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Morpho-Anatomical Traits for Woody- Plant Adaptation to Drought: Case of *Atriplex canescens* in Southwest Algeria

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Abstract: Water is vital in the life of plants. A decrease in its availability can cause a change in the characteristics of the soil-plant-atmosphere continuum to make the plant more tolerant of dry environments.In this article, we tested the behavior of *Atriplex canescens* with respect to water availability by (i) analyzing the size and shape of the leaves and (ii) determining the role of vascular elements in the reaction of woody in the middle. *Atriplex canescens*, is native to the southwest of the United States and was introduced in 2004 in the high steppe plains of Algeria in order to enrich the forage potential of this vast area. The study of vascular elements establishes the existence of heterogeneity for the diameter of latewood vessels. The diameter of the initial wood vessels, the number of woody combs per unit length as well as the number of vessels /mm^2 are homogeneous. Analysis of the morphology of the leaf shows that the surface, the length of the main vein and the width of the leaves are heterogeneous (20% <CV <60%). Analysis (ANOVA) revealed the existence of a very significant difference (P <0.0001) between the histo-morphological characters studied. When water is unavailable, *Atriplex canescens* responds with a 25%(¼) reduction in the perspiration surface. The leaves are 35% narrower (1/3) and slightly stretched (3%). In secondary wood histology, vessels become less numerous with a reduction of 25% (¼). In initial wood and final wood, the vessels are respectively less open by 10% and 20%. The vessels also change layout with a more marked presence in the latewood. The operating life of the sapwood is longer with a delay in the establishment of duraminization.

Key words: *Atriplex canescens* · Xicity · Leaf morphology · Wooden vessels · Algerian southwest

INTRODUCTION

Despite the hostility of the natural environment characterized by unfavorable climatic and edaphic constraints, the Algerian high steppe plains with an area of 20 million hectares play an important ecological and socio-economic role. According to [1, 2, 3] alfa (Stipa tenacissima), white sagebrush (Artemisia herba alba), esparto (Lygeum spartum), remt (Arthrophytum scoparium) and other species of alfalfa and ariplex constitute biological material of choice for the enrichment of the flora, the protection of the soil and the improvement of fodder availability in these arid zones with rainfall of less than 400mm / year. The objective of this study is to analyze the histo-morphological behavior of Atriplex canescens, a fodder species introduced in 2004 into these areas with a view to diversifying and increasing the fodder potential offered to mixed herds according to statistics from the specialized services. of the Ministry of Agriculture and Rural Development (2019) of 28 million sheep and 5 million goats.

The histo-morphological traits of a species generally describe the "strategy" of plants and their adaptation to the physical environment [4, 5].

Due to their visibility and ease of measurement in many species, leaf morphological traits are the most important functional traits of plants. [6, 7]. [8] report that the size of the leaf is related to the size of the plant, its histological structure and its ecological strategy in response to biotic or abiotic disturbances. According to

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[9] due to heat stress due to cold or drought, plants reduce the area of transpiration, either by slowing down growth or by loss of leaves, which is also reflected according to[10] Casper et al. (2001) bya modification in their number and their surface.[11, 12]discuss a strategy of heat dissipation by reducing the size of the leaves and changes in their shape as well as changes in the angle of insertion of the leaves. A reduction in the exposed leaf area is cited as a long-term response of Mediterranean plants to the intensity and duration of the dry period[13].

The plant's demand for soil water resources is dependent on the leaf area deployed and the evapotranspiration caused by these leaves as well as the transport of these resources in the plant via conductive elements [14]. Knowledge of the morphology of water-conducting cells is decisive for understanding the various biological processes of trees and the properties of wood [15, 16, 17]. The anatomical structure reflects the volume of pore space available for the transit of water and elements dissolved in wood [18]. The authors cited by [19] showed that the availability of water, temperature and light affect the pore space represented by the size and number of vessels [20] consider that the flow of conduction is strongly correlated with the diameter, the number of vessels and the density. In a Mediterranean climate, [21] argue that the size of the vessels is mainly controlled by the availability of water at the time of their differentiation and by the temperature.

In this study, *Atriplex canescens* will serve as a case to describe and analyze the different responses of woody plants to hostility in the environment in steppe areas with an emphasis on the structural and functional adaptations of plants to mitigate the negative effects of the plant water availability in drought conditions.

