v. 3, n. 33, 2023

International Journal of Health Science

CONDITIONS OF POPULATIONS OF Brosimum alicastrum SW DUE TO ANTHROPIC ACTIVITIES IN TWO MICROREGIONS OF MIDDLE SUBDEDUCIFOLA FOREST IN ARTEAGA, MICH., MEXICO

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Abstract: The study area is located in the town of Espinosa, municipality of Arteaga, Mich. The proposed objectives were: Identify impact factors in the populations of Brosimum alicastrum, evaluate the natural regeneration established and the growth of the seedlings, determine the value indices of importance, significance and diversity of the species. With the Google Earth System and GPS, the populations of the species were located, sampling units of 1000 m2 were located, the DN, height, CM were measured for trees greater than 10 cm, the Basal Area and Volume were calculated. in m3/ha; using the Muller-Dombois and Ellemberg method, the density, dominance, frequency and value of importance were derived; and with the Margalef method the diversity index was obtained. A GIS was created, in which 13 populations of Brosimum were located. The main results refer to the average DN of 41.8 cm, height 19.4 m, crown width 4.8 m, AB/ha 14.9 m2, volume/ha 159.9 m3, health and vigor 85%; the fruits are eaten by wild and domestic animals, those that manage to germinate if they are not in a protected environment are also consumed in the seedling state.
Keywords: Brosimum alicastrum, anthropic activities, value indices, diversity index and significance index.

INTRODUCTION

*Brosimum alicastrum*Sw is known as "huje" or "ramón", it is an ancestral and majestic species of the medium subdeciduous forest, distributed in micro-regions of the ejido el Valle and Anexos, municipality of Arteaga, Mich. Puleston, 1968, Demarest, 2004, Masson and Lopez et. to the. 2008, mention that Brosimum is one of the dominant trees in the jungles of Mexico and Central America and was one of the main sources of food for the Maya of the classic period (250 to 900 AD). The Mayans, as a farming and hunting people, recognized the value of this species, appreciating the nutritional values of the seed, the productivity of the crops, its importance as a source of food for game species such as deer, and the environmental resistance that has compared to other annual crops. Some anthropologists assume that by using B. alicastrum as food and to ensure the permanent availability of a meat source, these cultures managed to achieve much denser and healthier populations than with current maize-based agro-ecosystems. This is because B. alicastrum is a better food than corn, since it produces four times more per hectare (TEF, 2010). Berg, 1972, among the disadvantages of the species is being susceptible to damage by browsing the plant and damage by rodents to the seeds. FAO 2009, at present, and due to the lack of knowledge of its benefits, this species is felled for use as firewood and due to the change in land use for the planting of annual crops, crops for export or pastures. The Equilibrium Fund estimates that in all of Mesoamerica and Mexico, more than 75% of the forests where Brosimum inhabits have been lost, a situation that represents a threat both to biodiversity and to the destruction of a healthy, nutritious and resistant food source. climate changes. Central America has one of the highest rates of forest loss, between 1990 and 2005, about 64 million hectares were lost, equivalent to 7% of the forested area of this region. The populations of Brosimum in these conditions, without having planning and management instruments, over the years the extensions have been diminished, favored by clandestine logging for domestic use, subjected to the trees by clearing for agricultural purposes, use of the fruits by the locals as food for human consumption and coffee, for livestock and wildlife the foliage and fruits. The objectives proposed in this research were: Qualitatively and quantitatively characterize populations of Brosimum alicastrum in two microregions in the municipality of Arteaga, Mich.; Identify factors that impact Brosimum populations regarding adult trees, fruit production and natural regeneration; evaluate the variation of the conditions presented by the studied populations; determine the indices of value of importance, significance and diversity of the species. Identify factors that impact Brosimum populations regarding adult trees, fruit production and natural regeneration; evaluate the variation of the conditions presented by the studied populations; determine the indices of value of importance, significance and diversity of the species. Identify factors that impact Brosimum populations regarding adult trees, fruit production and natural regeneration; evaluate the variation of the conditions presented by the studied populations; determine the indices of value of importance, significance and diversity of the species.

MATERIALS AND METHODS

1. Study area location

The study area is located in the Chuta River Hydrological Region (RH) 17, in the Pisada de la vaca micro-watershed in the El Valle y Anexos ejido, named "La Sierra" and the RH18 Rafts the Garita,ofprivate property in the Espinosa Tenure, named Los Hujes y Guayabillas, in the municipality of Arteaga, Michoacán, Mexico, Fig.1.

2. Description, habits and importance of Brosimum

Bibliography was reviewed to define the taxonomy and botanical description of the species, the phytogeography in Mexico and Michoacán, habits and problems in Michoacán, importance, regional and local uses, forms of cultivation and management.

