Qualitative Characterization of Xylem Vessels of 23 Woody Trees and Shrubs in Northeastern Mexico: Its Significance

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Abstract

The present study was undertaken to determine the variability of secondary xylem vessel characteristics of 23 woody trees and shrubs at Linares, Northeast Mexico. The results revealed a large variability in secondary xylem vessel characteristics. Species are grouped on the basis of vessel lengths, breadth and inclination of end walls which are considered to be related to taxonomic delimitation, evolutionary trends and adaptation of the species to xeric environment.

Keywords: Adaptation, evolutionary trends, secondary xylem vessels, taxonomy, variability

1. Introduction

Trees and shrubs are predominant in a forest ecosystem and play a vital role in the supply of timbers, fuel woods and various forest products for mankind and forage for grazing animals in the forests (Reid et al., 1990). Wood is important in wood industry. The quality of wood and its utility is greatly influenced by its anatomical structure due to which a lot researches have been undertaken on wood anatomy in the area of dendrology. A large variability exists in wood anatomical traits which could help in taxonomic determination, quality and utility of a particular wood. Wood is composed of various components, such as xylem vessels, wood fibres, wood parenchyma, ray cells and inclusions such as tannins, crystals etc (Maiti et al., 2015). It is interpreted by Maiti and Rodriguez (2015) that the wood anatomy could predict the adaptive capacity to environments. On the other hand, xylem density is related to water stress (Jacobsen et al., 2007). Pattern of xylem structure contribute to evolutionary trend of water transport (Sperry, 2003; 2005). High density of lignified wood fibres and compact wood tissue could contribute hard and strong wood for the manufacture of strong furniture, where a large amount of parenchyma, and loose woo tissue could produce soft wood suitable for fabrication of soft furniture, paper pulp, fire woods etc.

Xylem vessels play an important role in the conduction of water and minerals absorbed by roots upwards to stems and other plant organs necessary for metabolic functions. These are described by the activity of secondary cambium in the stem. Xylem vessels with vessels pits on cell walls are cylindrical in shape with opening at both ends and of various sizes. These are minute in diameter and united end to end to form capillary tubes growing upwards in the stem in the upward transport of water and mineral elements. From evolutionary stand point the size and diameter of vessels represent evolutionary status. It is reported by many researchers (Bailey and Tupper, 1918; Carlquist, 1983; Baas et al., 1983; Baas et al., 2004) that woody plants with long and narrow vessel diameter are primitive. On the other hand, the species having a very short barrel shaped and broad vessel diameter is evolutionary advanced Vessel size determines evolutionary trend of the species (Bailey and Tupper, 1918). It is reported by few authors that species having narrow vessel diameter act against cavitations and occlusion under drought stress (Carlquist, 1983; Baas et al., 1983).

2. Materials and Methods

2.1. Study site

The study was undertaken in the municipality of Linares, Nuevo Leon in Forest Faculty of Universidad Autonoma de Nuevo Leon (24°47'N; 99°32'W), at an elevation of 350 m amsl. The type of climate is subtropical and semiarid condition with hot summer. The average monthly air temperatures oscillate between 14.7 °C in January to 23 °C in August, although the common temperature in summer is 45 °C. The average annual precipitation is approximately 805 mm with a bimodal distribution. This site is situated in soils which are dark brown deep vertisols. The predominant vegetation is Tamaulipan Thorn Scrub or subtropical thorn scrub (COTECOCA, 1973).

2.2. *Technique used*

Technique for maceration of wood for observation of wood fibre cells is described by Maiti et al. (2015). A small piece of wood of each species was dipped in concentrated nitric acid and plugged with cotton. Then the test tubes are kept in boiling water bath until the wood pieces started disintegration. Then, the macerated vessels cells were stained with safranin (1%) and observed under microscope and taken photographs with digital camera fixed with microscope. The woody trees and shrubs included in this study are mentioned in Table 1.

3. Results and Discussion

The morphological characteristics of secondary xylem vessels are depicted in the plates. It is observed that there exist large variations among 23 species in xylem vessels characteristics with respect to the length, breadth, inclination of the end wall opening and types and orientation of vessel pits on vessel walls. Few examples may be cited here. The species having long and narrow vessels with inclined end walls. Some species possess vessels, medium in length, medium in breath and slightly inclined end wall. On the other hand, some species possess very short, truncated and straight end walls. We observed that large variations are observed in pits on the vessel walls, round, elliptical or scalariform which are wide spaced, close, alternate or opposite in orientation. All these variations are reported by authors as indicators of evolutionary trends as well as capacity of transport of water. In view of the above the species are broadly classified as below.