Atriplex canescens is a chenopodiacea native to the southwestern United States [22]. It is a bushy shrub in the form of tufts of 1 to 3 m in height which produces where the natural vegetation is deeply degraded and with annual precipitations of 200 to 400 mm from 2000 to 4000 kg of dry matter per year and per ha high protein forage [23].

MATERIALS AND METHODS

Study Sites: The experiment was carried out during the end of the first half of 2018 in the steppe zone located south of the city of Tlemcen in the far west of Algeria. The two sites chosen for monitoring the behavior of Atriplex canescens are part of a program of the agricultural services department with a view to increasing the pastoral potential of the area by planting this species on an experimental basis in 2004 and 2005 respectively. The sites are respectively spread over 100 ha for station 1 where water resources are less satisfactory and 20 ha for station 2 where water resources are temporarily abundant.

The first site is located in the Maghoura area (N 34 ° 18'20.8 "; O 01 ° 36'23.9 ") on the road connecting El Aricha to Sidi El Djilali, it belongs to the public domain and its exploitation as land of range cannot exceed 2 months per year in order not to exhaust its forage potential. The second privately owned site is located 25 km south of the town of Sebdou on the road towards El Aricha (N 34 ° 28'21.7 "; W 01 ° 16'19.9"). Called "Sehb El Bghal", it is located a stone's throw from the village "Belhadji Boucif", it is located in a depression along a temporarily flowing stream.

According to [24], the soils in this steppe region are most often based on marly and sandstone formations sometimes associated with calcareous and gypsum flows. The climate data for this area according to [25] for the period (1985 - 2015) are : (i) the mean temperature of the warmest month (M) and the mean temperature of the coldest month (m) are respectively 29.35°C and 0.3°C; (ii) the annual mean temperature is 17.6°C; (iii) the annual precipitation is 220 mm and (iv) the pluviometric quotient of Emberger Q2 is 26.22 which corresponds to the lower semi-arid stage.

Collecting Samples: Atriplex canescens sheet samples were taken from two sites depending on the availability or unavailability of water. From each site, 100 leaves were taken from the four exposures on ten tufts / shrubs spaced in a linear North-South arrangement respectively of 10 m in the least watered station and 3 m in the other station in order to stay at near the river.

The harvested leaf samples were placed in plastic bags to prevent desiccation and possibly shrinkage. The measurements were taken as soon as possible after collection (within 4 to 8 h). The measurements were taken as soon as possible after collection (within 4 to 8 h). In the laboratory, the leaves were first given a general description. Subsequently, they were scanned (Scanner HP Scanjet G4010) and processed by image analysis software (euromax).

In addition to the geographical information (latitude, longitude and altitude), the tuft / shrub of Atriplex canescens was measured for height, number of branches, large and small diameter of the tuft / shrub. Figure 1 mentions the key functional features of leaf morphology: (i) length of the midrib, (ii) leaf width and (iii) leaf surface.

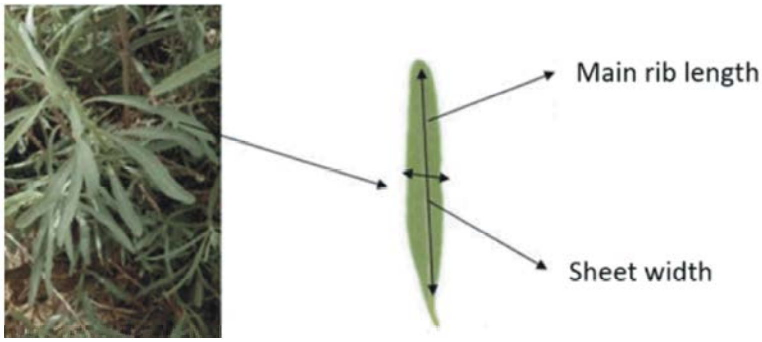


Fig. 1: Functional features of the leaf morphology of *Atriplex canescens*

The study of histological features requires the making of microscopic sections according to a protocol of sampling small blocks for analysis, in relation to the agreed objective. The sections thus obtained were photographed using a photonic microscope with an OXION type camera. Anatomical measurements were then performed using the image analysis software. The execution of thin sections, the terminology used and the characterization of the wood were established according to the terminology of [26]. Cross sections were used to measure tangential diameters and vessel frequency. For these measurements and for each site we took ten observations where each microscopic element was measured ten times, for a total of 100 measurements for each element. The frequency of woody rays per unit length was associated as an anatomical parameter for assessing behavior.

