

Floristic Comparison of an Arizona Sky Island and the Sierra Madre Occidental in Eastern Sonora: the Huachuca Mountains and the Yécora Area

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Abstract—The floras of the “Sky Island” Huachuca Mountains, Arizona (994 taxa; 316 km²; 1,524–2,885 m elevation, 1,361 m elevational range; 31°30′N) and the “mainland” Sierra Madre Occidental near Yécora, Sonora (1,284 taxa; ca. 2,080 km²; 820–2,140 m, 1,320 m elevational range; 28°24′N) were compared. Only 6.5% and 5.1% of the floras were non-native. Compositae, Gramineae, and Leguminosae contained 39.3% and 40.2% of the taxa. The Apachian floristic element (38.8%) in the Huachuca flora best reflected the 39.9% native taxa shared with Yécora. The plant diversity in the Yécora area is much greater than in any of the Arizona Sky Islands.

Introduction

The “Sky Island” mountain ranges in southeastern Arizona (Heald 1951) form a floristically diverse archipelago which is a northwestern extension of the “mainland” Sierra Madre Occidental in northwestern Chihuahua and northeastern Sonora. The floras of the Chiricahua, Pinaleño, Mule, Huachuca, Patagonia, Santa Rita, Pajarito, Rincon, and Santa Catalina Mountains show pronounced similarities although there are marked differences related to substrate, land use, topography, surface water, and geographic location (see discussion in Bowers and McLaughlin 1996). The local floras of these ranges are usually referred to as Madrean Floristic Province, reflecting their affinities with the Sierra Madre Occidental. The Sierra Madre Occidental is the massive *cordillera* in Western Mexico that extends 1,350 kilometers from Colima to northwestern Chihuahua and northeastern Sonora (Rzedowski 1978).

In this paper, we compare the flora of the Huachuca Mountains Sky Island in southwestern Cochise County, Arizona, with the Sierra Madre Occidental “mainland” flora in the Yécora area in east-central Sonora.

Study Areas

Huachuca Mountains

The Huachuca Mountains is a north-northeast trending range in Cochise County that extends from the International border 35 kilometers into Cochise County, Arizona. The range is in Coronado National Forest and the Fort Huachuca Military Reservation. The area is drained on the northeast and south by the San Pedro River and on the west by the Santa Cruz River, which both flow southward into Sonora. Paleozoic and Mesozoic sediments including limestone resting on a Precambrian granite base are the dominant rock types in

the range. The vegetation ranges from desert grassland with Chihuahuan Desert elements to oak woodland, and pine-oak, pine, and mixed-conifer forests at higher elevations. The flora study area is an area of 316 km² with elevations from 1,524 to 2,885 m, an elevational range of 1,361 m.

Yécora

The Municipio de Yécora extends 75 kilometers from the Chihuahua border westward into Sonora in the broad Río Mayo Region of southern Sonora and adjacent Chihuahua (Gentry 1942; Martin et al. 1998). It is located 335 km southeast of the Huachuca Mountains. Mexican federal highway 16 (MEX 16) passes through the Municipio, connecting Hermosillo, Sonora, and La Junta, Chihuahua (Búrquez et al. 1992). It is the only paved highway that crosses the Sierra Madre Occidental between the Durango-Mazatlán highway (MEX 40) in southern Sinaloa and MEX 2 along the Arizona border in northern Sonora. Most of the Yécora region is in the Río Yaqui drainage with only the southeastern edge of Mesa del Campanero in the Río Mayo basin. Most of the substrates in the study area are rhyolite, andesite, or basalt.