Botanical collections were carried out to compare the characteristics of the species and monitoring through the establishment of sampling units to integrate the records of the phenology of leaves, flowers and fruits.

Classification and description

a) the ctaxonomic classification, is detailed in Fig.2.

b) botanical description

Root. The root system is strong. Some roots are superficial and the trunk is frequentlyrreinforced by buttresses.

Shape. Evergreen or subevergreen tree, retains its foliage throughout the year. It does not produce dormant buds but continually produces new leaves, unless the temperature is so low that growth stops; 20 to 30 m high, with a normal diameter of 50 to 120 cm.

trunk / branches. Straight, cylindrical trunk with large and well-formed buttresses, from 1.5 to 4 m high, the clean bole from 6 to 10 m per trunk, flattened. Ascending and pendulous branches.

Cup. Pyramidal, dense or open and irregular.

Leaves. Alternate, simple, short stalked, falcate; blades 4 to 18 cm long by 2 to 7.5 cm wide, ovate-lanceolate to ovate or elliptic, with entire margin; bright green above, grayish green below.

Cortex. External, smooth, grayish brown, with yellowish tones, rounded lenticels. Internally yellowish cream in color, fibrous to granular, with abundant milky exudate, slightly sweet and sticky and total thickness of 7 to 12 mm.

Flowers).ORnisexual, solitary and axillary. The male ones are gathered in globose catkins, lacking a corolla. The females are in oblong, oval heads, with smaller scales.Floweryellow staminate and green pistillate flower.

Fruit(s). Drupe 2 to 3 cm in diameter, globose with fleshy pericarp, yellowish green to orange or red when fully ripe, with a sweet taste and smell, covered on the surface with numerous white scales; containing 1 to 2

Fig. 1. Macro and microlocation of the study area.

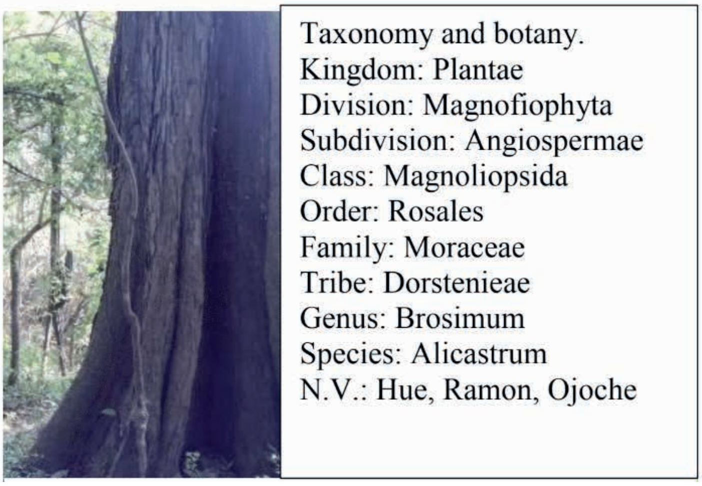


Fig. 2. Taxonomic classification.

Fig. 3. Botanical characteristics of Brosimum alicastrum.

seeds per fruit.

Seeds). Size 9 to 13 mm long by 16 to 20 mm wide, spherical and flattened at both ends, covered with a papery testa of a light brown color, green, thick and starchy.

Sexuality. It is a monoecious plant; their sexuality changes from the feminine to the masculine state from a certain stage of their life cycle, Fig.3.

3. Geographic Information System Integration

Through the image of Google Earth, thematic cartography edited by INEGI and field sampling, the populations of Brosimum were delimited, the description of the physical environment and the Geographic Information System was built, which includes the forest cartography.

4.Description of the physical medium

Records were made for health status, phenology, spacing pattern, physiognomy and dominance, based ontothe Kraft classification; the botanical composition, geoform of the site, geological material, soil unit, slope, exposure, light penetration at ground level, asl, and evidence of anthropogenic damage by domestic livestock and wildlife were defined.

Through the methodology of Gómez Tagle and Esquivel 2007, the climatic sheet and associated parameters in the Brosimum populations were determined, the water balance and the Mass Curve of the pluvial precipitation of the study region were determined.either.

5. Sampling units and dasometric parameters

Sampling units of 1000 m2 were delimited in which the DN, height were measured and the dasometric variables of basal area and volume were calculated, through the formulas AB = D^2 (π)/4, expressed in m^2/ha; and V = AB x Height x CM, in m^3/ha, respectively, Fig 4.

6. Feedback evaluation

In the sampling units, 10 m^2 plots were delimited in which the regeneration of the last two cohorts was evaluated, in terms of the number of seedlings, physical state and distribution.

