

**THE LEAF ESSENTIAL OIL OF *JUNIPERUS ZANONII* AND
COMPARISONS WITH THE OILS OF *J. JALISCANA*, *J.*
MONTICOLA AND *J. SALTILLENIS***

Robert P. Adams

Biology Department, Baylor University, Box 97388, Waco, TX
76798, USA
email Robert_Adams@baylor.edu

and

Thomas A. Zanoni

New York Botanical Garden, 200th Street at Southern Blvd.
Bronx, NY 10458-5126

ABSTRACT

The first report on the composition of the leaf essential oil of *Juniperus zanonii* is presented and the oil compared to the oils of closely related species: *J. jaliscana*, *J. monticola* f. *monticola*, *J. m. f. compacta*, *J. m. f. orizabensis* and *J. saltillensis*. The leaf oil of *J. zanonii* is dominated by sabinene (30.9%), terpinen-4-ol (13.5%) and manoyl oxide (11.7%) with moderate amounts of γ -terpinene (5.6%), citronellal (4.3%), and abietatriene (3.4%). *Juniperus saltillensis* oil is dominated by camphor (44.5%) and α -pinene (12.1%) with moderate amounts of sabinene (7.7%), limonene (2.6%) and camphene hydrate (2.2%). The oils of the monticolan junipers (*J. m. f. monticola*, *J. m. f. compacta*, *J. m. f. orizabensis*) are dominated by bornyl acetate (34.8, 44.2, 10.7%) and contain three compounds not found in other taxa in this study: δ -2-carene, linalyl acetate and methyl citronellate. However, these three forms have a surprising amount of variation among them. The oil of *J. jaliscana* is dominated by α -pinene (49.5%), limonene (15.1%) and β -phellandrene (10.0%). *Phytologia* 92(2): 256-265 (August 2, 2010).

KEY WORDS: *Juniperus zanonii*, *J. jaliscana*, *J. monticola* f. *monticola*, *J. m. f. compacta*, *J. m. f. orizabensis*, *J. saltillensis*, leaf essential oil composition, Cupressaceae, terpenes.

Recently, Adams et al. (2010) recognized the shrubby subalpine juniper from Cerro Potosi and adjacent peaks as a new species, *Juniperus zanonii* R. P. Adams, distinct from the *J. monticola* Mart. f. *compacta* Mart. from the trans-volcanic region of central Mexico. This was based in part on analyses of nrDNA and trnC-trnD sequences (Adams 2008) of the serrate leaf margined junipers of the western hemisphere that indicated the closest relative to the *J. zanonii* was *J. saltillensis* M. T. Hall (Fig. 1), not *J. monticola* Mart. In fact, *J. monticola* appears in a clade with *J. jaliscana* Mart. (Fig. 1).

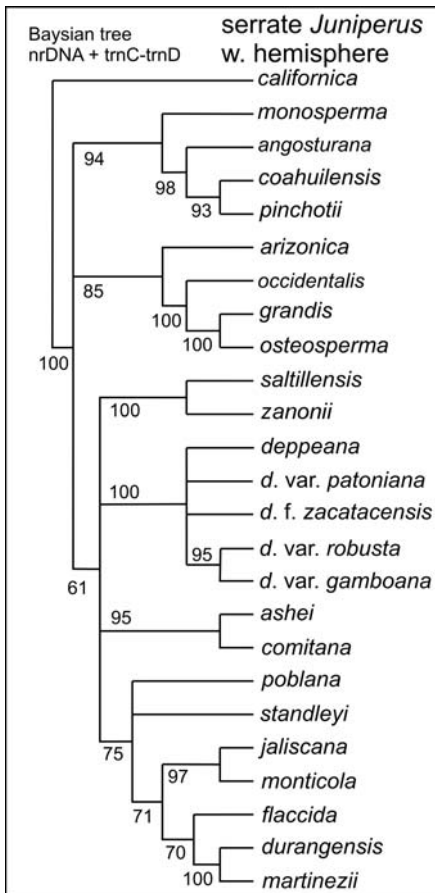


Figure 1. Bayesian tree for the serrate-leave *Juniperus* of the western hemisphere (modified from Adams, 2008) based on nrDNA + trnC-trnD. *J. zanonii* is in a well supported clade with *J. saltillensis*, whereas *J. monticola* (f. *monticola*) from El Chico National Park, Hidalgo, is in a clade with *J. jaliscana*.