The study of the variability of each histo-morphological trait in the same station and between stations is based on an analysis of variance (ANOVA).

RESULTS

The Characteristics of the Leaf Morphology of *Atriplex canescens*: Both sites offer a tuft with a physiognomy shown in Figure 2.

Table 1 shows the dendrometric characteristics of the average tuft measured on the basis of the ten tufts at the two sites.

In the El-Aricha site, the action of the drying wind, the soil and the availability of water are respectively undone by the shelter from the depression, the richness of the alluvial soils and the ease of access to water. Thanks to temporary flows and the presence of the water table in the alluvial deposits of depressions and basins. Due to these favorable growing conditions, the dendrometric characteristics of the *Atriplex canescens* clumps / shrubs samples from the site show a higher and more extensive clump. In addition to the difficult environmental conditions, the Maghoura site, which is in the public domain, is under pressure where the annual rotation of two months of operation seems not to be respected. It is true that the environmental conditions are unfavorable, but the high number of strands per tuft, an average of 15 against 7 in the El Aricha site, is an indicator of the overexploitation of these courses offered free of charge to the breeders.

The leaves of *Atriplex canescens* illustrated in Figure 3 have a pendulous appearance, briefly petiolate or subsessile, more or less lengthily attenuated at the base entire, alternate, linear- lanceolate, uninervated, greyish green and silvery gray with golden reflections, from 3 to 5 cm long by 0.3 to 0.5 cm wide, accompanied by smaller axillary leaves (0.5 to 1.5 cm by 0.1 to 0.3 cm).

The measurement of variations in the morphological traits of mature leaves in Atriplex canescens in relation to the two sites gave the following results (Table 2).

The average morphological features of the Atriplex canescens leaf in the two stations are shown in Table 2. Standard deviations are low, reflecting consistent data within each morphological trait. The unfavorable vegetation conditions of the Maghoura station generate a leaf that is more or less homogeneous in its width (2.3mm; +/- 0.04) and in its area (30.1mm²; +/- 0.06). In response to these unfavorable growing conditions, the leaf of Atriplex canescens develops particular morphological adaptations. Indeed, the results significantly give a less developed, stretched and narrower sheet.

The Histological Characteristics of *Atriplex canescens* Wood

Descriptive Characters: The observation of the two discs in Figure 4 obtained from the most developed strand of the middle tuft shows 12 and 13 rings respectively for the Maghoura station and the El-Aricha station.

Fig. 2: The two categories of Atriplex canescens tufts (left): tuft from El Aricha station; (right): tuft of the Maghoura station

Table 1: Characteristics of the medium tuft of *Atriplex canescens*

Site	Water	Wind	Soil	Altitude (m)	Height (m)	Tall Diameter (m)	Small Diameter (m)	Nbre strands
Maghoura	- - -	+++	Superficial	1091	0.84	1.39	1.07	15
El Aricha	+++	- - -	Deep	1095	1.71	2.53	2.23	07

Table 2: Morphological features of the Atriplex canescens leaf

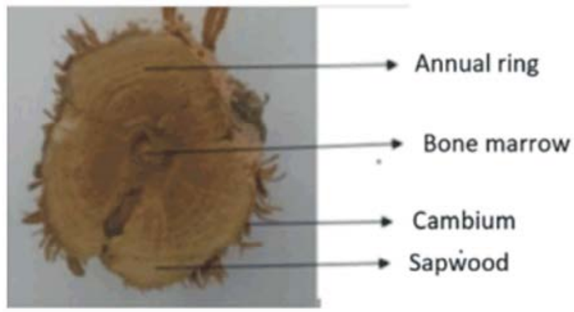
	Maghoura		El-Aricha		Test [Z]		
Morphological traits of the leaf	X	σ	X	σ	obs	crit	
Length (mm)	17, 9	0, 30	17, 4	0, 34	-1, 16	1, 96	(****)
Width (mm) (mm)	2, 3	0, 04	3, 6	0, 22	5, 29	1, 96	(****)
Area (mm^2)	30, 1	0, 06	41, 4	0, 10	9, 18	1, 96	(****)

Fig. 3: The general appearance of the *Atriplex canescens* sheet

The proportion of functional wood (sapwood) is higher in Maghoura station compared to El Aricha station. Is the long period of sapwood activity a first adaptation of wood to difficult growing conditions ?.