7. Species Importance Value Index (IVI)

The values of density, dominance, frequency and importance value were determined with the methodology proposed by Muller-Dombois and Ellenberg (1974):

Density: Number of trees per species/total number of trees per ha*100.

$$D = \sum \quad ni * \frac{100}{Ni}$$

Frequency: Number of subsamples in which the species appears *100/total number of subsamples.

$$f = nma * \frac{100}{nts}$$

Dominance: Basal area by species *100/ Total basal area.

$$D = ABE * \frac{100}{ABT}$$

Importance Value Index: was determined through the following equation:

$$IVI = Densidad + Frecuencia + Dominancia$$

The result is expressed as a percentage in relation to the surface it occupies in the hectare.

With the species, DN, tree height, altitude, slope, and exposure data, a schematic and generalized profile of the species distribution was built, and comparative graphs were built on average height, basal area, and volume.

8. Diversity index

The diversity indices of the populations

International Journal of Health Science ISSN 2764-0159 DOI 10.22533/at.ed.1593332302058

Fig. 4. Sampling units and dasometric data.

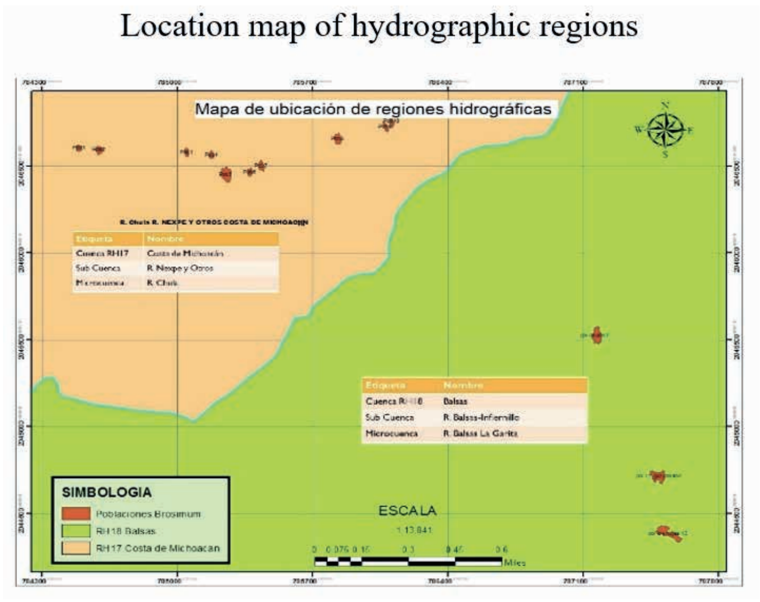


Fig. 5. Hydrological location of the study area.

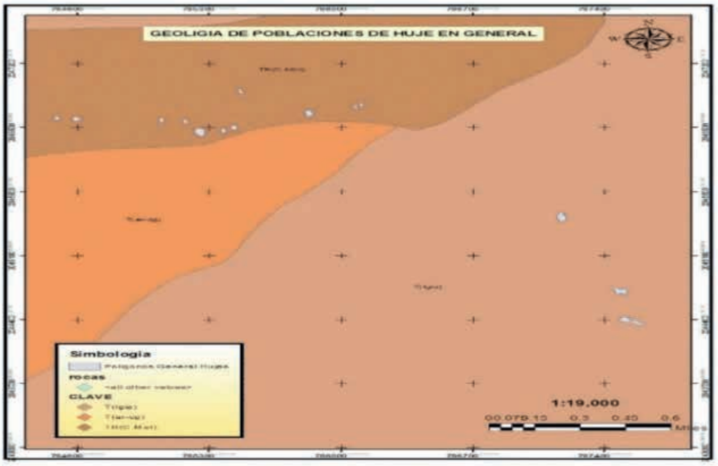


Fig. 6. Geology in the study area.

indicate how rich in species the systems are, as well as how common or rare a certain species can be, for which the Margalef methodology was applied.

$$DMG = \frac{S-1}{Ln(N)}$$

RESULTS AND DISCUSSION

1. Variables of the physical environment and Geographic Information System hydrological location

The hydrology formed by permanent runoffs from the Piedras de Amolar Ravine and Los Cajones Ravine, with good quality water and temporary runoffs, which form the Pisada de la vaca micro-basin, 10 populations of Brosimum are located; and in the Balsas la Garita river micro-basin, there is a permanent runoff, which is exhausted in the dry season, leaving water where the populations of Brosimum are located are three, Fig. 5.

geology

The chronostratigraphy of the Sierra and the Hujes Guayabillas is located in the Region of the Intrusive Igneous Rocks of Granite and Granodiorite T (Gr-Gd), they belong to the Cenozóic and the Tertiary Period, as well as areas of Metamorphic Rocks, Complex Metamorphic Rocks TR (C. Met.), from the Mesozoic and the Triassic Period INEGI (1985), Fig. 6.

floors

In the populations located in the Sierra, there are three soil units: Ortic Acrisol, Chromic Luvisol and Eutric Regosol; and in the Hujes Guayabillas micro-basin, the Lithosol and Regosol eutric units are shown, Fig. 7.