I. Species having long and narrow xylem vessels, mostly with inclined end walls (opening).

1. Species having vessels, medium in length and breadth with less inclined end walls, narrow vessels.

Acacia rigidula, Bernardia myricifolia, Celtis pallida, Condalia hookeri, Croton suaveolens, Fraxinus greggii, Helietta parvifolia, Karwinskia humboldtiana, Lantana macropoda, Prosopis laevigata, Quercus virginiana, Zanthoxylum fagara

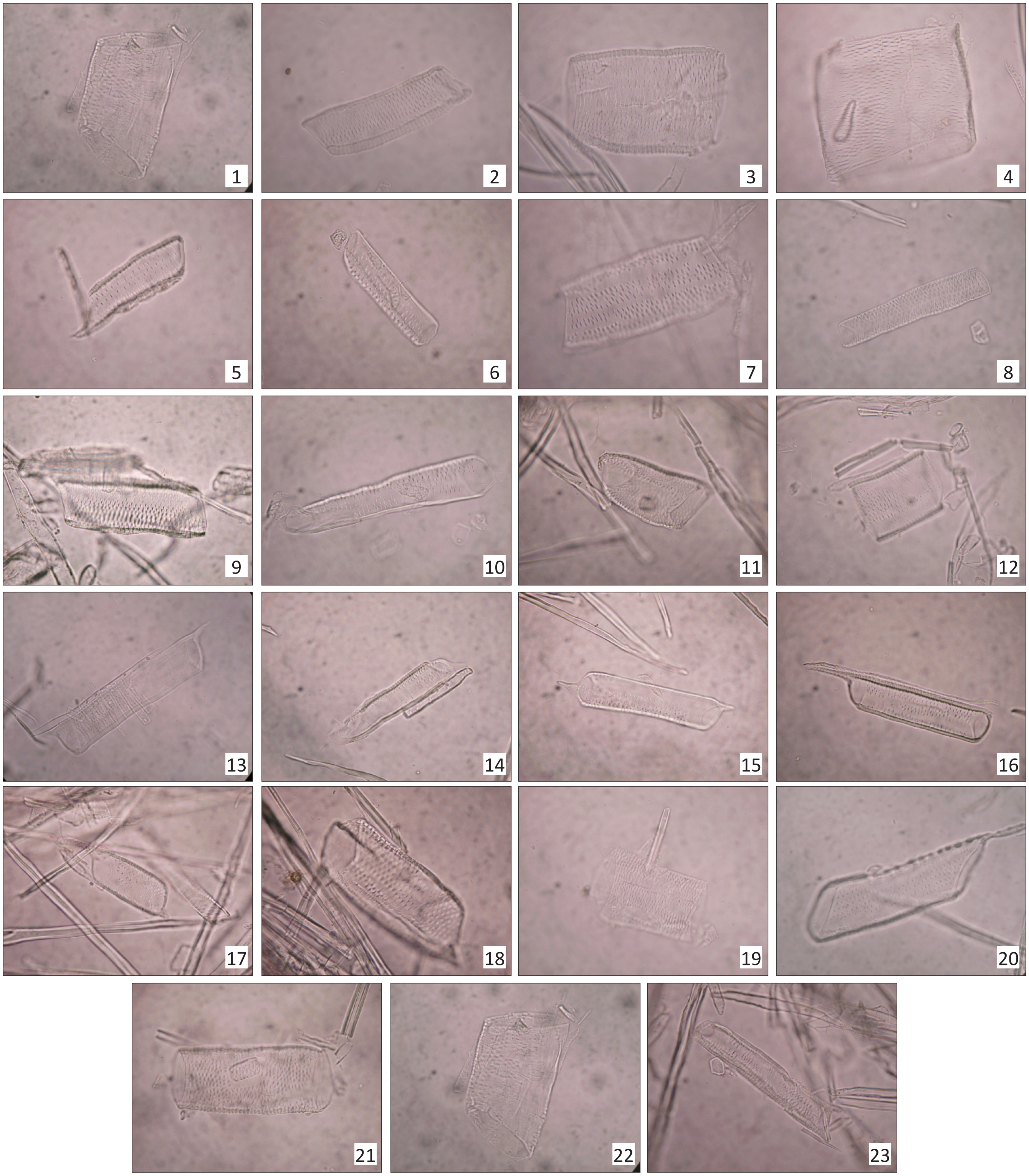
2. Species having xylem vessels, short, truncated, very broad and almost straight end walls.i

Acacia farnesiana, A. shaffneri, A. wrightii, Caesalpinia mexicana, Cordia boissieri, Ehretia anacua, Eysenhardtia poystachya, *Leucophyllum frutescens*, *Parkinsonia aculeata*, *Retama sphaerocarpa, Salix lasiolepis*

In the context of literature, the morphological characteristics of secondary xylem vessels may be related to evolutionary trends. Carlquist (1983), Bailey and Tupper (1918) reported that the species having long and narrow vessels with inclined end walls are primitive, while those with short and broad vessels and straight end walls are evolutionarily advanced. In this respect the species having vessels, medium in length and breadth with less inclined end walls are considered as moderately advanced species. On the other hand, the species having xylem vessels, short, truncated, very broad and almost straight end walls are considered evolutionally advanced. It is reported that the pattern of xylem structure

