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# Structure of a *Prosopis juliflora* (Sw.) DC. population established in a temporary riverbed in the Microregion of Cariri in the State of Paraiba

# Estrutura de uma população de *Prosopis juliflora* (Sw.) DC. estabelecida no leito de um rio temporário na Microrregião do Cariri Paraibano

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## Abstract

The aim of this study was to evaluate the structure of a *Prosopis juliflora* population established in Serra Branca riverbed, in the Municipality of São João do Cariri, Paraíba . Nineteen months after the most recent flooding of the riverbed, 30 equally spaced transects were set up at a distance of 25 m apart from each other. Along the transects, 191 quadrant points were plotted (all at 5 m distance both from the river and from adjacent points), and 764 individuals of *P. juliflora* were sampled. The individuals that were closer to the intersection center of each quadrant point were surveyed, with measurements taken of the distance between them and to the point, their diameter at ground level (DGL), and total height. An average distance of 2.04 m was recorded between individuals (estimated density of 2,403 individuals $ha^{-1}$), with the diameter ranging from 0.12 to 8.27 cm, and plant height from 0.01 to 3.0 m. The population of *P. juliflora* was composed predominantly of regenerating individuals, providing evidence that the occupation of the area by this invasive species was still in the early and middle stages of establishment. The results, in particular the rapid growth in diameter and height of young individuals, emphasized the ability of *P. juliflora* to occupy new niches, which ensures its competitive advantage in relation to native species.

**Key words**: Caatinga, population structure, mesquite

## Resumo

O objetivo deste trabalho foi avaliar a estrutura de uma população de *P. juliflora* estabelecida no leito do rio Serra Branca, no município de São João do Cariri, Paraíba. Dezenove meses após a última enchente foram demarcados 30 transectos equidistantes 25 m. Ao longo dos transectos 191 pontos quadrantes foram plotados (distantes 5 m das margens do rio e entre pontos) e 764 indivíduos de *P. juliflora* foram amostrados. Os indivíduos mais próximos do centro de intersecção de cada ponto quadrante foram mensurados, tomando-se a distância entre estes e o ponto, o diâmetro ao nível do solo (DNS) e a altura total. Constatou-se uma distância média de 2,04 m entre indivíduos (densidade estimada de 2.403 indivíduos.$ha^{-1}$), com diâmetro variando de 0,12 a 8,27 cm e altura das plantas de 0,01 a 3,0 m. A

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população de *P. juliflora* era formada, predominantemente, por indivíduos regenerantes, o que evidencia que o processo de ocupação da área pela referida invasora ainda estava em estágio inicial e médio de invasão. Os resultados, em particular o rápido crescimento em diâmetro e altura dos indivíduos jovens, enfatizam a capacidade de *P. juliflora* de ocupar novos nichos, o que lhe assegura vantagens competitivas, em relação às espécies autóctones.
**Palavras-chave:** Caatinga, estrutura de população, algaroba

## Introduction

Global biological diversity has been changing rapidly, with the major factors responsible for this being: land conversion, climate change, pollution, non-sustainable use of natural resources and, more recently, the introduction of exotic species that ultimately become invasive. Biological invasions are currently one of the highest cause of biodiversity loss globally, second only to the direct action of human beings on natural habitats (SAKAI et al., 2001; BASKIN, 2002; GISP, 2005).

Several authors have considered invasive exotic species as an important component of global change, due to their potential to change primary productivity, decomposition, hydrology, nutrient cycling and the natural disturbance regime (VITOUSEK et al., 1997; STEIN; KUTNER; ADAMS, 2000; ZALBA et al., 2000; HARROD, 2001; LEVINE et al., 2003; MARTINS; LEITE; HARIDASAN, 2004; MOONEY, 2005; ZENNI, 2006; ZALBA; ZILLER, 2007; BARNEY; WHITLON, 2008).

Currently, several factors are noted causing instability in the biophysical environment, with further loss of biodiversity, in the Caatinga biome (LEAL; TABARELLI; SILVA, 2003; LEAL et al., 2005; PENNINGTON; LEWIS; RATTER, 2006). Of these, particular emphasis is placed on the biological invasion of plants, which increases interference in the environment due to the presence of exotic species (ANDRADE, 2006; PEGADO et al., 2006; ANDRADE, FABRICANTE; ALVES, 2008). Of the many exotic invader species, *Prosopis juliflora* (Sw.) DC. (Fabaceae: Mimosoidae) is particularly noted for its aggressiveness and competitive advantage in relation to native species, which prevent the growth of other species in its vicinity.

