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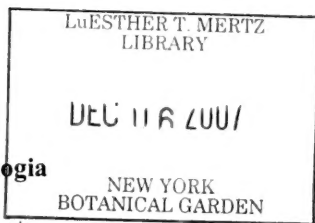
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**CHARACTERIZATION OF THORN-SCRUB WOODLAND
COMMUNITIES AT THE CHAPARRAL WILDLIFE
MANAGEMENT AREA IN THE SOUTH TEXAS PLAINS,
DIMMIT AND LA SALLE COUNTIES, TEXAS**

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ABSTRACT

The composition of semiarid grasslands in southwestern North America has changed during the past 150 years with woody species increasing in density and cover. This brush encroachment involves mostly native species, many of which are woody members of the Fabaceae (legume family) that have increased in importance because of changes in local biotic and/or abiotic factors. At the Chaparral Wildlife Management Area, Dimmit and La Salle counties, Texas, thorn-scrub woodland communities are common. In some, *Prosopis glandulosa* (honey mesquite) is the most important species, however, other thorny woody legume species are prominent, and sometimes dominate the community. Common taxa are *Senegalia berlandieri* [= *Acacia berlandieri* (guajillo, fern acacia)], *S. greggii* [= *Acacia greggii* (catclaw acacia)], *S. roemeriana* [= *Acacia roemeriana* (Roemer's acacia)], *Vachellia bravoensis* [= *Acacia schaffneri* var. *bravoensis* (twisted acacia)], *V. farnesiana* [= *Acacia farnesiana* (huisache)], and *V. rigidula* [= *Acacia rigidula* (blackbrush)]. In the communities studied, thorny woody legume species had importance values between 87 and 157

(possible 200). Between 11 and 20 woody and succulent species were present in these communities with a total of 28 species recorded.

KEY WORDS: *Acacia s.l.*, *Prosopis glandulosa*, South Texas Plains, thorn-scrub woodlands.

The composition and structure of semi-arid grasslands in southwestern North America has changed during the past 150 years (Van Auken 2000). Although some changes are the result of the invasion of exotic species, most changes involve dramatic increases of native woody taxa that were historically present in low densities (Johnston 1963, Archer et al. 1988, Archer 1989).

The flat, deep soils of much of the South Texas Plains once supported an open savanna with a ground layer of short grasses and forbs in which *Prosopis glandulosa* (honey mesquite), along with lesser numbers of other shrubs and trees, which were clustered or scattered. This region also contained a mosaic of rocky, broken uplands that were dominated by relatively dense brushy vegetation. This open savanna has changed to brushy thorn-scrub woodland within the last 150 years apparently due to anthropogenic forces (Correll and Johnston 1970, Van Auken 2000, Ruthven 2001).

The change to thorn-scrub woodland was primarily the result of overgrazing by domestic livestock and fire suppression (Archer et al. 1988, Ruthven et al. 2000, Ruthven 2001). Honey mesquite was the pioneer woody species involved in this transition to thorn-scrub woodland, and is currently the common dominant throughout the southwestern United States and adjacent Mexico (Ruthven 2001). Species representing two genera of thorny legumes (*Senegalia* and *Vachellia*) were also major components of these thorn-scrub woodlands.

The genera *Senegalia* and *Vachellia* are segregates of the genus *Acacia* (*sensu lato*). Based on morphological and genetic evidence, it is evident that the genus *Acacia s.l.* is polyphyletic. Also, there has been an accumulation of data, derived from molecular studies, that has led to a better understanding of probable relationships within the genus *Acacia s.l.*, as well as the position of the genus within the Mimosoideae. These studies confirmed that the genus *Acacia s.l.* should be separated into as many as five genera, including *Senegalia*

(Seigler et al. 2006) and *Vachellia* (Seigler and Ebinger 2005). The common species of these two genera in Texas include *Senegalia berlandieri* [= *Acacia berlandieri* (guajillo, fern acacia)], *S. greggii* [= *Acacia greggii* (catclaw acacia)], *S. roemeriana* [= *Acacia roemeriana* (Roemer's acacia)], *Vachellia bravoensis* [= *Acacia schaffneri* var. *bravoensis* (twisted acacia)], *V. farnesiana* [= *Acacia farnesiana* (huisache)], and *V. rigidula* [= *Acacia rigidula* (blackbrush)]. These well-armed species are common throughout the arid and semi-arid environments of the South Texas Plains (Isely 1998), and along with *Prosopis glandulosa* are important sources of animal fodder, fuel, and timber (Fagg and Stewart 1994).

Thorn-scrub woodlands are common at the Chaparral Wildlife Management Area (CWMA), located in the northern part of the South Texas Plains ecological region. The importance and distribution of honey mesquite and other thorny legumes is determined by various biotic and abiotic factors, such as climate, moisture, edaphic conditions, present and past grazing pressures, and fire. The objective of this study was to examine the structure and composition of thorn-scrub woodland communities to understand better the importance, distribution, and habitat preferences of thorny legume species.

STUDY AREA

The study area was on the Chaparral Wildlife Management Area (28°20'N, 99°25'W) in the northern half of the South Texas Plains (Ruthven et al. 2000, Ruthven 2001). Located in Dimmit and La Salle counties, 12 km west of Artesia Wells, CWMA is deer-proof fenced and about 6,150 ha in size. Purchased in 1969 by the Texas Parks and Wildlife Department, it serves as a research and demonstration area. The area around CWMA is rangeland, most holdings being large cattle ranches.

Hot summers and mild winters characterize the climate of CWMA. The average daily minimum winter (January) temperature is 5°C, the average daily maximum summer (July) temperature is 37°C, the growing season is 249 to 365 days, and the average annual precipitation (1951 to 1978) is 55 cm (Stevens and Arriaga 1985). The precipitation patterns are bimodal with peaks occurring in late spring (May and June), and early fall (September and October). Short-term periods of drought are common and rainfall can be highly variable

between locations (Norwine and Bingham 1985). An all-time low record of 7.16 cm fell during 1917 in Cotulla, a small town 25 km northeast of CWMA (Correll and Johnston 1970).

Soils of CWMA are dominated by Duval very fine, sandy loams, gently sloping and Duval loamy fine sands, 0 to 5% slope (Gabriel et al. 1994, Stevens and Arriaga 1985). The soil surface layer is reddish brown, slightly acid, very friable, and 0 to 40 cm thick. Also present are shallow limestone ridges (calcareous rises) where soils are mildly to moderately alkaline and have a caliche layer near the surface. Topography is level to gently rolling with an average elevation of 175 m above mean sea level.

Domestic livestock have grazed the CWMA since the 18th century (Lehmann 1969). Sheep production dominated from about 1750 to 1870 when cattle became the major livestock. Before 1969, grazing was continuous on the entire area. From 1969 to 1984 a four-pasture rest-rotation system was employed. Cattle were absent from the study area from 1984 to 1989. Grazing resumed in 1990, and, until 2002, CWMA utilized a high intensity, low frequency rotational grazing system. Stocking rates averaged one Animal Unit per 12 ha (Ruthven 2001). A prescribed burn program was initiated at the CWMA in 1997, but none of the sites examined in the present study has been burned (Ruthven, personal communication). Most of the CWMA was chained in 1948 (Ruthven, personal communication). Chaining involves the use of two large tractors with a very heavy linked chain connected at each end to one of the tractors. The chain is pulled across the site, disrupting and pulling out much of the vegetation (Lehmann 1984).

METHODS

During the summer of 2001, five thorn-scrub woodland communities were studied at the CWMA. These sites were selected based on the recommendations of CWMA site personnel who located sites where the vegetation was mature and least disturbed. All sites were upland, nearly level areas, where minimal disturbance, other than grazing, was observed. At four of the sites (1, 2, 3, and 4), a single line transect was randomly established near the center of the long axis of each community. At 30 m intervals along the length of the transect, circular plots 0.03 ha in size were located (a minimum of 10 plots) and

all woody plants and succulents greater than 0.4 m tall were identified and their height and average crown diameter determined to the nearest dm. As *Senegalia roemeriana* was found only in one small area, the entire community was examined (Site 5). This site (50 m x 50 m in size) was divided into subplots to facilitate sampling, and all woody plants greater than 0.4 m tall were measured and identified as described above. Data from the plots were used to determine density, average cover, relative density, relative cover, and importance value (IV) for each species at each site. The IV is calculated as the sum of the relative density and relative cover. Sorensen's Index of Similarity (ISs) was used to determine the degree of similarity between the study sites: $ISs = 2C/(A+B) \times 100$ (Mueller-Dombois and Ellenberg 1974).

At each study site, soil samples ($n = 16$) were taken, both under shrub and tree canopies and in open areas between shrub clusters. All samples were analyzed by the Texas Agricultural Extension Service, Soil Testing Laboratory, College Station, Texas for pH, salinity, and macro-nutrients (ppm in available form). A random sample from each site was analyzed for soil texture. Significant differences between sites for pH and the various macro-nutrients was tested with procGLM ($p < 0.05$) using SAS (1986).

RESULTS

The number of woody and succulent species recorded for the five thorn-scrub woodland sites ranged from 11 to 20 with 28 different species recorded, six being thorny species of legumes (Tables 1 thru 5). Of the 28 species encountered, seven occurred on each of the five sites: *Celtis pallida* (spiny hackberry), *Condalia hookeri* (brazil), *Diospyros texana* (Texas persimmon), *Forestiera angustifolia* (narrowleaf forestiera), *Opuntia engelmannii* (prickly pear), *O. leptocaulis* (tasajillo), and *Prosopis glandulosa*. *Opuntia engelmannii*, *O. leptocaulis*, and *Prosopis glandulosa* were common species in most of the communities and had high densities, covers, and IV's. *Prosopis glandulosa* was the dominant species with the highest IV on two sites (2 and 5) and was second at site 3, whereas one of the two species of *Opuntia* ranked third or higher on all sites. The remaining species listed above were recorded for all sites; though they were sometimes common, they never dominated the community, always ranking fourth or lower in IV. For woody vegetation of all five sites, the Sorensen

Index of Similarity ranged from 51.6 to 84.8 (Table 6), but was usually greater than 66 indicating that sites were very similar (Mueller-Dombois and Ellenberg 1974).

Though one or two species of the genus *Senegalia* and/or *Vachellia* were among the top three species at each study site, they commonly shared dominance with *Prosopis glandulosa*, and/or a species of *Opuntia*. *Vachellia rigidula* was found on three sites, ranking first in IV on site 4 and third on site 1 (Tables 1, 4, and 5). *Vachellia bravoensis* occurred on four sites, ranking third or lower in IV on all sites (Tables 1, 2, 3, and 5). Other thorny legume species were restricted to one or two sites. *Senegalia roemeriana* was second in IV on site 5 (Table 5), *S. greggii* ranked first on site 1 (Table 1), and *S. berlandieri* occurred on two sites, ranking second on site 4, and was uncommon on site 1 (Tables 1, 4).