The vegetation gradient along MEX 16 ranges from foothills thornscrub (460–550 m elevation) and tropical deciduous forest (500–1,160 m) to oak woodland (1,050–1,700 m), pine-oak forest (1,220–2,240 m), valley grassland (1,200–1,700 m), and mixed-conifer forest (1,900–2,100 m; Búrquez M. et al. 1992; Martin et al. 1998; Reina et al. 1999). Special habitats in the Municipio include riparian areas, ciénegas (Van Devender et al. 2003), and gossans. Gossans are relatively bare areas of reddish, highly acidic (pH to 4.0) soils derived from hydrothermally altered volcanic rocks with oak woodland or pine-oak forest at 820–1,000 m surrounded by tropical deciduous forest on unaltered soils (Goldberg 1982).

For comparison with the Huachuca flora, only taxa recorded in gossan woodlands, oak woodland, pine-oak forest, and grassland were compared, excluding those in foothills

thornscrub and tropical deciduous forest in an area of about 2,080 km² at 820 to 2,140 m elevation, an elevational range of 1,320 meters. The lower elevation of the Yécora study area compared to the Huachuca Mountains (1,524–2,885 m elevation) reflects a well known latitudinal effect where equivalent montane vegetation types occur at different elevations (see discussion in Marshall 1957).

Methods

Huachuca Mountains

There has been interest in the flora of the Huachuca Mountains for over a century, beginning with the collections of John G. and Sara P. Lemmon in 1882. Bowers and McLaughlin (1996) reported a total of 994 taxa for the Huachuca Mountains based on University of Arizona Herbarium (ARIZ) specimens, taxa cited in Kearney and Peebles (1960), and recent collections. Between August 1990 and June 1994, Bowers, McLaughlin, and their colleagues collected 1,154 specimens including 147 species new to the flora on 41 trips to the study area between 1990 and 1994. Their specimens are in ARIZ.

Yécora

Although the intrepid Howard Gentry's book on the Río Mayo flora was published in 1942, he only made a few collections near Santa Ana and Yécora in 1958. The first plant collection in the Yécora area was made by Richard S. Felger in 1955. Between 1955 and 1994, at least a few plants were collected on 90 trips to the Yécora area, involving 102 collectors. In 1968 and 1970, Campbell W. Pennington collected 186 specimens as part of his anthropological studies of the Mountain Pima Indians. Deborah E. Goldberg made significant collections in the Santa Ana area as part of her doctoral dissertation on gossan woodlands in 1975–1977 and 1980. In his spare time, Padre Guillermo (Bill) Trauba made over 500 plant collections in the Municipio and built a personal herbarium during his Catholic missionary activities in 1996–1998. Other individuals including Mark Fishbein (326 collections), Paul S. Martin (217 collections), Richard S. Felger (129 collections), Alberto Búrquez M. (118+ collections), Thomas F. Daniel (88 collections), José Luis León de la Luz (74 collections), and Richard Spellenberg (56+ collections) made important collections in the Municipio. As part of the present inventory of the Municipio de Yécora, we made 5,450 collections (most with duplicates) on 30 field trips between May 1995 and March 2004 (Reina et al. 1999; Van Devender et al., in press). Specimens were deposited in ARIZ, the Universidad de Sonora (USON), and 15 other institutions in the United States and Mexico. Additional taxa from the Municipio were reported in Beetle and Johnson (1991) and Martin et al. (1998; mostly ARIZ specimens). Currently 1,691 taxa of vascular plants have been recorded from the Municipio.

New species have steadily been discovered and described from the Municipio de Yécora since 1989 (Henrickson and Van Devender 1999; Nesom 1998; Roalson 1999; Spellenberg

1999; Turner 1995a,b; Van Devender and Turner 1997; and others). Recent botanical studies in the Municipio include the local flora of the *Sphagnum* seep at the Ciénega de Camilo (Van Devender et al. 2003), noteworthy sedges (Roalson et al. 2002), diversity and distribution of grasses (Van Devender et al., in press), and pollen analyses and vegetation history (Ortega R. 2000).

