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EFFECT OF GRAZING BY STEERS AND A LONG DROUGHT ON A CAATINGA LIGNEOUS STRATUM IN SEMI-ARID NORTHEAST, BRAZIL

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Abstract - A Caatinga vegetation was submitted to various grazing intensities (GI) by steers (1981-84) to verify their effect on ligneous stratum degradation. The study involved four GI: Heavy (1 steer/6.7 ha); Moderate (1 steer/10.0 ha); Light (1 steer/13.3 ha); Exclosure (no grazing). Areas under grazing varied from 40 to 80 ha, whereas exclosure had 20 ha. The research had two replications, occupying a total area of 400 ha. Data of woody species new plants density (NP) were determined annually in 1 m^2 plots, and data of shrubs and trees density were determined by Point-Centered Quarter Method in 1982 and in 1984. NP density (Mean = 3.38 plants/m^2) was neither affected by GI, nor by years, although it was highest in 1984 (3.83 plants/m^2), the rainiest year. Taking into account the eight areas, there was linear relation (P<0.01) between 1982 and 1984 tree densities. There was linear relation between tree density and density of tree species in shrub stages in 1982, but not in 1984, because the drought probably affected shrubs but not trees. There was, for some tree and shrub species, linear relation between adult plant and NP densities. This fact occurred more in 1982. There was in 1983 a very high germination of the tree *Tabebuia spongiosa* (22.14 seedlings/m^2), there being a linear relation (P<0.01) between NP and tree density.

Key words: Dry woodlands, shrubs and trees, new plants, native pastures, *Tabebuia spongiosa*.

EFEITO DO PASTEJO POR NOVILHOS E DE UMA SECA PROLONGADA SOBRE O ESTRATO LENHOSO DE UMA CAATINGA DO NORDESTE BRASILEIRO.

Resumo - Uma pastagem nativa de Caatinga foi submetida a intensidades de uso (IU) por bovinos (1982-84), para se verificar o efeito sobre a degradação do estrato lenhoso. A pesquisa envolveu quatro IU: Pesada (1 bovino/6,7 ha); Média (1 bovino/10,0 ha); Leve (1 bovino/13,3 ha); Exclusão (sem uso). As áreas sob pastejo variaram de 40 a 80 ha, enquanto que a Exclusão ocupou 20 ha. A pesquisa teve duas repetições, ocupando uma área total de 400 ha. Dados de densidade de plantas novas (PN) de espécies lenhosas (altura < 0,5 m) foram coletados anualmente, em parcelas de 1 m^2, enquanto que dados de densidade de arbustos e árvores foram coletados pelo Método dos Quadrantes em 1982 e 1984. A densidade de PN (Média = 3,38 plantas/m^2) não foi afetada por IU, e nem pelo efeito dos anos, embora ela tenha sido mais alta em1984 (3,83 plantas/m^2) , o ano mais chuvoso. Levando-se em consideração as oito áreas, houve relação linear (P<0,01) entre as densidades de 1982 e 1984 das árvores. Houve relação linear entre a densidade de árvores e a densidade de arbustos de espécies arbóreas apenas em 1982, não havendo em 1984, pois a grande seca de 1982 provavelmente afetou arbustos, não afetando árvores. Houve para algumas espécies arbustivas e arbóreas, relação linear entre a densidade de plantas adultas e a densidade de plantas novas. Ocorreu em 1983, uma alta germinação de plantas (22,14 plântulas/m^2) da árvore *Tabebuia spongiosa*, havendo relação linear (P<0,01) entre densidades de plântulas e das árvores.

Palavras-chave: Matas secas, arbustos e árvores, plantas novas, pastagens nativas, *Tabebuia spongiosa*.

INTRODUCTION

Caatinga, a thorny deciduous dry woodland that covers most of the Brazilian Northeast, is dominated by woody plants, and may be the native pasture with the highest density of shrubs and trees in the world. In researches conducted on native pastures in Africa (KELLY & WALKER, 1976), in USA (RIPPEL et al., 1983), and in Australia (WALKER et al., 1986), in which shrubs and trees densities were determined, no data higher than densities in Caatinga were found. Also, in the proceedings of a symposium that took place in Africa, which was devoted exclusively to the ligneous stratum as source of forage (Le HOUÉROU 1980), there was no paper which had registered a density higher than that found in Caatinga.

In spite of being less sensitive to overgrazing than pastures dominated by herbaceous stratum, Caatinga has also been degraded (ANDRADE-LIMA, 1981), but there are no evidences that degradation was caused by overuse by livestock. It was caused probably by shifting cultivation and wood harvest because Caatinga-covered region is densely populated. Santos et al. (1999) cite extensive grazing as one of the causes that has impeded the natural replacement of old plants of *S. tuberosa* by new ones, but there are no evidences of this fact. On the other hand, it has been commented on the media that Caatinga and Amazon Forest are the Brazilian Biomas less degraded.