On all study sites, the soil texture was relatively uniform, being sandy loams with 61 to 75% sand, 12 to 20% silt, and 11 to 19% clay, and none were saline (Table 7). Soils of sites 1, 2, 3, and 5 were mildly to strongly acidic, mostly low to very low in available nitrates, phosphorus, and sodium, but with moderate to high amounts of available potassium, magnesium, sulfur, and calcium (Table 7). Soils of site 4, in contrast, were from a calcareous ridge (cuestas). Soil pH here was mildly to moderately alkaline with high available phosphorous and magnesium, all being significantly different ($p < 0.0001$) from other sites; whereas the level of available sodium was significantly lower ($p < 0.0001$). Although all sites had relatively high levels of available calcium, site 4, was significantly higher ($P < 0.0001$).

DISCUSSION

The thorn-scrub vegetation of CWMA and surrounding area was representative of that associated with the South Texas Plains (South Texas Brush Country or Tamaulipan Brushlands). In much of this rangeland, *Prosopis glandulosa* was the dominant species, with about 10 to 15 other woody or succulent, mostly thorny species, varying in abundance and composition. At the CWMA, honey mesquite was usually the dominant woody species, but, on some sites, other woody legumes were dominant or co-dominant (Johnston 1963, Correll and Johnston 1970).

Honey mesquite-dominated woodland with various species of *Senegalia* and *Vachellia* as co-dominants was the most common plant community on the CWMA. This woodland community, where dominant trees were more than 3 m tall and formed a 26-60 percent canopy, would be equivalent to the Deciduous Woodland, Mesquite-Huisache Series (*Prosopis glandulosa*-*Vachellia farnesiana*) of Diamond et al. (1987) with other thorny legume species replacing huisache. At three study sites, mesquite was dominant with *Vachellia bravoensis* (Tables 2, 3), or *Senegalia roemeriana* (Table 5) as co-dominants.

Vachellia bravoensis, a large shrub only rarely exceeding 3 m in height, was common at the CWMA. Except for the *Vachellia rigidula*/*Senegalia berlandieri* community on the calcareous crests, *V. bravoensis* ranked third to sixth in IV on all sites. *Senegalia roemeriana*, in contrast, was rare at CWMA. We found this species at just one site, where, along with *Prosopis glandulosa*, it dominated the community in a small area less than 75 m across (Table 5). At this site, soil pH was nearly neutral (6.5), and available calcium was relatively high (1101 ppm) (Table 7). Isely (1998) did not report *Senegalia roemeriana* for the South Texas Plains. Correll and Johnston (1970) list the distribution of this species as farther north and west in Texas, being frequent in the Trans Pecos, and infrequent on caliche cuestas in the southern part of the Edwards Plateau.

Vachellia rigidula and *Senegalia berlandieri* dominated limestone ridges and caliche cuestas of the CWMA. This community, in which the dominants were shrubs or small trees 0.5 to 3 m tall, and formed 26 percent or more of the total canopy, would be equivalent to the Deciduous Shrubland, Blackbrush Series (*Vachellia rigidula*) of Diamond et al. (1987). *Vachellia rigidula* appeared to be fairly site specific at the CWMA, ranking first in IV on the calcareous ridge (Site 4) and third in IV on the dry ridge that supported the *Senegalia greggii*/*Opuntia*/*Vachellia rigidula* community (Site 1). This species appears to be well adapted to dry sites with high levels of available calcium. *Senegalia berlandieri*, in contrast, was a component of disturbed habitats at CWMA, often along roadsides, in arroyos, and other disturbed areas, but was an important stand component on the limestone ridge (Site 4). This species is common throughout southern and western Texas and is exceedingly abundant on limestone ridges and caliche cuestas (Correll and Johnston 1970, Isely 1998). At this site,

the alkaline soils (pH of 8.0) and extremely high concentration of available calcium appear beneficial to this species. *Senegalia berlandieri* and *Vachellia rigidula*, act as nurse trees, and facilitate the recruitment of woody and succulent species (Jurena and Van Auken 1998).

Senegalia greggii had a restricted distribution at CWMA (Site 1) being common only on a dry sandy ridge. At this location catclaw acacia was the dominant member of the community, accounting for one-third of the total IV. This community, which is probably maintained by fire, grazing, and sandy soil, should be classified as the Catclaw Acacia Series, Deciduous Scrubland (*Senegalia greggii*). The woody vegetation at this site was short with only a few individuals being more than 2 m tall (Table 1). Canopy cover was estimated at 25 to 30 percent, and the scattered woody shrubs were mostly small and compact. No individuals of *S. greggii* were more than 2 m tall, and most were less than 1 m tall. Many were in clumps 1-2 m in diameter; the numerous, upright, bushy stems being connected by underground roots or stems.

Of the thorny species of woody legume species found at the CWMA, *Vachellia farnesiana* (huisache) was not common. This species was rare along roadsides and near arroyos, mostly in heavily disturbed habitats. *Vachellia farnesiana* is common throughout the South Texas Plains, but usually in more mesic habitats (Correll and Johnston 1970), where it is a co-dominant of the Deciduous Woodland, Mesquite-Huisache Series of Diamond et al (1987).

Though some of the acacia species at CWMA have distinct habitat preferences, the reasons for their continued importance, and the continued prevalence of thorn-scrub woodland communities they dominate is not entirely clear. Most information suggests that overgrazing and fire suppression were the primary causes of this encroachment (Van Auken 2000). When much of the South Texas Plains was covered with open savanna containing a dense groundcover of grasses and forbs, wildfires were frequent and of sufficient intensity to prevent encroachment by native woody species. However, overgrazing by livestock reduced the fuel load. At the same time, fire suppression allowed for a significant decrease in fire frequency creating ideal conditions for the rapid explosion of native invaders.

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Table 1. Density (#/ha) by height classes (m), mean crown cover (m²), relative frequency, relative crown cover, and importance value (IV) of the species encountered at the *Senegalia greggii*/*Opuntia/Vachellia rigidula* Site (site 1) 28°N 20' 22", 99°W 22' 46", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Total	Mean		Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+	Cover		Den.	Cover			
<i>Senegalia greggii</i>	480	130	--	--	610	1.62	36.7	31.9	68.6		
<i>Opuntia engelmannii</i>	170	77	--	--	247	1.71	14.8	13.7	28.5		
<i>Vachellia rigidula</i>	30	147	10	3	190	2.61	11.5	16.0	27.5		
<i>Opuntia leptocaulis</i>	157	63	--	--	220	0.74	13.2	5.2	18.4		
<i>Vachellia bravoensis</i>	87	43	--	--	130	1.88	7.8	7.9	15.7		
<i>Condalia hookeri</i>	7	27	13	3	50	5.75	3.0	9.3	12.3		
<i>Colubrina texensis</i>	13	43	--	--	56	2.40	3.4	4.4	7.8		
<i>Prosopis glandulosa</i>	13	13	--	3	29	2.41	1.8	2.3	4.1		
<i>Celtis pallida</i>	30	13	--	--	43	0.96	2.6	1.3	3.9		
<i>Forestiera angustifolia</i>	--	7	3	--	10	6.77	0.6	2.2	2.8		
<i>Zanthoxylum fagara</i>	7	13	--	--	20	1.99	1.2	1.3	2.5		
<i>Diospyros texana</i>	3	13	3	3	22	1.26	1.4	0.9	2.3		
<i>Senegalia berlandieri</i>	--	--	3	3	6	5.41	0.4	1.2	1.6		
<i>Karwinskia humboldtiana</i>	--	10	--	--	10	1.21	0.6	0.4	1.0		
<i>Bumelia celastrina</i>	--	--	3	--	3	7.07	0.2	0.8	1.0		
<i>Lycium berlandieri</i>	--	7	--	--	7	2.34	0.4	0.5	0.9		
<i>Schaefferia cuneifolia</i>	--	3	--	--	3	5.31	0.2	0.6	0.8		
<i>Ziziphus obtusifolia</i>	3	--	--	--	3	0.95	0.2	0.1	0.3		
Totals	1000	609	35	15	1659	52.39	100.0	100.0	200.0		

Table 2. Density (#/ha) by height classes (m), mean crown cover (m²), relative frequency, relative crown cover, and importance value (IV) of the species encountered at the *Prosopis glandulosa* /*Opuntia/Vachellia bravoensis* Site (site 2) 28°N 18' 09", 99°W 21' 40", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Total	Mean Cover	Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+						
<i>Prosopis glandulosa</i>	90	83	43	243	459	15.16	30.6	58.4	89.0	
<i>Opuntia engelmannii</i>	326	103	7	--	436	5.42	29.0	19.8	48.8	
<i>Vachellia bravoensis</i>	87	137	33	17	274	3.36	18.2	7.7	25.9	
<i>Ziziphus obtusifolia</i>	37	130	47	3	217	5.08	14.4	9.2	23.6	
<i>Colubrina texensis</i>	23	37	3	--	63	4.09	4.2	2.2	6.4	
<i>Aloysia gratissima</i>	3	27	--	--	30	2.18	2.0	0.6	2.6	
<i>Diospyros texana</i>	--	--	--	7	7	13.89	0.4	0.8	1.2	
<i>Condalia hookeri</i>	--	--	--	3	3	30.19	0.2	0.8	1.0	
<i>Celtis pallida</i>	--	--	3	3	6	7.24	0.4	0.4	0.8	
<i>Opuntia leptocaulis</i>	--	7	--	--	7	1.06	0.4	0.1	0.5	
<i>Forestiera angustifolia</i>	--	3	--	--	3	0.13	0.2	--	0.2	
Totals	566	527	136	276	1505	87.80	100.0	100.0	200.0	

Table 3. Density (#/ha) by height classes (m), mean crown cover (m²), relative frequency, relative crown cover, and importance value (IV) of the species encountered at the *Opuntia/Prosopis glandulosa/Vachellia bravoensis* Site (site 3) 28°N 18' 05", 99°W 21' 29", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Total	Mean Cove r	Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+						
<i>Opuntia engelmannii</i>	480	205	--	--	685	4.26	32.6	23.4	56.0	
<i>Prosopis glandulosa</i>	70	55	5	110	240	21.52	11.4	41.3	52.7	
<i>Vachellia bravoensis</i>	115	205	30	5	355	3.67	16.9	10.4	27.3	
<i>Aloysia gratissima</i>	25	150	70	5	250	3.35	11.9	6.7	18.6	
<i>Colubrina texensis</i>	110	145	--	--	255	2.78	12.1	5.7	17.8	
<i>Bumelia celastrina</i>	10	25	20	30	85	7.54	4.1	5.1	9.2	
<i>Diospyros texana</i>	10	10	15	15	50	6.37	2.4	2.5	4.9	
<i>Forestiera angustifolia</i>	70	5	--	--	75	0.34	3.6	0.2	3.8	
<i>Celtis pallida</i>	10	15	5	5	35	5.54	1.7	1.6	3.3	
<i>Ziziphus obtusifolia</i>	5	20	--	--	25	9.65	1.2	1.9	3.1	
<i>Zanthoxylum fagara</i>	--	--	5	5	10	12.58	0.5	1.0	1.5	
<i>Opuntia leptocaulis</i>	20	--	--	--	20	0.24	1.0	0.1	1.1	
<i>Schaefferia cuneifolia</i>	--	5	--	--	5	1.33	0.2	0.1	0.3	
<i>Condalia hookeri</i>	--	5	--	--	5	0.79	0.2	--	0.2	
<i>Lycium berlandieri</i>	5	--	--	--	5	0.39	0.2	--	0.2	
Totals	930	845	150	175	2100	80.35	100.0	100.0	200.0	

