STRUCTURE AND DIVERSITY OF A SUBMONTANE SCRUB COMMUNITY IN TAMAULIPAS, MEXICO

Arturo Mora-Olivo, Eduardo Alanís-Rodríguez, Jonathan J. Marroquín-Castillo, Tania I. Sarmiento-Muñoz, José Guadalupe Martínez-Ávalos, Fortunato Garza-Ocañas and Jorge Ariel Torres-Castillo

SUMMARY

*A submontane scrub vegetation from the State of Tamaulipas, Mexico, is described based on the analysis of richness, diversity and structure. Results indicate that this scrub is diverse (29 species) when compared to other similar plant communities in Northeastern Mexico and an ecotone was observed with low deciduous forests. Most species are widespread and two recorded species (*Neopringlea integrifolia *and* Iresine orientalis*) are endemic to the Sierra Madre Oriental. Although the site is close to a natural protected area, there are signs of anthropogenic pressure threatening the conservation of this submontane scrub.*

Introduction

Thornscrubs are a common vegetation type forming communities that are widely distributed in arid and semiarid zones in the North of Mexico (Rzedowski, 1978) and, they have been severely damaged by different anthropogenic activities such as land use changes (Arriaga, 2009). For this reason, floristic and ecological studies of thornscrubs are required in order to implement future management and conservation policies.

Several studies have been reported regarding thornscrubs from Northeastern Mexico. For example, in the State of Coahuila the submontane scrubs from Sierra de Zapalinamé were described (Gómez *et al*., 2011), and in the State of Nuevo León the Tamaulipan thornscrubs (Reid *et al*., 1990; Alanís *et al*., 2013), desertscrub rosetophilous (Alanís-Rodríguez *et al*., 2015a), desertscrub microphyll (Mora-Donjuán *et al*., 2014) and submontane scrub (Canizales-Vázquez *et al*., 2009; Estrada- Castillón *et al*., 2012; Alanís-Rodríguez *et al*., 2015b) have been studied. So far, no specific research on scrubs in the State of Tamaulipas has been carried out. Among some of the studies regarding some general aspects of scrub vegetation from the State of Tamaulipas are those by González-Medrano (1972) from the Northwest, and those by Martínez-Ojeda and González-Medrano (1977) on the Southeast part of this state.

Scrubs are distributed in the North and Central part of the State of Tamaulipas (Sánchez-Colón *et al*., 2009) and are usually located in plain surfaces although they also occur at the lower part of the Sierra Madre Oriental, where they are known as submontane scrubs (Villegas-Durán *et al*., 2000). This vegetation type is one of the most common ones on the slopes of the Sierra Madre Oriental adjacent to the state capital, Ciudad Victoria (Villegas-Durán *et al*., 2000). Although this portion of the Sierra is within the boundaries of the protected natural area known as 'Altas Cumbres', urban sprawls has a negative influence on growth of the nearest plant communities including scrubs and place them in a risk status (Anonymous, 1997).

Considering the lack of information about this vegetation type, it is important to study the quantitative ecology of scrubs in this region of Mexico. Therefore, the main objective of this study was to evaluate the structure and floristic diversity of a submontane scrub in the western part of Ciudad Victoria, Tamaulipas, Mexico.

Materials and Methods

Study area

The study was carried out in a submontane scrub in Northeastern Mexico, in the municipality of Ciudad Victoria, Tamaulipas, Mexico, located at 23º44'11.14''N and 99º10'57.82''W, at an altitude of 390masl. (Figure 1).

Field evaluation

Trees, shrubs and herbs from the study area, were sampled in September 2015. Four sampling sites 10×10m were established and all trees, shrubs and herbs including succulents were sampled. In each sampling site structural parameters: total height (h) and basal diameter (d0.10) plants were taken.

KEYWORDS / Ecotone / Northeast Mexico / Scrub / Sierra Madre Oriental /

Recibido: 11/07/2016. Modificado: 05/10/2016. Aceptado: 10/10/2016.