In different regions of the world, *P. juliflora* has started to occupy niches other than its places of origin, and in several cases this distribution is linked to anthropogenic factors (MWANGI; SWALLOW, 2005; VAN KLINKEN; GRAHAM; FLACK, 2006; EL-KEBLAWY; AL-RAWAI, 2007). Its invasion of wide areas of the north-east semi-arid region is already recorded. In certain areas, mainly in riparian forests and low areas of deeper soils, there exist only large massive high-density populations of exotic species (PEGADO et al., 2006). The absolute dominance of *P. juliflora* in these areas threatens local biodiversity, the final consequences of which are unpredictable and unmeasurable (ANDRADE, 2006). Andrade, Fabricante and Alves (2008) draw attention to the importance of the affected ecosystems, which constitute areas of relevant social and environmental interest for Caatinga and related ecosystems, and where water is more abundant and the biodiversity is potentially higher.

Directly comparing areas invaded by *P. juliflora* with other sites typical of Caatinga, Andrade, Fabricante and Oliveira (2009; 2010) registered major differences in species richness and diversity in the areas where *P. juliflora* **is present**. The authors calculated an environmental impact index, noting worrying values which were higher than in other regions of the world hosting different invasive species.

The aim of this study was to evaluate the structure of a *Prosopis juliflora* (Sw.) DC. population, established in a stretch of the Serra Branca riverbed, in the Microregion of Cariri Paraibano, in order to describe the establishment potential of this species in this type of ecosystem.

## Material and Methods

The study was carried out in a stretch of the Serra Branca riverbed, which passes through the Boa Vista farm (7º23'27''S, 36º31'58''W and altitude of 458 m), in the Municipality of São João do Cariri, Microregion of Western Cariri in the State of Paraíba. The Cariri is within the Caatinga domain, considered an important physiographic region, presenting a considerable species' richness, average degree of endemism, high degree of fragility and high anthropic pressure (SAMPAIO et al., 2002).

Data sampling was performed on March 2008, 19 months after the last flood in the studied river, with the riverbed remaining flooded for more 60 days, according to statements by local inhabitants. This period of flood was enough to extinguish all the plant populations established in its riverbed.

Thirty transects were established (equally spaced 25 m apart) from one river bank to the other, along the riverbed; these transects were used to allocate quadrant points (the method used in the survey), set out at five meters from each other and from the river banks. The four *P. juliflora* individuals closest to each quadrant point were surveyed, measuring the distance to the sample point, the trunk diameter at ground level (DGL) and total height. Overall, 191 points were established and 764 individuals of *P. juliflora* were sampled.

In order to facilitate the interpretation and discussion of the results, the DGL and height measurements of the plants sampled were distributed in different frequency classes. The number of classes for each variable was obtained using Sturges' formula, and the interval of classes through the continuous variables method (ARANGO, 2005). For each class, the absolute and relative densities, and the absolute and relative frequencies, of the individuals sampled were calculated (LAMPRECHT, 1964; KENT; COKER, 1999): the classes that presented less than five individuals were analyzed with the previous class.

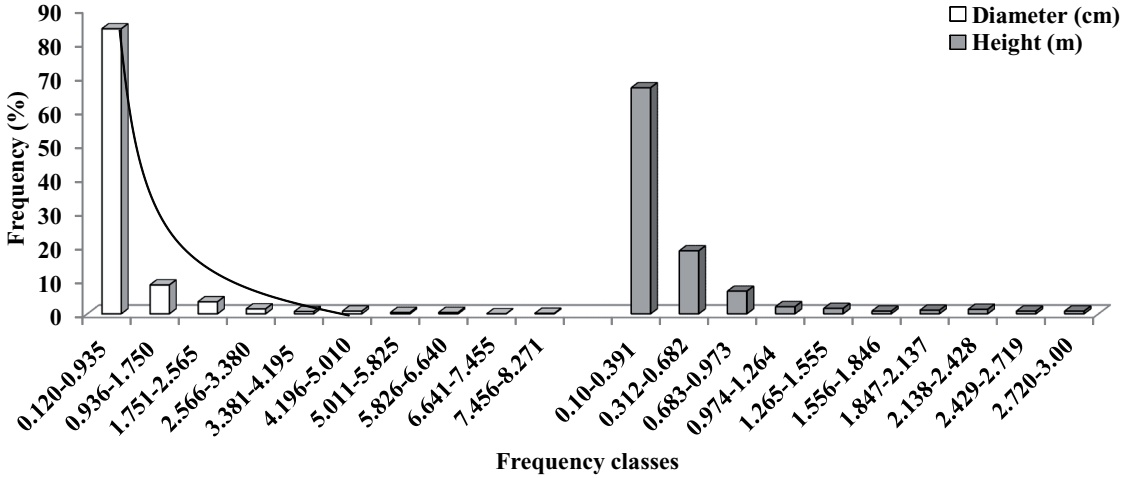
The spatial distribution pattern of *P. juliflora* was determined for each size class using Morisita's index of dispersion (MORISITA, 1962); the correlation between the size classes was determined through Pearson's linear correlation coefficient (TRIOLA, 1999); the statistical significance was calculated through t tests ($p \leq 0.05$) (LEHMANN, 1997). The data analyses were carried out using the software Mata Nativa 2© (CIENTEC, 2002) and Bioestat 5.0© (AYRES et al., 2007).