Table 4. Density values at the *Vachellia rigidula*/Senegalia berlandieri Site (site 4) 28°N 18' 56", 99°W 20' 44", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Mean Cover	Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+	Total				
<i>Vachellia rigidula</i>	190	285	120	60	655	4.20	20.2	26.6	46.8
<i>Senegalia berlandieri</i>	55	105	110	90	360	9.55	11.1	33.2	44.3
<i>Opuntia engelmannii</i>	335	100	--	--	435	3.17	13.4	13.3	26.7
<i>Portieria angustifolia</i>	510	70	--	--	580	0.64	17.9	3.6	21.5
<i>Schaefferia cuneifolia</i>	380	20	--	--	400	0.64	12.3	2.4	14.7
<i>Lycium berlandieri</i>	45	120	25	--	190	3.03	5.8	5.6	11.4
<i>Prosopis glandulosa</i>	10	--	15	15	40	18.51	1.2	7.2	8.4
<i>Ziziphus obtusifolia</i>	40	75	5	--	120	2.64	3.7	3.1	6.8
<i>Opuntia leptocaulis</i>	120	30	--	--	150	0.90	4.6	1.3	5.9
<i>Forestiera angustifolia</i>	90	45	--	--	135	0.76	4.2	1.0	5.2
<i>Karwinskia humboldtiana</i>	25	15	--	--	40	1.72	1.2	0.7	1.9
<i>Ephedra antisyphilitica</i>	25	10	--	--	35	1.17	1.1	0.4	1.5
<i>Celtis pallida</i>	20	15	--	--	35	1.21	1.1	0.4	1.5
<i>Leucophyllum frutescens</i>	5	15	5	--	25	2.11	0.8	0.5	1.3
<i>Koeberlinia spinosa</i>	10	--	--	--	10	4.42	0.3	0.4	0.7
<i>Zanthoxylum fagara</i>	--	5	--	5	10	1.16	0.3	0.1	0.4
<i>Diospyros texana</i>	5	--	--	--	5	2.01	0.2	0.1	0.3
<i>Condalia hookeri</i>	--	5	--	--	5	1.13	0.2	0.1	0.3
<i>Bumelia celastrina</i>	--	5	--	--	5	0.50	0.2	--	0.2
<i>Eysenhardtia texana</i>	5	--	--	--	5	0.28	0.2	--	0.2
Totals	1870	920	280	170	3240	59.75	100.0	100.0	200.0

Table 5. Density (#/ha) by height classes (m), mean crown cover (m²), relative frequency, relative crown cover, and importance value (IV) of the species at the *Prosopis glandulosa*/Senegalia roemeriana Site (site 5) 28°N 19° 14', 99°W 24' 50", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Total	Mean Cover	Rel. Den.	Rel. Cover	IV
	4-1	1-2	2-3	3+						
<i>Prosopis glandulosa</i>	36	44	40	84	204	11.83	9.4	35.0	44.4	
<i>Senegalia roemeriana</i>	100	124	48	28	300	2.83	13.9	12.3	26.2	
<i>Opuntia leptocaulis</i>	264	112	--	--	376	1.04	17.4	5.7	23.1	
<i>Opuntia engelmannii</i>	108	64	12	--	184	3.13	8.5	8.4	16.9	
<i>Condalia hookeri</i>	8	48	32	40	128	5.95	5.9	11.0	16.9	
<i>Vachellia bravoensis</i>	64	100	20	--	184	2.75	8.5	7.4	15.9	
<i>Gymnosperma glutinosum</i>	108	68	--	--	176	0.49	8.2	1.3	9.5	
<i>Celtis pallida</i>	12	28	28	8	76	3.90	3.5	4.3	7.8	
<i>Aloysia gratissima</i>	--	48	36	--	84	1.85	3.9	2.3	6.2	
<i>Karwinskia humboldtiana</i>	28	52	8	--	88	1.57	4.1	2.0	6.1	
<i>Lantana horrida</i>	64	20	--	--	84	1.53	3.9	1.9	5.8	
<i>Colubrina texensis</i>	16	28	8	--	52	4.31	2.4	3.2	5.6	
<i>Lycium berlandieri</i>	16	52	--	--	68	1.42	3.1	1.4	4.5	
<i>Schaefferia cuneifolia</i>	12	12	20	--	44	1.71	2.1	1.1	3.2	
<i>Forestiera angustifolia</i>	28	20	--	--	48	0.89	2.2	0.6	2.8	
<i>Diospyros texana</i>	--	4	12	4	20	5.53	0.9	1.6	2.5	
<i>Condalia spathulata</i>	8	16	--	--	24	0.87	1.1	0.3	1.4	
<i>Portieria angustifolia</i>	16	--	--	--	16	0.23	0.8	0.1	0.9	
<i>Vachellia rigidula</i>	--	--	4	--	4	2.01	0.2	0.1	0.3	
Totals	888	840	268	164	2160	53.84	100.0	100.0	200.0	

Table 6. Similarity Index of the five study sites where thorny woody legume species were common, Chaparral Wildlife Management Area, Dimmit and La Salle counties, Texas.

	<i>Site 1</i>	<i>Site 2</i>	<i>Site 3</i>	<i>Site 4</i>
Site 2	69.0			
Site 3	84.8	84.6		
Site 4	78.9	51.6	68.6	
Site 5	70.3	66.7	70.6	61.5

Table 7. Soil texture (% sand, silt, clay), salinity, pH, and macro-nutrients (ppm) of the soils on the study sites where thorny woody legume species were common, Chaparral Wildlife Management Area, Dimmit and La Salle counties, Texas. For pH and macro-nutrients, the range is given with the average value given beneath in parentheses. Different letters indicates significant difference between sites.

	Site 1 (n=15)	Site 2 (n=14)	Site 3 (n=13)	Site 4 (n=18)	Site 5 (n=2)
Texture					
Sand	75%	71%	71%	61%	77%
Silt	12%	12%	16%	20%	8%
Clay	13%	17%	13%	19%	15%
Salinity	none	none	none	none	none
pH	5.1-6.9 (6.1)a	4.6-6.2 (5.3)b	4.5-6.6 (5.2)b	7.7-8.3 (8.0)c	6.3-6.6 (6.5)a
Nitrate-N	4-6 (5.0)a	5-23 (8.6)b	5-9 (6.2)ab	4-9 (5.6)a	5 (5.0)a
Phosphate	1-5 (2.7)a	1-10 (5.6)a	3-8 (5.3)a	5-24 (16.8)b	2-3 (2.5)a
Potassium	151-320 (230.3)a	226-462 (323.9)b	205-364 (266.5)a	198-361 (287.7)ab	301-358 (329.5)ab
Calcium	660-1323 (925.5)a	469-1497 (721.9)a	495-1428 (784.8)a	3515-23291 (13886.8)b	981-1221 (1101.0)a
Magnesium	91-192 (134.6)ab	84-225 (144.5)a	76-145 (107.2)b	146-413 (242.4)c	141-178 (159.5)a
Sodium	99-271 (198.5)a	98-255 (214.9)a	106-258 (189.5)a	32-235 (82.9)b	217-250 (233.5)a
Sulfur	8-26 (18.7)ac	6-29 (22.2)abc	8-30 (18.8)ac	14-47 (26.8)bc	22-24 (23.0)c

**MELAMPODIUM MOCTEZUMUM (ASTERACEAE:
HELIANTHEAE), A NEW SPECIES FROM SONORA, MEXICO**

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ABSTRACT

A new species, *Melampodium moctezumum*, is described from Mpio. de Moctezuma, Sonora, Mexico and Cochise County, southeastern Arizona, U.S.A. It is closely related to the more southwestern *M. cupulatum* but can be distinguished from that taxon by several features, most notably by its broader, coarser, more venose, markedly lobed leaves.

KEY WORDS: Asteraceae, Heliantheae, *Melampodium*, Mexico, Sonora, Arizona.

Routine identifications from Sonora, Mexico and the southwestern U.S.A. have revealed the following novelty:

***Melampodium moctezumum* B. L. Turner, sp. nov.**

Melampodium cupulatum A. Gray similis sed foliis laminis venosis valde lobatis (vs. integris) in petiolos tenues gradatim descrescentibus (vs. sessilibus vel brevipetiolatis) et flosculis radii plerumque 2-6 mm longis (vs 5-10 mm).

Annual herbs 15-45 cm high. **Stems** reddish, erect, 1-4 mm diameter, sparsely pubescent to glabrous. **Larger mid-stem leaves** 4-6 cm long, 1.0-1.8 cm wide; petioles 0.3-2.0 cm long, the blades markedly venose with lobed or irregularly serrate margins, appressed-pilose and punctate-glandular on both surfaces. **Peduncles** 2-7 cm long. **Heads** 6-9 mm high, 8-20 mm wide (with rays expanded). **Outer involucrel bracts** 5, broadly ovate, ca 5 mm high, connate for 2/3-4/5 their length,

their margins scarious. **Receptacle** conical, ca 6 mm high, 2 mm wide. **Pales** oblanceolate, 3-4 mm long with flabellate, fimbriate, yellow-orange apices. **Ray florets** 12-15; ligules "yellow-orange," 2(3)-6(7) mm long, 1-2 mm wide. **Disk florets** numerous; corollas yellow-orange. **Achenes** 3-4 mm long, somewhat falcate laterally, markedly tuberculate, epappose, hoodless.

TYPE: **MEXICO. SONORA:** Mpio. de Moctezuma, 13.7 km NNW of Tepache on road to Moctezuma (Son 117), sparse scrub on basalt cobble plain, 730 m, 17 Aug 2003, *A. L. Reina G. 2003-943* (with T. R. Van Devender and Z. Liu). (Holotype: TEX; isotype: ARIZ).

ADDITIONAL COLLECTIONS EXAMINED (TEX): **MEXICO. SONORA:** Mpio. de Moctezuma, 18.1 km SSE of Moctezuma, "locally common annual," 14 Aug 2006, *Reina 2006-486*; 21.4 km SSE of Moctezuma, 697 m, 19 Oct 2003, *Van Devender 2003-1228* (with A. L. Reina); 19.6 km SSE of Moctezuma, on road to Tepache, 19 Oct 2003, *Van Devender 2003-1230*; 18.9 km SSE of Junction with Moctezuma-Huasabas Hwy on road to Tepache, 635 m, 14 Sep 2006, *Van Devender 2006-802*.