Arturo Mora-Olivo. Doctor in Biological Sciences, Universidad Nacional Autónoma de México. Professor-researcher, Universidad Autónoma de Tamaulipas (UAT), Mexico. Address: Instituto de Ecología Aplicada, UAT. División del Golfo 356, 87019 Ciudad Victoria, Tamaulipas, Mexico. e-mail: amorao@uat.edu.mx

Eduardo Alanís-Rodríguez. Forest Engineer, M.Sc. in Forest Sciences and Doctor in Natural Resorces Management, Universidad Autónoma de Nuevo León (UANL), Mexico. Professor-researcher, UANL, Mexico.

Jonathan Jesús Marroquín-Castillo. Forest Engineer, M.Sc. in Forest Sciences and doctoral student in Natural Resorces Management, UANL, Mexico.

Tania Isela Sarmiento-Muñoz. Forest Engineer, UANL, Mexico. Environmental services provider.

José Guadalupe Martínez-Ávalos. Doctor in Forest Sciences, UANL, Mexico. Professor-researcher, UAT, Mexico.

Fortunato Garza-Ocañas. Doctor of Sciences, Oxford University, UK. Professor-researcher, UANL, Mexico.

Jorge Ariel Torres-Castillo. Doctor in Plant Biotechnology, Centro de Investigación y de Estudios Avanzados, Instituto Politécnico Nacional, Mexico. Professor-researcher, UAT, Mexico.

ESTRUCTURA Y DIVERSIDAD DE UNA COMUNIDAD DE MATORRAL SUBMONTANO EN TAMAULIPAS, MÉXICO

Arturo Mora-Olivo, Eduardo Alanís-Rodríguez, Jonathan J. Marroquín-Castillo, Tania I. Sarmiento-Muñoz, José Guadalupe Martínez-Ávalos, Fortunato Garza-Ocañas y Jorge Ariel Torres-Castillo

RESUMEN

Se describe un matorral submontano en el estado de Tamaulipas, México, con base en el análisis de la riqueza, la diversidad y la estructura. Los resultados indican que este matorral es diverso (29 especies) comparado con otras comunidades vegetales similares en el noreste de México y se observa un ecotono con selva baja subcaducifolia. La mayor parte de los elementos son de amplia distribución aunque se registraron dos especies endémicas a la Sierra Madre Oriental (Neopringlea integrifolia e Iresine orientalis). *A pesar de que el sitio se encuentra cercano a un área natural protegida, existen indicios de presión antropogénica que ponen en riesgo la conservación de este matorral submontano.*

ESTRUTURA E DIVERSIDADE DE UMA COMUNIDADE DE MATAGAL SUBMONTANE EM TAMAULIPAS, MÉXICO

Arturo Mora-Olivo, Eduardo Alanís-Rodríguez, Jonathan J. Marroquín-Castillo, Tania I. Sarmiento-Muñoz, José Guadalupe Martínez-Ávalos, Fortunato Garza-Ocañas e Jorge Ariel Torres-Castillo

RESUMO

Descreve-se um matagal em formações submontanas no estado de Tamaulipas, México com base na análise de riqueza, diversidade e estrutura. Os resultados indicam que este matagal é diverso (29 espécies) se comparado com outras comunidades similares de plantas do nordeste do México e observa-se um ecótono com floresta semidecídual de terras baixas. A maior parte dos elementos são de ampla distribuição, embora tenham se detectado duas espécies endêmicas da "Sierra Madre Oriental" (Neopringlea integrifolia e Iresine orientalis). *Ainda que o local esteja próximo de uma área natural protegida, há sinais de pressão antropogênica que ameaçam a conservação desse matagal de formações submontanas.*

Figure 1. Location of the study area. The top left image shows Northeastern Mexico; top right side image shows the state of Tamaulipas and the municipality of Ciudad Victoria. The lower image shows the spatial distribution of sampling sites.

