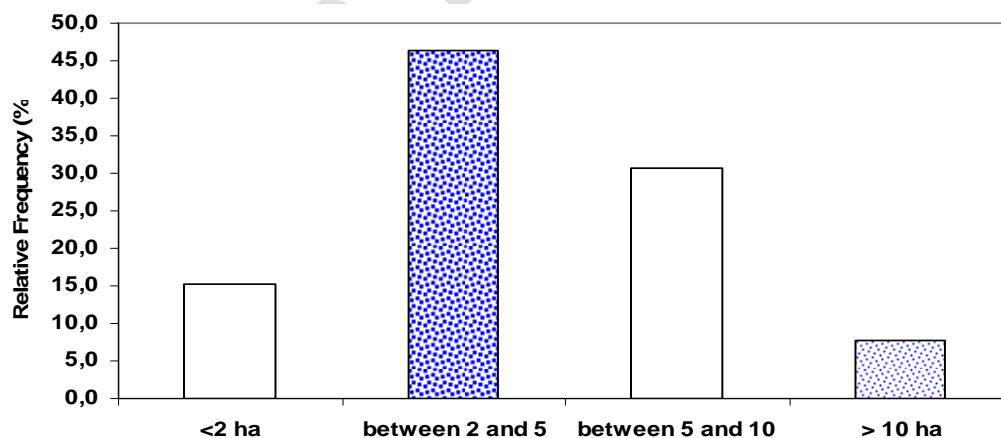
261 3.1 The importance of forage palm in feeding ruminants and carmine cochineal.

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

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

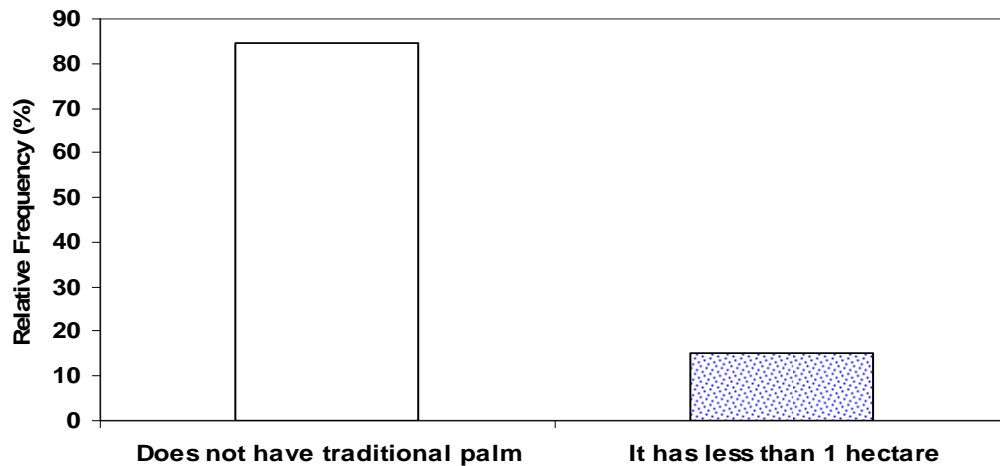
269 It is observed (Fig. 6) that 61.6% of the sizes of the areas planted with palm are equal to or less than 5
270 hectares; 30.8% are between 5 and 10 ha and only 7.8% exceed 10 ha. It should be noted, however, that
271 these areas existed traditional forage palm plantations, but were totally or partially decimated by carmine
272 cochineal, these results are fully in agreement with those found in most of the other northeastern states
273 by [5] and [15].

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



278
279 Fig. 6. Relative frequency of the traditional forage palm area (giant cultivar), before the carmine
280 cochineal. Boa Vista, Paraiba, Brazil.

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



285
 286 Fig. 7. Relative frequency of the producers that still have the traditional palm (giant cultivar). Boa Vista,
 287 Paraiba, Brazil.

288
 289 It is important to note that, before the arrival of the carmine cochonila, around 2001, the semi-arid
 290 Northeast had the largest cultivated palm area in the world (500 thousand hectares), making it possible,
 291 during the dry season, to feed the largest herd of goats and sheep (about 10 million) across the country,
 292 representing 90% of the national herd. As of 2001, the giant palm (*O. ficus-indica*) has been decimated
 293 by this plague. The results presented here agree with those found for the same micro-region or the
 294 northeast region by other authors [5], [8], [9] and [20] who claimed to be carmine cochineal a potentially
 295 devastating pest. Scapls are insects that feed on the sap of plants. Usually they associate by forming
 296 groups of several individuals that are called colonies, and Carmine cochineal is thus named because it is
 297 the raw material of the carmine dye that is produced from female cochineal of that species. The pest has
 298 been decimating the palms in several places in the northeastern semi-arid region, and especially those in
 299 the semiarid dairy basins of Paraiba, one of the driest micro regions in this state, where the palm is the
 300 main and / or only alternative to feed the herd and , therefore, responsible for the development of
 301 livestock.

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



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

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

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

315 Scallops also excrete a sugary substance that favors the attack of fungi and also attracts ants. Attacked
316 rackets turn yellow and then die. Therefore, production losses can be total, making livestock in the
317 affected regions unfeasible, which agrees with the results of [23], **without the traditional forage palm,**
318 **the solution was the partial or total sale of the herd. The cattle ranchers who persist in continuing**
319 **the livestock activity, the alternative is to revitalize areas decimated by carmine cochineal, with**
320 **clones resistant to this pest.**

321 **The** program has contributed gradually and slowly, revitalizing with more productive cultivars and those of
322 better nutritive value, such as the varieties Miúda (*Nopalea cochinillifera*) and Ear of Elephant (*Opuntia*
323 *sp.*), have been the most promising. This alternative technology has been the only hope for the
324 maintenance of livestock, goat breeding and sheep farming that are the basis for the sustainable
325 development of the semi-arid Paraíba. As small producers have low purchasing power, the replacements
326 of areas decimated by carmine cochineal by varieties tolerant to this parakeet have been occurring
327 slowly.

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

332

333 **4. CONCLUSION**

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335 The irregularity in the rainfall regime in the semi-arid state of Paraíba, Brazil, does not favor the formation
336 of native pasture, especially during the long dry season. For this condition, forage palm (*Opuntia ficus*
337 *indica* Mill) is the main or only source of food for cattle, goats and sheep, **and** forage palm is an important
338 alternative to for the cultivation and animal feed in semi-arid conditions due to its high dry matter, good
339 dry matter yield and to good nutritional value.

340 However, with the incidence of carmine cochineal (*Dactylopius opuntiae*), in this geographic cut, the
341 alternative is revitalization with resistant cultivars of carmine cochineal. In the northeastern semi-arid, the
342 carmine cochineal has already decimated almost all the plantations of the traditional forage palm (giant
343 variety). If it does not have this forage, the only alternative of the producer is to reduce the herd and,
344 consequently, the cattle activity.

345 **At all events**, under the conditions of the Paraíba semi-arid, the palm is the only forage that resists and
346 produces great amount of dry matter, even during the dry period, **and** the program of revitalization of the
347 traditional palm cultivation, by varieties resistant to carmine cochineal, has been made slowly, the option
348 and by clones of the varieties Miúda and Ear of Mexican Elephant. The acceptance and the animal
349 digestibility are very good.

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

353

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