Cattle and goats are the main livestock species predominating in the São Francisco Sertão Zone, and in most properties, both species are reared together. It has been already proved that Caatinga manipulation, such as thinning or slashing, to increase herbaceous stratum or to put ligneous stratum foliage at the reach of animals, increases their performance per area many folds (ARAÚJO FILHO, 1990). In woody species dominated pastures, a high stocking rate might not have a damaging effect on woody plants, as observed by Kelly & Walker (1976). In Caatinga pastures, 15 ha/head of cattle is usually recommended (BANCO DO NORDESTE DO BRASIL, 1971).

As there is lack of information on which stocking rates by cattle could cause degradation on both herbaceous and ligneous strata of Caatinga, a research was conducted in the period 1981-84, with this objective.

MATERIALS AND METHODS

The research was conducted at the Caatinga Experimental Station (9° 21' S Lat; 370 m altitude) of EMBRAPA-Agricultural Research Center for the Semi-Arid Tropics (Embrapa Semi-Árido), in Petrolina Municipality, Pernambuco. The area has flat topography and yellow podzolic soils with the following characteristics: pH = 5.8; $Ca^{2+} + Mg^{2+}$ = 3.3 m.e.; Al^{3+} = 0.07 m.e.; P = 3.5 ppm. Annual potential evaporation is 2,630 mm (AMORIM NETO, 1985), with a mean annual rainfall of 556 mm (Table 1), 80% of it falling in the period December-April, the period of highest evapotranspiration. The vegetation is an arboreous-shrubby Caatinga with the tree stratum dominated by *Mimosa tenuiflora* (Wildd.) Poir. Tree stratum covers only 88.1% of the area, and the participation of *M. tenuiflora* is 50.4% (ALBUQUERQUE & BANDEIRA, 1995). Shrub stratum is dominated by five species: *Lippia microphylla* Cham., *Croton rhamnifolius* (Kunth em.) Muell. Arg., *Calliandra depauperata* Benth., *Cordia leucocephala* Moric., and *Bauhia cheilantha* (Bong.) Steud. and they contribute to 96.5% of this stratum. In the lower stratum, there is the dominance of the terrestrial bromeliaceae *Neoglaziovia variegata* (Arr. Cam.) Mez, although with a phytomass highly variable, and of the herbaceous species *Herrissantia crispa* (L.) Briz. and *Selaginella convoluta* Spring.

The Caatinga Experimental Station, 2,780 ha, although expropriated by federal government in 1968 for irrigation projects, it was never used for this objective, being fenced only in 1976 by Embrapa. In this period, the area was kept under communal grazing by small goat and cattle raisers, under undefined stocking rates. After fencing, the area was kept free of grazing until the start of the research.

It was conducted from August/1978 to August/1984, but most of the data were already published by Albuquerque (1999). The data reported here were collected from May/1982 to May/1984. Four grazing intensities (GI) were tested: heavy (H) - 1 steer/6.7 ha; moderate (M) - 1 steer/10.0 ha; light (L) - 1 steer/13.3 ha; Exclosure (Excl.), without use. All GI had two replications (R), totaling eight paddocks. As six steers were used per replication, experimental units under grazing varied from 40 to 80 ha, totaling 400 ha, with both 20 ha replications of the Exclosure. There was no fence dividing Exclosure replications.

To evaluate the influence of grazing intensities on new plants density of woody species, macroplots of 100 m^2 (20 x 5 m) were marked systematically on the paddocks, in the following numbers: six, 12, 18 and 24 macro plots on each replication of Exclosure, GI-heavy, GI-moderate and GI-light, respectively, making up a total of 120 macroplots. Before 1982, only 60 macroplots were evaluated and the number was not uniform among treatments. In each macroplot, density of new plants (height < 0.5 m) was determined once annually in May, by placing at random, five 1-m^2 (2 x 0.5 m) quadrats. Cover of the "tangle" made up by *N. variegata* plus new plants of woody species plus herbaceous species was determined by visual estimation.

Table 1. Pluviometric precipitation (October/1980-September/1984, and historical mean (October/1963-September/2002). Bebedouro Experimental Station (*ca*. 6 km from experimental area). Petrolina, PE - Brazil.