Fertile botanical samples (flower and fruits) were collected from all species and in every site and specimens were prepared using the techniques reported by Lot and Chiang (1986). Plant species were taxonomically determined at the laboratory using specialized literature from Veracruz (Gómez-Pompa, 1978-2005), Texas (Correll and Johnston, 1979) and Mexico (Pennington and Sarukhán, 1998).

Analysis of information

Alpha diversity was determined (Moreno, 2001) using the Margalef index (D_{Mg}), based on quantification of number of species present (i.e. specific richness) and the Shannon index (H'), based on the numeric structure of the community (i.e. the proportional distribution of the abundance for species). The corresponding equations are:

$$D_{Mg} = \frac{S\ 1}{1n(N)}$$

$$H = \sum_{i=1}^{S} p_i\ 1n(p_i)$$

$$p_i = n_i / N$$

where S: number of species present, N: total number of individuals and n_i: number of individuals of species i.

Species abundance was determined considering the number of individuals, their dominance by canopy cover and its frequency by their presence in the sampling sites. These results at the taxon level are referred as importance value index (IVI), which acquires percentage values in a 1-100 scale (Müeller-Dombois and Ellenberg, 1974). The following equation was used for estimating relative abundance (AR_i) for species:

$$AR_i = \left(A_i \Big/ \sum A_i \right) \times 100$$

$$i = 1 \ldots n$$

$$A_i = N_i / S$$

where A_i: absolute abundance, N_i: number of individuals per species i, and S: sampling surface in ha. The relative dominance (DR_i) was evaluated as

$$DR_i = \left(D_i \Big/ \sum D_i \right) \times 100$$

$$i = 1 \ldots n$$

$$Di = Abi / S$$

where D_i: absolute dominance and Ab_i: canopy area for the species i ($A = \pi/4 \times d^2$) (Romahn and Ramírez, 2006).

The relative frequency (FR_i) was obtained with the equation

$$FR_i = \left(F_i \Big/ \sum F_i \right) \times 100$$

$$i = 1 \ldots n$$

$$F_i = P_i / NS$$

where F_i: absolute frequency, P_i: number of sites where the species i is present, and NS: total number of sampling sites.

Finally, the IVI is defined as (Whittaker, 1972)

$$IVI = \frac{\sum_{n}^{i=1}\left(AR_i, DR_i, FR_i\right)}{3}$$

where AR_i: relative abundance of the species i with respect to the total abundance, DR_i: relative dominance of the species i with respect to the total dominance, and FR_i: relative frequency for the species i with respect to the total frequency.

Results

Richness

In the study area 29 vascular plants species from 27 genera and 17 families were recorded (Table I). Fabaceae is the family with more species, with five, followed by Euphorbiaceae and Malvaceae with three each, and Amaranthaceae, Cactaceae, Ulmaceae and Verbenaceae with two respectively. These families had in total 17 genera and 19 species i.e. 65.52% of the registered flora in the study area.

Structure

The structure was analyzed in a stratified manner (Table II). Results showed a total density of 2,925 ind/ha for the tree layer, 775 ind/ha for the shrub layer and 400 ind/ha for the herb layer. The Fabaceae, Euphorbiaceae and Ulmaceae families were the most important for the tree layers, with a 72.15% IVI; while Cactaceae, Euphorbiaceae and Amaranthaceae were the most important for the shrub layer, with a 65.36% IVI. For the herbaceous layer the most important families were Cactaceae, Talinaceae, and Acanthaceae, with 70.44% IVI. At the species level, regarding the importance value, *Croton niveus*, *Acanthocereus tetragonus* and *Opuntia engelmannii* were the most relevant at each layer.

Regarding relative dominance, the largest values for the tree layer occurred with *Croton niveus*, *Celtis pallida*, *Neopringlea integrifolia* and *Havardia pallens* (41.78, 17.69, 16.01 and 10.15% respectively). *Croton niveus* had the largest basal area ($8.99m^2 \cdot ha^{-1}$) and mean height (4.70m), which confirms its importance in the tree layer. Regarding the shrub and herbaceous layers, *Acanthocereus tetragonus* and *Opuntia engelmannii* had 84.57 and 97.24% relative dominance, respectively; these values were higher than those of all other species, revealing their physiognomic role in these layers.