Table 1: List of woody trees and shrubs studied

Sl. No.	Family	Growth type	Scientific name
1.	Leguminoseae	Shrub	*Acacia farnesiana* (L.) Willd
2.	Leguminoseae	Shrub	*Acacia rigidula* Benth.
3.	Mimosaceae	Tree	*Acacia schaffneri* (S. Watson) F.J. Herm.
4.	Fabaceae	Tree	*Acacia wrightii* Benth.
5.	Euphrobiaceae	Shrub	*Bernardia myricifolia* (Scheele) S. Watson.
6.	Ulmaceae	Shrub	*Celtis pallida*Torr.
7.	Leguminoseae	Tree	*Caesalpinia mexicana* A.Gray
8.	Rhamnaceae	Shrub	*Condalia hookeri* M.C. Johnst.
9.	Boraginaceae	Shrub	*Cordia boissieri* A.DC.
10.	Euphrobiaceae	Shrub	*Croton suaveolens* Torr.
11.	Boraginaceae	Shrub	*Ehretia anacua* I.M.Johnst.
12.	Fabaceae	Shrub	*Eysenhardtia polystachya* (Ortega) Sarg.
13.	Oleaceae	Tree	*Fraxinus greggii* A.Gray
14.	Rutacea	Shrub	*Helietta parvifolia* (A. Gray) Benth.
15.	Rhamnaceae	Shrub	*Karwinskia humboldtiana* (Willd. ex Roem. & Schult.) Zucc.
16.	Verbenaceae	Shrub	*Lantana macropoda* Torr.
17.	Scrophulariaceae	Shrub	*Leucophyllum frutescens* (Berland) I.M. Johnst.
18.	Caesalpiniaceae	Tree	*Parkinsonia aculeata* L. (syn. *Retama sphaerocarpa* L.)
19.	Fabaceae	Tree	*Prosopis laevigata* (Humb. & Bonpl. ex Willd.) M.C.Johnst.
20.	Fagaceae	Tree	*Quercus virginiana* P. Miller
21.	Fabaceae	Shrub	*Retama spaerocarpus* L.
22.	Salicaceae	Tree	*Salix lasiolepis* Benth.
23.	Rutaceae	Shrub	*Zanthoxylum fagara* (L.) Sarg.



1: *Acacia farnesiana* (L.) Willd.; 2: *Acacia rigidula* Benth.; 3: *Acacia schaffneri* (S.Watson) F.J.Herm; 4: *Acacia wrightii* Benth.; 5: *Bernardia myricifolia* (Scheele) S. Watson.; 6: *Celtis pallida* Torr.; 7: *Caesalpinia mexicana* A. Gray; 8: *Condalia hookeri* M.C. Johnst; 9: *Cordia boissieri* A. DC.; 10: *Croton suaveolens* Torr.; 11: *Ehretia anacua* (Teran & Berl.) I.M. Johnst; 12: *Eysenhardtia polystachya* (Ort.) Sarg.; 13: *Fraxinus greggii* A. Gray.; 14: *Helietta parvifolia* (A. Gray) Benth; 15: *Karwinskia humboldtiana* (Schult.) Zucc; 16: *Lantana macropoda* Torrey; 17: *Leucophyllum frutescens* (Berl.) I.M. Johnst.; 18: *Parkinsonia aculeata*; 19: *Prosopis laevigata* (H. & B.) Jonhst.; 20: *Quercus virginiana* Mill.; 21: *Retama sphaerocarpa* (L.) Boiss; 22: *Salix lasiolepis*; 23: *Zanthoxylum fagara* (L.) Sarg and contribute to capacity of water transport (Sperry, 2003, 2005). In this respect, the species belonging to the second group having broad xylem vessels are expected to have greater capacity of water transport. On the other hand, the species having narrower vessel diameter is reported to act against cavitations and occlusions under acute water stress (Carlquist, 1983; Jacobsen et al., 2007). Therefore, the species having narrow or medium narrow vessels are expected to be adapted in drought situations in semiarid regions of Northeast Mexico. With respect to pits, it has been stated by Bailey and Tupper (1918) the species having scalariform, elipptical pits are primitive traits while those round pits with alternate arrangement on vessels walls are advanced from the stand point of evolution. In this study, variations in the shape, size and orientations of pits on vessel walls were observed. Few examples are mentioned below:

Species having more or less round and, alternate pits in vessel walls: *Acacia farnesiana, Celtis paillida, Condalia hookeri, Karwinskia humboldtiana, Parkinsonia aculeate, Salix lasiolepis.* These species are considered as evolutionary advanced.

Species having elliptical, alternate pits: *A. rigidula, A. shaffneri, A. wightii, Casesalpinia mexicana, Cordia boissieri.* These species are considered as moderately advanced.

4. Conclusion

The present study demonstrates large variation in secondary xylem characteristics which could be related to taxonomic determination of the species, evolutionary trends and capacity of adaptation to xeric environments.

5. Future Research

Future research needs to be directed to verify this hypothesis. These hypotheses need to be confirmed in future study. There is need to study number of woody species and also study on quantitative traits to determine their role in evolution and adaptation to xeric environments.

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