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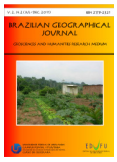
Brazilian Geographical Journal: Geosciences and Humanities research medium



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Evaluation of the performance of species in the reforestation process on the headwaters of Clemências stream, Quirinópolis (Goias State, Brazil), from 2009 to 2010

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ARTICLE HISTORY

Received: 16 August 2011
Accepeted: 22 October 2011

KEY-WORDS:
Cerrado
Recovery of degraded areas
Riparian vegetation

ABSTRACT

The objective of this study was to evaluate the performance of species in a reforestation process carried out on the headwaters of a stream called Clemências, in Quirinópolis, GO. It was measured the height, diameter at the soil surface of the planted area and the percentage of mortality of the species planted in there. A high mortality was observed, which may be connected with the absence of a correct management in the place, particularly with the crown in the locality of the seedlings, and also to a prolonged drought. *Cecropia pachystachya*, *Jacaranda cuspidifolia*, *Clitorea fairchildiana*, *Enterolobium contortisiliquum*, *Leucaena leucocephala* e *Dipteryx alata*, had higher survival rates, therefore they are recommended to use in reforestation of degraded areas. Most species suffered drastic reduction in their vegetation cover in the dry season, indicating that leaf abscission can be an escape mechanism because of the water stress.

PALAVRAS-CHAVES:
Cerrado
Recuperação de área degradada
Vegetação ripária

RESUMO – AVALIAÇÃO DO DESEMPENHO DE ESPÉCIES NATIVAS EM REFLORESTAMENTO NA CABECEIRA DO CÓRREGO DAS CLEMÊNCIAS NO MUNICÍPIO DE QUIRINÓPOLIS-GO. Neste estudo objetivou-se avaliar o desempenho de espécies em um reflorestamento realizado na Cabeceira do Córrego das Clemências, em Quirinópolis, GO. Foram medidos a altura, o diâmetro na superfície do solo, a área da copa e porcentagem de mortalidade das espécies plantadas. Foi registrada uma grande mortalidade no período amostrado, a qual pode estar relacionada com a ausência de manejo no local, principalmente quanto ao coroamento no entorno das mudas, e também à estiagem prolongada. *Cecropia pachystachya*, *Jacaranda cuspidifolia, Clitorea fairchildiana, Enterolobium contortisiliquum*, *Leucaena leucocephala* e *Dipteryx alata*, apresentaram maiores porcentagens de sobrevivência sendo, portanto, recomendadas para a aplicação em reflorestamentos de áreas degradadas. A maioria das espécies sofreu drástica redução na cobertura vegetal no período seco, indicando que a abscisão foliar pode ser um mecanismo de escape ao estresse hídrico.

PALABRAS-CLAVES:
Cerrado
Recuperación de áreas degradadas
Vegetación ribereña

RESUMEN – EVALUACIÓN DEL DESEMPEÑO DE ESPECIES NATIVAS EN LA REFORESTACIÓN LLEVADA A CABO EN LA CABECERA DEL CÓRREGO DAS CLEMÊNCIAS, EN QUIRINÓPOLIS, GO. Este estudio tuvo como objetivo evaluar el desempeño de especies en la reforestación llevada a cabo en la cabecera del Córrego das Clemências, en Quirinópolis, GO. Se midió la altura, el diámetro en la superficie del suelo, el área de la corona y el porcentaje de mortalidad de las especies plantadas. Una alta mortalidad se registró en el período de la muestra, que puede estar relacionado con la ausencia de gestión en su lugar, sobre todo por la corona en las cercanías de las plantas, y también a la prolongada sequía. *Cecropia pachystachya*, *Jacaranda cuspidifolia, Clitorea fairchildiana, Enterolobium contortisiliquum*, *Leucaena leucocephala* e *Dipteryx alata*, tenían mayores tasas de supervivencia tanto, se recomienda para su uso en la reforestación de áreas degradadas. La mayoría de las especies sufrieron una drástica reducción de la cobertura vegetal en la estación seca, lo que indica que la abscisión de las hojas puede ser un mecanismo de escape al estrés hídrico.