The highest relative frequency values found in the three layer were for *Croton niveus*, *Celtis pallida*, *Ebenopsis ebano*, *Havardia pallens* and *Neopringlea integrifolia* with 12.12%. For the shrub layer, *Iresine orientalis* had the highest relative frequency with 14.81%, followed by *Acalypha phleoides*, *Mimosa malacophylla* and *Croton cortesianus*, with 11.11% each. Finally, at the herbaceous layer, *Rivina humilis* and *Siphonoglossa canbyi* are the species with the highest relative frequency (25.00%) while none of the other species exceeds 16.67%.

Diversity

The three layers had a Margalef index of 6.27 and the species diversity had a Shannon index of 2.81.

TABLE I
INVENTORY REGISTERED AT THE STUDY AREA

Family/Scientific name	Common name	Biologic form
Acanthaceae		
Siphonoglossa canbyi (Greenm.) Hilsenb.		Herb
Amaranthaceae		
Celosia nitida Vahl	Chía	Herb
Iresine orientalis G.L. Nesom		Shrub
Asteraceae		
Trixis inula Crantz		Herb
Boraginaceae		
Cordia boissieri DC.	Anacahuita	Tree
Cactaceae		
Acanthocereus tetragonus (L.) Hummelinck	Jacubo	Shrub
Opuntia engelmannii Engelm.	Nopal cuijo	Shrub
Euphorbiaceae		
Acalypha phleoides Cav.		Herb
Croton cortesianus Kunth	Palillo	Herb
Croton niveus Jacq.		Tree
Fabaceae		
Acacia farnesiana (L.) Willd.	Huizache	Tree
Ebenopsis ebano (Berland.) Barneby & J.W. Grimes	Ébano	Tree
Havardia pallens (Benth.) Britton & Rose	Tenaza	Tree/Shrub
Leucaena leucocephala (Lam.) de Wit	Guaje	Tree
Mimosa malacophylla A. Gray	Rascahuevos	Shrub
Malvaceae		
Abutilon trisulcatum (Jacq.) Urb.	Tronadora	Herb
Hibiscus phoeniceus Jacq.		Herb
Pseudabutilon umbellatum (L.) Fryxell		Herb
Phytolaccaceae		
Rivina humilis L.		Herb
Portulacaceae		
Talinum triangulare (Jacq.) Willd.	Verdolaga	Herb
Rubiaceae		
Randia obcordata S. Watson	Cruceto	Tree
Rutaceae		
Zanthoxylum fagara (L.) Sarg.	Uña de gato	Tree
Sapindaceae		
Neopringlea integrifolia (Hemsl.) S. Watson	Corvagallina	Tree
Solanaceae		
Capsicum annuum var. *glabriusculum* (Dunal) Heiser & Pickersgill	Chile piquín	Shrub
Ulmaceae		
Celtis pallida Torr.	Granjeno	Tree
Phyllostylon rhamnoides (J. Poiss.) Taub.	Cerón	Tree
Verbenaceae		
Lantana achyranthifolia Desf.		Herb
Citharexylum berlandieri B.L. Rob.	Revientacabras	Tree/Shrub
Violaceae		
Hybanthus mexicanus Ging.		Shrub