Climate

The comparison of data from the year 1958 to 1998 and from 2007 to 2015 of climatic averages had the following results.

The Sierra, the Hujes and Guayabillas, are included in two GroupsClimate:A(C) Semi-warm subgroup, whose climatic formula is A(C) w1 (w). Belonging to the Semi-warm Sub-humid Type with rains in summer, and % of winter rain less than 5, and intermediate in terms of humidity.

Subgroup of warm climates A, with climatic formula A w1(w), of the Warm Subhumid Type with summer rains and % of winter rain less than 5, and intermediate in terms of humidity, Fig. 8.

2. Climate sheet and associated parameters

The average annual temperature regime is 22.34 ºC, the maximum of 25.48 ºC registered in August and the minimum of 19.60 °C, the coldest month is January; and thermal oscillation of 5.88 ºC.

The average annual precipitation is 910.58 mm; the rainy season is in summer from June to October and the rainiest month is September with 219.24 mm; the dry period is 7 months, with a % dryness of 58.33 and the driest month is April with 2.3 mm; the frequency of hailstorms is imperceptible.

Evapotranspiration, an annual average of 1029.72 mm is recorded, so there is a water deficit of 119.15 mm per year, which indicates that in the dry season, the vegetation suffers from stress due to the temperatures that are recorded and the lack of humidity, Table 1.

Hydric balance

The water balance is determined by the relationship between the average annual rainfall and the Annual Mass Curve, where and despite giving a 20% safety margin due to uncontrolled external factors, there is an annual volume of water that is loses 319, 489 m^3 Table 2, in the microregion of Pisada de la

Fig. 7. Soil units and their development.

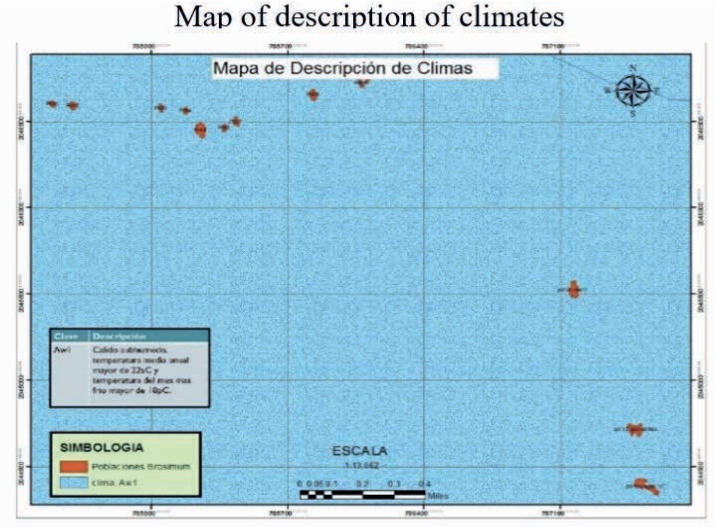


Fig. 8. Description of the climatic groups.

Tabla 1. HOJA CLIMÁTICA Y PARÁMETROS ASOCIADOS EN POBLACIONES DE *Brosimum alicastrum* Sw

Lugar :	**Arteaga**	**Región:**	Coord.:	LATITUD :	18° 21' 19"	CLIMA :	Awoi
Sitio :	**Arteaga**	**Balsas la Garita**		LONGITUD :	102° 17' 27"	Suelo :	
Altit.:	940 msnm		Veget:	Selva Media subcaducifolia y baja caducifolia			Acrisol órtico regosol, litosol
Años :	50		Geol.:	T (GR-GD); K (A)			
			Ts (ar-cg)			Uso :	Forestal y pecuario
Mes	Precip.mm		Temp. C		Evapot.mm		
	anual		med. An.		med. An.		
Ene.	25.08		20.22		65.26		
Febr.	16.06		20.36		66.41		
Mar.	10.67		21.06		72.47		
Abr.	2.30		22.38		84.89		
May.	33.00		23.75		99.03		
Jun.	133.39		23.59		97.27		
Jul.	157.06		23.46		95.93		
Ag.	180.27		25.48		118.82		
Sept.	219.24		22.81		89.20		
Oct.	106.63		23.74		98.97		
Nov.	20.53		22.01		81.30		
Dic.	6.36		19.60		60.17		
ANUAL :	**910.58**	T.med=	**22.37**	ET.an=	**1029.72**		
P.max.med	219.24	T.max=	25.48	D.H.=	**-119.15**		
P.min.med	2.30	T.min=	19.60				
P.inv.%:	6.39	Osc.T=	5.88				
#Mes.sec.:	7.00						
%Int.sec.:	58.33						
EROSIVIDAD	DE LLUVIA	HORAS FRÍO					
ANUAL =	150.40	TOTAL=	-403.680242	(números negativos			
Febr/Mayo=	1.61	Nov. =	-142.628595	sin significado)			
Jun/Sept =	135.11	Dic. =	-73.8591794				
Oct/En =	13.69	En. =	-91.6510367				
		Febr.=	-95.5414308				
RIESGO DE EROSIÓN							
RIESGO/AN=	42.11	Ton/Ha/a					
Suelo =	Litosol/Acrisol/Regosol						
EROSIV.AN=	150.40						
Erodabil.=	0.50						
Textura =	1.00						
Pendiente=	0.35						
Cobertura=	1.60						