Month	Precipitation (mm)				
	1980-81	1981-82	1982-83	1983-84	Historical mean
Oct.-Nov.	56.0	14.6	0.0	62.8	62.3
Dec.	34.0	90.7	82.2	7.2	78.0
Jan.	20.3	10.4	90.0	20.5	77.0
Feb.	4.8	20.6	166.4	3.9	81.0
Mar.	340.3	79.1	205.2	314.2	131.0
Apr.	20.5	97.4	0.8	122.9	79.4
May	0.5	1.4	0.0	44.6	18.7
Jun.-Sep.	8.4	50.2	37.6	29.2	29.0
Total	484.8	364.4	552.8	605.3	556.4

Aiming at detecting some influence of GI on the arboreous-shrub stratum, another approach was adopted, that is, in the eight experimental units, the density of shrubs (height > 0.5 m) and trees was determined in 1982 and 1984, by the Point-Centered Quarter Method (COTTAM & CURTIS, 1956). In the areas of 40 (GI-heavy), 60 (GI-moderate) and 80 ha (GI-light), 100, 150 and 200 points, respectively, were evaluated. In the Exclosure, 56 and 42 points were evaluated in Repetitions I and II, respectively. The points were distributed in lines and the distance between points varied from 21 to 26 m, to avoid the same shrub or tree being measured twice. Compass was used to walk in the bush in straight line. In each quarter, two distance measures were taken, one for shrub and the other one for tree. Distinction between shrub and tree followed criteria of Walker (1976). Lianas were considered as shrubs.

Data were analyzed taking into account for analysis of variance, the effects of grazing intensity and years on woody species new plants density, and of grazing intensity on arboreous-shruby stratum. Linear relation analysis were also conducted between trees, shrubs and new plant density in 1982 and 1984, and between the tree *Tabebuia spongiosa* Riz. density and the 1983 density of its new plants, in the eight experimental areas.

RESULTS AND DISCUSSION

New plants density was neither affected by GI nor by years (Table 2). The relative mean density in the period 1983-84 was higher in GI-light (1 steer/13.3 ha), and this leads to the conclusion that the effect might have been of area factor instead of GI, because relative increase in density in 1983-84, in GI-heavy (1 steer/6.7 ha), was higher than in GI-moderate and Exclosure, and in a 400 ha experimental area, variation among plots might be very high. In present research, variation between repetitions of the same treatment was high. The last research year was the rainiest in the period, and this contributed to make GI without effect. On the other hand, Friedel (1986), in the Australian Semi-arid, detected influence from sheep and rabbits on woody seedlings, but no effect from cattle. Caatinga is a dense vegetation and this aspect makes it less susceptible to overgrazing, because there not being isolated plants, the animals would have the tendency to browse all adult woody plants equally. In Australian ranges, woody plants being isolated, would be more susceptible to overgrazing by sheep, as detected by Hacker (1984a).

There was no effect of GI on new plants density, but it could there have been effect on cover. Albuquerque (1999) had shown that GI had no influence on frequency of herbaceous species, and Hacker (1984b) had already indicated that use of frequency data instead of cover could obscure some responses. In present case, cover data did not show any trend of GI, indicating that the effect was of precipitation. Data could not be analyzed statistically because, as they were derived of visual evaluations, this task should have been distributed uniformly between the two technicians, and this did not occur.

As from analysis of variance, there was no influence of grazing (P>0.05) on density of shrubs and trees from 1982 to 1984. Regarding the great difference of 29.6% between 1982 and 1984 densities (20.362 vs.14.334 plants/ha) (Table 3), already discussed in Albuquerque (1999), it was not caused by overgrazing but probably by the big drought of the 1981-82 period.

The disappearance was higher in paddocks with higher densities. In three paddocks, that is, in GI-heavy (RI) and in Exclosure (RI and RII), as densities were low, there were increases from 1982 to 1984, and both areas are in opposite position regarding GI. There was also influence of species in the rate of disappearance, being higher in "tender" species, that is, in those species that can be broken easily. In three "tender" species, *C. leucocephala*, *L. microphylla* and *Lantana camara* L., the mean difference was 54.9%, whereas in four "hard" species, *C. depauperata*, *B. cheilantha*, *C. rhamnifolius* and *C. sonderianus*, mean difference was only 4.77%. According to Bille (1978), in the 1972 big drought occurring at Sahel (Africa), there was the death of *ca*. 50 % of shrubs, even with a density much lower in comparison to density in present study. But in Africa, there were other livestock species, such as camels, sheep and goats, causing overgrazing, and when there is more than one species grazing in the same place, the chances of degradation in a drought increase. In present study, although the period 1980-81 is not included in data collection, its low precipitation might have caused stress in the ligneous stratum, that was extended to 1981-82. It can be noted that, in that period, most of the precipitation (70.2%) occurred in one month.

Table 2. Density of NP (height < 0.5 m) of woody species, alteration in density in the period 1983-84, in relation to 1982, and cover of "tangle" made up by *N. variegata* plus NP plus herbaceous species, in the period 1982-84, in a Caatinga under four grazing intensities (GI) by steers [heavy (H) = 1 steer/6.7 ha; moderate (M) = 1 steer/10 ha; light (L) = 1 steer/13.3 ha; Excl. = exclosure; R = repetition].