A comparison of *J. zanonii* with *J. jaliscana*, *J. monticola* f. *monticola*, *J. monticola* f. *compacta* and *J. saltillensis* using 27 SNPs from nrDNA and petN-psbM (Adams et al., 2010) revealed (Fig. 2) that *J. zanonii* is not closely related to *J. monticola* f. *compacta* (from Pico Ixtaccihuatl) and that plants of *J. m.* f. *monticola* and f. *compacta* could not be resolved (Fig. 2) using these sequences.

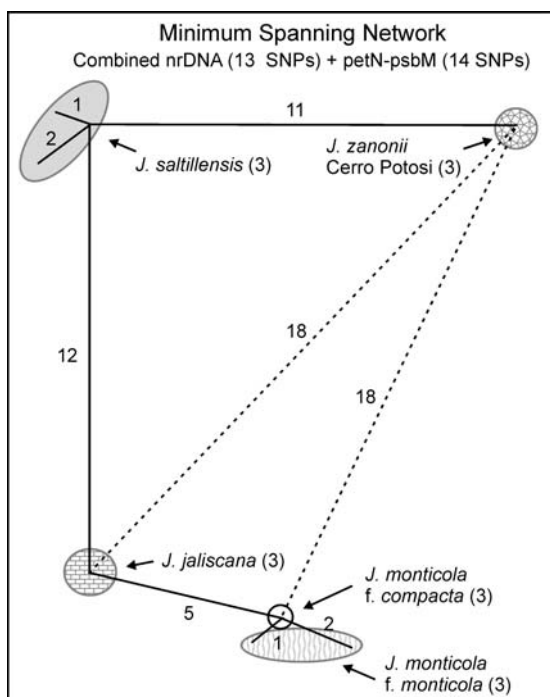


Figure 2. Minimum spanning network based on 27 SNPs from nrDNA and petN-psbM. Adapted from Adams et al. (2010).

The compositions of the leaf essential oils of the related taxa have been reported: *J. jaliscana* (Adams, Zanoni and Hogge, 1985); *J. monticola* f. *monticola*, *J. m.* f. *compacta*, *J. m.* f. *orizabensis* (Adams et al. 1980a) and *J. saltillensis* (Adams et al. 1980b). A summary of the compositions of the leaf essential oils of the serrate junipers of the western hemisphere has been presented by Adams (2000). It is worth

noting that many unknown compounds reported in these early papers are now identified in this updated examination of the aforementioned oils.

The purpose of the present study is to present the first analysis of the leaf essential oil of *J. zanonii* and compare its composition with that of closely related species: *J. jaliscana*, *J. monticola* f. *monticola*, *J. m. f. compacta*, *J. m. f. orizabensis* and *J. saltillensis*.

MATERIALS AND METHODS

Specimens collected: *J. jaliscana*, Adams 6846-6848, 12/12/1991, 940 m, 19 km E of Mex. 200 on the road to Cuale, Jalisco, Mexico; *J. monticola* f. *compacta*: T. A. Zaroni 2601-2618, Pico Ixtaccihuatl, Mexico; *J. monticola* f. *monticola*, Adams 6874-6878, 12/20/1991, 2750 m, El Chico National Park, Hidalgo, Mexico; *J. monticola* f. *orizabensis*: T. A. Zaroni 2627-2636, Pico de Orizaba, Vera Cruz, Mexico; *J. saltillensis*, Adams 6886-6890, 12/21/1991, 2090 m, on Mex. 60, 14 km E. of San Roberto Junction, Nuevo Leon, Mexico; *J. zanonii*, Adams 6898-6902, 12/21/1991, 3490 m, Cerro Potosi, Nuevo Leon, Mexico. Voucher specimens are deposited at BAYLU.

Isolation of Oils - Fresh leaves (200 g) were steam distilled for 2 h using a circulatory Clevenger-type apparatus (Adams, 1991). The oil samples were concentrated (ether trap removed) with nitrogen and the samples stored at -20°C until analyzed. The extracted leaves were oven dried (100°C, 48 h) for determination of oil yields.