1 Introduction

Humid areas are natural ecosystems which suffer periodic or permanent flooding. In these eco systems the water is the determinative factor of the abiotic and biotic conditions (KEDDY, 2000) constituting, in such a way, an important ecosystem, therefore they shelter an uneven diversity of species of the fauna and flora and a high number of ecological processes which regulate them (MALTCHIK; BERTOLUCI; ERBA, 2003). In the region of the Cerrado biome, even though the physiognomic of well drained ground is predominant, that also occurs in humid areas such as bushy areas, humid fields and in trails. Due to the importance of these riparian forests, mainly in regarding to the protection of sources of groundwater, the legislation recognizes them as areas of permanent preservation (BRASIL, 1992). But, even

protected by law, with the occupation of the Cerrado biome, the riparian vegetations have suffered alterations from anthropic nature, that in some cases become irreversible, due to its small capacity of regeneration (CARVALHO, 1991).

There are, In between the irreversible damages, the extinguishing of species key and processes of degradation such as, plagues, illnesses, erosion, leaching and endogamy; this doesn't only results in the loss of the capacity of regeneration of the species, but also in the elimination of the biotic and abiotic components in them (ENGEL; PARROTTA, 2003). In these cases, the intervention, through reforestation, becomes necessary, in order to stabilize and revert the degradation processes, speeding up and directing the natural succession (ENGEL; PARROTTA, 2003), that is, in this specific case of the riparian vegetation, it assures the maintenance of the quality and quantity of the hydric resources, and also, the local biodiversity.

Dias; Griffith (1998), believe that the recovery of degraded areas can be appraised with a set of action that could be used to provide the reestablishment of conditions of previously existing balance and support in a natural ecosystem, demanding a systematic boarding of planning and visioning in the long term. The succession models have been used to develop projects of plantation (KAGEYAMA et al., 1992; REIS; ZAMBONIM; NAKAZONO, 1999) and to foresee if the projects of restoration will reach its objectives (PARKER, 1997). In this way, the restoration projects has an objective to create, since the start of the process of recovery, a forest that will be rich in native species, in general, chosen by their ecological aptitudes and their potential in attracting to the fauna dispersive seeds that come from neighboring areas, that way they will bring new seeds and speed up the local process of recovery (RODRIGUES; GANDOLFI, 1996).

Young (2000) affirms that the restoration processes intrinsically are related with the vegetation, what explains why the majority of the works of evaluation of the success of the reforestations is concentrated in the studies on the dynamics of vegetal community (LEOPOLD et al., 2001). The evaluation and the monitoring of the implanted areas propitiate to understand the processes meanings that take the structuring of the communities and the function of each specie in the outbreak of one or some processes and in the creation, maintenance or transformation of habitats, thus, It will be able to evaluate if the recovery is being successful in the place, generating knowledge for recovery of other degraded areas.

In this context, the present work had as objective to evaluate the performance of species in a reforestation process carried out on the headwaters of a stream called Clemências, in Quirinópolis, GO, by implementing types of vegetation indicators.

2. Methods and Materials

The study was done on the headwaters of a stream called Clemências and carried through in an area of 2,22 hectares. This source of groundwater is situated in a farm named Santa Maria, in the edge of the road that binds the urban perimeter of Quirinópolis from the GO-206 highway. The city is situated in a Micro-region number 18, in the South of Goiás.

The plantation was carried out in December 6th, in 2008, using thirteen native species of the Cerrado biome and exotic specie (Table 1). It´s important to mention that on the day of the plantation, the seedlings used in the plantation were donated by the São Francisco Sugar Mill, São João Group, and by the Municipal Garden of Quirinópolis-GO. It has, also, been planted seeds of *Anacardium humile* A. St. - Hil. (Anacardiaceae, cajuzinho-do-cerrado), which were in tubetes, and for this reason they could not resist to a dry period that occurred soon after the plantation. For that reason, this specie was not mentioned in this study.

Table 1. List of species which were used in the plantation.