	Parte anexa para el calculo de evapotranspiracion				
	por el metodo de Thomthwaite				
	Ind. de calor		ET= 1.6*(t*10/I)^a		ET= (et*0.97)*10
	(t/5)^1.514		et sin corr.		et corregida
En. ic=	8.29	et s/c=	6.73		65.26
Febr. ic=	8.38	et s/c=	6.85		66.41
Mar. ic=	8.82		7.47		72.47
Abr. ic =	9.67		8.75		84.89
Mayo ic =	10.58		10.21		99.03
Jun. ic=	10.47		10.03		97.27
Jul. ic =	10.39		9.89		95.93
Ag. ic=	11.77		12.25		118.82
Sept. ic=	9.95		9.20		89.20
Oct. ic=	10.58		10.20		98.97
Nov. ic =	9.43		8.38		81.30
Dic. ic =	7.91		6.20		60.17
IC anual =	116.24	ET s/c=	106.16	ET cor=	1029.72
Coef."a"=	2.59				
	TABLA PARA AJUSTE DE VALORES				
	EN TIEMPOS DE CONCENTRACION DE CUENCAS				
	HIDROGRAFICAS				
				COBERTURA	FACTOR
				80%	2.0
	TC = 0.02 (L 1.12)			65%	1.0
		H 0.38		50%	0.8
				40%	0.7
				25%	0.5
				10%	0.2

vaca, being an important volume that can be captured and used through soil conservation works, or other types of collection infrastructure that help regeneration in the critical months of water scarcity.

Annual Mass Curve

The Mass Curve clearly reflects the relationship between the average annual precipitation indicated in brown and evapotranspiration in blue and therefore the water deficit, Table 3, Fig. 9.

3. Dispersal of Brosimum populations

The altitudinal range of dispersion of the species in the Pisada de la Vaca microregion is from 1040 to 1160 masl, while in the Balsas la Garita microregion it is from 920 to 1040, with an elevation difference of 160 m in each microwatershed. such dispersion is shown in the elevation model, Fig. 10.

4. Concentration of dasometric results of populations of Brosimum alicastrum

4.1. mmicroregion Footprint of the cow

In this microregion there are 10 populations of Brosimum scattered in ravines in small patches with an average surface area of 2000 m^2, they are very old populations inaverage 64 years, the state of health is 89 % and vigor 81%, in advanced ages the characteristic of rotting of the stems at the base prevails, with damages of 20%: the average diameter is 40 cm, the population with the largest diameter is the 4 of 52.8 cm, the thinnest diameters are in the 8 of 31.7 cm, for which reason it is attributed to be the youngest; the average height is 22.4 m, thethe highest is the 4 of 30.3 m, the lowest is the 5 of 15.4 m; the average volume is 7,680 m^3, the population that concentrates the greatest volume is 4 of 38,345 m^3, the one with the lowest volume is 3 of 1,127 m^3; and the average number of trees is 4, the population with the highest number is 5 of 12 and the least amount occurs in populations 2, 3, 6, 7, and 9, Figs.11 to 14.

4.2. River micro-basin

In this microregion there are 3 populations of Brosimum, scattered in the ravine that are born in Guayabillas and extend to the hujes, forming small patches with an average surface area of 4000 m^2; very old populations of 107 years, the state of health of 82 % and vigor 80%, in advanced ages the characteristic of rotting of the stems prevails at the base with damages of 25 %; the average diameter of 45.9 cm, the population with the largest diameter is 13 of 51.9 cm, the one with the thinnest diameters is 12 of 41.7 cm, therefore, the three populations are old, with an average height of 20.9 m; the average volume is 39,951 m^3, the population with the highest volume is 11 with 55,072 m^3, the one with the lowest volume is 12 with 19,689 m^3; and the average number of trees is 17, the population with the greatest number is 11 with 20 and the least quantity is 12 with 12, Figs. 15 to 18.