The general shape of the microscopic cross section given in Figure 5 shows the stretch of latewood in a uniform tangential band along the mass of the wood. The initial wood occupies ¾ of the transverse image. The pore arrangement shows that Atriplex canescens wood has a "semi-porous" arrangement. The early wood has one to three rows of pores that are slightly larger than those of the late wood.

In the El-Aricha station (Fig. 6), the pores of the initial wood are either grouped together in a diamond sleeve, or aligned radially across the width of the ring. The final wood gives a flaming or conical appearance to the two presentation modes. In the Maghoura station, the pores are largely confined in the final wood, few are those which extend throughout the mass of the wood.



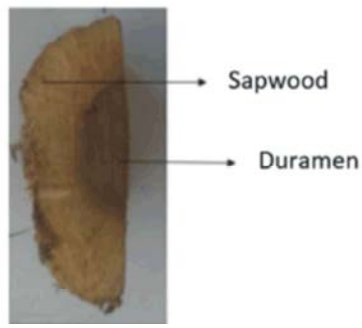


Fig. 4: Macroscopic view of the two wooden discs. (top), Maghoura station; (bottom), El-Aricha station

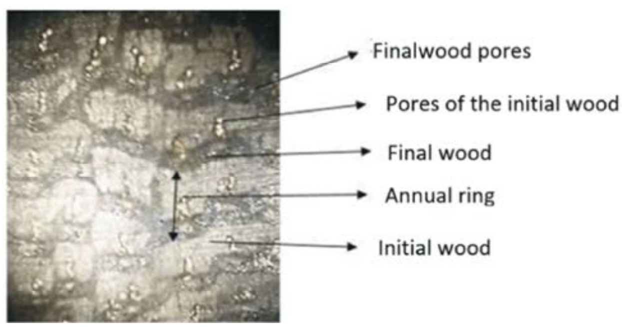
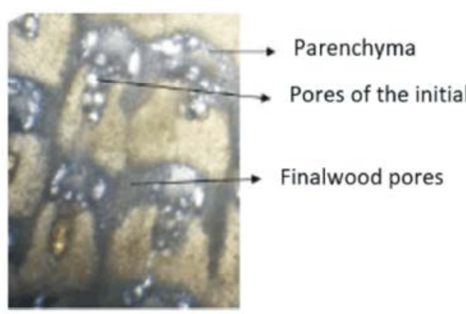


Fig. 5: General appearance of the microscopic transverse structure of *Atriplex canescens* wood



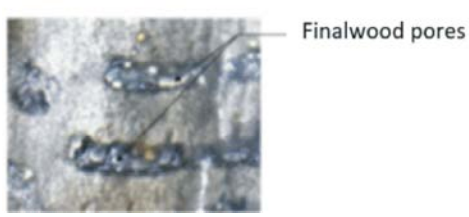


Fig. 6: Microscopic structure of the pores of the initial and final wood El-Aricha wet station (top) and Maghoura dry station (bottom)