UNITED STATES: ARIZONA. Cochise Co.: W side of Peloncillo Mts., across road from Cottonwood Creek Cemetery, 12 Sep 1987, *Kluever s. n.* (ARIZ); W side of Peloncillo Mts., across road from Cottonwood Cemetery, 7.5 mi E of Guadalupe Canyon turnoff, 4550 ft, 9 Aug 1990. *Warren 90-16* [with Kluever] (ARIZ, ASU, TEX)).

Van Devender (pers. comm.) has provided the following comments regarding its habitat at the type locality and surroundings:

The new species is found in the basalt lava plains along Sonora Highway 117 between Moctezuma and Tepache in the Municipio de Moctezuma. Lava plain starts at 17.3 km SSE of Moctezuma and extends 12.6 km before dropping into the Rio Tepache about 7 km N of Tepache. The lava plains are a very unusual habitat with medium to small black basalt rocks in a matrix of dark brown, clay rich soil. The vegetation is foothills thornscrub, although the plants are often widely spaced and of smaller stature compared to the same vegetation on rocky slopes. Dominants include various

legumes (*Acacia cochliacantha*, *A. farnesiana*, *A. occidentalis*, *Haematoxylon brasiletto*, *Parkinsonia praecox*, and *Prosopis velutina*), tree ocotillo (*Fouquieria macdougalii*), guayacan (*Guaiacum coulteri*), organpipe cactus (*Stenocereus thurberi*), and a prickly pear (*Opuntia* sp.). In the summer rainy season, the combination of rocky substrate and rich soil yields a profusion of annual and perennial herbs. The basalt lava flowed south and west from Cerro Blanco about 500,000 years ago into the late Pleistocene (Mead et al. 2006), providing a maximum time for the isolation of the new species.

Melampodium moctezumum is seemingly closely related to both *M. appendiculatum* and *M. cupulatum* but differs in having leaves petiolate with markedly venose blades, their margins lobate to irregularly serrate (vs sessile, weakly venose and margins entire). The characters called to the fore and its relative geographical isolation suggest specific status for the taxon; at least no intermediates between the several taxa were detected among the numerous specimens of *M. appendiculatum* and/or *M. cupulatum* on file at LL, TEX. Distribution of these taxa is shown in Figs. 2 and 3.

Collections of *M. moctezumum* from the U.S.A. have somewhat larger heads with longer rays but otherwise appear very similar to the Mexican collections.

According to its collectors, the florets of *M. moctezumum* are "orange-yellow" and the plants are said to be locally "abundant." The species is named for the Municipio of Moctezuma, where first collected.

ACKNOWLEDGEMENTS

I am grateful to ARIZ and ASU for the loan of specimens; to my colleague, Guy Nesom, for the Latin diagnosis and reviewing the paper; and to my colleague Tom Van Devender for his insistence that the taxon had some sort of biological reality.

LITERATURE CITED

Mead, J.I. et al. 2006. Tropical marsh and savanna of the late Pleistocene in northeastern Sonora. Southwestern Naturalist 51: 226-239.



Fig. 1. Holotype of *Melampodium moctezumum*.

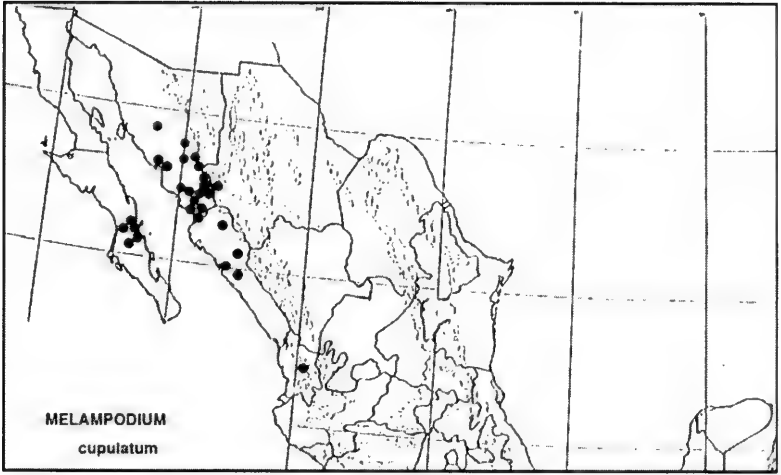


Fig. 2. Distribution of *Melampodium cupulatum*.

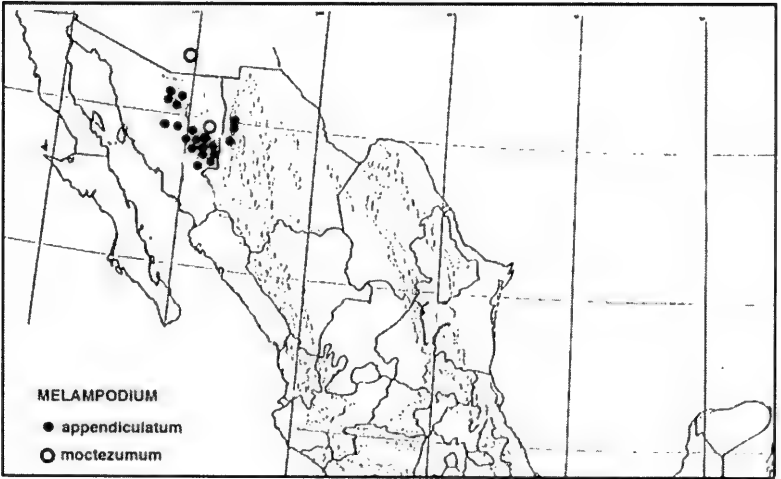


Fig. 3. Distributions of *M. appendiculatum* (closed circles) and *M. moctezumum* (open circles).

JUNIPERUS MARITIMA, THE SEASIDE JUNIPER, A NEW SPECIES FROM PUGET SOUND, NORTH AMERICA

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ABSTRACT

Based on analyses of terpenoids, nrDNA and trnC-D SNPs as well as morphology and ecology, a new cryptic species, *Juniperus maritima*, from the Puget Sound region is recognized. The species, previously included in *J. scopulorum*, is characterized by having seed cones that mature in one year (14-16 months), seeds usually exerted from the cone, obtuse scale leaf tips, usually reniform seed cones, scale leaves overlap less than 1/5 the length, and branchlets smooth and reddish-brown. Called the seaside juniper, it grows on rocky areas (rarely sand dunes) near the sea, in Puget Sound.

KEY WORDS: *Juniperus maritima*, Puget Sound, *J. scopulorum*, *J. virginiana*, cryptic species, terpenoids, nrDNA, trnC-trnD, SNPs.

The smooth leaf margined (40X) junipers in the western hemisphere are very widespread and are composed of the Caribbean *Juniperus*: *J. barbadensis* L., *J. bermudiana* L., *J. gracilior* Pilg., *J. g. var. ekmanii* (Florin) R. P. Adams, *J. g. var. urbaniana* (Pilg. & Ekman) R. P. Adams, *J. lucayana* Britt., and *J. saxicola* Britt. & P. Wilson; the Mexican junipers: *J. blancoi* Mart. var. *blancoi*, *J. b. var. huehuentensis* R. P. Adams, S. Gonzales & M. G. Elizondo, and *J. mucronata* R. P. Adams and the Canada/ United States junipers: *J. horizontalis* Moench, *J. scopulorum* Sarg., *J. virginiana* L. and *J. v. var. silicicola* (Small) E. Murray (Adams, 2004).

Juniperus scopulorum and *J. virginiana* are weedy junipers that occupy millions of acres in the United States and Canada. Adams (1983) analyzed the leaf terpenoids of populations of *J. scopulorum*

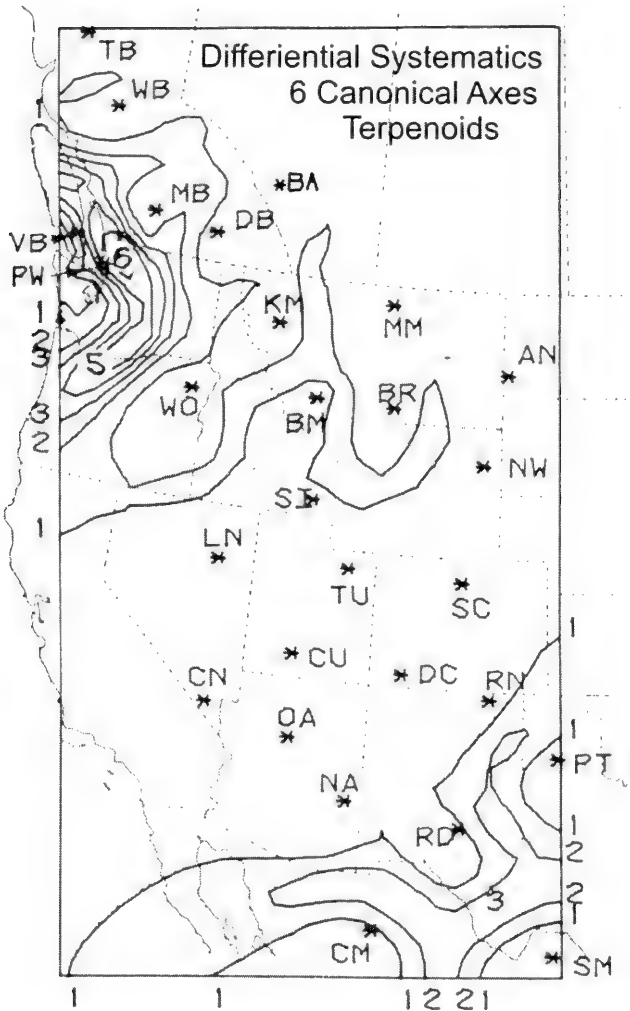


Figure 1. Contoured differentiation based on the first 6 canonical axes using leaf terpenoid data (from Adams, 1983). Areas with close contour lines are areas of high differentiation.

from throughout its range and found that much of the variation within putative *J. scopulorum* was due to differentiation in populations from Puget Sound from the balance of the range of *J. scopulorum* (Fig. 1). The differentiation of the two populations sampled in the Puget Sound (VB, Vancouver Isl., B.C.; PW, Whidbey Isl., WA) accounted for 50.2% of the variance among all 17 populations (Adams, 1983). It was hypothesized that the Puget Sound populations have been genetically isolated from the main, Rocky Mountain populations since the Pleistocene (or earlier) (Fig. 2). Notice (Fig. 2, A) that the Puget Sound

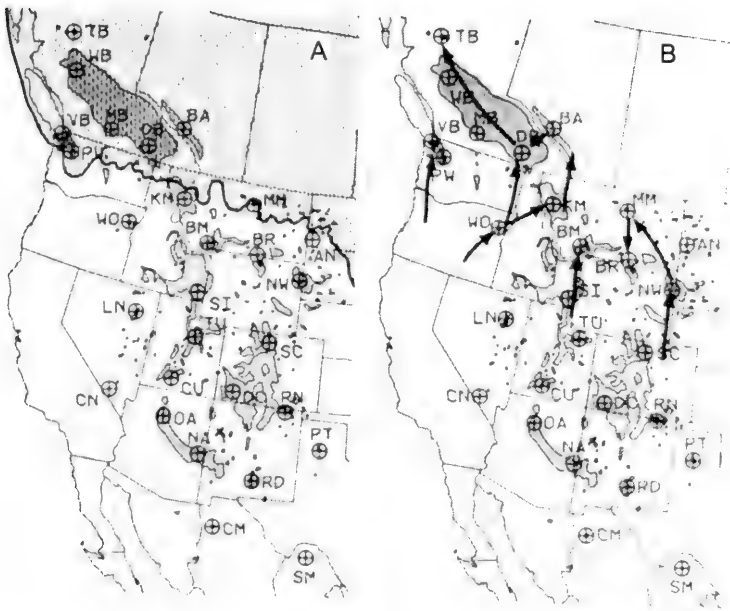


Figure 2. A. Maximal Wisconsin ice cover showing the extinction of local populations of *J. scopulorum*. B. Proposed refugia and recolonization following the Wisconsin (adapted from Adams, 1983).

populations were thought to have retreated to a refugium south of their present distribution and that no common refugia are indicated for the Puget Sound populations and *J. scopulorum* from the Rocky Mountains (Fig. 2 B).