Results

Although, the Huachuca Mountains and Yécora floras have similar vegetation types (grassland, oak woodland, pine-oak forest, and mixed-conifer forest) and elevational ranges (1,361 and 1,320 m), there are important differences in area (316 km² and ca. 2,080 km²) and substrate (sedimentary and volcanic-igneous rocks). The number of taxa recorded for the Huachucas is much less than in the Yécora flora (106 versus 124 families, 476 versus 503 genera, and 994 versus 1,284 species plus additional intraspecific taxa, 929 versus 1,220 native; table 1). Bowers and McLaughlin (1996) correlated species diversity in Sky Island mountain ranges with elevational range, a reflection of topographic and habitat diversity. A regression analysis of the number of native species against elevational range showed that the Huachuca Mountains flora (929 native taxa/1,361 m) has the greatest plant diversity in the southeastern Arizona Sky Islands. However, with 1,220 native taxa/1,320 m elevational range, the Yécora flora is much more diverse than any of the Arizona Sky Islands. Moreover, using the lower elevational limit of non-gossan oak woodland (1,050 m) raises the diversity even higher.

In general, the Huachuca and Yécora floras are similar. Both areas have 65 non-native exotic taxa, accounting for 6.5% and 5.1% of the floras. The families with the most native taxa are Compositae (168 and 224), Gramineae (96 and 139), and Leguminosae (80 and 128) in both floras. The native taxa in five other families (Euphorbiaceae, Pteridaceae, Scrophulariaceae, Labiatae, and Convolvulaceae) have more or less the same rank orders in the two floras. The taxa in these eight families in both floras account for about half (49.7% and 53.2%) of the native taxa.

A ratio of the number of Huachuca taxa divided by the number of Yécora taxa (HU/YE) provides insight into the floristic differences (table 1). The families Cruciferae, Rosaceae, and Liliaceae are clearly more important in the Huachucas than in Yécora while the Pteridaceae are equally important. The remaining nine families including Gramineae (31% more), Leguminosae (37% more), Convolvulaceae (38% more), Labiatae (51% more), and Malvaceae (61% more) are more important in Yécora.

Looking at the HU/YE ratio for genera also is insightful. Although, *Muhlenbergia* (20 taxa) is important in the Huachucas, Yécora is a major center of diversity for muhlies with 41% more taxa. One interesting shift is in the Cyperaceae with 133% more *Carex* in the Huachucas than in Yécora. However, Yécora has 48% more *Cyperus* plus six *Carex* and an additional 29 sedges in seven other genera, reflecting the greater diversity of *Carex* in temperate floras and *Cyperus* in tropical floras. *Asclepias* and *Euphorbia* (including *Chamaesyce* and *Poinsettia*) are about equally important in the two floras while

Table 1—Comparison of the floras of the Huachuca Mountains (HU), Arizona, and the Yécora area (YE), Sonora.