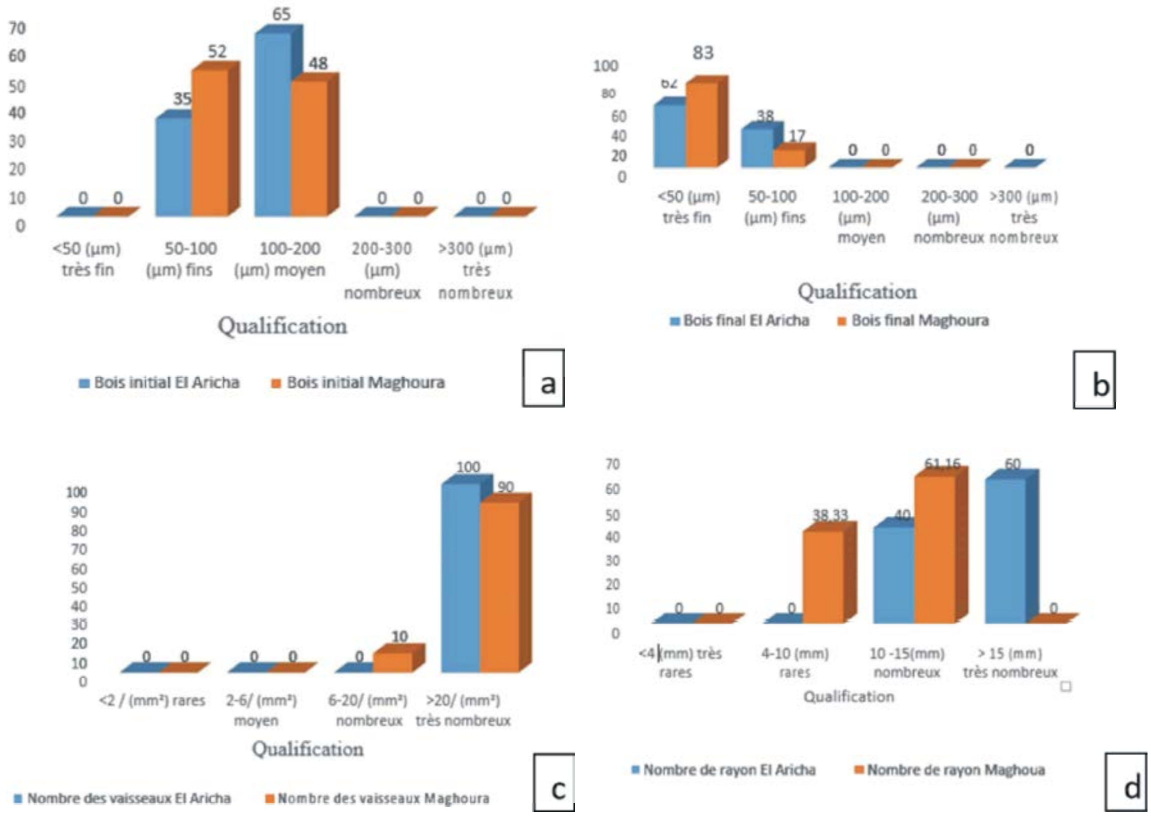


Fig. 7: Anatomical characteristics of Atriplex canescens wood in the two stations
(a), diameter of the vessels of the initial wood; (b), diameter of the final wood vessels;
(c) frequency of vessels; (d)number of spokes / mm

Table 3: Effect of station on histological parameters of Atriplex canescens wood

	Maghoura		El Aricha		Test [Z]		
Histological parameters	X	σ	X	σ	obs	crit	
Initial wood pores (µm)	103, 19	15, 61	112, 22	21, 01	3, 45	1, 96	(****)
Final wood pores (µm)	37, 05	15, 02	47, 26	14, 28	4, 92	1, 96	(****)
Vessels /mm²	9, 96	1, 93	15, 15	2, 35	13, 15	1, 96	(****)
Rays/mm	23, 10	2, 92	40, 28	3, 48	26, 69	1, 96	(****)

Quantitative Characters: The histograms in Figure 7 show the size and frequency of wood vessels at the two sites as well as the number of woody combs per unit length.

Depending on the characteristics given by [26], the initial 200 measurement vessel diameter of the wood places *Atriplex canescens* wood in the category of "medium" pore wood. Figure 7.a shows that in the Maghoura station, the "average" pores represent 48% of cases against 52% of "fine" type pores. In the favorable conditions station of El-Aricha, the "medium" pores dominate up to 65%, the "fine" types constitute 35% of cases. The vessels in the final zone belong to the category of wood with "very fine" pores, the histogram of Figure 7.b shows the dominance of this class (62%) for the El Aricha station and (83%) for the station. Maghoura. The rest of the pores are: "fine" type with a percentage of (38%) for the El-Aricha station and (17%) for the Maghoura station. Figure 7.c shows that the vessels are "very numerous" in the El Aricha station (100%) and in the Maghoura station (90%). Figure 7.d shows that the woody rays / mm belong in the Maghoura station to two categories: the "rare" category (38%) and the "numerous" category (61%). At El Aricha station, the rays are either "many" (40%) or "very many" (60%).

Regarding the effect of the station on the measured parameters, Table 3 summarizes the effect of the station on the quantifying histological parameters studied.

The average histological features of *Atriplex canescens* wood in the two stations are shown in Table 3.