Common name	2 Scientific name	**Family**	**Ecologic group**
1. baru	*Dipteryx alata* Vogel	Fabaceae	Late secondary
2. angico	*Anadenanthera colubrina* (Vell.) Brenan	Fabaceae	pioneer
3. embaúba	*Cecropia pachystachya* Trécul	Cecropiaceae	pioneer
4. ipê-roxo	*Handroanthus heptaphyllus* (Vell.) Mattos	Bignoniaceae	late secondary
5. jucá	*Caesalpinia ferrea* Mart.	Fabaceae	pioneer
6. jacarandá	*Jacaranda cuspidifolia* Mart.	Bignoniaceae	pioneer
7. jatobá	*Hymenaea courbaril* L.	Fabaceae	climax
8. leucena*	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	pioneer
9. pau-formiga	*Triplaris americana* L.	Polygonaceae	Early secondary
10. tamboril	*Enterolobium contortisiliquum* (Vell.) Morong	Fabaceae	pioneer
11. marmelada	*Alibertia edulis* (Rich.) A. Rich. ex DC.	Rubiaceae	climax
12. cinzeiro/calabura	*Muntingia calabura* L.	Meliaceae	pioneer
13. sombreiro	*Clitoria fairchildiana* R.A. Howard	Fabaceae	pioneer
14. pata-de-vaca*	*Bauhinia variegata* L.	Fabaceae	pioneer

*Exotic Specie. Source: Duarte et al. (2010).

The chosen model for the plantation was based on the allocation of 50% of primary species, 25% of secondary species and 25% of climax species. The hollows were made with minimum dimensions of 30 cm of diameter for 40 cm of depth, there was a space of about 4 x 4m between themselves without alignment that would reproduce a similar forest to the natural one, as illustration in Figure 1.

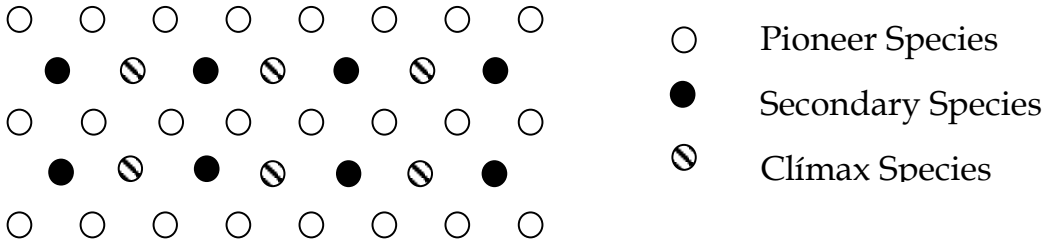

Figure 1. Model of the plantation on the headwaters of the stream "Clemências" on the farm "Santa Maria" in Quirinópolis, GO (DUARTE et al., 2010).

The climate of the region, according to Köppen, is of the type Aw, with rains in the summer and the season is relatively dry in the winter and the annual average temperature is 21°C. From May to August, lower temperatures are verified (18°C to 20°C), being the average between 11°C and 15°C. The absolute minimum temperatures are registered in July. In the hottest months (from September to February), the average temperature is from 29°C to 31°C - and It is not rare that the temperature rises to 40°C. The average annual precipitation is around 1.400mm, mainly from November to February, months of great water excess in the ground, and it can be superior to 400 mm. In contrast, from May to September rain falls is scarce, however, hydric deficit is not very high, it is about 150 mm (Sig on line, 2007 apud SOUZA; SANTOS, 2008).

In 2009, between the 3,000 plant seedlings of native species that were planted, 300 individuals had aluminium plaques numbered on them. The criterion on choosing the

individuals in the field was asystematic, measuring the plants until they were reaching the established number. In the second data collection, in 2009, 36 individuals had not been found because they were without the aluminium plaques. These individuals had been discarded, thus remaining a total of 264 individuals for study (DUARTE et al., 2010). In 2010 the collections had been carried out from March (rainy period) to August (dry period).

The height, the diameter in the surface of the ground and the area of the top of the plants had been measured. For the measurement of the total height and the diameter of the stem on the level of the ground it was used a tape measure and a caliper rule. In the ramified species, the three branches with bigger diameter (d) had been measured, and, later, D/π it was calculated the circumference (c) through the formula C =, and, then, the basal area using the formula $AB = C2/4\pi$. The calculation of the basal area was carried out for each measure separately so that it was possible, in the case of the individuals that had more than one branch, to add the basal area of the same ones, that way they could get an approaching value of the real dimension of the stem, more than from when the diameters are added. The crown of the plant area (AC) was calculated by the formula of the ellipse ($AC = x\ b\ x\ \pi/4$), becoming two orthogonal measures done with a measuring tape. The percentage of mortality of the planted species was calculated from the number of the seedlings (or plant starts) that had died in relation of the first measurement and the last one.