Recently, Schwarzbach et al. (2008), using combined ITS and trnC-D sequence data in their study of the phylogeny of *Juniperus*, found that an individual from Puget Sound came out in the clade with *J. virginiana*, not in the clade with *J. scopulorum*. This prompted the author to reexamine the terpenoid data (Adams, 1983). Figure 3 shows a PCO of the terpenoids. Four distinct entities are resolved: *J. horizontalis*, *J. scopulorum*, *J. virginiana*, and the Puget Sound populations. It should be noted that each stick represents the mean of 15 individuals (a total of 441 individuals analyzed for over 100 terpenoids, with the 30 terpenoids with the highest F ratios utilized for PCO). These data are robust and must be given significant weight in assigning the taxonomic position of the Puget Sound populations.

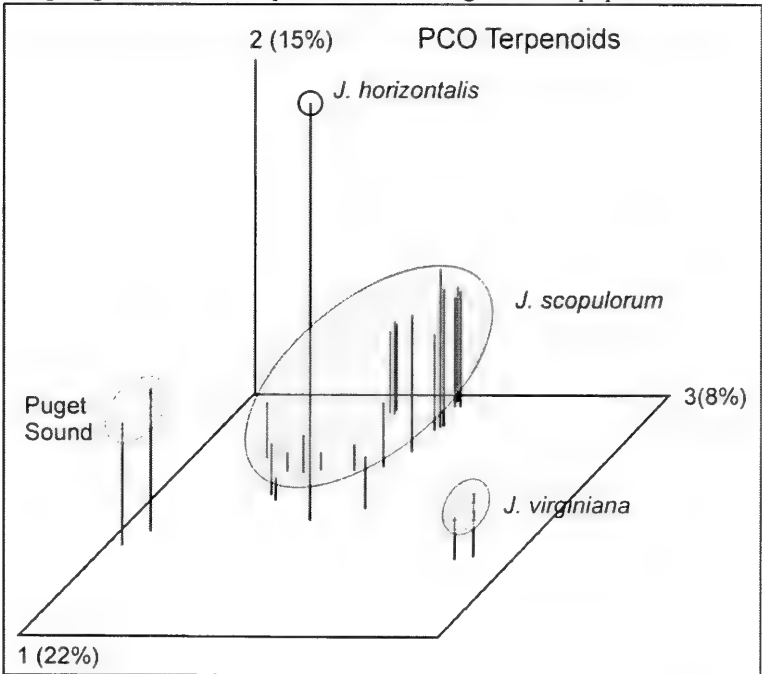


Figure 3. Principal coordinate ordination (PCO) utilizing terpenoid data from Adams (1983). Each of the sticks represents population mean of 15 individuals, except for the 2 Puget Sound populations that contained 8 and 13 samples.

Because the ITS and trnC-D sequence data (Schwarzbach et al. 2008) fails to support a conspecific status of the Puget Sound population and *J. scopulorum*, it seemed prudent to make additional collections and analyze additional samples using several DNA methods.

The purpose of this paper is to compare ITS and trnC-D SNPs (single nucleotide polymorphisms) analyses of junipers from Puget Sound with *J. scopulorum* and *J. virginiana* with previous terpenoid, morphological and ecological data to determine the taxonomic status of the Puget Sound (seaside) juniper.

MATERIALS AND METHODS

Specimens used in this study are shown in table 1. Voucher specimens are deposited at BAYLU herbarium Baylor University.

One gram (fresh weight) of the foliage was placed in 20 g of activated silica gel and transported to the lab, thence stored at -20° C until the DNA was extracted. DNA was extracted using the Qiagen DNeasy mini kit (Qiagen Inc., Valencia CA).

SNPs obtained from DNA sequencing

ITS and trnC-trnD amplifications were performed in 50 µl reactions using 10 ng of genomic DNA, 3 units Qiagen Taq polymerase, 5 µl 10x buffer (final concentration: 50 mM KCl, 10 mM Tris-HCl (pH 9), 0.01% gelatin and 0.1% Triton X-100), 1.75 mM MgCl₂, 20 µl Q solution (2X final), 400 µM each dNTP, 1.8 µM each primer and 4%(by vol.) DMSO.

Primers (5'-3'):

ITS: ITSA = GGA AGG AGA AGT CGT AAC AAG G;

ITSB = CTT TTC CTC CGC TTA TTG ATA TG.

ITSA and ITSB primers from Blattner (1999).

trnC-trnD: CDFor: CCA GTT CAA ATC TGG GTG TC

CDRev: GGG ATT GTA GTT CAA TTG GT

CDFor, CDRev primers from Demesure et al. (1995).

CD10F: AAA GAG AGG GAT TCG TAT GGA

CD3R: AAC GAA GCG AAA ATC AAT CA

CD10F and CD3R primers from Andrea Schwarzbach (per. comm.)

The following PCR conditions were used: MJ Research Programmable Thermal Cycler, 45 cycles, 94°C (1 min.), 50°C (1 min.), 72°C (1 min.), with a final step of 72°C (5 min.). The PCR reaction was subjected to purification by agarose gel electrophoresis (1.5% agarose, 45 min.). The nrDNA primers (ITSA, ITSB) produced a band of approx. 1120 bp. The internal trnC-trnD primers, CD10F-CD3R produced a band of approx. 850 bp. In each case the band was excised and purified by use of a Qiagen QIAquick gel extraction kit.

The gel purified DNA band with the appropriate primer was sent to McLab Inc. for sequencing. Sequences for both strands were edited and a consensus sequence was produced using Chromas, version 2.31 (Technelysium Pty Ltd.). Alignments were done using Clustal W and then manually corrected. Indels were coded with a "-" for the first nucleotide and "I" for succeeding nucleotides such that an indel was treated as a single mutation event. Sequences were deposited in GenBank (table 1).

SNPs analyses

Aligned data sets (nrDNA and trnC-trnD) were analyzed by CLEANDNA (Fortran, R. P. Adams) to remove invariant data and nucleotides that only varied by a single polymorphism among individuals. Mutational differences were computed by comparing all SNPs, divided by the number of comparisons over all taxa (= Gower metric, Gower, 1971; Adams, 1975). Principal coordinate analysis was performed by factoring the associational matrix using the formulation of Gower (1966) and Veldman (1967). A minimum spanning network was constructed by selecting the nearest neighbor for each taxon from the pair-wise similarity matrix, then connecting those nearest neighbors as nodes in the network (Adams, et al. 2003).

Table 1. Specimens collected, locations and GenBank accession numbers. All specimens deposited at BAYLU.

Taxon/collection #	Location	GenBank acc.
<i>J. scopulorum</i>		
Adams 10895 -10897	Kamas, UT	ITS: EF608963-65 trnCD EF608988-90
<i>J. virginiana</i>		
Adams 6753-6755	Hewitt, TX	ITS: EF608980-82 trnCD: EF609002-04
Adams 10230 -10232	Knoxville, TN	ITS: EF608973-75 trnCD: EF608996-98
<i>J. v. var. silicicola</i>		
Adams 9186-88	Ft. DeSoto Park, Mullet Key, FL	ITS: EF608977-79 trnCD: EF609009-11
<i>J. maritima</i>		
Adams 11056-58	Brentwood Bay (BB) Vancouver Isl., BC	trnCD: EF608985-87
Adams 11061-63	Cowichan Bay (CB) Vancouver Isl., BC	ITS: EF608968-70 trnCD: EF608992, EF609007, EF608993
Adams 11064	Yellow Point (YP) Vancouver Isl., BC	ITS: EF608984 trnCD: EF608991
Adams 11065-66	Lesqueti Isl. (LS) BC	ITS: EF608967 trnCD: EF609000-01
Adams 11067-68	Friday Harbor (FH) San Juan Isl., WA	ITS: EF608971 trnCD: EF608994-95
Adams 11075	Whidbey Isl. (WI) Cranberry L., WA	ITS: EF608983 trnCD: EF609005
Adams 11076	Fidalgo Isl. (FI) State Park, WA	ITS: EF608972 trnCD: EF609006
Adams 11077-78	Skagit Isl. (SK), WA	ITS: EF608966, EF608976 trnCD: EF609008, EF608999

RESULTS AND DISCUSSION

Analysis of the nrDNA (ITS) sequences revealed little variation among these essentially sibling species. One exception was individual 11076 from Fidalgo Island, WA that had a 67 bp deletion at position 399. The tree appeared to be morphologically similar to other trees in the area and it is assumed that this indel represents a single mutational event. A few single nucleotide mutations were found among individuals and removed from the data. This resulted in 18 SNPs among *J. scopulorum*, *J. virginiana*, *J. v. var. silicicola* and the Puget Sound (seaside) junipers. Factoring the associational matrix resulting in eigenroots that accounted for 55.4%, 24.8%, 6.1%, and 4.2% before they began to asymptote. Notice that two degrees of freedom (axes 1,2) accounted for 80.2% of the variance! This implies that there are only 3 groups ($n-1 = 2$).

Ordination of the individuals (Fig. 4) revealed three groups: *J. scopulorum*, *J. virginiana* (including var. *silicicola*) and the Puget Sound junipers. The minimum spanning network shows (Fig. 4) that the Puget Sound junipers are nearly equidistant between *J. scopulorum* (5 bp) and *J. virginiana* (4 bp). The ITS SNPs, although not plentiful, are fully congruent with the terpenoid and morphological data.

Analysis of the trnC-trnD cpDNA sequences proved to be difficult. Numerous indels and single mutational events were present. Figure 5 shows the variation encountered in the sequence length (1580 bp). This includes both nucleotide substitutions and single indels. NCBI blast of the region from CD10F to CD3R did not yield information on the nature of the conserved regions where these primers reside.

