Colegio de Postgraduados

Identification of the Morphology of *Tamarix* spp. in the Mexicali Valley, Baja California, Mexico

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ABSTRACT

Objective: The predominant species of *Tamarix* spp. in the Mexicali Valley is unknown, and due to the scarce information available, this study aims to expand the knowledge of the morphology of *Tamarix* spp. in the Mexicali Valley, Baja California, Mexico.

Design/methodology/approach: For this research, five branches with inflorescences and roots of *Tamarix* spp. trees were collected from four selected locations in the Mexicali Valley. The collection was carried out during the flowering season from March to August, considering branches between 2.50 and 3.50 cm in height. The morphological descriptions were based on fresh plants using an Olympia optical microscope.

Results: After the morphological analysis was carried out at the different sampling sites, the predominant salt cedar genotype found in the Mexicali Valley corresponded to *Tamarix chinensis*. In addition, it was found high electrical conductivity measured in the upper soil layer (20 cm depth) was found to be caused by the excretion of salts through the glands of the leaves of this species. Consequently, salt cedar species can inhibit other vegetation types, although it can benefit honey bee production.

Findings/conclusions: *Tamarix chinensis* was the predominant salt cedar species throughout the sampling sites under the conditions of this study. The high electrical conductivity measured in the upper soil layer (20 cm depth) shows that salt cedar species can inhibit the growth of other vegetation types, although it can be beneficial for honey bee production.

Keywords: Varietal description, pollen, soil, salinity, pH.

INTRODUCTION

The Salt Cedar known as *Tamarix* spp. originates from Eurasia, specifically from southern Europe and some areas of Africa. It appears along the banks of arid and semi-arid regions in northern Mexico and the southern part of the American continent, such as Argentina and the western United States [1, 2] and Australia [3, 4]. During the years 1830 to 1920, eight species of the genus *Tamarix* were introduced into the United States,

such as *Tamarix ramosissima* and *Tamarix parviflora* [5], occupying around 650,000 ha in 23 states of the United States and becoming the most abundant genus in the riparian areas of the southwest, thus creating a significant factor of environmental alteration and economic impact [6, 7]. The two species with the broadestdistribution, from the northern plains of the United States to northern Mexico, are *Tamarix ramosissima* Ledebour and *Tamarix chinensis* Loureiro, which often hybridize among each other, and two other species, *Tamarix canariensis* Willdenow and *Tamarix gallica* Linneo [8], are found on the Gulf Coast of Mexico. A fifth species, *Tamarix parviflora* de Candolle, is more commonly found in the Pacific's coastal channels. In Argentina, Dimitri *et al.* [9] cite five species that have been cultivated, *Tamarix anglica*, *Tamarix gallica*, *Tamarix juniperina*, *Tamarix parviflora*, and *Tamarix pentandra*. Natale *et al.* [2], based on their plant taxonomy, they conclude that *Tamarix juniperina*, *Tamarix pentandra*, and *Tamarix anglica* are synonyms of *Tamarix chinensis* [10-11], as well as *T. ramosissima* and *T. gallica* [10, 12-13], respectively. These findings confirm the existence of four species in Argentina: *T. gallica*, *T. ramosissima*, *T. chinensis*, and *T. parviflora*.

The cedar or salt pine was primarily introduced for erosion control, as a physical windbreak, and as an ornamental in the 19th century [14]. It is considered an aggressive plant colonizer with adaptation to a various of environmental conditions, allowings it to displace all types of plants. However, it has caused severe ecological and economic damage to water resources and wildlife in western North America [15]. Salt pine can be controlled by chemical herbicides, mechanical removal, and burning [14], but these methods are costly and can cause significant damage to native plants and wildlife. Despite this, *Tamarix* spp., in arid-saline environments, is considered a plant with resistance to water stress and tolerance to salts [16].