Overall, the standard deviations are low, apart from the latewood vessel diameter, indicating consistent data within each histological trait. The unfavorable growing conditions of the Maghoura station generate vessels that are more or less homogeneous in their initial wood diameter (103.19 μm; +/- 15.61) and in their frequency / mm^2 (9.96; +/- 1.93) as well as in the number of woody combs / mm (23.10; +/- 2.92). In response to these unfavorable growing conditions, the wood of *Atriplex canescens* develops specific histological adaptations. Indeed, the results give significantly fewer and less open vessels in the initial wood and in the final wood in response to the deficiency of the medium in water. Woody combs are also less frequent in the station under unfavorable conditions.

DISCUSSIONS

The morphological features of the vegetation have been interpreted by some authors as a means of resisting drought.According to [27, 28], a reduced leaf area has been proposed as one of the key traits allowing Mediterranean oaks to resist water deficit. By reducing the transpiring surface, the plant slows down its gas exchange with the exterior and regulates the water potential of the soil [29, 30]. According to [31], the adaptations drawn from morphological features (less developed, stretched and narrower leaf) allow the plant to limit its dehydration, in fact, the aerial parts are the most sensitive, the leaves adapted to the conditions. of deficiency offer the plant the possibility of continuing to explore the soil while limiting its transpiration [32]. Thus, root water uptake proportionally compensates for water loss from transpiration [29], the vessels thus transporting water absorbed by the roots to the aerial parts subject to transpiratory loss.The descriptive study of the vessels shows that in the station under Maghoura's deficient conditions, the pores are almost confined in the latewood, rare are those that extend throughout the mass of the wood. On the other hand, in the watered station of El-Aricha, the pores of the initial wood are either grouped together in a diamond sleeve, or aligned radially along the ring. The quantitative results show that the size and frequency of the vascular elements of Atriplex canscens wood bathing in water conditions unfavorable to vegetation are clearly less developed compared to a well watered station.It appears that the smaller diameters and the arrangement of the vessel elements are related to a lower water conductivity at the base and to the drought vulnerability of the species. According to [33] trees modify the development of wood to create anatomical features able to alleviate stress due to drought, this modification can be observed in tree rings but also in the morphology of conductive cells that change in response to environmental conditions.

Woody combs are parenchyma cells which provide the functions of conduction of raw sap, support for the stem and storage of chemicals are significantly less frequent in the Maghoura dry station, i.e. 23 rays / mm compared to 40 rays / mm in the watered station. According to [34, 35], the results reflect a weak conduction activity and regulation of the flow of sap in the dry station.

The results of [36] show that under conditions of climatic deficiencies, the vessels in the holm oak in a high forest or coppice regime become "thin", less numerous and longer, the woody rays are less wide and extended.This structure observed under xicity conditions generates a dense wood. [30] observed a significant reduction in radial growth and vessel size as well as a slight increase in density in three young plants of the genus Quercus (Q. robur; Q. petraea and Q. pubescens) submitted. to drought constraints during the first three years of their development.

A low growth rate in woody plants results in a high tissue density of the different organs[37, 38]which protects conifers and angiosperms from the effect of water stress [39, 8]. According to [40, 41], when the drying out of the soil combines with a high demand for evaporation, the plant with large vessel diameters incurs obstruction of the xylem vessels which can lead to the plant mortality.

Faced with the performance of Atriplex canscens under certain conditions, the question arises and according to [42] Cortes *et al*., (2020) is to what extent the success of these exotic plantations affects the natural resources of arid lands.

CONCLUSION

Despite the hostility of steppe areas characterized by dry soil and climate, Atriplex canscens develops very specific morphological and anatomical adaptations in order to survive.

The synthesis of the results shows a reduction in the evaporating surface. The leaf becomes less developed on the surface and stretched in the direction of the midrib. The wood maintains its sapwood in a functional state and consequently delays duraminization. The vessels are less numerous and less open in the initial wood and in the late wood. The vessels are also more present in the final wood, rare are those which are prolonged in all the mass of wood. Woody combs are also less frequent in the station under unfavorable conditions.

Understanding the physiognomy of plants and the anatomy of wood, which are important characteristics in assessing the vulnerability of species to the severity of an environment, will enable new approaches to predict and mitigate the future effects of drought on plants. In terms of wood anatomy, knowledge of the mechanisms related to vascular elements must be interpreted in terms of the physiology of responses of the whole tree to its environment.

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