

INVESTIGATION OF THE WOOD ANATOMY OF *JUNIPERUS*
(CUPRESSACEAE) FOR TAXONOMIC UTILIZATION

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ABSTRACT

The wood anatomy of twenty three taxa of *Juniperus* of the Western Hemisphere was analyzed and data presented for rays/mm, growth ring size, ray cell height, tracheid lumen size, tracheid wall thickness, and tracheid pit and border diameter. The genus was found to be very homogenous in its wood anatomy. Species differed only quantitatively and could not be separated due to overlapping ranges for these data. The wood anatomical characters examined were not useful for taxonomic purposes at the species level in *Juniperus*.

KEY WORDS: Cupressaceae, *Juniperus*, wood anatomy

The *Juniperus* species of the Western Hemisphere include approximately 43 taxa. They may be divided into several groups based on morphology (Zanoni & Adams 1978; Adams 1995) and DNA (Adams 1994; Adams & Demeke 1993):

Section *Juniperus* (acicular leaves, articulated at the base):

J. communis L. var. *saxatilis* Pall. and var. *depressa* Pursh

Section *Sabina* (scale like and decurrent leaves, not articulated at the base) (see serrate and smooth leaves below):

Serrate leaves (most taxa are associated with arid lands):

J. angosturana R.P. Adams (= *J. monosperma* (Engelm.) Sarg. var. *gracilis* Mart.); *J. ashei* Buch.; *J. californica* Carr.; *J. coahuilensis* (Mart.) Gaussen ex R.P. Adams var. *coahuilensis* (= *J. erythrocarpa* Cory, in part, see

Adams 1994) and var. *arizonica* R.P. Adams; *J. comitana* Mart.; *J. deppeana* Steudel var. *deppeana* and f. *sperryi* (Correll) R.P. Adams and var. *pattoniana* (Mart.) Zanoni; var. *robusta* Mart., and var. *zacatacensis* Mart., *J. durangensis* Mart.; *J. flaccida* Schlecht. var. *flaccida*, var. *martinezii* (Perez de la Rosa) Silba, and var. *poblana* Mart.; *J. gamboana* Mart., *J. jaliscana* Mart., *J. monosperma* (Engelm.) Sarg.; *J. monticola* Mart. f. *compacta* Mart., f. *monticola*, and f. *orizabensis* Mart.; *J. occidentalis* Hook. var. *australis* (Vasek) A.H. & N.H. Holmgr. and var. *occidentalis*; *J. osteosperma* (Torr.) Little; *J. pinchotii* Sudw.; *J. saltillensis* M.T. Hall; and *J. standleyi* Steyerem.

The entire (or smooth) leaf margined junipers are mostly associated with more mesic habits or mountains. These junipers can be divided into the mainland and Caribbean Island species (Adams 1995):

Smooth leaves, Mainland:

J. blancoi Mart.; *J. horizontalis* Moench; *J. scopulorum* Sarg. and *J. virginiana* L. var. *virginiana* and var. *silicicola* (Small) E. Murray.

Smooth leaves, Caribbean Islands:

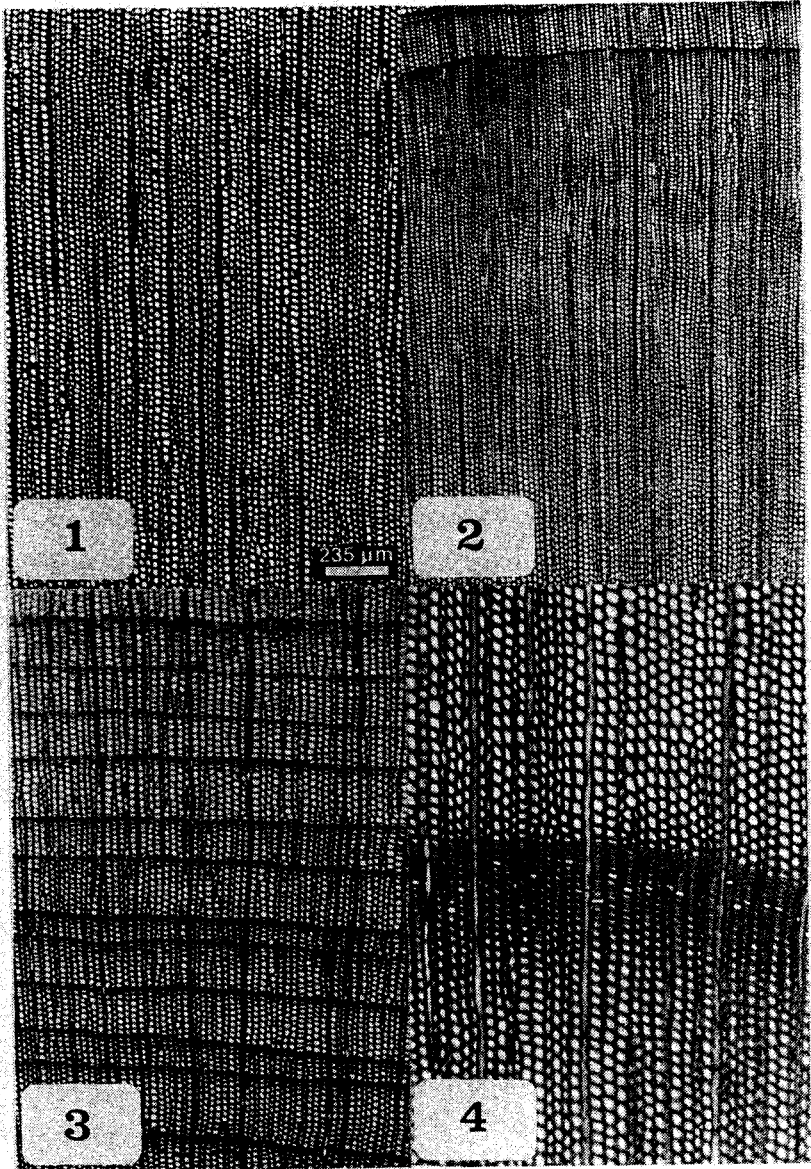
J. barbadosensis L.; *J. bermudiana* L.; *J. gracilior* Pilger var. *gracilior*, var. *ekmanii* (Florin) R.P. Adams, and var. *urbaniana* (Pilger & Ekman) R.P. Adams; *J. lucayana* Britton; *J. saxicola* Britt. & P. Wilson.

The wood of the timber-producing members of the family share the following features: latewood never conspicuous, alternate bordered pits of the tracheids lacking, tracheids without spiral thickenings, parenchyma present and frequently abundant, cupressoid (Pierce 1937) cross-field pits present, except in *Thuja*, and resin ducts lacking.

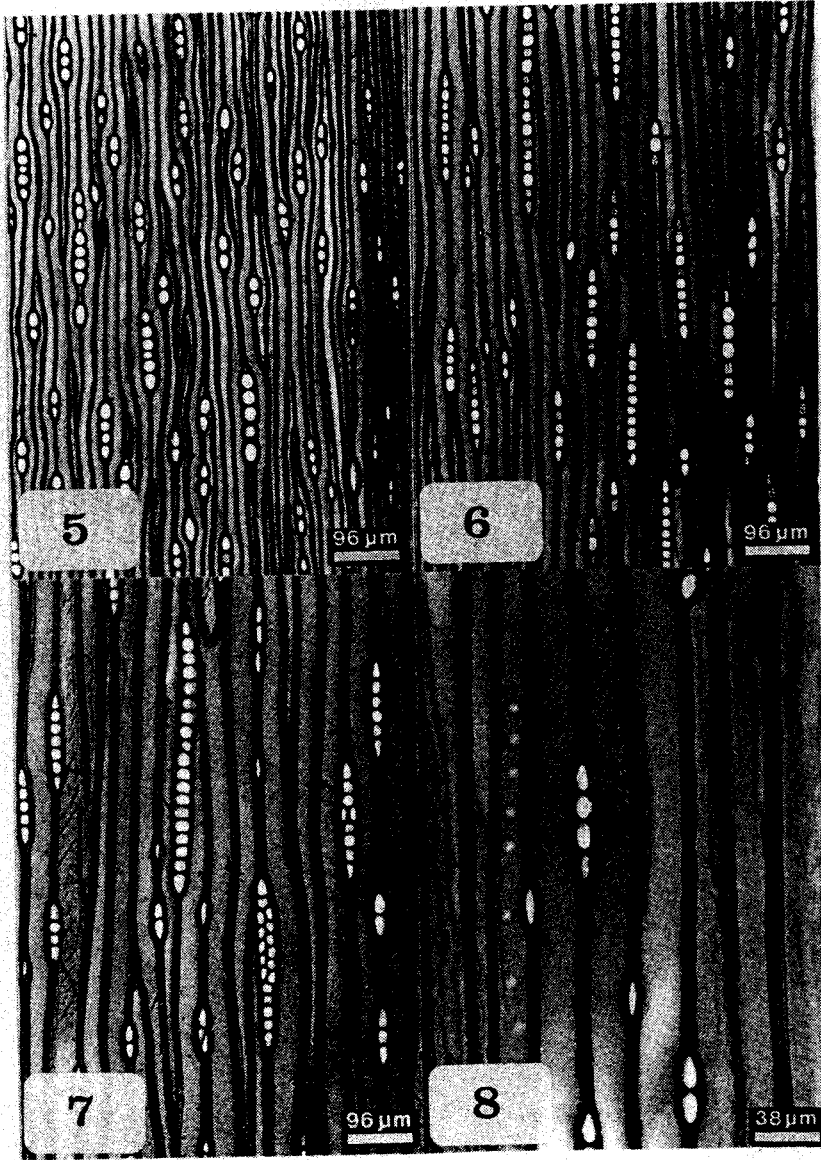
Many species of *Juniperus* are readily distinguished from all other conifers (except *Cupressus* and *Cedrus*) by the peculiar cedar-like odor which one normally associates with pencils. In fact, the cedarwood oil is practically identical for *Juniperus ashei*, *J. virginiana*, and *Cupressus funebris* Endl. (Adams 1991). Anatomically, these species are separated from most other gymnosperm woods by the presence of abundant parenchyma with nodular transverse walls and the cupressoid cross field pits.