While for some, the invasion of *Tamarix* is considered one of the worst ecological disasters in the riparian ecosystems of North America [5], other studies have found that it can be beneficial for other living organisms such as *Apis mellifera* [17] and the willow flycatcher (*Empidonax traillii*) [18]. For *Apis mellifera*, *Tamarix* spp. cannot be considered a toxic tree. The same authors [17] conducted a palynological characterization of honey bees in the Mexicali Valley and Ensenada, Baja California, showing that 65% of the honey was monofloral, mainly from *Tamarix* spp. and *Prosopis* spp., respectively. Similarly, Alaniz *et al.* [17] indicated that the main nectar resources used by *Apis mellifera* in the Mexicali Valley are *Tamarix* spp., *Prosopis*, and *P. strice*. The honey production in the Mexicali Valley contains 60% of the dominant pollen from *Tamarix* spp. [17]. The predominant species of *Tamarix* spp. in the Mexicali Valley is unknown. Due to the scarce information available, this study aims to expand the knowledge of the morphology of *Tamarix* spp. in the Mexicali Valley, Baja California, Mexico, identifying the plant morphology (root type, stem type, flower type, leaf type) and the main chemical characteristics of the soil where it develops.

MATERIALS AND METHODS

Description of the study area

The soil and plant sampling of *Tamarix* spp. was conducted at four strategically chosen sites in the Mexicali Valley during the flowering season from March to August 2017 in

Mexicali, Baja California. These sites were: 1. On the lands of a cooperating farmer at Kilometer 26 on the Mexicali-Algodones highway, 32° 37' 17.4" N, 115° 08' 28.1" W; 2. Agricultural Sciences Institute of Autonomous University of Baja California (ICA-UABC), 32° 14' 14.93" N, 115° 12' 6.67" W; 3. Ejido Nuevo León (Ej. Nuevo León), 32° 24' 25.09" N, 115° 11' 33.01" W; and 4. Ejido Delta (Ej. Delta), 32° 21' 28.83" N, 115° 11' 20.91" W, respectively. The combined georeferenced locations of these three areas are 32° 25' 10.9" N, 115° 11' 32.8" W.

The Mexicali Valley is characterized by a desertic climate, with summer temperatures peaking at 50 °C and winter temperatures dropping to as low as −7 °C. The average annual temperature is 22.3 °C, and the average annual precipitation is 58 mm. The region's flat topography, with an altitude ranging from −2 to 43 meters above sea level (masl), plays a significant role in the study [19].

Soil sampling

Soil sampling was carried out, obtaining 10 samples in each selected area to prepare a composite sample, aiming to collect salt cedar and soil roots during the flowering stage of approximately 20-year-old specimens. The samples were identified and transported to the Water and Soil Laboratory at the Institute of Agricultural Sciences, UABC. Additionally, during the soil and root collection, branches with leaves and inflorescences were collected and transferred to the Laboratory of Agricultural Sciences to verify, using taxonomic keys for plants, the specific specimen of salt cedar being analyzed [20].

Three subsamples were taken per tree (500 g of soil and roots) at depths of 20 cm, 40 cm, and 60 cm, respectively. Trees were selected based on their robustness (1.40±10 cm diameter measured at 1.50 m height), tree height (15.0±1.0 m), and color (intense opaque green) (Figure 1). The collected material was placed in dark plastic bags, labeled with corresponding collection data, and stored in a thermal container with ice, maintaining a temperature between 4±2 °C during transport to the laboratory. Soil electrical conductivity and pH analyses were conducted according to Aguilar *et al.* [21].

Morphological description of the plant

For each tree (10 in each area), five branches with inflorescences and roots of selected *Tamarix* spp. trees were obtained at each site. Collection took place during the flowering season from March to August, focusing on branches between 2.50 and 3.50 cm in height. Morphological descriptions were based on fresh plants, and an Olympus optical microscope was used. For the morphological description and comparison of the tree, descriptions from species outlined by Natale *et al.* [2] and Arianmanesh *et al.* [22] were referenced, along with the Technical Guide for varietal description of Jamaica [23], the latter aiming to include additional plant structures not described by other authors.

RESULTS AND DISCUSSION

The selected *Tamarix* plants aged over 5 years for flower sampling are shown in Figure 1.

Figure 1. *Tamarix* spp. plants.