3. Results and Discussion

There was a first collection of 189 individuals and a second one of 119 individuals (Table 2). In that period 70 individuals died. The only evaluated individual, *Muntingia calabura* L., did not survive. Beyond this specie, the lowest survival rates had been presented by *Handroanthus heptaphyllus* (Vell.) Mattos (38.8%), *Alibertia edulis* (Rich.) A. Rich. ex DC. (41.6%) and *Bauhinia variegata* L. (50%). The great mortality in this period can be related with no maintenance of a clean circular area around the stem of the seedling (plant starts). Until the plantation and rounding up of the native plants at the end of 2008, the area was used for cattle, that´s the reason why it was implanted species of *Urochloa*, which had remained in the place, even after It had ceased the cattle breeding business. Due to presence of this grassy type of plant, the regeneration of the native vegetation in that area has occurred very slowly. During the research it was observed that the plant seedlings had been suffocated by the grassy ones. According to Bocchese et al. (2007) the grassy types of plants present fast growth of the reticular system and aerial parts, what at the same time, leads to a competition with the other individuals for ambient factors, beyond that, some species, such as, woody ones have allelopathic activity in development. These grassy ones have great reproductive strength, great capacity of dispersion and germination, being in an advantage situation when comparing with the native plant seedlings in the reforestation process (PIVELLO; SHIDA; MEIRELLES, 1999).

Table 2. List of the species that had been used in the plantation in the Farm Santa Maria in Quirinópolis (GO). M = number of monitored seedling; S =number of survivors; (%) of S= survival rate; F = final measure (October of 2009), I = initial (March of 2010) and F= final (August of 2010) height, BA = basal area and VC= vegetal cover.

Common name	Specie	YEAR	N	% de S	HEIGHT (m)	AB (mm)	VC (cm)
baru	*Dipteryx alata*	2009 - F	20	100,0	0,18	0,18	100,53
		2010 - I	15	73,3	0,18	0,19	118,37
		2010 -	11		0,25	0,30	81,80

		F					
angico	*Anadenanthera colubrina*	2009 - F	45	97,8	0,74	0,33	1.697,10
		2010 - I	36	61,1	1,08	1,09	2.977,66
		2010 - F	22		1,01	1,15	256,30
embaúba	*Cecropia pachystachya*	2009 - F	2	100,0	0,16	0,27	80,38
		2010 - I	1	100,0	0,32	0,65	280,24
		2010 - F	1		0,42	0,80	120,89
ipê-roxo	*Handroanthus heptaphyllus*	2009 - F	50	98,0	0,15	0,10	183,27
		2010 - I	36	38,8	0,16	0,21	177,97
		2010 - F	14		0,12	0,23	7,56
jucá	*Caesalpinia ferrea*	2009 - F	0	0	-	-	-
		2010 - I	-	-	-	-	-
		2010 – F	-		-	-	-
jacarandá	*Jacaranda cuspidifolia*	2009 - F	7	100,0	0,22	0,17	197,27
		2010 - I	5	100,0	0,31	0,32	443,21
		2010 - F	5		0,25	0,45	36,00
jatobá	*Hymenaea courbaril*	2009 - F	25	84,0	0,28	0,23	140,62
		2010 - I	15	60,0	0,26	0,31	153,91
		2010 - F	9		0,34	0,36	204,58
leucena	*Leucaena leucocephala*	2009 - F	19	100,0	0,85	1,10	2.217,45
		2010 - I	17	76,5	1,05	1,85	2.017,17
		2010 - F	13		1,13	2,09	752,57
pau-formiga	*Triplaris americana*	2009 - F	25	92,0	0,15	0,37	105,76
		2010 - I	9	66,6	0,17	0,49	93,15
		2010 - F	6		0,20	0,71	221,50
tamboril	*Enterolobium contortisiliquum*	2009 - F	47	100,0	0,61	0,77	686,36
		2010 - I	38	78,9	0,89	1,68	1.011,28
		2010 - F	30		0,83	2,23	482,90
marmelada	*Alibertia edulis*	2009 - F	16	75,0	0,35	0,31	1.118,57
		2010 -	12	41,6	0,76	1,50	1.641,50