5. Importance Value Index

The micro-regions present contrasts in their components and values, the Pisada de la vaca has lower values than the Balsas la Garita region, apparently the latter is better, however, they are older populations and severe impacts on the trees, Table 4.

6. Diversity index

The diversity indices of the populations indicate how rich in species the systems are, as well as how common or rare a certain species can be. Tables 5 and 6 show that they are practically the same in the two micro-watersheds.

CONCLUSIONS

1. The trees of populations 11, 12 and 13 are very old, their ages are estimated to

				ha	km²											
to =	MICRO-BASIN AREA =			475	= 4.75		arteaga	Awoi								
C =	RUNOFF COEFFICIENT =			0.36												
to =	PERCENT UTILIZATION =			0.50												
CONCEPT	FOUNTAIN	UNIT	Jan	Feb	Sea	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL	
PPTAC.MSG	CFE	mm	25.08	16.06	10.67	2.30	33.00	133.39	157.06	180.27	219.24	106.63	20.53	6.36	910.58	mm
ETP. MENS	Thornwaite	mm	65.26	66.41	72.47	84.89	99.03	97.27	95.93	118.82	89.20	98.97	81.30	60.17	1,029.72	mm
INFILT.8%	research	mm	2.01	1.29	0.85	0.18	2.6396	10.6715	12,565	14,422	17,539	8.53	1.64	0.5085	72.85	mm
Ptc. Eff.	subtract.	mm	-42.19	-51.63	-62.65	-82.77	-68.67	25.45	48.56	47.03	112.50	-0.87	-62.42	-54.32	-191.99	mm
PtcEf x EC	Boards	mm	-15.19	-18.59	-22.56	-29.80	-24.72	9.16	17.48	16.93	40.50	-0.31	-22.47	-19.56	-69.12	mm
VOL PPTAC.		mm3	-72.14	-88.29	-107.14	-141.54	-117.43	43.52	83.04	80.43	192.37	-1.48	-106.73	-92.89	-328.30	mm3
MA CURVE		mm3	-36.07	-44.15	-53.57	-70.77	-58.72	21.76	41.52	40.21	96.19	-0.74	-53.37	-46.45	-164.15	mm3
(vol.pp X apr)	appr %)															
Safety margin		80%												-5,173.11		
														-2,327.90		

Table 2. Determination of the general balance and the mass curve of contributions of the Pv. Cow footprint.

Jan	Feb	Sea	opened	May	Jun	Jul	Aug	sept	Oct	Nov	Dec	TOTAL	
-72.14	-88.29	-107.14	-141.54	-117.43	43.52	83.04	80.43	192.37	-1.48	-106.73	-9289		mm3
-36.07	-44.15	-53.57	-70.77	-58.72	21.76	41.52	40.21	96.19	-0.74	-53.37	-46.45		mm3
					43.52								
					83.04								
					80.43								
					192.37								
				ANNUAL MASS	399.36	Mm3 = Thousands of cubic meters							
				ANNUAL MASS	399,362	m3 = cubic meters							
				SAFETY MARGIN	319,489	m3 = cubic meters							

Table 3. Progressive water balance.

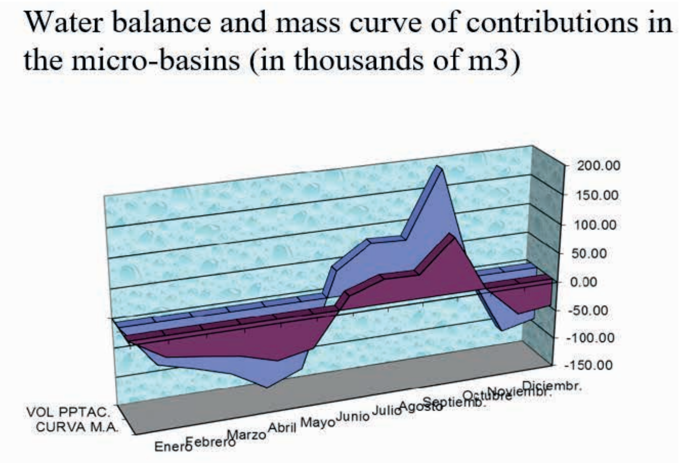


Fig. 9. Graphical representation of the water balance.