Table 1 presents the results of electrical conductivity ranging from 110 to 20 dS m^{-1} and soil pH ranging from 7.16 to 8.2 for the sampling sites. Figures 2 and 3 graphically illustrate these findings showing higher electrical conductivity in the upper soil layer (20 cm depth), which correlates with increased salt concentration. These findings are crucial for understanding the impact of *Tamarix* spp. on soil salinity levels [24].

Previous studies have shown that *Tamarix* spp., through its root system, can extract water from great depths with high salt content due to survival needs and ultimately excrete it through special glands in its leaves [25-27]. This process explains the higher salinity values in the upper soil layer [28-30]. As for the soil pH, is characteristic of soils in arid zones to be slightly alkaline, which limits nutrient absorption [31], and electrical conductivity indicates soil salinity levels [26].

Table 2 presents the morphological description of the *Tamarix* spp. according to various authors [2, 10-13, 22], the plant is presented, which corresponds to *Tamarix chinensis*. Additionally, Alaniz *et al.* [17] conducted a study on the identification of pollen types in species in the Mexicali Valley. Of the 52 honey samples analyzed, 38% were monofloral from *Tamarix* spp. (salt cedar) (Figure 4), indicating that this species is significant for honey production.

Table 1. Soil characteristics of *Tamarix* spp. growth.

Sampling site	Soil depth (cm)	Electrical conductivity (dS/m)	pH
Instituto de Ciencias Agrícolas, UABC	20	110.80	7.16
	40	101.30	7.31
	60	97.30	7.52
Ejido Delta	20	82.20	7.42
	40	86.00	8.07
	60	69.5	7.52
Ejido Nuevo León	20	18.34	8.02
	40	21.29	7.76
	60	37.50	7.54
Km 26. Carr. Mexicali-Algodones	20	115.00	7.80
	40	109.00	8.00
	60	102.00	8.20

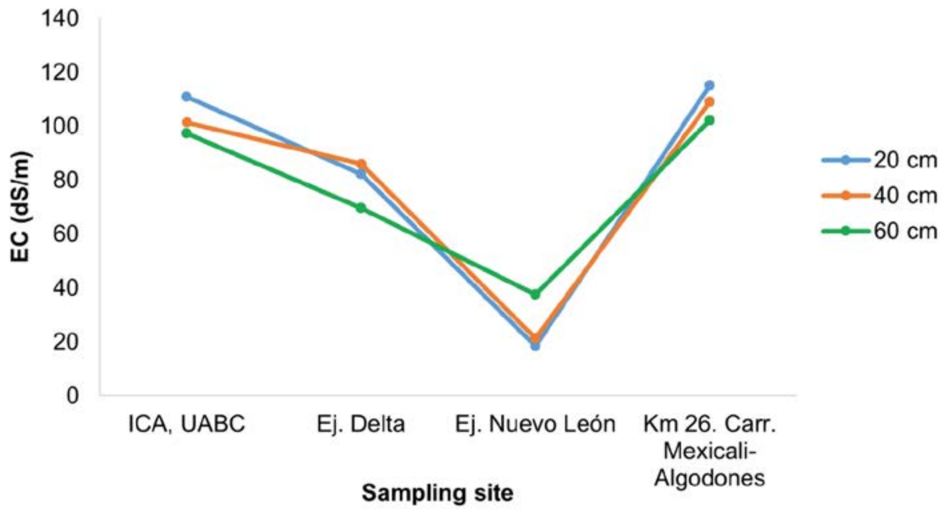


Figure 2. Variability of electrical conductivity at sampled soil depths.