## Results and Discussion

The probable age of the *P. juliflora* individuals sampled in this survey was, at most, one and a half years, since the population started to establish only after the last flood (19 months previously). According to Maltchik (1999), changes occur in the physical and chemical properties of the substrate of semi-arid rivers after flooding, mainly due to the concentration of phosphorus. This could favor the establishment of the invader population. Nascimento (2008), in evaluating different invaded areas in the States of Pernambuco and Bahia, noted that *P. juliflora* tends to present higher establishment and development in areas with higher contents of humidity and phosphorus available in the soil, as supported by his direct observations.

The population frequency of *P. juliflora* was distributed in ten classes of diameter: a higher frequency of individuals (84.16%) was observed in the first diameter class (0.12 to 0.935 cm), followed by the second class (0.936 to 1.750 cm) with a frequency of approximately 10% (Figure 1). It was observed that there is a reduction in the number of individuals per diameter class, with increasing diameter. Andrade, Fabricante and Oliveira (2009; 2010) register similar results in their evaluation of the impacts of *P. juliflora* invasion in the Microregions of Curimataú and Seridó in the States of Paraíba and Rio Grande do Norte, where a higher number of individuals were observed to be in the smaller diameter classes, affirming that, in these areas, populations were in a marked expansion process.

**Figure 1.** Diameter and height distributions of a *P. juliflora* population occurring in the Serra Branca riverbed in the Municipality of São João do Cariri – PB.




**Source**: Elaboration of the authors.

The higher DGL values registered in this study (7.4 and 8.2 cm) for individuals at approximately one and a half year of age, represent approximately 55% of the maximum diameter encountered in *P. jufliflora* individuals at around 15 years of age (SOUSA; MENDES; SOUZA, 2007) and 23% of the maximum height in Caatinga plants with 20 years of invasion (ANDRADE, FABRICANTE; ALVES, 2008). Comparing the higher diameter values of *P. juliflora* with the maximum diameter of Caatinga vegetation, abandoned 15 years ago, it was verified that the invader species had already reached 55.14% of their maximum diameter development (SOUSA; MENDES; SOUZA, 2007). It therefore has the fastest initial growth for this invasive species in the study area.

Regarding its height (Figure 1), it was observed that approximately 67 % of *P. juliflora* individuals were encountered in the first height class (0.10 to 0.391 m), decreasing the number of individuals while the hipsometric class increased. However, individuals of more than two meters of height were recorded: these were mostly one and a half years of age, which corresponds to the period between the last river flood and this survey. These results show that the taller individuals recorded in this study had already reached over 37% of the height of *P. juliflora* individuals fully established in riparian areas, and surveyed by Pegado (2004) and Pegado et al. (2006), which were 8.0 m high at around 20 years of age. When compared to two Caatinga areas in the region of Assaré – CE, one with 10 and the other with 15 years of abandonment (SOUSA; MENDES; SOUZA, 2007), it was observed that *P. juliflora* reached, on average, 50% of the height observed in both areas.