Chemical Analyses - The oils were analyzed on a HP5971 MSD mass spectrometer, scan time 1/ sec., directly coupled to a HP 5890 gas chromatograph, using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column (see 5 for operating details). Identifications were made by library searches of our volatile oil library (Adams, 2007), using the HP Chemstation library search routines, coupled with retention time data of authentic reference compounds. Quantitation was by FID on an HP 5890 gas chromatograph using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column using the HP Chemstation software.

RESULTS AND DISCUSSION

The compositions of the leaf oils are shown in Table 1. The leaf oil of *J. zanonii* is dominated by sabinene (30.9%), terpinen-4-ol (13.5%) and manoyl oxide (11.7%) with moderate amounts of γ -terpinene (5.6%), citronellal (4.3%), and abietatriene (3.4%).

Juniperus saltilensis leaf essential oil is dominated by camphor (44.5%) and α -pinene (12.1%) with moderate amounts of sabinene (7.7%), limonene (2.6%) and camphene hydrate (2.2%).

The oil of *J. jaliscana* is dominated (Table 1) by α -pinene (49.5%), limonene (15.1%) and β -phellandrene (10.0%) with moderate amounts of myrcene (4.5%) and β -pinene (2.3%).

The oils of the monticolan junipers (*J. m. f. monticola*, *J. m. f. compacta*, *J. m. f. orizabensis*) are dominated by bornyl acetate (34.8, 44.2, 10.7%) and contain three compounds not found in other taxa in this study: δ -2-carene, linalyl acetate and methyl citronellate. The oil of *J. m. f. monticola* also contains moderate amounts of α -pinene (15.1%), limonene (6.7%), β -phellandrene (6.8%) and elemol (5.4%), whereas *f. compacta* contains moderate amounts of sabinene (17.8%), β -phellandrene (6.3%), terpinen-4-ol (9.8%), elemol (5.7%) and manoyl oxide (6.3%) and *f. orizabensis* has α -pinene (6.5%), limonene (7.9%), β -phellandrene (7.8%) and camphor (4.4%). Despite the seemingly small amount of variation seen in the DNA sequences for nrDNA and petN-psbM (Fig. 2), these three forms have a surprising amount of variation in their leaf essential oils.

It is interesting that the oil of *J. m. f. compacta* shares some similarity to *J. zanonii*. Note the similar amounts of sabinene, terpinen-4-ol, manoyl oxide and abietatriene (Table 1). However, *J. m. f. compacta* and *J. zanonii* differ considerably in the concentrations of borneol, bornyl acetate, β -phellandrene, citronellal and many trace components (Table 1).

ACKNOWLEDGEMENTS

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Table 1. Comparison of leaf essential oils of *J. jaliscana* (Jal), *J. monticola* f. *monticola* (MM), *J. m. f. compacta* (MC), *J. m. f. orizabensis* (MO), *J. saltillensis* (Salt) and *J. zanonii* (Zan). Compounds in bold appear to separate the taxa. t = trace, < 0.1%, RI = retention index on DB-5. Unidentified compounds have the four strongest ions listed.