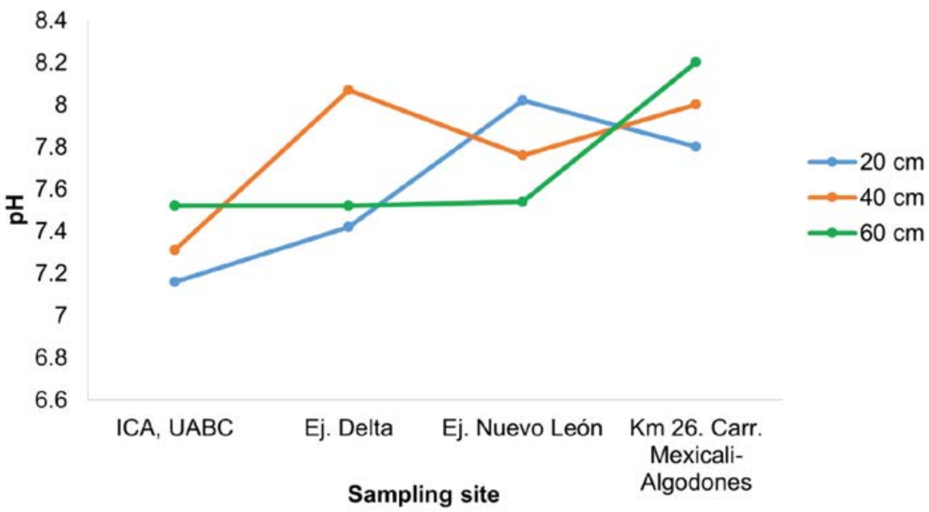


Figure 3. Variability of pH at sampled soil depths.

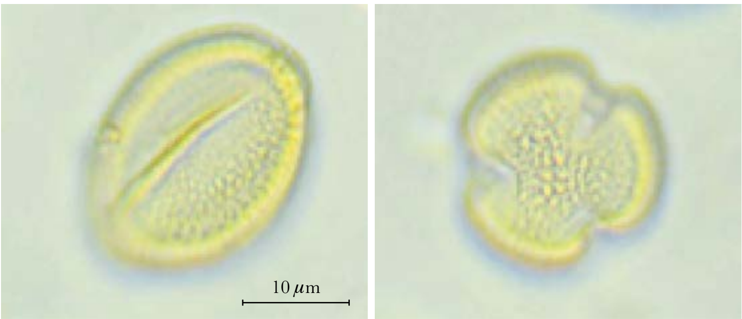
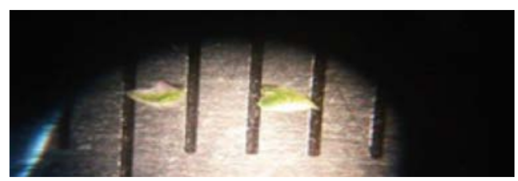


Figure 4. Pollen of *Tamarix* spp., selected by *Apis mellifera* in the Mexicali Valley, B.C., permission granted by the author: Luis Alaniz G. [17].

Table 2. Morphological description of the *Tamarix* plant.

Stem	Red-brown color	
Leaf	Pubescence on upper surface (absent or very weak), leaf shape and color (lanceolate, green), leaf margin (smooth).	
Root	Adventitious roots	
Inflorescences	1.5-6 cm	
		
Flower	They are sepals of 1 mm with smooth margins, green in color.	
	Ovate petals, 2 mm in size.	 
	Flowers pentamerous or with five stamens opposite the sepals, with filaments alternating with the lobes of the nectary disc, some or all, similar to what was reported by Natale *et al*. [2].	

CONCLUSIONS

The species of *Tamarix* collected at sampling points in the Mexicali Valley are similar to *Tamarix chinensis*. In some locations, this species is considered harmful due to its displacement of native species, as its water and soil requirements are not restrictive. However, it could also be considered beneficial for reforesting arid and saline soils due to its minimal soil and climate requirements. Its ability to extract salts from groundwater and deposit them in the surface soil layer can inhibit the germination of other vegetation types, as demonstrated by the results showing higher conductivity in the top 20 cm of soil. Conversely, in the Mexicali Valley, this species has brought benefits to sustainability in honey production due to the selectivity of its pollen by *Apis mellifera*.

Although Alaniz found benefits in honey production, with 38 % of honey derived from *Tamarix* spp. pollen, more detailed studies are needed to determine if the presence of this species has led to a reduction in native vegetation and, therefore, a loss of biodiversity.