Year	Treatments								
	H-RI	H-RII	M-RI	M-RII	L-RI	L-RII	Excl.-RI	Excl.-RII	**Mean**
	.... New plant density (plants/m²)[1]								
1982	2.133	5.134	2.311	4.311	3.275	1.550	4.467	2.433	**3.202**
1983	3.467	4.083	3.400	3.533	3.000	1.192	2.833	3.400	**3.114**
1984	4.683	3.365	2.167	3.367	5.083	3.983	4.533	3.467	**3.831**
Mean	**3.428**	**4.194**	**2.626**	**3.737**	**3.792**	**2.242**	**3.944**	**3.100**	**3.383**
	.... Change in relation to 1982 (%)............								
1982	**100.00**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
1983	162.54	79.53	147.12	81.95	91.60	76.90	63.42	139.74	**105.3 a**[2]
1984	219.55	65.54	93.77	78.10	155.21	256.97	101.48	142.50	**139.1 a**
Mean/R	**191.04**	**72.53**	**120.4**	**80.02**	**123.40**	**166.93**	**82.45**	**141.12**	
Mean/GI	**131.78 A**		**100.21 A**		**145.16 A**		**111.78 A**		**122.23**
	.... Cover (%)[3]								
1982	6.17	5.83	6.11	10.67	6.21	6.96	7.67	6.33	**6.99**
1983	31.17	19.50	31.83	35.17	14.13	27.50	26.00	20.00	**25.66**
1984	52.67	38.17	58.72	63.78	29.83	44.21	24.50	34.50	**43.30**

[1] NP of the tree *Tabebuia spongiosa* Riz. are not included; [2] Means with same lower case letters in the column, and with same capital letters in the line are not statistically different (Duncan; P<0.05); [3] Cover data were not analyzed statistically, because participation of technicians that performed visual evaluations was not

Table 3. Density of shrubs and trees and change (%) of density in 1984, in relation to 1982.

Year	Treatments								
	H-RI	H-RII	M-RI	M-RII	L-RI	L-RII	Excl.-RI	Excl.-RII	**Mean**
	.... Density of shrubs (plants/ha)								
1982	21,626.7	9,999.9	23,669.4	25,194.0	21,624.0	30,775.5	14,082.4	15,925.8	**20,362.2**
1984	10,781.6	12,867.4	14,201.4	12,321.8	13,453.1	8,702.6	14,922.7	27,423.8	**14,334.3**
Change	**49.85**	**128.67**	**60.00**	**48.91**	**62.21**	**28.28**	**105.97**	**172.20**	**70.40**
Mean/GI	**89.26 a**		**54.46 a**		**45.25 a**		**139.09 a**		
	.... Density of trees (plants/ha)								
1982	349.44	460.80	372.00	345.64	577.58	545.58	467.33	489.26	**450.95**
1984	316.05	338.01	314.04	366.43	452.32	556.84	437.63	496.07	**409.67**
Change	**90.44**	**73.35**	**84.42**	**106.01**	**78.31**	**102.06**	**93.64**	**101.39**	**90.85**
Mean/GI	**81.90 a**		**95.22 a**		**90.19 a**		**97.52 a**		

Regarding data on shrub species density determined by Quarter Method and new plant density (height < 0.5 m) determined in 1 m^2 quadrat (Table 4), in most of the species it appears there is no relation between them, and one of the reasons is that plants not reaching fruiting age are included as adult plants. In addition, the methods were different. But, even using different methods, they covered almost uniformly each study area. So, in some cases there was significant linear relation ($P<0.05$) between adult and new plant densities (Table 5). As it can be seen in Table 5, the two other species in which there was linear relation, are "hard" species, that is, little affected by a drought. From Table 4, it might be noted that new plant density of any specific species do not follow any standard in relation to mother plant. For example, although total new plant density did not vary from 1982 to 1984, new plant density by species much varied, some species varying more than three times from 1982 to 1984, such as *C. ramnifolius* and *L. microphylla*, two important shrub Caatinga species. It was already detected (ALBUQUERQUE et al., 2001) that new plant density is highly and negatively influenced by *N. variegata* density.