Each of the *J. v. var. silicicola* samples (3 indivs.) had a 254 bp deletion in the CD10F - CD3R region not found in any other samples. *Juniperus v. var. silicicola* is a coastal juniper from the sand foredunes of se United States. Analyses including *J. v. var. silicicola* samples in the data set showed it to be quite differentiated in its trnC-trnD sequence, so these were removed from further consideration for the trnC-trnD data.

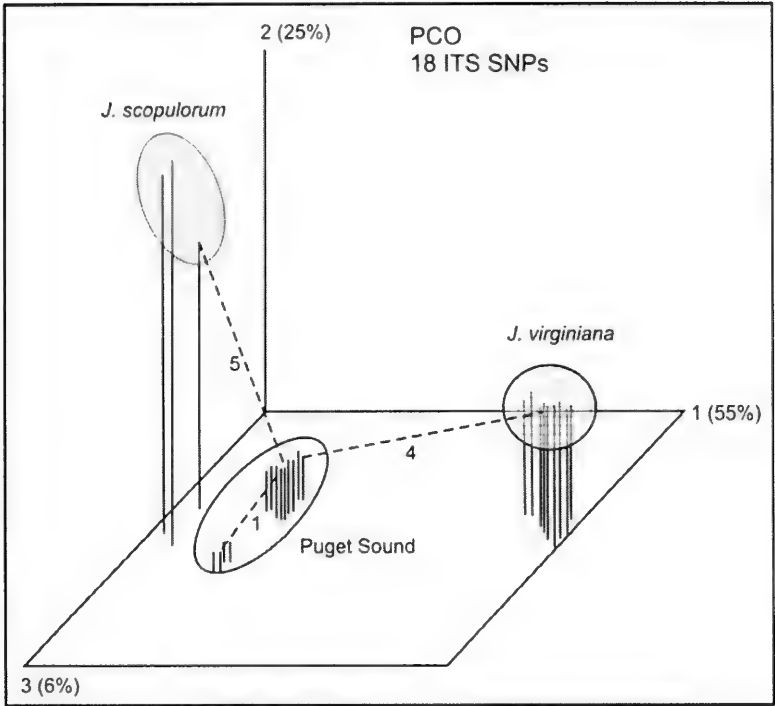


Figure 4. PCO ordination of based on 18 SNPs of ITS sequence data.

Juniperus scopulorum (3 indivs.) each had a 4 bp (TATA) insert at position 986, not shared with either *J. virginiana* or the Puget Sound junipers. *Juniperus virginiana* (6 indivs.) had an insert of 4 bp (TTTT) at position 262 not found in any other samples.

Four trees in the study had a 4 bp indel at position 712. These trees were from Friday Harbor (TATT, TATT), Fidalgo Island (TAAT) and Whidbey Island (TAAT). The population from Fidalgo Island is only about 10 km north of the Whidbey Island population. However, the Skagit Island population, only 5 km east of the Whidbey Island population, did not have the indel.

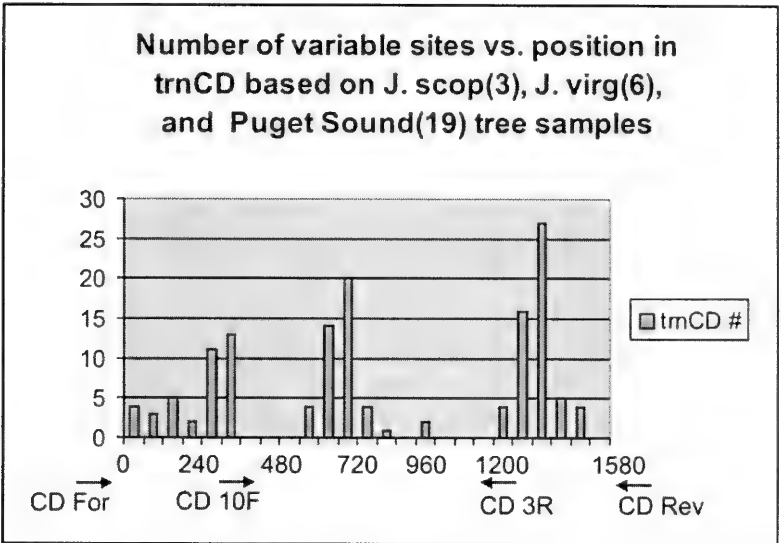


Figure 5. Frequency distribution of variable sites in the trnC-trnD region.

Principal Coordinates analysis of the association measures using 78 polymorphic SNPs from the trnC-trnD sequences produced three eigenroots before the eigenroots began to asymptote. These three eigenroots accounted for 25.8%, 14.6% and 11.6% of the variation among individuals. Three eigenroots implies that 4 groups are present in the data. However, ordination (Fig. 6) shows two principal groups: *J. scopulorum* and *J. virginiana* / Puget Sound individuals.

These two groups (axis 1) accounted for 26% of the variation among the individuals. There is a partial separation of the *J. virginiana* individuals (V, fig. 6), but it is incomplete. Considerable variation exists among the Puget Sound individuals, but a detailed examination failed to correlate their ordination with geography.

The trnC-trnD data seem similar to the trnL-trnF cp data from *J. occidentalis* Hook. var. *australis* (Vasek) A. & N. Holmgr.

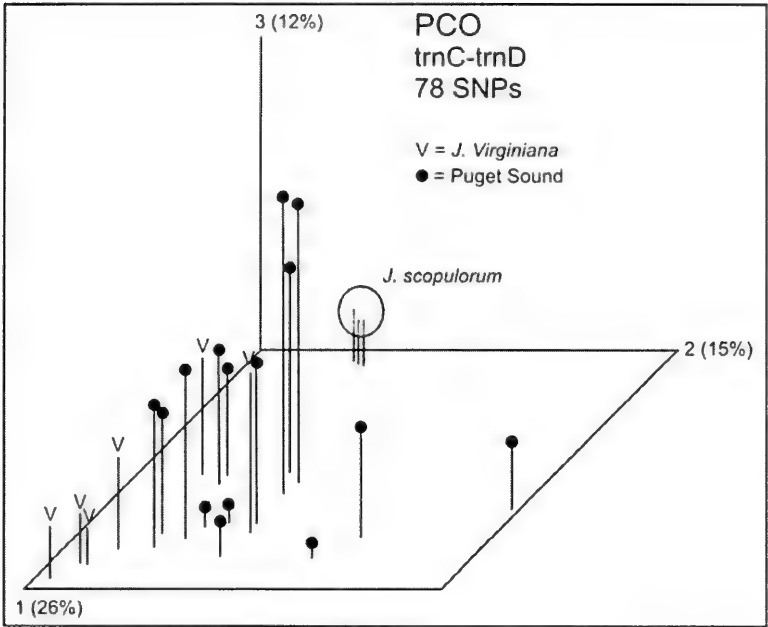


Figure 6. PCO ordination of *J. scopulorum*, *J. virginiana* and Puget Sound individuals based on 78 SNPs.

(now *J. grandis* R. P. Adams) and *J. osteosperma* (Torr.) Little from Terry et al. (2000). The latter workers found that a cp haplotype, a mutation at position 436 (at the 3' position of the *Tru 9I* restriction site), was invariant within *J. o. var. australis* (*J. grandis*), but varied clinally (with some notable exceptions) from the area of sympatry (w. Nevada) to Utah. However, several populations in UT, CO and WY, the farthest removed from *J. o. var. australis*, had high frequencies of the cp haplotypes. They considered three explanations: inheritance of ancestral polymorphism, intraspecific polymorphism, and hybridization between *J. occidentalis* var. *australis* and *J. osteosperma*. Of course, Vasek (1966) has already made a strong case for hybridization between these taxa based on morphological data. Terry et al. (2000) opted for the hybridization (and introgression) as the explanation with gene flow (via pollen) from *J. o. var. australis* to typical *J. osteosperma*. This

would be in agreement with the transfer of cpDNA via pollen from *J. o. var. australis*, but not the reverse flow. However, one can not rule out the persistence of ancestral cpDNA as another explanation. In any case, analysis of the trnL-trnF sequences gave a picture of incomplete separation between these morphologically well defined *Juniperus* species.

This appears to be the case for trnC-trnD cp data for *J. virginiana* and the Puget Sound junipers. The trnC-trnD PCO (Fig. 6) stands in contrast to the terpenoid data (Fig. 3) and ITS data (Fig. 4).

A striking aspect of the Puget Sound, seaside junipers is their habitat. They all grow at the seaside (or lakeside) on granite or sand (Fig. 7). This is a very different kind of habitat than that found in *J. scopulorum* and *J. virginiana*. *Juniperus scopulorum* grows on dry, rocky mountainous soils. *Juniperus virginiana* is more cosmopolitan, growing in limestone areas as well as deep soils. Both *J. scopulorum* and *J. virginiana* are weedy junipers that invade old fields and disturbed roadsides. In contrast, the seaside juniper is not weedy and usually appears as if it is relictual (i.e., older trees, with few or no seedlings). The Puget Sound juniper's habitat seems to be very restricted and has only been collected in a few locations (Fig. 7). The Puget Sound climate is very different than the Rocky Mountain or the eastern US climates, having a mild, wet regime. In short, the Puget Sound juniper has evolved physiological genes to facilitate its growth in such an environment.

Is the Puget Sound, juniper a distinct species? Ownbey (1950) has provided us with a very practical species definition. He emphasizes that species are natural groups, characterized by: 1. a combination of distinctive morphological features (and/or chemical/ DNA features, *my addition*); 2. The taxa are reproducing under natural conditions; and 3. There is not free gene exchange between the taxa concerned.

How can we apply the 'Ownbey species concept' to the present taxonomic problem?

1. The taxa are natural groups, characterized by a combination of distinctive morphological features (and/or chemical/ DNA features, *my addition*).

Recently, Issakainen (1999) wrote "We easily forget that different parts of a single organism's genome may have a different evolutionary history." We might modify his statement to read "different parts of the genome may be under differential selection pressure." We, as taxonomists, have relied on morphology as the deciding data for the recognition of species, varieties, and indeed most of our nomenclatural taxa. This is only natural, as the morphology is "what you see." The morphology is a product of the plant's genes plus the environment. The genes are composed of DNA and in tomato the genome size is about 700,000,000 base pairs (bp) versus 4,000,000 bp in *E. coli* and 230,000,000,000 bp in man (Brown, 1986) and these appear to represent 20,000 to 30,000 genes (Somerville and Somerville, 1999). The amount of the genome that we see in the morphology is not known precisely. But, in an interesting study of two species of goldenrod (*Solidago*), Charles and Goodwin (1953) made the following estimates for the minimum number of genes for several key taxonomic characters:

<u>Character</u>	<u>Minimum number of genes</u>
leaf margins: entire vs. serrate	7
leaf surface: glabrous to pubescent	6
leaf thickness	6
basal leaves: length	8
leaf cuticle: degree of sculpturing	5
stomatal apparatus: length	3

Thus, for these 6 key characters separating *S. sempervirens* and *S. rugosa*, they estimated that the species differed by a minimum of 35 genes. How many DNA base pairs this represents is unknown.