REFERENCES

1. CONANP y FMCN. (2015). Protocolo para el control y erradicación del Pinabete (*Tamarix aphylla*). Secretaría de Medio Ambiente y Recursos Naturales. México.
2. Natale, E. S., Gaskin, J., Zalba, S. M., Ceballos, M., & Reinoso, H. E. (2008). Especies del género *Tamarix* (Tamaricaceae) invadiendo ambientes naturales y seminaturales en Argentina. *Sociedad Argentina de Botánica, 43*(1-2), 137-145. ISSN: 0373-580X
3. Natural Resources, Environment and The Arts, Northern Territory (NRETA). (2008). Athel Pine - National Best Practice Management Manual - Managing athel pine and other Tamarix weeds in Australia. National Athel Pine Management Committee, NRETA Weeds Publications
4. Wild Matters (2023). Best practice management for the control of athel pine (*Tamarix aphylla*); Addendum to the Weeds of National Significance national best practice guide for athel pine. A Weeds Australia publication, report to Centre for Invasive Species Solutions. ISBN: 978-1-922971-35-7.
5. DeLoach, C. J., Carruthers, R. I., Lovich, J. E., Dudley, T. L., Smith, S. D. (2000). Ecological interactions in the biological control of saltcedar (*Tamarix* spp.) in the United States: Toward a new understanding. Proceedings of the X International Symposium on Biological Control of Weeds 56. Montana State University.
6. Zavaleta, E. (2000). The Economic Value of Controlling an Invasive Shrub. *AMBIO: A Journal of the Human Environment, 29*(8), 462-467. https://doi.org/10.1579/0044-7447-29.8.462.
7. Colorado Department of Natural Resources. (2004). 10 year strategic plan on the comprehensive removal of tamarisk and the coordinated restoration of Colorado's native riparian ecosystems. Denver, Colorado.
8. Gaskin, J. F. & Schaal, B. A. (2002). Hybrid Tamarix widespread in U.S. invasion and undetected in native Asian range. *Proceedings of the National Academy of Sciences, 99*(17), 11256-11259. https://doi.org/10.1073/pnas.1324032.
9. Dimitri, M. J. (Ed.). (1988). Enciclopedia Argentina de Agricultura y Jardinería, Tomo 1, Editorial ACME, Buenos Aires, Argentina.
10. Baum, B. R. (1978). The genus *Tamarix*. The Israel Academy of Sciences and Humanities. Jerusalem, Israel.
11. Dubois, M., Van den Broeck, L., & Inzé, D. (2018). The Pivotal Role of Ethylene in Plant Growth. *Trends in Plant Science, 23*(4), 311-323. https://doi.org/10.1016/j.tplants.2018.01.003
12. Zhengyi, W. & Raven, P. H. (Eds.). (1994). Flora de China. Missouri Botanical Garden (St. Louis). http://flora.huh.harvard.edu/china/.
13. Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M. & Webb, D. A. (Eds.). (1968). Flora Europaea. Vol. 2: Rosaceae to Umbelliferae. Cambridge University Press, Cambridge, UK.
14. Ali, S. J. & Qaiser, M. (Eds.). (2001). Flora de Pakistan. Missouri Botanical Garden (St. Louis). https://www.mobot.org/MOBOT/Research/pakistan/welcome.shtml
15. Di Tomaso, J. M. (1998). Impact, Biology, and Ecology of Saltcedar (*Tamarix* spp.) in the Southwestern United States. *Weed Technology, 12*(2), 326-336. https://doi.org/10.1017/S0890037X00043906.
16. Morán, P. J., DeLoach, C. J., Dudley, T. L., & Sanabria, J. (2009). Open field host selection and behavior by tamarisk beetles (*Diorhabda* spp.) (Coleoptera: Chrysomelidae) in biological control of exotic saltcedars (*Tamarix* spp.) and risks to non-target athel (*T. aphylla*) and native *Frankenia* spp. *Biological Control, 50*(3), 243-261. https://doi.org/10.1016/j.biocontrol.2009.04.011.
17. Graf, W. L. (1982). Tamarisk and river-channel management. *Environmental Management*, 6, 283-296. https://doi.org/10.1007/BF01875060.
18. Alaniz, G. L., Ail, C. C. E., Villanueva, G. R., Delgadillo, R. J., Ortíz, A. M. E., García, M. E. & Medina, C. T. S. (2017). Caracterización palinológica de mieles del valle de Mexicali, Baja California, México. *Polibotánica, 43*(), 1-29. ISSN 1405-2768.
19. MacGregor-Fors, I., Ortega-Álvarez, R., Barrera-Guzmán, A., Sevillano, L., & del-Val, E. (2013). Tamarisk? Avian responses to the invasion of saltcedars (*Tamarix ramosissima*) in Sonora, México. *Revista Mexicana de Biodiversidad, 84*(4), 1284-1291. https://doi.org/10.7550/rmb.33904.
20. Meza, L. M., Quintero, M., García, R., & Ramírez, J. (2010). Estimación de Factores de Emisión de PM10 y PM2.5, en Vías Urbanas en Mexicali, Baja California, México. *Información Tecnológica, 21*(4), 45-56. http://dx.doi.org/10.4067/S0718-07642010000400007.