	Huachucas				Yécora				Shared			
	Native taxa 929	Number exotics 65	Total taxa 994		Native taxa 1220	Number exotics 65	Total taxa 1284		Native taxa 371	Number exotics 25	Total taxa 396	
Total flora												
Families	Native taxa 168	Number exotics 7	Total taxa 175	Rank order	Native taxa 224	Number exotics 2	Total taxa 226	Rank order	Native taxa 75	Number exotics 1	Total taxa 76	Native taxa HU/YE ratio 0.75
Compositae				1				1				
Gramineae	96	22	118	2	139	22	161	2	53	9	62	0.69
Leguminosae	80	6	86	3	128	3	131	3	42	1	42	0.63
Euphorbiaceae	30	0	30	4	34	0	34	5	11	0	11	0.88
Pteridaceae	30	0	30	5	30	0	30	7	12	0	12	1
Scrophulariaceae	25	3	28	6	33	1	34	6	8	0	8	0.76
Labiatae	17	1	18	7	35	3	38	4	6	2	8	0.49
Convolvulaceae	16	0	16	8	26	1	27	8	9	0	9	0.62
Cruciferae	15	3	18	9	7	6	13	12	4	2	6	2.14
Rosaceae	15	3	18	10	7	1	8	13	4	0	4	2.14
Liliaceae	13	0	13	11	10	0	10	11	2	0	2	1.3
Solanaceae	13	0	13	12	16	5	21	10	3	0	3	0.81
Malvaceae	7	0	7	13	18	1	19	9	3	0	3	0.39
Genera	Native taxa 21	Number exotics 0	Total taxa 21	Rank order	Native taxa 22	Number exotics 0	Total taxa 22	Rank order	Native taxa 7	Number exotics 0	Total taxa 7	Native taxa HU/YE ratio 0.95
Euphorbia				1				3				
Muhlenbergia	20	0	20	2	34	0	34	1	12	0	12	0.59
Asclepias	14	0	14	3	13	0	13	9	3	0	4	1.08
Carex	14	0	14	4	6	0	6	10	3	0	3	2.33
Cyperus	13	0	13	5	25	3	28	2	13	1	12	0.52
Cheilanthes	12	0	12	6	14	0	14	7	6	0	6	0.86
Dalea	12	0	12	7	20	0	20	4	5	0	5	0.6
Erigeron	11	0	11	8	14	0	14	8	6	0	6	0.79
Ipomoea	10	0	10	9	17	0	17	5	7	0	7	0.59
Salvia	3	0	3	10	15	0	15	6	1	0	1	0.2

four other genera (*Dalea*, *Erigeron*, *Ipomoea*, and *Salvia*) are from 21% to 80% more important in Yécora.

Discussion

Bowers and McLaughlin (1996) classified all native species in the Huachuca Mountains flora into floristic elements based on McLaughlin's (1989) system of floristic areas for the Western United States. He recognized five floristic provinces: Cordilleran, Intermountain, Sonoran, Californian, and Madrean. The Madrean floristic province was subdivided into Widespread, Regional, Central Arizonan, Chihuahuan, and Apachian floristic elements/districts. In this method, each species are assigned to phytogeographic floristic areas based on their frequency of occurrence in local floras rather than their actual geographic distributions. They concluded that 69.9% of the native Huachuca flora were Madrean floristic elements.

In the present comparison, 39.9% of the native Huachuca flora are shared with the Yécora flora. This is very close to the 38.8% Apachian floristic elements in the Huachuca flora. The Apachian floristic district of the Madrean phytogeographic province is centered in southeastern Arizona (McLaughlin 1989). We conclude that restricting 'Madrean' floristic province species to Apachian taxa in McLaughlin's analyses would give better predictions of the actual percentages of species shared with the Sierra Madre Occidental. As Bowers and McLaughlin (1996) pointed out, the Apachian elements were most common in the oak woodlands and pine-oak forests in the Huachucas. In these communities, many of the dominant trees and shrubs are widespread, resulting in very Sierra Madrean appearing habitats in Sky Islands even if only 40% or less of their floras actually occur in the mainland Sierra Madre Occidental.

The Huachucas have additional plants in high mixed-conifer forest (Cordilleran or Rocky Mountain), desert grassland, and Chihuahuan Desert plants, which are not found on the western slope of the Sierra Madre Occidental. Although lowland tropical plants were excluded from the comparisons, the woodlands and forests of Yécora are rich in montane tropical plants such as *Achimenes grandiflora*, *Begonia* spp., *Clethra mexicana*, *Hydrangea seemannii*, *Ilex* spp., *Pinus maximinoi*, *Quercus tarahumara*, *Stenorrhynchos aurantiacus*, *Tillandsia erubescens*, and *Tigridia pavoniana*, which do not occur in the Western United States.

Acknowledgments

We greatly appreciate the support of Tom Daniel, Mark Fishbein, Richard Spellenberg, George Ferguson, John and Charlotte Reeder, Bill Trauba, Billie Turner, and many others through field trip participation, identifications, and sharing information. We thank George Ferguson, Mark Fishbein, and Francisco Molina for their careful reviews.

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