RI	Component	Salt	Zan	MC	MO	MM	Jal
846	(E)-2-hexenal	-	-	-	0.3	-	0.1
846	(E)-3-hexenol	-	-	-	-	-	0.6
849	ethyl isovalerate	-	0.2	-	-	0.1	-
921	tricyclene	0.4	-	0.2	0.9	1.0	0.1
924	α -thujene	0.3	1.8	0.4	-	-	t
932	α-pinene	12.1	3.0	4.5	6.5	15.1	49.5
945	α -fenchene	-	-	-	-	-	t
946	camphene	0.8	t	0.3	1.8	1.4	0.5
961	verbenene	1.8	0.2	t	-	1.8	0.1
969	sabinene	7.7	30.9	17.8	t	t	0.1
974	β -pinene	1.3	0.6	0.5	0.2	0.9	2.3
988	myrcene	1.9	1.6	1.5	2.4	3.0	4.5
1001	δ-2-carene	-	-	0.7	2.3	0.1	-
1002	α -phellandrene	t	0.3	t	0.4	0.1	t
1008	δ -3-carene	0.4	-	0.2	0.2	t	t
1014	α -terpinene	0.5	0.3	1.2	0.2	0.1	t
1020	p-cymene	0.1	0.2	0.8	0.7	0.2	0.1
1024	limonene	2.6	1.0	-	7.9	6.7	15.1
1025	β-phellandrene	1.3	1.1	6.3	7.8	6.8	10.0
1026	1,8-cineole	0.1	-	-	-	-	-
1044	(E)- β -ocimene	0.1	-	-	0.1	0.2	0.2
1054	γ-terpinene	0.8	5.6	2.4	0.4	0.6	0.4
1063	unknown, 88,101,43,158	0.2	-	-	0.7	1.0	-
1065	cis-sabinene hydrate	0.3	0.9	1.0	-	t	-
1067	cis-linalool oxide (furanoid)	-	-	0.1	t	-	-
1086	terpinolene	0.7	1.7	-	0.7	0.8	1.1
1092	C10-OH, 96,109,137,152	2.8	-	-	-	0.6	-
1095	linalool	0.6			1.4	1.1	0.2
1098	trans-sabinene hydrate	-	1.0	1.3	-	-	-
1100	n-nonanal	-	0.1	-	t	-	t
1102	isopentyl-isovalerate	-	0.1	0.1	-	-	-
1112	3-methyl-3-buten-methylbutanoate	-	0.2	0.2	-	0.2	t
1114	endo-fenchol	-	-	-	-	-	t
1118	cis-p-menth-2-en-1-ol	0.2	0.8	0.8	-	0.1	t

RI	Component	Salt	Zan	MC	MO	MM	Jal
1122	α -campholenal	-	-	-	t	-	0.1
1135	trans-pinocarveol	-	-	-	-	-	0.1
1136	trans-p-menth-2-en-1-ol	-	0.5	0.5	0.9	0.1	-
1141	camphor	44.5	0.1	1.6	4.4	1.0	0.1
1144	neo-isopulegol	-	0.3	-	-	0.4	-
1145	camphene hydrate	2.3	t	0.2	1.4	1.0	0.1
1148	citronellal	1.0	4.3	0.4	-	-	-
1155	iso-pulegol	-	0.2	-	-	-	-
1165	borneol	0.8	-	3.2	2.0	1.8	0.2
1167	umbellulone	-	-	-	0.4	-	-
1172	cis-pinocamphone	0.1	-	-	-	-	t
1174	terpinen-4-ol	1.9	13.5	9.8	0.7	0.6	0.1
1179	p-cymen-8-ol	t	-	0.1	0.1	t	0.1
1186	α -terpineol	0.2	0.5	0.5	0.3	0.2	0.5
1193	4Z-decanal	0.2	-	-	-	-	-
1195	cis-piperitol	-	0.2	0.1	0.4	t	-
1195	myrtenol	-	-	-	-	-	t
1195	methyl chavicol	-	0.2	-	-	-	-
1207	trans-piperitol	-	0.4	0.5	0.5	0.1	-
1215	trans-carveol	-	-	-	-	-	t
1218	endo-fenchyl acetate	-	-	-	0.1	0.1	0.1
1223	citronellol	1.5	1.4	0.3	-	t	-
1232	thymol, methyl ether	-	-	0.1	t	-	0.1
1235	trans-chrysanthenyl acetate	0.5	-	-	-	1.1	-
1239	carvone	-	-	-	t	-	-
1241	carvacrol, methyl ether	-	-	-	-	-	t
1247	C10-OH, 41,109,119,152	0.6	-	-	-	-	-
1249	piperitone	-	-	0.2	0.4	-	-
1254	linalyl acetate	-	-	t	0.2	0.1	-
1255	4Z-decenol	0.2	-	-	-	-	-
1257	methyl citronellate	-	-	0.2	t	0.1	-
1274	pregeijerene B	0.5	1.0	0.9	0.3	0.9	-
1275	isopulegol acetate	-	-	-	-	0.1	-
1287	bornyl acetate	0.9	0.1	10.7	44.2	34.8	1.1
1289	thymol	0.1	-	0.3	-	-	-
1298	carvacrol	-	-	-	0.1	0.2	-
1312	citronellic acid	0.1	0.2	0.2	0.1	0.1	-
1346	α-terpinyl acetate	-	-	0.2	0.6	0.1	-
1403	methyl eugenol	t	0.3	-	-	-	-
1448	cis-muurolo-3,5-diene	-	-	0.3	-	-	0.3
1417	(E)-caryophyllene	t	-	-	0.4	t	0.2