Phillips (1968) and Panshin & de Zeeuw (1964) reported that *Juniperus virginiana* and *J. lucayana* differ from other *Juniperus* species by the presence of nodular thickenings on the vertical end walls of the rays. Nevertheless, according to Jacquot (1955), the wood structure of the genus *Juniperus* is very homogeneous and the differences between the various species are mostly biometrical.

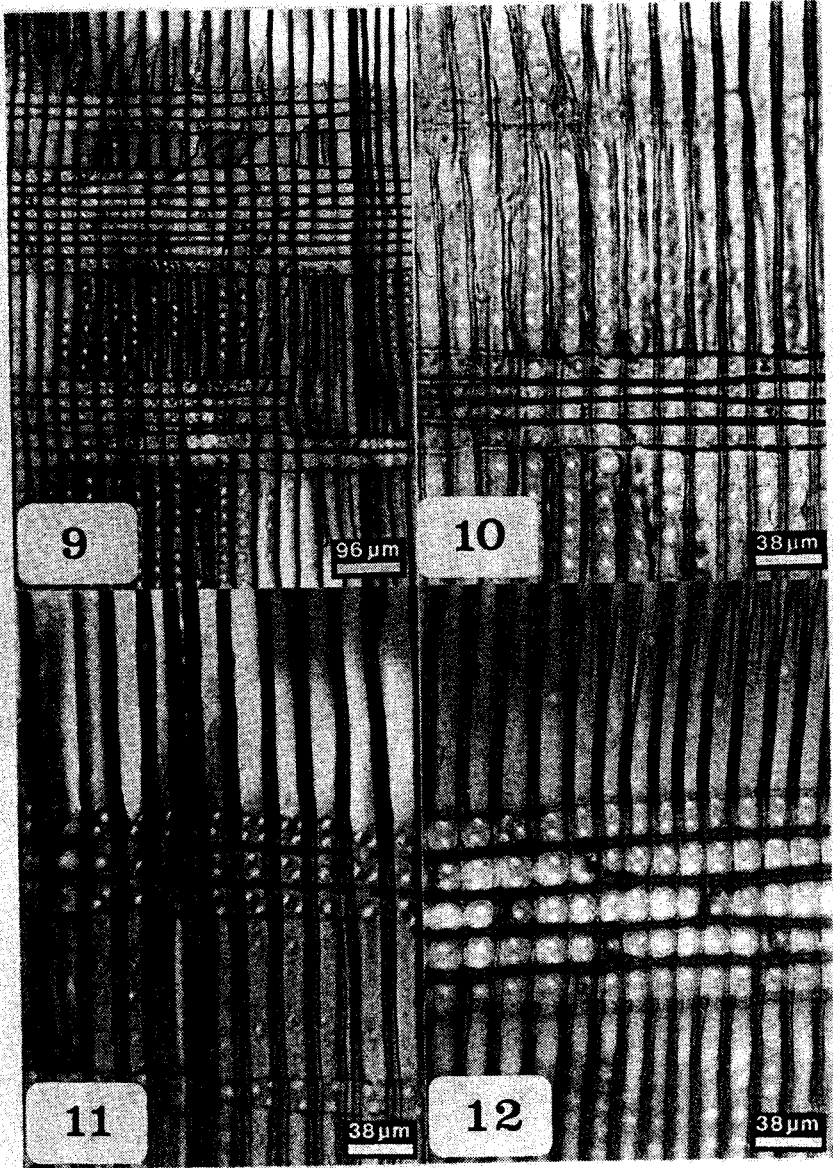
A systematic examination of the wood anatomy of the *Juniperus* from the Western Hemisphere has not been reported. The present research was an exploratory effort to evaluate the taxonomic utility of wood anatomy using a large portion of the *Juniperus* species (section *Sabina*) in the Western Hemisphere.