There was in 1983, a great germination of seeds of the tree *T. spongiosa*, as occurred in a goat research, conducted during the same period (ALBUQUERQUE et al., 2004). *T. spongiosa* new plant (NP) densities in 1982, 1983 and 1984 were 0.189, 22.14 and 1.326 plants/m^2 (Table 5), respectively, whereas total NP density of all woody plants, excluding that tree, were 3.202, 3.114 and 3.831 plants/m^2 (Table 2), respectively. Taking into account *T. spongiosa* density in the eight experimental areas determined by Quarter Method, and NP density determined in 1 m^2 quadrat, it was detected a significant ($P<0.01$) linear relation between them (Figure 1). The causes of this high germination are unknown, but various factors might be involved. Angevine & Chabot (1979), reviewing this matter, emphasized the deficiency of good studies on ligneous species germination in general, and on tropical species in special. Grice & Westoby (1987), studying the germination of two shrubs in 11 places and during five seasons in Australia, noted that as in *Cassia* spp. as in *Acacia victoriae*, there was significant influence of seasons and places on new plants density. Taking into account 11 places, in *Cassia* spp., there was season in which lowest and highest values were 0.06 and. 21.7 plants/m^2, whereas in *A. victoriae*, lowest and highest values were 3.3 and 25.7 plants/m^2, respectively. Setterfield & Williams (1996) verified that post-dispersion conditions for germination and establishment are probably more important than seed supply. In the case of *T. spongiosa*, probably both factors, that is, seed supply and post-dispersion conditions had some influence on the high germination, because linear relation attests that tree density contributed to seed supply. Barbosa (2002), studying germination and growth strategies for eight Caatinga tree species with fast germination, including two *Tabebuia* spp. (*T. impetiginosa* and *T. aurea*), did not bring up any factor that could explain the occurrence of this high germination of *T. spongiosa*. Another tree species, *C. leptophloeos*, also had a high germination in 1984 (Table 6), although much lower than *T. spongiosa*, there being linear relation with tree density/84 (Table 7). The causes of this high germination are also unknown. It might be seed supply or only coincidence. It there has been some concern on the re-establishment of this tree, because, due to its soft wood, it is very used by craftsmen for carving "carrancas" or "ugly faces", a piece that originally was put in the prow of the boats navigating the São Francisco River to avoid bad spirits, and now, with fading of the lend, it has become very commercialized as ornamental piece. To make it, it is necessary to knock down the tree.

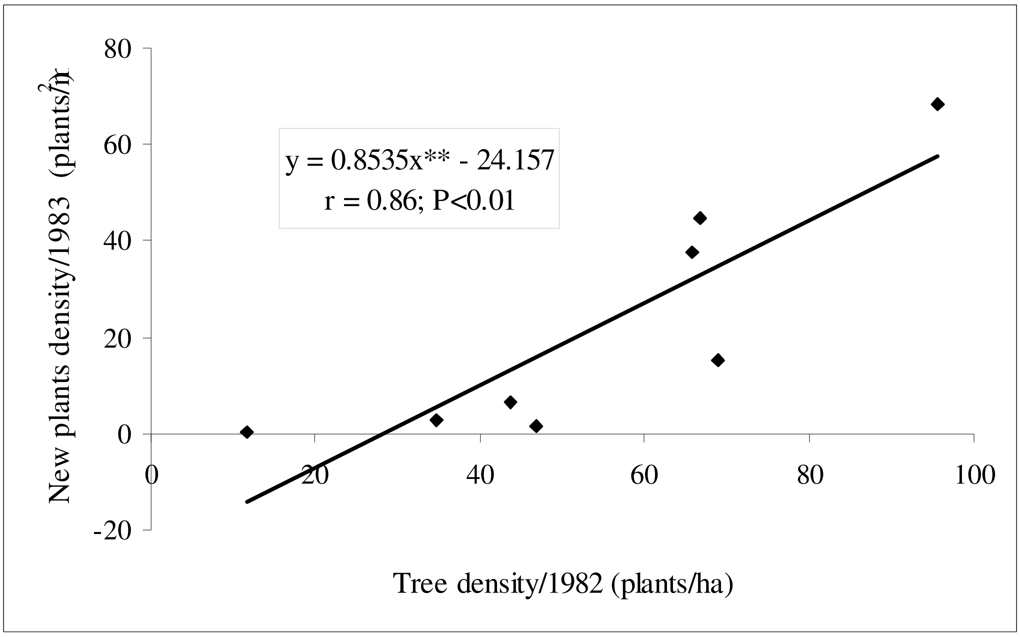

Figure 1. Linear relation between tree density/1982 and new plant density/1983 (height < 0.5 m) of *T. spongiosa*, in eight experimental areas.

Table 4. Mean shrub density (height > 0.5 m), determined by Quarter Method, and mean NP density (height<0.5 m) determined in 1 m^2 quadrat, in eight experimental areas under use by steers.