It was observed that the maximum height values recorded were approximately 10% higher than the exotic species *Leucaena leucocephala* (Lam.) de Wit., cultivated for almost one and a half years in the Caatinga area (SOUZA et al., 2008). When compared to other exotic species cultivated in the same region since eight years previously, it was observed that, after one and a half years, *P. juliflora* had already reached a height of approximately 50% of *Leucaena diversifolia* (Schldl.) Benht, 52% of *Caesalpinia velutina* (Britton and Rose) Standley, 68% of *Ateleia herbert-smithii* Pittier and 100% of *Caesalpinia coriaria* (Jacq.) Willd (DRUMOND et al., 2008).

Analyzing the current growth data and comparing them to the results obtained in the studies cited above, a superior growth trend of *P. juliflora* was observed in comparison to the other species. This fact may be related to the different environmental factors determining the species' behavior profile in both situations analyzed, since the present study evaluated a growth where the interspecific competition rates are very low, which would significantly influence individuals' speed of development, as well as their initial establishment success.

As set out in Table 1, the estimated population density of the *P. juliflora* population was 2,404.73 individuals $ha^{-1}$, of which 2,023.87 individuals $ha^{-1}$ corresponded to individuals of the first diameter class (0.120 to 0.935). Pegado et al. (2006) observed that the higher density values in the woody and regenerating strata of a Caatinga area invaded by *P. juliflora*, were 1,240 and 2,128 individuals $ha^{-1}$, respectively. Similar values in different Caatinga areas invaded by *P. juliflora* were registered by Andrade, Fabricante and Oliveira (2009; 2010), revealing the invasive potential of this species in Caatinga regions.

**Table 1.** Structural parameters for each frequency class of diameter of a *P. juliflora* population, occurring in the Serra Branca riverbed in the municipality of São João do Cariri – PB: number of individuals (Ni); absolute density (AD); relative density (RD); absolute (AF) and relative (RF) frequency.

| Nº of Classes | Diameter Classes (cm) | Ni | AD | RD | AF | RF |
|---|---|---|---|---|---|---|
| 1 | 0,120-0,935 | 643 | 2.023,87 | 84.16 | 99,49 | 64,63 |
| 2 | 0,936-1,750 | 65 | 204,59 | 8.51 | 28,80 | 18,71 |
| 3 | 1,751-2,565 | 27 | 84,98 | 3.53 | 12,04 | 7,82 |
| 4 | 2,566-3,380 | 11 | 34,62 | 1.44 | 4,71 | 3,06 |
| 5 | 3,381-4,195 | 5 | 15,73 | 0.65 | 2,62 | 1,70 |
| 6 | 4,196-5,010 | 6 | 18,88 | 0.79 | 3,14 | 2,04 |
| 7 | > 5,011 | 7 | 22,03 | 0.92 | 3,14 | 2,04 |
| **Total** | | **764** | **2.404,73** | **100** | **153,93** | **100** |

**Source**: Elaboration of the authors.

In surveys of the woody component in the same study region, densities were observed of 970.83 individuals $ha^{-1}$ and 1,000 individuals $ha^{-1}$ for the two native species *Croton sonderianus* Müll. Arg. (ANDRADE et al., 2005) and *Caesalpinia pyramidalis* Tul. (BARBOSA et al., 2007), respectively, which are lower than those registered for *P. juliflora* in the present study. In surveys in Caatinga areas in the State of Paraíba, native species were sampled with density values lower than those verified for *P. juliflora*, for example: *C. sonderianus*, 1,100 individuals $ha^{-1}$ (PEREIRA et al., 2001); *Thiloa glaucarpa* (Mart.) Eichl., 567 individuals $ha^{-1}$ (PEREIRA et al., 2002); *Pithecellobium diversifolium* G.P. Lewis., 890 individuals $ha^{-1}$ (ANDRADE et al., 2007); *C. pyramidalis*, 775 individuals $ha^{-1}$ (FABRICANTE; ANDRADE, 2007).

Table 2 notes Morisita's index of dispersion ($I_d$) and the distribution pattern of the population of *P. juliflora*. In the first and second classes, individuals' distribution in the population was aleatory (0.766 and 0.819), which suggests a strategy of avoiding intraspecific competition in the initial development stages. However, for the following classes, a grouped distribution pattern was observed, presenting $I_d$ values higher than 1.471. According

to Krebs (1989), an $I_d$ value lower than 1 indicates aleatory distribution, a value equal to 1 indicates a regular distribution, and values higher than 1 indicate grouping, or clumped distribution.

According to Jankauskis (1990), a species distribution pattern is represented by its distribution in the study area, that is, the frequency with which the individuals occur in the sample units. Although a certain species presents a high occurrence in the area, its dispersion in different size classes may be very irregular (CARVALHO, 1983), as was observed in this work, which presented a variation in the dispersion across different diameter classes from 0 to 12.8 values of $I_d$ (Table 2).