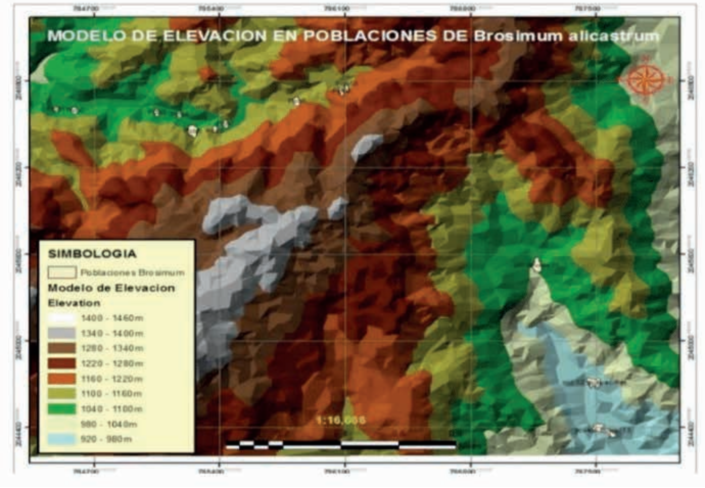
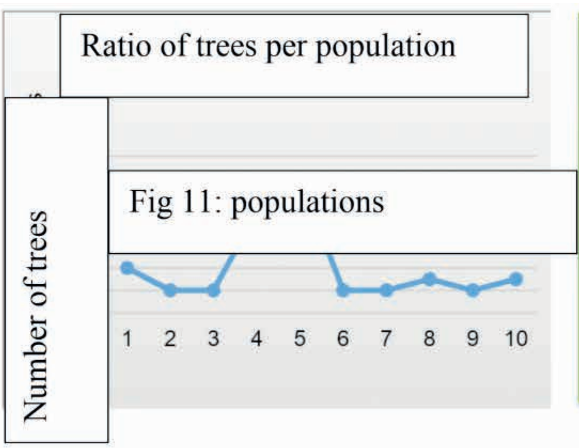
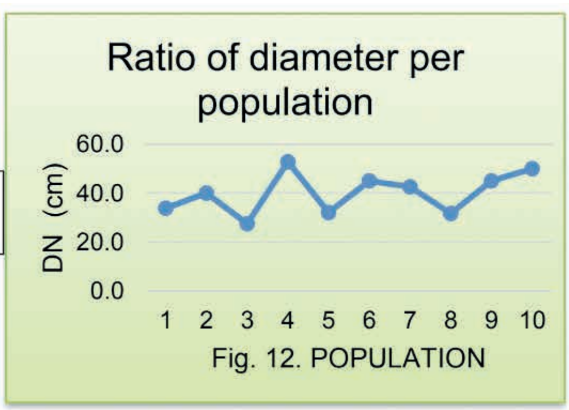
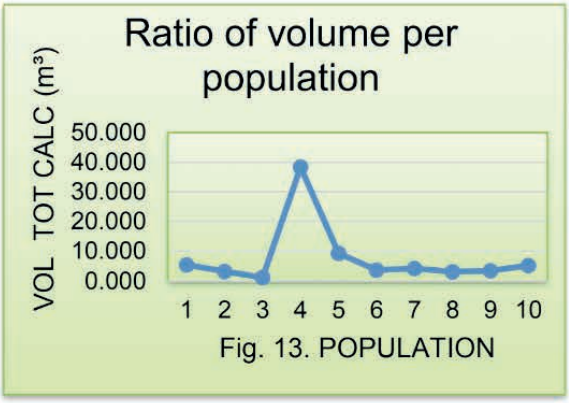


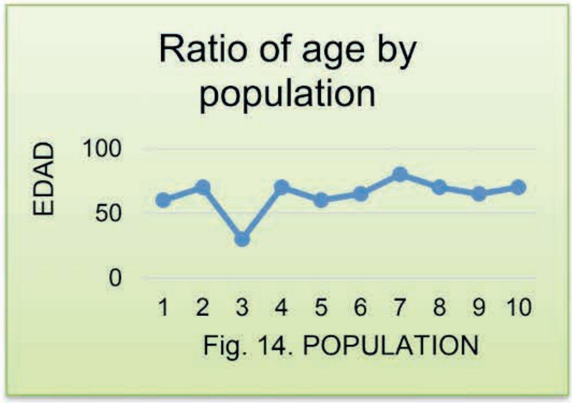
Fig. 10. Description of the climatic groups.