Species	Year				
	1982		1983	1984	
	Shrubs[1]	NP	NP	Shrubs[1]	NP
	.... Density (plants/ha)				
Cordia leucocephala	4,441.2	5,582.9	5,857.2	2,229.1	4,760.0
Calliandra depauperata	2,798.9	2,052.5	1,339.9	2,171.4	1,350.7
Croton rhamnifolius	2,732.0	8,753.1	2,694.9	2,620.2	3,107.2
Bauhinia cheilantha	1,553.1	3,954,4	5,128.5	1,623.1	3,405.8
Lippia microphylla	1,438.6	469.2	434.4	815.7	1,572.5
Solanum chaetacanthum Dun.	1,418.7	458.33	343.7	308.4	284.7
Lantana camara L.	1,133.3	493.1	851.1	323.0	1,281.3

Croton sonderianus Müell. Arg.	990.1	770.4	791.3	1,019.0	646.3
Liana (Local name = Cipó preto)	322.9	90.28	239.6	163.8	3,631.5
Cardiospermum alicacabum L.	224.7	13.89	62.50	33.7	340.7
Argythamnia gardneri Müell. Arg.	218.8	1,142.36	1,027.4	518.3	1,104.6
Liana (Local name = Cipó branco)	197.6	194.44	111.11	37.5	350.7
Jatropha pohliana Müell. Arg.	148.0	791.67	1,336.8	183.8	822.5
Cassia granulata Riz.	66.7	73.33	41.67	60.9	24.31
Ciscus coccinea Mart. ex Planch.	44.2	135.42	65.97	65.6	138.9
Pilosocereus gounellei Web.	19.53	21.25	0.00	0.00	0.00
Arrojadoa rhodantha (Gurke) Br.& Rose	19.33	62.90	41.70	26.28	20.80
Jacaratia corumbensis Kuntze.	4.93	13.90	13.90	0.00	0.00
Other shrub species	648.0	430.56	726.11	525.3	2,358.1
Tree species in shrub stage	1,941.6[2]	[3]	[3]	1,609.3[2]	[3]
Total	**20,362.2**	**25,503.9**	**21,107.6**	**14,334.3**	**25,200.6**

[1] Some data of theses columns already published in Albuquerque (1999), but they differ a little because, in this table, Exclusion was divided in two replications, making up eight experimental areas, instead of seven; [2] Data also present in Table 6; [3] Data present only in Table 6.

Table 5. Correlation coefficients among shrub and NP densities of main shrub species, in the eight experimental areas that compose Table 4

Species	Correlation coefficients (P<0.05)				
	Shrubs/82 vs. Difference Shrubs/82 minus Shrub/84	Shrubs/82 vs. Shrubs/84	Shrubs/82 vs. NP/82	Shrubs/82 vs. NP/83	Shrubs/84 vs. NP/84
*C. Alicacabum**	0.99	0.88	0.79	0.76	0.85
*L. camara**	0.98				
*C. leucocephala**[1]	0.95				
*L. microphylla**	0.91	0.77			
All shrubs	0.88				
*C. depauperata***	0.72	0.96	0.79	0.76	0.82
*C. sonderianus***		0.94		0.91	0.71

[1] * for "soft" wood; ** for "hard wood (criteria of the author).

Regarding tree species density data, as occurred with shrub species, it appears there be no relation between adult plant and new plant densities, with exception of some species (Table 6). As occurred with shrubs, the density of NP and shrubs of tree species do not follow any standard in relation to mother-plant, that is, the tree with highest amount of shrubs and NP should have been *M. tenuiflora*, and this did not occur. There was, for some species in the eight study areas, linear relation between tree and shrub densities in 1982, and tree and new plant density in 1982 and 1983 (Table 7). In 1984 there was less cases, and this would be an indication of the drought that messed up the relationship between adult and young plants. There was linear relation between total tree density and tree density in shrub stage/1982 (Figure 2). This relation is illustrated by the fact that, in 1984 there was no relation due to shrub mortality of 17.11%, probably caused by drought. In some species such as *C. phyllacanthus*, density in shrub stage is lower than in tree stage. In total tree density, there was a difference of 9.14% between 1982 and 1984 (450.9 vs. 409.7 plants/ha), and this is considered a normal tree mortality, aggravated a little by the drought, the linear relation in the period being kept

Table 6. Mean tree and shrub densities (height > 0.5 m), determined by Quarter Method, and mean NP density (height<0.5 m) determined in 1 m^2 quadrat, in eight experimental areas under use by steers.