		I					
		2010 - F	5		0,73	2,19	1670,00
cinzeiro	*Muntingia calabura*	2009 - F	1	100,0	0,38	0,24	408,86
		2010 - I	1	0,0	0,94	0,80	1.071,50
		2010 - F	0		-	-	-
sombreiro	*Clitorea fairchildiana*	2009 - F	2	100,0	0,71	3,04	3.759,22
		2010 - I	2	100,0	1,09	5,97	3.273,05
		2010 - F	2		0,98	8,07	1.896,00
pata-de-vaca	*Bauhinia variegata*	2009 - F	4	100,0	0,23	0,28	103,49
		2010 - I	2	50,0	0,29	1,14	153,46
		2010 - F	1		0,11	1,58	16,48
	TOTAL 2009-F		251				
	TOTAL 2010-I		189				
	TOTAL 2010-F		119				

2009 – Source: Duarte et al. (2010).

The other factor that has been the cause for the great mortality of the plants was the dry weather in the year of 2010. Although, the place has some more humid paths, the depth of the water table in the dry period increases and as the plants are establishing in the place, and they do not present a well developed reticular system able to reach the water table. Moreover, the plantation of the species was prioritized in dry regions, taking in account that there is a road in the place that functions as a barrage and it floods, in rainy periods, than, the region becomes humid.

The species that had presented greater survival rates had been *Cecropia pachystachya* Trécul, *Jacaranda cuspidifolia* Mart. and *Clitorea fairchildiana* R.A. Howard, all with 100% of survival; *Enterolobium contortisiliquum* (Vell.) Morong (78.9%), *Leucaena leucocephala* (Lam.) de Wit (76.5%) and *Dipteryx alata* Vogel (73.3%) (Table 2). These species had also presented high survival rates (100%) in the year of 2009 (DUARTE et al., 2010). Between them only *Dipteryx alata* is late secondary, the others are pioneer. Kageyama; Gandara (2000) had identified the pioneer anthropic species those of faster growth, which are typical pioneers and those which are not typical pioneers that play the role of typical pioneers in degraded areas.

In the second group there is the late secondary, which in these areas it plays the role of pioneers. The great variation of survivals observed for the studied species suggests that there is an existence of an adaptive differential of survival on each of the species to the general degraded environment conditions (FONSECA et al., 2001). In between the different native species there, there are the ones that have greater phenotypic plasticity and, therefore, greater capacity of adaptation to different ambient variations.

In between the twelve species that had been kept in the place, seven had presented negative averages of growth in their height. But, the species that had presented positive average of growth in their height, those had been very short, in comparison with their growth in the year of 2009 (DUARTE et al., 2010). The factor that has been the cause for the short growth in their height is the dry season in the year of 2010.

With less water availability, the plant is affected in its growth (RUIZ-ERASO, 2009). According to Taiz; Zeiger (2004) water plays a very important role in the life of a plant. A small disequilibrium in the water flows can cause hydric deficit and severe functioning of the innumerable cellular processes, compromising the growth, or even, the survival rate of the plants.

The attack of ants could explain the negative growth of the seven species. Newbery; Foresta (1985) enlighten that vegetal species, in their initial establishment, suffer enormous pressure from herbivores, which represents one of the factors that limits the growth and even the survival of the plants.

Between the species that had presented positive growth in their average height are *Dipteryx alata, Cecropia pachystachya, Hymenaea courbaril* L.*, Leucaena leucocephala* and *Triplaris americana* L.. The good growth and low requirement of fertilization and maintenance of *Dipteryx alata* suggest excellent potential for recovery of degraded areas (HERINGER, 1978). *Cecropia pachystachya* is a pioneer specie type, a settler of bare places, has a fast growth, and it is a very important key in the regeneration of degraded areas for the fact that they attract dispersive animals and improve the properties of the ground, what will propitiate more favorable conditions for the establishment of other species (MOSSRI, 1997). *Hymenaea courbaril* is little demanding in the fertilizing and humidity of the ground, generally occurring in well drained lands, It plays a very important role in the composition of heterogeneous reforestations and in the reforestation of parks and great gardens (LORENZI, 2002).