RI	Component	Salt	Zan	MC	MO	MM	Jal
1451	trans-muurolo-3,5-diene	t	-	-	-	-	t
1452	α -humulene	-	-	-	-	-	0.3
1461	cis-cadina-1(6),4-diene	-	-	-	-	-	0.3
1465	cis-muurolo-4(14),5-diene	-	-	-	-	-	0.5
1475	trans-cadina-1(6),4-diene	-	-	0.2	-	-	t
1480	germacrene D	-	-	-	-	-	1.1
1493	trans-muurolo-4(14),5-diene	t	-	0.7	-	-	-
1493	epi-cubebol	-	-	0.4	-	-	-
1495	epi-cubebene	-	-	-	-	-	t
1500	α -muurolo-ene	-	-	-	-	-	0.1
1501	epi-zonarene	-	-	-	-	-	0.1
1513	γ -cadinene	-	-	-	-	-	0.6
1513	cubebol	-	-	0.6	-	-	-
1521	trans-calamenene	-	-	-	-	-	0.1
1522	δ -cadinene	-	-	0.3	-	-	0.9
1528	zonarene	-	-	0.2	-	-	-
1531	cis-calamenene	-	-	t	-	-	-
1537	α -cadinene	-	-	-	-	-	0.1
1544	α -calacorene	-	-	-	-	-	0.1
1548	elemol	1.4	2.5	5.7	2.4	5.4	-
1559	germacrene B	-	-	-	0.1	0.2	-
1574	germacrene-D-4-ol	-	-	-	-	-	0.1
1582	caryophyllene oxide	-	-	-	0.1	-	t
1600	cedrol	-	-	t	0.2	-	-
1608	humulene epoxide II	-	-	-	-	-	t
1608	C ₁₅ OH, 43,109,119,220	0.1	-	-	0.5	0.6	-
1627	1-epi-cubenol	0.1	-	0.7	-	-	-
1630	γ -eudesmol	0.2	0.4	1.3	0.5	1.0	-
1638	epi- α -cadinol	-	-	-	-	-	1.1
1638	epi- α -muurolo-ol	-	-	-	-	-	1.0
1644	α -muurolo-ol	-	-	-	-	-	0.2
1649	β -eudesmol	0.3	0.4	2.6	0.5	0.9	-
1652	α -eudesmol	0.3	0.5	1.9	0.5	1.2	-
1652	α -cadinol	-	-	-	-	-	1.5
1670	bulnesol	0.1	0.1	0.4	0.3	0.5	0.1
1688	shyobunol	-	-	0.2	-	-	-
1746	8- α -11-elemodiol	0.3	0.2	0.2	-	0.2	-
1792	8- α -acetoxylemol	0.3	0.7	2.0	0.5	1.2	-
1958	iso-pimara-8(14),15-diene	-	0.6	t	-	-	t
1988	manoyl oxide	1.5	11.7	6.3	0.2	1.0	0.2

RI	Component	Salt	Zan	MC	MO	MM	Jal
1987	iso-pimara-7,15-diene	-	-	-	0.2	0.5	-
2009	epi-13-manoyl oxide	-	0.1	t	-	-	-
2055	abietatriene	0.3	3.4	3.1	0.3	1.1	0.3
2087	abietadiene	-	0.3	t	t	0.5	0.1
2105	iso-abienol	0.3	-	1.4	-	0.1	-
2256	methyl sandaracopimarate	1.5	-	-	-	-	-
2282	semperviol	0.4	0.1	0.1	-	-	-
2298	4-epi-abietal	-	-	0.1	-	t	t
2314	trans-totarol	0.2	t	0.6	0.1	0.7	0.6
2331	trans-ferruginol	0.1	t	0.1	-	t	t
	Number of cpds.	60	52	69	59	63	71