Tree species	Year						
	1982			1983	1984		
	Trees[1]	Shrubs	NP	NP	Trees[1]	Shrubs	NP
	Density (plants/ha)						
Mimosa tenuflora	169.4	236.3	76.81	1,444.4	148.1	236.7	746.5
Caesalpinia microphylla Mart.	64.50	499.2	2,089.9	1,874.6	58.41	488.6	1,655.8
Tabebuia spongiosa	54.24	307.8	1,895.4[2]	221,388.5[2]	55.09	344.7	13,260.4[2]
Mimosa arenosa (Willd.) Poir.	37.87	478.3	2,996.9	3,222.2	32.28	236.2	2,753.9
Cnidoscolus phyllacanthus (Pohl.) Müell. Arg.	30.02	16.25	38.19	291.2	21.96	24.02	121.9
Manihot pseudoglaziovii Pax & K. Hoffm.	27.55	124.7	770.4	514.3	30.08	59.89	1,957.9
Commiphora lepthophloeos (Mart.) J.B. Gillet	19.63	22.06	114.6	500.0	16.27	5.07	4,746.5
Cnidoscolus vitifolius Müell. Arg.	12.69	3.26	65.97	201.4	13.94	19.69	169.7
Acacia piauhiensis Benth.	12.22	49.43	145.8	0.00	12.47	69.65	242.6
Sapium lanceolatum (Müell. Arg.) Herbert.	3.81	20.35	83.33	62.50	1.98	10.44	62.08
Piptadenia obliqua (L.) Pers.	3.73	59.25	69.44	1,805.6	4.90	59.79	291.67
Aspidosperma pyrifolium Mart.	2.18	8.19	0.00	0.00	1.68	1.37	0.00
Pseudobombax simplicifolium A. Robyns	2.17	0.00	21.25	62.50	2.15	0.00	27.78
Spondias tuberosa Arr. Cam.	1.90	0.00	0.00	0.00	2.51	0.00	0.00
Schinopsis brasiliensis Engl.	0.75	86.39	20.83	20.83	1.58	29.70	10.42

Cereus jamacaru P. DC	1.37	0.00	0.00	27.80	1.07	0.00	0.00
Pilosocereus glaucescens (Lab.) Byl. & Rowl.	0.79	0.00	0.00	0.00	2.05	0.00	0.00
Capparis flexuosa L.	0.00	5.25	0.00	0.00	0.00	0.00	13.90
Other tree species	6.11	24.85	20.84	0.00	3.12	23.39	329.7
Total	**450.9**	**1,941.6**	**6,514.3**	**10,027.4**	**409.7**	**1,609.3**	**13,130.7**

[1] Some data of these columns already published in Albuquerque (1999), but they differ a little because, in this table, Exclusion was divided in two replications, making up eight experimental areas, instead of seven; [2] Due to high germination in 1983, data were not summed in total.

Table 7. Correlation coefficients among trees, shrubs and new plant (NP) densities of main tree species, that compose data of Table 6.

Tree species	Correlation coefficient (P<0.05)					
	Trees/82 vs. Trees/84	Trees/82 vs. Shrubs/82	Trees/82 vs. NP/82	Trees/82 vs. NP/83	Trees/84 vs. Shrubs/84	Trees/84 vs. NP/84
C. vitifolius	0.97					0.87
M. arenosa	0.95	0.97		0.93	0.88	
A. piauhiensis	0.91	0.97	0.96			0.77
P. obliqua	0.89	0.81	0.80		0.95	
C. phyllacanthus	0.88	0.74				
M. tenuiflora	0.87	0.80	0.72			
C. leptophloeos	0.80					0.92
M. pseudoglaziovii	0.79					
T. spongiosa	0.78			0.86 (Fig. 1)		
A. piryfolium	0.75					
All trees	0.79 (Fig. 3)	0.78 (Fig. 2)				