21. Felger, R. S. (2000). Flora of the Gran Desierto and Río Colorado of Northwestern Mexico. University of Arizona Press, Tucsón, Arizona.
22. Aguilar, S. A., Etchevers, B. J. D., & Castellanos, R. J. Z. (1987). Análisis químico para evaluar la fertilidad del suelo. Sociedad Mexicana de la Ciencia del Suelo. Chapingo, Estado de México. 217 p.
23. Arianmanesh, R., Mehregan, I., Assadi, M., & Nejadsattari, T. (2016). Comparative Morphology of the Genus *Tamarix* (Tamaricaceae) in Iran. *International Letters of Natural Sciences, 60*(), 1-12. https://doi.org/10.56431/p-6s8gxp
24. SAGARPA – SNICS. (2014). Guía técnica para la descripción varietal de Jamaica [*Hibiscus sabdariffa* (L.) Torr.]. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Servicio Nacional de Inspección y Certificación de Semillas. Tlalnepantla, Edo. de México.
25. Pathak, H. & Rao, D. L. N. (1998). Carbon and nitrogen mineralization from added organic matter in saline and alkali soils. *Soil Biology and Biochemistry, 30*(6), 695-702. https://doi.org/10.1016/S0038-0717(97)00208-3.
26. Waisel, Y. (1991). The glands of *Tamarix aphylla*: a system for salt recretion or for carbon concentration? *Physiologia Plantarum, 83*(3), 506-510. https://doi.org/10.1111/j.1399-3054.1991.tb00127.x
27. Imada, S., Acharya, K., & Yamanaka, N. (2012). Short-term and diurnal patterns of salt secretion by *Tamarix ramosissima* and their relationships with climatic factors. *Journal of Arid Environments*, 83, 62-68. https://doi.org/10.1016/j.jaridenv.2012.03.006.
28. Dawalibi, V., Monteverdi, M., Moscatello, S., Battistelli, A., & Valentini, R. (2015). Effect of salt and drought on growth, physiological and biochemical responses of two *Tamarix* species. *iForest - Biogeosciences and Forestry, 8*(6), 772-779. https://doi.org/10.3832/ifor1233-007
29. Barhoumi, Z., Djebali, W., Smaoui, A., Chaïbi, W., & Abdelly, C. (2007). Contribution of NaCl excretion to salt resistance of *Aeluropus littoralis* (Willd) Parl. *Journal of Plant Physiology, 164*(7), 842-850. doi:10.1016/j.jplph.2006.05.008.
30. Yuan, F., Leng, B., & Wang, B. (2016). Progress in Studying Salt Secretion from the Salt Glands in Recretohalophytes: How Do Plants Secrete Salt? *Frontiers in Plant Science*, 7:977. https://doi.org/10.3389/fpls.2016.00977
31. Wei, X., Yan, X., Yang, Z., Han, G., Wang, L., Yuan, F., & Wang, B. (2020). Salt glands of recretohalophyte Tamarix under salinity: Their evolution and adaptation. *Ecology and Evolution, 10*(17), 9384-9395. https://doi.org/10.1002/ece3.6625
32. Vásquez-Dean, J., Maza, F., Morel, I., Pulgar, R., & González, M. (2020). Microbial communities from arid environments on a global scale. A systematic review. *Biological Research, 53*(1). https://doi.org/10.1186/s40659-020-00296-1