Irving and Adams (1973) applied these methods to estimate the minimum number of genes controlling monoterpenes in *Hedeoma*. They found that 20 monoterpenoids were inherited by from 1 to 7 genes, with an average of 1.95 genes per compound. Thus, these 20 monoterpenoids appeared to be inherited by a minimum of 39 genes. Again a small sample of the total genome.

If *Solidago* and *Hedeoma* have 20,000 to 30,000 genes as commonly expected in plants (Somerville and Somerville, 1999), then the *Solidago* morphology and *Hedeoma* monoterpenes are small samples of these genomes. Somerville and Somerville (1999) show that, in *Arabidopsis*, 54% of the genes can be assigned a known function. Although they did not show morphology *per se*, they did show that of the genes with known function, approximately 5% control cell structure and 6% code for secondary metabolism in *Arabidopsis*.

For the case of the seaside (Puget Sound) juniper, the taxon is distinct from both *J. scopulorum* and *J. virginiana* in its terpenoids and ITS sequences. It is also differentiated in its physiology, enabling it to grow in a habitat foreign to both *J. scopulorum* and *J. virginiana*. Clearly the Puget Sound juniper (seaside juniper) is characterized by a combination of terpenoid, ITS DNA and physiological traits, these independent of those relating to morphology.

2. The taxa are reproducing themselves under natural conditions.

Of immediate concern upon examining the Puget Sound juniper, was that it might be an escaped cultivar of *J. virginiana*. *Juniperus virginiana* was (and continues to be) commonly cultivated by settlers moving westward in the United States. It is a very common ornamental tree found at homesteads, cemeteries and parks in the central and western United States. Several groups of early immigrants came to the Pacific Northwest. Likely, the earliest were the Spanish and Portuguese sailors and explorers. It is extremely unlikely that these explorers, who apparently did not build permanent settlements in the Pacific Northwest would have brought *J. virginiana* for cultivation. The most likely group of settlers were the Anglos from the eastern United States who used the Oregon Trail to migrate to the Pacific Northwest between 1841 and 1869. Apparently, Hudson Bay trappers and Russians visited Puget Sound as early as 1830 (Steve Erickson, pers. comm.). So any junipers older than 176 years old (in 2006) would have pre-dated the earliest known Anglo settlers.

Although juniper growth rings are not reliable in desert regions due to lack of rings in dry years, the precipitation of Puget Sound is very consistent with a wet season each year. Therefore, the

growth rings should be a very good measure of the age of junipers in the area. In 2006, the author cored several very large junipers in Puget Sound. Table 2 shows the growth rings varied from 86 to 210 rings. A linear exploitation gives values over 400 yr. Most of the cores had uniform ring spacing for the region scored, except for 11070, Lesqueti

Table 2. Estimated ages and sizes of junipers in the Puget Sound area.

<u>Tree and Location</u>	<u>trunk radius</u>	<u># rings counted</u>	<u>% radius counted</u>	<u>approx. age</u>
11065, Yellow Point, BC	22.8 cm	128 in 22.8 cm	100%	128 yr.
11061, Cowichan Bay, BC	35.5 cm	167 in 20.8 cm	58.6%	> 167 yr. ca. 285 yr.
11065, Lesqueti Island, BC	35 cm	163 in 29 cm	82.9%	> 163 yr. ca. 196 yr.
11070, Lesqueti Island, BC	64 cm	210 in 11cm	17.2%	> 210 yr ca. 400- 500
11067, Friday Harbor, San Juan Isl.	40 cm in 24 cm	86	60%	> 86 yr. ca. 140 yr.
11072, English Camp, San Juan Isl.	106.7	92 in 18 cm	33.7%	> 92 yr. ca. 273 yr.
11077, Skagit Island, WA	118.6 cm	140 in 20 cm	33.7%	>140 yr. ca. 415 yr.

Island, that had very compressed rings in the 11 cm that was scoreable. It is clear that the seaside juniper predates Anglo settlement and the taxon is naturally occurring. In addition, high genetic variation between the seaside junipers, argues against the introduction by settlers. Recent introduction would have produced a genetic bottleneck effect that is not present in these populations. Although there is almost universal damage to the seed cones by insects, resulting in exserted seeds, the seaside juniper is reproducing itself under natural conditions.

3. There is not free gene exchange between the taxa.

The nearest population of *J. scopulorum* is about 140 km east of Puget Sound at Ross Lake, BC. The nearest population of *J. virginiana* is in central Nebraska, several thousand km to the east. It seems unlikely that gene flow is currently occurring between the seaside juniper and either *J. scopulorum* or *J. virginiana*.

In summary, the seaside juniper of Puget Sound is an entity that is genetically defined (primarily by its chemistry and DNA sequences), reproducing itself under natural conditions and is not interbreeding with other juniper species. Because of this, I recognize it as a new species as follows:

Juniperus maritima R. P. Adams **sp. nov.** Type: Canada, BC, Vancouver Island, Brentwood Bay, Lat 48° 34.794' N; Long 123° 20.211' W, elev. 5 m., 29 May 2006, R. P. Adams 11056 (HOLOTYPE: BAYLU, ISOTYPE: V).

A *J. scopulorum* similis sed differt strobilis seminiferis in 14-16 menses maturescentibus, seminibus plerumque ex strobilo exsertis, et apicibus foliorum squamiformium obtusis. Differt a *J. virginiana* strobilis seminiferis majoribus (6-8 mm) saepe reniformibus, seminibus plerumque ex strobilo exsertis, foliis squamiformibus minus quam 1/5 longitudinis imbricatis, et ramulis laevibus porphyreis.

This species is similar to *J. scopulorum* but differs in that the seed cones mature in 1 year (14-16 months), seeds are usually exserted from the cone, and the scale leaf tips are obtuse (Table 3). It differs

from *J. virginiana* in having larger seed cones (6-8 mm) that are often reniform, seeds usually exerted from the cone, scale leaves overlap less than 1/5 the length, and branchlets are smooth and reddish-brown.

Table 3. Morphological comparison of *J. maritima*, *J. scopulorum* and *J. virginiana*.

	<i>J. maritima</i>	<i>J. scopulorum</i>	<i>J. virginiana</i>
seed cones mature	1 yr (14-16 mos.)	2 years	1 year
seed cone diam.	6-8 mm	6-9 mm	3-6(7) mm
seed cone shape	globose to reniform	globose to reniform	ovoid
seeds per cone	(1) 2	(1) 2 (3)	1-2 (3)
exserted seeds	ubiquitous	rare	rare
scale leaf overlap	< 1/5 length	< 1/5 length	> 1/4 length
scale leaf tips	obtuse	acute to obtuse	acute
branchlets (6-15mm, diam.)	smooth, reddish-brown	smooth, bright reddish-brown	brown with persistent old leaves

Junipers maritima is known only from the Puget Sound area (Fig. 7). It is usually found in rocky areas, often within meters of the water. However, a population exists on coastal sand dunes near Cranberry Lake, Whidbey Island, WA. No other population has been found on sand, so that site is likely atypical.

Population Status

The Lesqueti Island population (LS, Fig. 7) is in a nature reserve and consists of hundreds of trees. It appears to be a robust population and not threatened.

The Yellow Point population (YP, Fig. 7) at Yellow Point Resort, private land, has tens of trees that appear to be reproducing, but development and human impact at the resort threatens it.

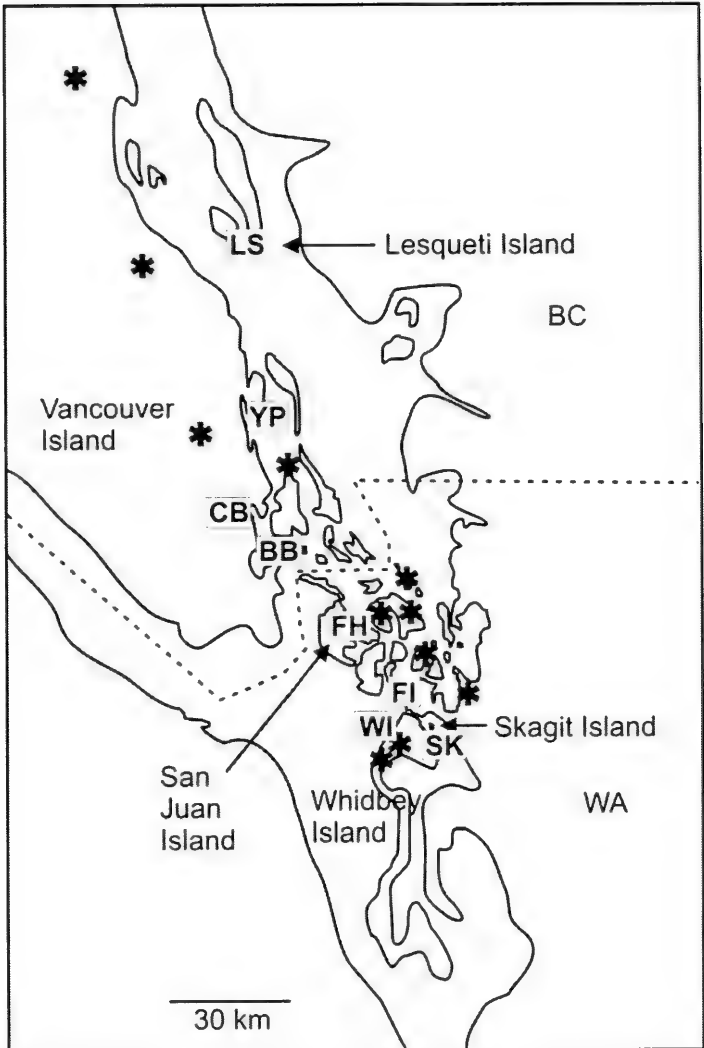


Figure 7. Distribution of *Juniperus maritima* based on Adams field collections (acronyms) and herbarium specimens (stars) from V, WS, and WTU.

The Cowichan Bay population (CB, Fig. 7) is on private land. Approximately 10 trees were seen. No seedlings or saplings were observed.

The Brentwood Bay population (BB, Fig. 7) consists of 6 mature trees on seaside granite. It is at the north end of the Tsartlit Reserve and is protected from development.

The Friday Harbor plants are found chiefly on rocks at the Univ. of Washington Marine Station (8-10 trees) and at the NPS, English Camp (6 old, mature trees) on the opposite side of San Juan Island. These sites are protected from development.

The Fidalgo Island, Washington State Park, Anacortes, WA was the most robust population examined with hundreds of trees of various ages. It is in a protected park and its future looks secure.

On Whidbey Island, a natural population was found on coastal sand dunes in Deception Pass Park (near Cranberry Lake). There are 10-20 trees, all very stunted from constant ocean winds and salt spray. Some age differences were observed. The site is in a park and protected from cutting. However, beach use and a large storm could threaten this population. Several other seaside junipers appear to have been planted at houses in the interior of Whidbey Island and are growing well in deep soil.

About 10 individuals were seen on Skagit Island, ranging from very old to young saplings. Skagit Island is a protected area so, aside from fires, this little population appears stable.