Figures 1-4. Transverse sections. 1. *Juniperus monosperma* (Adams 6884) México; 2. *J. saxicola* (Adams 5284) Cuba; 3. *J. barbadensis* (Adams 5368) St. Lucia; 4. *J. monticola* f. *monticola* (Adams 6874) México.



Figures 5-8. Tangential sections. 5. *Juniperus saltilensis* (Adams 6886); 6. *J. deppeana* var. *zacatensis* (Adams 6840); 7. *J. gracilior* var. *ekmanii* (Adams 3107); 8. *J. barbadensis* (Adams 5368).



Figures 9-12. Radial sections. 9. *Juniperus gamboana* (Adams 6864); 10. *J. saxicola* (Adams 5284); 11. *J. barbadensis* (Adams 5368); 12. *J. monticola* f. *monticola* (Adams 6874).

WOOD SAMPLES

Wood samples were obtained from the following taxa: (species, herbarium voucher number, location): *Juniperus angosturana*, Adams 6884, México; *J. ashei*, Adams 5105, U.S.A. (Texas); *J. barbadensis*, Adams 5368, St. Lucia; *J. blancoi*, Adams 6849, México; *J. coahuilensis*, Adams 4988, U.S.A. (Texas); *J. comitana*, Adams 6862, border México-Guatemala; *J. deppeana* var. *patoniana*, Adams 6838, México; *J. deppeana* var. *robusta*, Adams 6825, México; *J. deppeana* var. *zacatacensis*, Adams 6840, México; *J. durangensis*, Adams 6832, México; *J. ekmanii*, Adams 3107, Haiti and Adams 5243, Dominican Republic; *J. flaccida* var. *flaccida*, Adams 6892, México; *J. flaccida* var. *poblana*, Adams 6871, México; *J. gamboana*, Adams 6864, border México-Guatemala; *J. gracilor*, Adams 5242, Dominican Republic; *J. jaliscana*, Adams 6846, Mexico; *J. lucayana*, Adams 5280, Cuba; *J. monosperma*, Adams 5027, U.S.A. (Texas); *J. monticola* f. *compacta*, Adams 6898, México; *J. monticola* f. *monticola*, Adams 6874, México; *J. pinchotii*, Adams 5006, U.S.A. (Texas); *J. saxicola*, Adams 5284, Cuba; *J. scopulorum*, Adams 4973, U.S.A. (Utah). All vouchers are at SRCG.

METHODS

Transverse, radial, and tangential sections were cut at 20-30 μm thickness on a sledge microtome. All slides were stained with Safranin. Averages were based on 25 randomly selected measurements. The IAWA list of microscopic features (IAWA Committee 1989) was used for some of the methodology.

RESULTS

The wood anatomy of *Juniperus* of the Western Hemisphere has the following characteristics (see Table 1 and Figs. 1-12):

Growth rings: Distinct, as a result of a marked contrast between the final rows of the latewood tracheids and the succeeding rows of the earlywood tracheids. The number of growth rings per mm is very variable, from 0.1 up to 5.5, commonly between 0.6 and 1.5 (Table 1).

Table 1. Summary of the wood anatomy for some *Juniperus* of the Western Hemisphere.