TABLE II
STRUCTURAL PARAMETERS OF THE SPECIES AT THE TREE LAYER*

Layer	Species	Abundance		Dominance (basal area)		Frequency		Mean	IVI
		N/ha	%	$m^2 \cdot ha^{-1}$	%	F_i	FR_i	height	
Tree layer	*Croton niveus*	625	21.37	8.99	41.78	100	12.12	4.70	25.09
	Celtis pallida	700	23.93	3.81	17.69	100	12.12	3.85	17.92
	Ebenopsis ebano	625	21.37	1.09	5.05	100	12.12	3.97	12.85
	Havardia pallens	375	12.82	2.18	10.15	100	12.12	4.07	11.70
	Neopringlea integrifolia	175	5.98	3.45	16.01	75	9.09	5.20	10.36
	Randia obcordata	100	3.42	1.23	5.73	100	12.12	5.17	7.09
	Phyllostylon rhamnoides	125	4.27	0.21	0.96	75	9.09	3.70	4.78
	Leucaena leucocephala	75	2.56	0.07	0.34	50	6.06	3.57	2.99
	Zanthoxylum fagara	50	1.71	0.13	0.62	50	6.06	3.65	2.80
	Acacia farnesiana	25	0.85	0.20	0.91	25	3.03	7.00	1.60
	Cordia boissieri	25	0.85	0.08	0.39	25	3.03	4.50	1.42
	Citharexyllum berlandieri	25	0.85	0.08	0.37	25	3.03	4.00	1.42
Tree layer summed up		2925	100	21.52	100	825	100	4.45	100
Shrub layer	*Iresine orientalis*	150	19.35	0.00	1.67	100	14.81	1.27	11.95
	Acanthocereus tetragonus	50	6.45	0.13	84.57	50	7.41	1.75	32.81
	Acalypha phleoides	100	12.90	0.00	0.31	75	11.11	1.55	8.11
	Mimosa malacophylla	75	9.68	0.00	0.94	75	11.11	1.23	7.24
	Croton cortesianus	75	9.68	0.00	0.68	75	11.11	1.25	7.16
	Citharexylum berlandieri	75	9.68	0.01	4.09	50	7.41	1.53	7.06
	Trixis inula	50	6.45	0.00	0.11	50	7.41	1.40	4.66
	Hybanthus mexicanus	25	3.23	0.01	5.03	25	3.70	1.60	3.99
	Havardia pallens	25	3.23	0.00	1.23	25	3.70	1.50	2.72
	Abutilon trisulcatum	25	3.23	0.00	0.45	25	3.70	1.80	2.46
	Pseudabutilon umbellatum	25	3.23	0.00	0.31	25	3.70	1.40	2.41
	Capsicum annuum var. *glabriusculum*	25	3.23	0.00	0.31	25	3.70	1.60	2.41
	Hibiscus phoeniceus	25	3.23	0.00	0.11	25	3.70	1.20	2.35
	Lantana achyranthifolia	25	3.23	0.00	0.11	25	3.70	1.40	2.35
	Celosia nitida	25	3.23	0.00	0.05	25	3.70	1.20	2.33
Shrub layer summed up		775	100	0.16	100	675	100	1.45	100
Herbaceous layer	*Opuntia engelmannii*	25	6.25	0.05	97.24	25	8.33	0.70	37.27
	Talinum triangulare	150	37.50	0.00	1.13	50	16.67	0.51	18.43
	Siphonoglossa canbyi	75	18.75	0.00	0.47	75	25.00	0.20	14.74
	Rivina humilis	75	18.75	0.00	0.12	75	25.00	0.57	14.62
	Croton cortesianus	50	12.50	0.00	0.08	50	16.67	0.50	9.75
	Iresine orientalis	25	6.25	0.00	0.97	25	8.33	0.90	5.19
Herbaceous layer summed up		400	100	0.05	100	300	100	0.56	100

* Abundance (number of individuals N) and area covered (m^2) per hectare. IVI: importance value index. Species are ordered in each layer form lower to high according to their importance value.