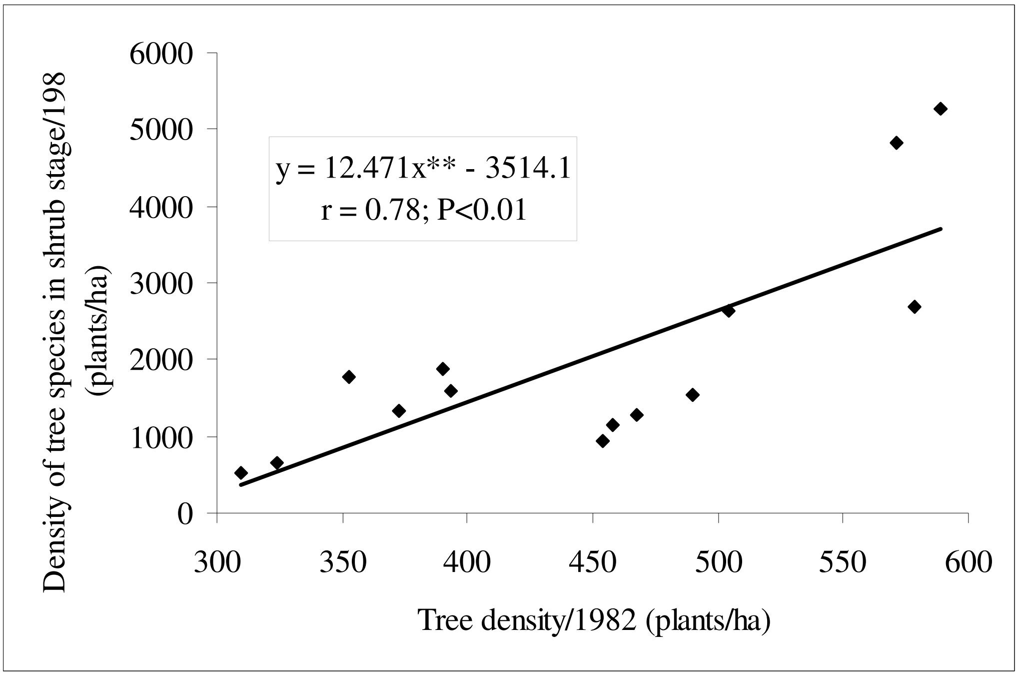

Figure 2. Linear relation between total tree density and total density of tree species in shrub stage in 1982, in 14 experimental areas (Note: Paddocks under use were subdivided).

(Figure 3). In Figures 2 and 3, 14 experimental areas were considered, due to the division of the six areas under use in two subdivisions.

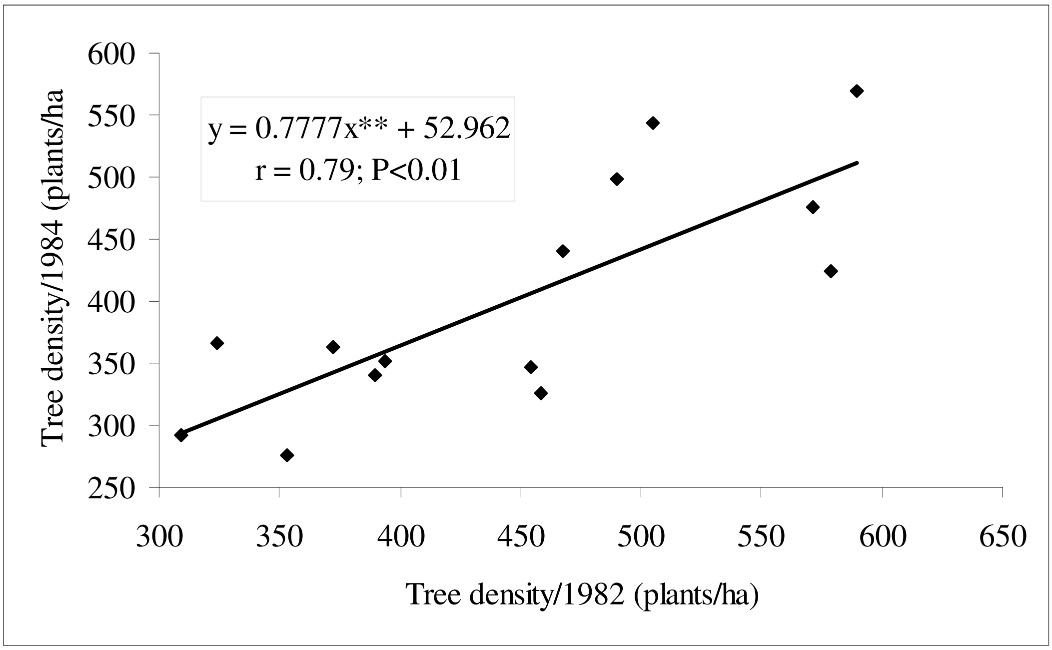

Figure 3. Linear relation between total tree densities in 1982 and in 1984, in 14 experimental areas (Note: Paddocks under use were subdivided).

Regarding the extended lists of shrubs and trees (Table 4 and 6), some species have received more attention in recent researches, due to some attributes. Among shrubs, the gigantic tubers of *J. corumbensis*, weighing around 70 kg fresh weight, have been studied as a source of forage (LIMA, 1984). Among trees, *M. pseudoglaziovii*, considered toxic for livestock when fresh,, it has become an excellent forage when hay, due to its high acceptability, high crude protein content and already adapted to the environment (ARAÚJO et al., 2004). *C. flexuosa* has been studied as source of forage, because it stays completely green at the peak of dry season (SOARES, 1989). Regarding the absence of shrubs and new plants of *S. tuberosa*, there are no evidences of effect of extensive livestock grazing. There is the hypothesis of destruction of new plants by six-banded armadillo (*Euphractus sexcinctus* L. 1758), in search of water present in the small tubers (Nilton de B. Cavalcanti[1], personal information).

CONCLUSIONS

High grazing intensities by cattle did not affect woody species new plant density;

The 1981-82 drought probably affected shrub stratum, with high mortality in the paddocks with highest density, mainly of "soft" species, that is, those ones that might be broken easily. The linear relation between total tree density and total density of tree species in shrub stage, present in 1982, disappeared in 1984, probably due to the drought;

It was expected a linear relation between adult plant and new plant densities, but this occurred only with some species, and it might have been a coincidence. The causes of the high germination of the tree *T. spongiosa*, that generated a linear relation with adult tree density, are unknown.

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