Species	Rays/ mm	Growth rings/ mm	Ray height cells	Lumen (μm)	Wall (μm)	Pit diameter (μm) pit/border
Serrate leaves:						
<i>J. angosturana</i>	7(5-8)	0.1	1-10	29	3	4-5/10-13
<i>J. ashei</i>	7(4-8)	2.5	1-5(-6)	16	4	2-3/13-16
<i>J. coahuilensis</i>	7(6-9)	1.5	1-6(-7)	18	3	3/10-11
<i>J. comitana</i>	5-6	1.2	1-7(-9)	21	2-3	5/13
<i>J. deppeana</i>						
var. <i>patoniana</i>	8(7-9)	1.4	1-6	17	2-3	3/13
var. <i>robusta</i>	6(5-7)	0.75	1-11	28	3	3-4/11
var. <i>zacatacensis</i>	6(5-6)	1.2	1-12(-18)	21	2-3	2-3/10-11
<i>J. durangensis</i>	5(4-6)	1.6	1-5(-8)	23	2-3	3-5/13
<i>J. flaccida</i>						
var. <i>flaccida</i>	6(5-8)	0.7	1-6(-7)	18	3	3-5/10-11
var. <i>poblana</i>	5	1.5	1-5(-9)	26	3	3-4/13
<i>J. gamboana</i>	5-6	1.3	1-11	26	3	3-4/16
<i>J. jaliscana</i>	7-8	2.3	1-12	28	4	3-4/13
<i>J. monosperma</i>	7(6-9)	4.3	1-9(-14)	13	2	4/11
<i>J. monticola</i>						
f. <i>compacta</i>	7(6-9)	3.1	1-9(-11)	14	3	4/11
f. <i>monticola</i>	9(8-11)	0.6	1-9	16	3	4/11
<i>J. saltillensis</i>	9(7-11)	0.6	1-6(-7)	16	3	4/11
Smooth leaves:						
<i>J. barbadensis</i>	5	5.5	1-7	19	3	2-3/11
<i>J. blancoi</i>	6(4-8)	1.0	1-8(-16)	21	4	4-5/13
<i>J. gracillior</i>	4-5(3-6)	1.1	1-8(-9)	26	4	3/10-11
var. <i>ekmanii</i> (5243)	4(4-5)	1.5	1-8(-11)	19	3-4	3-4/10-11
var. <i>ekmanii</i> (3107)	6(5-7)	N.O.	1-20(-27)	40	3-4	5/10-13
<i>J. lucayana</i>	5(3-7)	2.8	1-4(-5)	18	3	3/11
<i>J. saxicola</i>	6(5-7)	2.0	1-4(-6)	24	3	3/10-13
<i>J. scopulorum</i>	8-9	2.9	1-8(-10)	18	3	3/10-13

N.O. = not observable.

Tracheids: Uniseriate rows of bordered pits (or rarely paired on the radial walls) are present on the radial walls of the earlywood and on both radial and tangential walls of the latewood. Pit apertures 2-4(-5) μm in diameter, the pits 10-13(-16) μm in diameter. Intercellular spaces well-marked as observed in the transverse sections. Maximum lumen diameter between 13 and 21 μm , very occasionally up to 40 μm , walls 2-4 μm . Length 1471-2356 (1205-2793) μm .

Rays: Homogeneous, composed of procumbent cells, 4-9 (3-11) per mm. Generally uniseriate, occasionally also some biseriate. Maximum number of cells rarely over 10, but in a few samples the highest rays up to 18-27 cells. However, the majority of the rays usually 1-4 cells in height.

Horizontal walls fairly thin to thick, sparsely pitted with large elliptical pits. End walls fairly thin to thick, well pitted.

Cross field pits cupressoid, (1-)2-4(-5) per cross field. These pits are regularly arranged, and sometimes show a tendency towards the taxoid type.

Parenchyma: Usually abundant throughout the growth ring, often arranged in tangential zones. Horizontal and tangential walls pitted, often nodular.

DISCUSSION

Nodular end wall thickenings were present in most cells in the *Juniperus* species of this study. It appears that this character can be used to separate *Juniperus* from other genera of the Cupressaceae. Thus, one can separate species of *Juniperus*, anatomically, from most other gymnosperm woods by the presence of abundant parenchyma with nodular transverse walls and the combination of at least some nodular vertical end walls in the rays and medium size cupressoid cross field pits.

The wood anatomy of *Juniperus* of the Western Hemisphere was found to be very homogeneous and differences were entirely quantitative (in agreement with Jacquot 1955) with respect to the characters included in this study (Table 1). These differences cannot be used to separate species, as the variation within species was larger than between species.

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