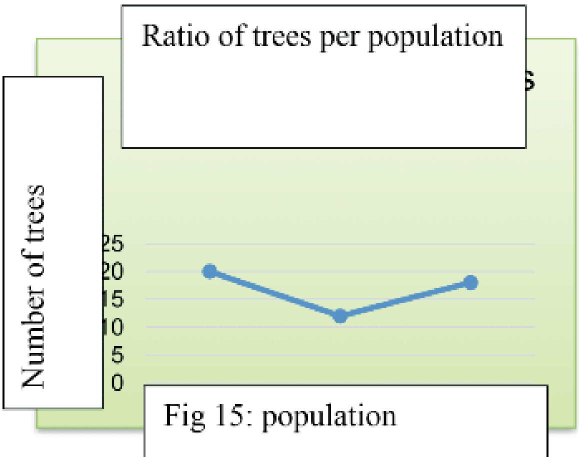


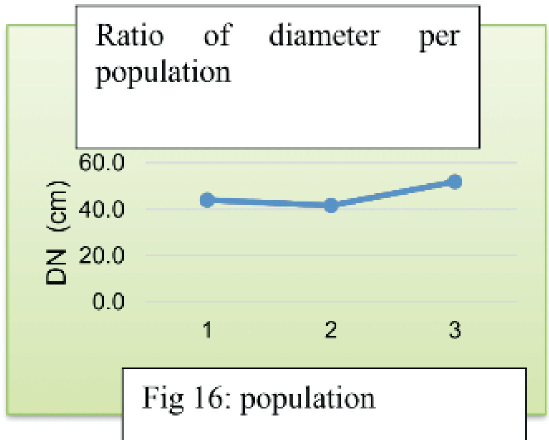


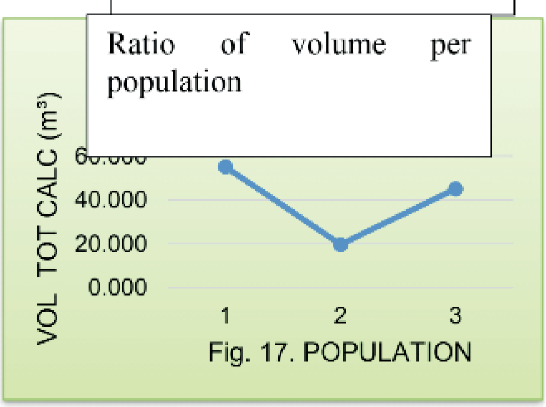
International Journal of Health Science ISSN 2764-0159
DOI 10.22533/at.ed.1593332302058

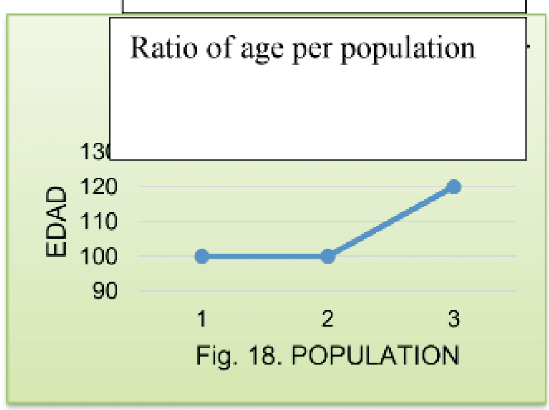












4.1. MICRO-BASIN FOOTPRINT OF THE COW				
Population	**Relative density**	**Frequency**	**Dominance**	**Value and Importance Index**
1 to 10	**0.34**	**38.6**	**5.97**	**44.9%**
4.2. LA GARITA RAFTS RIVER MICRO-BASIN				
Population	**Relative density**	**Frequency**	**Dominance**	**Value and Importance Index**
11 to 13	**1.30**	**71.35**	**3.23**	**%**

Table 4. Importance value indices by micro-region.

POP.	IND. dmg
1	1.67
2	0.40
3	2.34
4	2.59
5	3.68
6	2.14
7	2.45
8	1.24
9	1.73
10	2.12
Total	**2.03**

Table 5. Margalef index in Pisada de la vaca micro-watershed.

POP.	IND. dmg
eleven	2.60
12	3.93
13	1.13
Total	**2.55**

Table 6. Margalef index in the R. Balsas-la Garita micro-watershed.

be between 60 and 130 years, many are hollow at a height of 2 to 4 m, product of debarking for curative purposes that they suffered at an early age, they have rotted and are exposed to being blown over by the wind.

2. The reproductive strategy followed by the species is not working, since in general, all the populations have a lack of natural regeneration, three of the populations of the Pisada de la vaca micro-basin in 2013 had shoots from that season, however, in 2018 the monitoring was carried out and very few individuals of that cohort were found.

3. The populations present surfaces no greater than half a ha, with low tree densities and continuous death due to old age and rotting of the base of the trees.

4. Because it is a palatable species, cattle, horses, wild boars, deer, birds and many other species consume the fruits and browse, including shoots, leaving the soil without seeds for natural regeneration, including humans; in addition to other factors such as lack of sunlight at ground level, humidity, soils, density and dominance of individuals, slopes of the terrain, and natural or man-made disturbances.

5. Areas must be protected with perimeter fences to prevent grazing and the entry of wildlife, for at least 5 to 10 years, to give time for the shoots to grow, otherwise Brosimum populations will gradually disappear.

International Journal of Health Science ISSN 2764-0159 DOI 10.22533/at.ed.1593332302058

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