Leucaena leucocephala is originally from Central America and it has been spread out by the tropical regions of the world (TOKARNIA; DÖBEREINER; PEIXOTO, 2000), its deep reticular system allows the attainment of humidity in the deepest layers of ground, keeping it green during dry seasons, assuring a high resistance to long periods of drought (FINGER, 1992). In the areas where the average annual precipitation is 250 mm *L. leucocephala* can be presented as the dominant specie (FRANCO; SOUTO, 1986). It presents high percentage of germination, fast growth, easy nodulation and fast growth of its reticular system (CORDEIRO; SALATINO, 1995).

Triplaris americana occurs naturally in gallery of forests of the type semi deciduous, being the main potential use of this specie in the urban landscaping and the recovery of degraded areas. It is one of the heliophytic types of species of fast growth (LORENZI, 2002).

When comparing the last average of their height in 2009 (October) with the first measurement of it in 2010 (March) the species that had presented greater growth were *Alibertia edulis*, *Clitorea fairchildiana*, *Anadenanthera colubrine* (Vell.) Brenan*, Enterolobium contortisiliquum* e *Cecropia pachystachya*. The favorable period to its growth corresponded to the rainy one. Moreover, these species are pioneering, with the exception of *Alibertia edulis*, which is a climax and dioecious type (LORENZI et al., 2006). *Clitorea fairchildiana* presents fast development, being able to exceed two meters of height in two years of age (SCALON et al., 2006). *Anadenanthera colubrina* also presents fast development, reaching from four to five meters in its two years of age (LORENZI, 2002), and presents resistance to desiccation for the presence of the reserve agency (MAIA, 2004) which makes it an excellent option for reforestations in degraded areas. *Enterolobium contortisiliquum* is an ideal for reforestation of degraded areas for its fast initial growth, being able to reach four meters of height when it is two years old (LORENZI, 2002).

The species which presented greater growth in its basal area during the evaluated period are, in a decreasing sequence, *Clitorea fairchildiana*, *Alibertia edulis*, *Enterolobium contortisiliquum*, *Bauhinia variegata* and *Anadenanthera colubrine*. In the study of Souza; Santos (2008) *Bauhinia variegata* has presented the biggest

growth on its basal area. Duarte et al. (2010) had registered the biggest growth on the basal area of *Clitorea fairchildiana* and *Anadenanthera colubrine.*

The species which had shorter growth on basal area were *Handroanthus heptaphyllus*, *Hymenaea courbaril* and *Anadenanthera colubrina*. This result can be explained by the ecological characteristics of the first two species, which are considered a late secondary to climax types, presenting slow growth. On the other hand, the last one, which is a pioneer, may have allotted some resources in the studied period, growing in height, enabling adaptive advantages, such as, competition for sun light with other species in their surroundings.

Inherent to the vegetal covering, when comparing the year of 2009 (October) with the first measurement in 2010 (March), the majority of the species had presented increasing in their foliar cover.

In this period only *Leucaena leucocephala, Clitoria fairchildiana* and *Triplaris americana* had a reduction in vegetation cover. During the first and last measurement of 2010, which corresponded to the prolonged dry weather, most species suffered a drastic reduction in vegetation cover, except for *Hymenaea courbaril*, *Triplaris americana* e *Alibertia edulis*. Apparently, if there is a severe water restriction the higher will be the rates of species losing their leaves. This loss of their leaves is more concentrated during the dry season which favors and illustrates an escape mechanism from hydric stress (O'BRIEN et al., 2008). The decrease in the amount of water in the upper layers of the soil in dry season has been associated with the fall of their leaves due to the declining of hydric potential (CORLETT, 1993).

5 Final Considerations

During the period sampled it was recorded a high mortality, which may be related to absence of a correct management of the place, particularly for the crown levels of seedling and also because of the long period without raining.

The species that had presented greater survival rates had been *Cecropia pachystachya*, *Jacaranda cuspidifolia, Clitorea fairchildiana, Enterolobium contortisiliquum*, *Leucaena leucocephala* e *Dipteryx alata,* being, therefore, recommended for the application in reforestations of degraded areas.

Inherent to the vegetal cover, it was observed that the majority of the species suffered a drastic reduction in the vegetal covering in dry periods, indicating that the loss of their leaves could be a mechanism of escaping because of their hydric stress.

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