With respect to Pearson's Linear Correlation Index (ρ), Table 3 notes that only the correlations between the individuals of the first diameter class with the other classes were significant, as indicated by an F test at a probability level of 5%, whereas all correlations were perfect and negative.

**Table 2.** Morisita's index of dispersion ($I_d$) and pattern of distribution by diameter class of a *P. juliflora* population in the Serra Branca riverbed in the Municipality of São João do Cariri – PB.

| Nº of Classes | Diameter Classes (cm) | Ni | AD | RD | AF | RF |
|---|---|---|---|---|---|---|
| 1 | 0,120-0,935 | 643 | 2.023,87 | 84.16 | 99,49 | 64,63 |
| 2 | 0,936-1,750 | 65 | 204,59 | 8.51 | 28,80 | 18,71 |
| 3 | 1,751-2,565 | 27 | 84,98 | 3.53 | 12,04 | 7,82 |
| 4 | 2,566-3,380 | 11 | 34,62 | 1.44 | 4,71 | 3,06 |
| 5 | 3,381-4,195 | 5 | 15,73 | 0.65 | 2,62 | 1,70 |
| 6 | 4,196-5,010 | 6 | 18,88 | 0.79 | 3,14 | 2,04 |
| 7 | > 5,011 | 7 | 22,03 | 0.92 | 3,14 | 2,04 |
| **Total** | | **764** | **2.404,73** | **100** | **153,93** | **100** |

**Source**: Elaboration of the authors.

**Table 3.** Pearson's (ρ) Linear Correlation between the diameter classes of a *P. juliflora* population occurring in the Serra Branca riverbed in the Municipality of São João do Cariri – PB.

| Correlation | | (ρ) | F | Correlation | | (ρ) | F |
|---|---|---|---|---|---|---|---|
| Classe 1 | Classe 2 | -0,7178 | <0,0001* | Classe 3 | Classe 4 | 0,0595 | 0,4126$^{ns}$ |
| Classe 1 | Classe 3 | -0,4713 | <0,0001* | Classe 3 | Classe 5 | -0,0224 | 0,7576$^{ns}$ |
| Classe 1 | Classe 4 | -0,4184 | <0,0001* | Classe 3 | Classe 6 | -0,0604 | 0,4058$^{ns}$ |
| Classe 1 | Classe 5 | -0,2113 | 0,0035* | Classe 3 | Classe 7 | -0,0098 | 0,8928$^{ns}$ |
| Classe 1 | Classe 6 | -0,1735 | 0,0166* | Classe 4 | Classe 5 | -0,0302 | 0,6769$^{ns}$ |
| Classe 1 | Classe 7 | -0,2560 | 0,0004* | Classe 4 | Classe 6 | -0,0302 | 0,6769$^{ns}$ |
| Classe 2 | Classe 3 | 0,0232 | 0,7489$^{ns}$ | Classe 4 | Classe 7 | -0,0343 | 0,6361$^{ns}$ |
| Classe 2 | Classe 4 | 0,1034 | 0,1540$^{ns}$ | Classe 5 | Classe 6 | -0,0267 | 0,7130$^{ns}$ |
| Classe 2 | Classe 5 | -0,0273 | 0,4343$^{ns}$ | Classe 5 | Classe 7 | -0,0303 | 0,6761$^{ns}$ |
| Classe 2 | Classe 6 | -0,043 | 0,4765$^{ns}$ | Classe 6 | Classe 7 | 0,2611 | 0,0003* |
| Classe 2 | Classe 7 | -0,0433 | 0,5510$^{ns}$ | - | - | - | - |

**Source**: Elaboration of the authors.

Such results corroborate this species' establishment and growth potential in a new environment, forming a regenerating population in different development stages, and distributed throughout the area. Shiferaw et al. (2004) emphasize several strategies employed by the species in establishing in a new area: the high production of propagules; attractiveness of fruits to animals; propagules' resistance to animal digestion; the high longevity of the seed bank; reproductive precociousness; and fast development throughout time and space.

*P. juliflora* is characterized as an invasive species in the study region, presenting high establishment and initial development efficiency at new sites. It revealed a high capacity for strong development in diameter and height within one and a half years of establishment, as well as a high potential for distribution throughout the study area.

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