Discussion

Richness and structure

The studied submontane scrub consists mostly species that are widely distributed, though it includes endemic *Neopringlea integrifolia* (Calderón, 1996) and *Iresine orientalis* (Nesom 1982). This vegetation community has some typical species from the submontane scrub vegetation reported at the lower altitudes of the Sierra Madre Oriental, close to the city of Monterrey in the Northeastern Mexico (Estrada-Castillón *et al*., 2012; Alanís-Rodríguez *et al.,* 2015b). However, there is also transitional vegetation to low deciduous forests of neotropical distribution with species such as *Phyllostylon rhamnoides* and *Hybanthus mexicanus* (Ballard Jr, 1994; Pérez-Calix and Carranza-González, 1999). This is probably due to the proximity of canyons that include a tropical flora. It is important to mention that the study area has a similar physiognomy and species composition to the region known as Gómez Farías, Tamaulipas (located at ~80km from the present study area); Valiente-Banuet *et al* (1995) considered it as a low evergreen forest, where *Hybanthus mexicanus, Croton niveus, Randia obcordata, Rivina humilis, Phyllostylon rhamnoides* and *Zanthoxylum fagara* were the dominant species at the low, medium and high layers.

The Margalef (D_{Mg}= 6.27) and Shannon (H'= 2.81) indexes obtained indicate that this is a highly diverse community, similar to others from Northeastern Mexico. Alanís Rodríguez *et al.* (2015) evaluated a submontane thornscrub close to the city of Monterrey and recorded D_{Mg} = 6.02 and H'= 3.02. The values are also similar to those reported by Canizales Vázquez *et al.* (2009) in a submontane scrub in the Sierra Madre Oriental, where they reported D_{Mg}= 6.34 and H'= 3.00. Our results also showed similarities with some forest communities located at the south of the state of Tamaulipas and North of San Luis Potosi (Valiente-Banuet *et al.,* 1995), but are lower than those reported by Godínez-Ibarra and López-Mata (2002) and Zamora *et al.* (2008) from the subperennial and subdeciduous tropical forests located at the States of Veracruz and Yucatan, respectively.

Apparently, the floristic diversity from this region is the result of physiographic and climatic conditions and these factors may explain, in part, a transitional zone found between these vegetation communities. Martin (1958) and Treviño-Carreón *et al.* (2012) also reported this condition at a zone of intermountain transitional communities occurring between the mountain systems and the desert vegetation in the state of Tamaulipas.

The richness value reported of 29 species is similar to that reported by Alanís-Rodríguez *et al.* (2015b) in a vegetation community close to the city of Monterrey; their results are lower than those reported by Canizales-Velázquez *et al.* (2009) and Estrada-Castillón *et al.* (2012), who evaluated mature communities of submontane scrubs in Northeastern Mexico. Fabaceae was the most representative family at the tree layer, as also reported by Canizales-Velázquez *et al.* (2009) and Estrada-Castillón *et al.* (2012) from scrubs and similar to that reported by Zamora *et al.* (2008) for tropical forests areas.

Regarding the tree layer, Estrada-Castillón *et al.* (2012) reported that *Croton niveus*, *Celtis pallida*, *Neopringlea integrifolia* and *Havardia pallens* form low and medium scrubs, describing them as associations of non-thorny high shrubs. High dominance and frequency of *Croton niveus* has been reported to be a result of an aggregate distribution pattern (Valiente-Banuet *et al.,* 1995) which favors its establishment. Valiente-Banuet *et al.* (1995) reported this species in the low layer, although in this study it was found at the tree layer. In contrast, *Hybanthus mexicanus* occurring at the tree layer in this study differs from tropical forests ecosystems, where it occurs at the low layer.

It should be pointed out that flora from this scrub vegetation includes some disturbance indicating species such as: *Acacia farnesiana* (huizache) and *Leucaena leucocephala*, which were not dominant in the study area. In fact, it is known that cattle are introduced in the community from time to time and that people use wood for fuel.

Conclusions

The submontane scrub described has a high diversity of plant species. Also, there are some plant species that are related to an ecotone of tropical low forest from the submontane scrub. Most reported species have a wide distribution but it is interesting to highlight the presence of some species endemic to the Sierra Madre Oriental, such as *Neopringlea integrifolia* and *Iresine orientalis*. Despite the fact that the studied zone is located close to the limits of a protected natural area, some species may indicate a certain degree of damage caused by the rural and urban influence.

ACKNOWLEDGEMENTS

The authors acknowledge the support of Consultoría Servicios Técnicos para el Manejo de Recursos Naturales.

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