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Park, Whidbey Island, WA; Richard Hebda, Adolf Ceska, and John Pinder-Moss, Royal British Columbia Museum (V); Lance Goldy, Yellow Point Resort, BC; and Drew Chapman and Wade Calder, Lesqueti Island Ecological Reserve, BC. Thanks to Andrea Schwarzbach for trnC-trnD primers CD10F and CD3R sequence information and helpful advice. Thanks to Tonya Yanke for lab assistance. This research supported in part by funds from Baylor University.

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**ERYNGIUM HETEROPHYLLUM (APIACEAE) AND
ERIOCAULON LINEARE (ERIOCAULACEAE) DELETED
FROM THE LOUISIANA FLORA**

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As part of a project to develop a checklist of the Louisiana flora, we are examining species reported to be present in Louisiana and checking them against voucher specimens (MacRoberts and MacRoberts 2005, 2006). In this report, we eliminate two more species from previous Louisiana lists.

***Eryngium heterophyllum*.** Thomas and Allen (1996), Kartesz and Meacham (1999), USDA (2007), and NatureServe (2007) include *Eryngium heterophyllum* Engelm. (syn = *E. wrightii* A. Gray) in Louisiana on the basis of a specimen collected by D.S. and H.B. Correll in St. Martin Parish in 1938 (*Correll & Correll 9448 DUKE*; Correll and Correll 1941). We examined this specimen and found it to be *E. hookeri* Walp. The specimen had been previously annotated as *E. hookeri* by Charles Allen in 2000. *Eryngium heterophyllum* is a western species occurring no closer to Louisiana than west Texas (Turner et al. 2003, Kartesz and Meacham 2005). Kartesz and Meacham (2005) removed the species from the Louisiana flora but without explanation.

***Eriocaulon lineare*.** MacRoberts (1984, 1989), Thomas and Allen (1993), Kartesz and Meacham (1999, 2005), USDA (2007), and NatureServe (2007) include *Eriocaulon lineare* Small in Louisiana on the basis of two specimens (*Correll & Correll 9960 DUKE*; Correll and Correll 1941) and (*Pruski & Urbatsch 2639 NO*). We examined these specimens and found them to be *E. decangulare* L. and *Lachnocaulon anceps* (Walt.) Morong, respectively. The Correll and Correll specimen had already been annotated to *E. decangulare* by Harold Moldenke in 1945 and by Robert Kral in 1992. *Eriocaulon lineare* is found no closer to Louisiana than Alabama (Kral 2000).

Until voucher specimens to support their inclusion are found, these two species should be excluded from the Louisiana flora.

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**A NEW VARIETY OF *ERIOGONUM NUDUM*
(POLYGONACEAE) FROM CALIFORNIA**

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ABSTRACT

Eriogonum nudum var. *psychicola* is established for a population confined to the Antioch Dunes area of Contra Costa Co., California, where it is the primary host for the endangered Lange's metalmark butterfly (*Apodemia mormo langei*). Allied to var. *auriculatum* of western California, it may be recognized by its densely pubescent flowers.

KEY WORDS: *Eriogonum*, *Polygonaceae*, Antioch Dunes, Lange's metalmark butterfly, *Apodemia mormo langei*.

The Antioch Dunes wild buckwheat was mentioned in passing in my *Flora of North America* treatment of *Eriogonum* (Reveal 2005: 313). My failure to christen the taxon earlier was because I misplaced the specimens that now serves as the type after it was sent to Maryland. I am grateful to Dr. Charles Delwiche for relocating the collection.

***Eriogonum nudum* Douglas ex Benth. var. *psychicola* Reveal, var. nov.**

TYPE: UNITED STATES. **California**, Contra Costa Co., U.S. Fish and Wildlife Service's Antioch Dunes National Wildlife Refuge (Stamm Unit) east of Antioch, north of railroad tracks in a former vineyard on fine pale brown sand associated with *Bromus*, *Centaurea*, *Lactuca*, *Vicia*, and *Clarkia*, ca. N38°00'00", W121°47'50", T2N, R2E, sec. 18, 18 Aug 1997, B. Ertter 15766 (Holotype: UC; isotypes: BH, BM, BRY, CAS, GH, MO, NY, OSC, RSA, TEX, US, UTC, WTU).

A var. *auriculato* floribus dense pubescentibus differt.

Plants erect to spreading perennial herbs, (5) 8–15 (20) dm high, glabrous; *leaves* sheathing and occasionally at lower nodes, the leaf-blades 3–7 (9) cm long, 1.5–4.5 cm wide, densely white tomentose abaxially, floccose or glabrous adaxially, the margins undulate-crested; *flowering stems* 2–5 (10) dm long, often stout but not inflated; *inflorescences* cymose, 3–10 (15) dm long, 1–8 dm wide; *involucres* solitary or 2–3 in a cluster, (3) 4–5 mm long, glabrous; *flowers* white to pinkish, 2.5–3.5 mm long, densely pubescent.

Sand dunes in coastal grassland communities known presently only from the Antioch sand dunes area east of Antioch and just south of the San Joaquin River in northern Contra Costa Co., California; 3–15 (20) m elev. Flowering Jul–Oct.

Other specimens seen:

UNITED STATES. **California**, Contra Costa Co.: Antioch sand dunes, 7 Sep 1965, *W. Knight 1175* (CAS); Antioch sand dunes, 17 Aug 1935, *E. Lee & A. Carter 1630* (JEPS), *1631* (JEPS); sand dunes E of Antioch, 8 Oct 1947, *P. A. Munz 12204* (RSA); 2 mi E of Antioch, 19 Aug 1962, *J. Powell 308a* (CAS, MIN, UC); sand dunes E of Antioch, 7 Oct 1951, *P. Rubtzoff 825* (CAS), *826* (CAS); sand dunes E of Antioch, 14 Sep 1954, *P. Rubtzoff 1745* (CAS, UTC), *1746* (CAS); Antioch, 20 Aug 1958, *R. W. Thorp 20* (UC).

Eriogonum nudum var. *psychicola* (from the Greek *psyche*, butterfly, and *-cola*, dweller) is confined to the Antioch sand dunes area in west central California where it is the primary host for the federally endangered Lange's metalmark butterfly (*Apodemia mormo langei* J. A. Comstock). It grows in association with an atypical form of *Lupinus albifrons* Benth., *Gutierrezia californica* (DC.) Torr. & A. Gray, *Quercus agrifolia* Née, several introduced invasive species (*Bromus diandrus* Roth, *Centaurea solstitialis* L., *Lactuca serriola* L.), and two federally protected plants, *Oenothera deltooides* Torr. & Frém. var. *howellii* Munz (Antioch Dunes evening primrose) and *Erysimum asperum* (Nutt.) DC. var. *angustatum* (Rydb.) B. Boivin (Contra Costa wallflower). Historically, the sand dunes have undergone extensive modification due to industrialization to the point that most of the remaining dunes are now confined to the Antioch Dunes National

Wildlife Refuge. Even so, many of the dunes were mined prior to establishment of the Refuge for high-quality sand and requiring the U.S. Fish and Wildlife Service to bring in sand. Also, the wild buckwheat is being "cultivated" on newer dunes to provide additional plants for the butterfly (Nebhan & Buchmann 1996).

Antioch Dunes wild buckwheat is allied to those varieties of *Eriogonum nudum* in California that have leaves with rather strongly crisped leaf margins that sheath up a glabrous flowering stem.

- A. Leaf-blades densely woolly abaxially and grayish tomentose adaxially; involucre 5–10 per cluster; rare, Sierra Nevada, Tulare Co.....var. *murinum*
- AA. Leaf-blades tomentose abaxially, glabrous or nearly so adaxially; involucre solitary or 2–5 per cluster; widespread, coastal ranges.
 - B. Flowers densely tomentose; rare, Antioch Dunes, Contra Costa Co.....var. *psychicola*
 - BB. Flowers glabrous or (rarely) sparsely pubescent; flowering stems slender or more often slightly to strongly inflated; widespread, west central California.
 - C. Flowering stems not strongly inflated; involucre (2) 3–5; flowers white to pink.....var. *auriculatum*
 - CC. Flowering stems strongly inflated; involucre solitary; flowers pale yellow to yellow or white.....var. *indictum*

ACKNOWLEDGEMENTS

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**BIOLOGICAL STATUS AND DISTRIBUTION OF
THELESPERMA FLAVODISCUM (ASTERACEAE:
COREOPSIDEAE)**

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ABSTRACT

The biological status of *Thelesperma flavodiscum* vis-à-vis *T. filifolium* is discussed, along with the habitat proclivities of each. It is concluded that *T. flavodiscum* is a relatively uncommon, well-marked species that mostly occurs in deep sandy soils, while *T. filifolium* is a species of calcareous soils, the two taxa rarely occurring in close proximity. A map showing the distribution of *T. flavodiscum* is provided, along with comments upon new distributional records of the taxon in Arkansas and Louisiana.

KEY WORDS: Asteraceae, *Thelesperma*, Texas, Arkansas, Louisiana.

Strother (2006), in his treatment of *Thelesperma* for the Flora of North America maintained the species, *T. flavodiscum* (Shinners) B.L. Turner, but with the admonition, "Differences between *Thelesperma flavodiscum* and *T. filifolium* are subtle; they may be better treated as one species." The distinctions between the latter two taxa are scarcely subtle, as well documented by Melchert (1963), whose doctoral thesis on *Thelesperma* (albeit unpublished) was not cited by Strother. The latter author does, however, point out the major differences that mark the species, including that of habit (robust plants mostly 0.5-1.5 m high, vs 10-40 cm) and habitat (deep sandy soils vs clays or silty-clays). Observation of plants in the field by the present author show that the two taxa rarely, if ever, grow intermixed, although their distributions are partially sympatric, largely because of the disjunct distribution of *T. filifolium* populations in clay outliers within the sandy forest lands of eastern Texas, as correctly noted by Melchert

(1963). At the time of Melchert's study, relatively few collections of *T. flavodiscum* were available in herbaria, and his distribution map of the taxon was necessarily limited. I include here (Fig. 1) a map showing the distribution of *T. flavodiscum*, this based upon the cited specimens of Melchert (1963) and plants assembled at LL, TEX since his study.

It will be noted, as mapped by the present author, that *T. flavodiscum* is now known from the closely adjacent states of ARKANSAS (Hempstead County, *Kral 65476*, TEX; Miller County, *Thomas et al. 151,334*, TEX) and LOUISIANA (Caddo Parish, *Thomas et al. 120,635*, TEX). The Hempstead Co. collection from Arkansas was reportedly obtained from a "chalk outcrop," but perhaps not. As already noted, chalk or calcareous outcrops in Texas harbor plants of *T. filifolium*, these growing within the range of *T. flavodiscum*, presumably in close proximity of each other. It is possible that hybrids between these very different taxa occur upon occasion in such areas. Indeed, the cauline leaves of occasional plants of *T. filifolium* in eastern Texas (and eastern Oklahoma) resemble those of *T. flavodiscum*, but the flowering material of the former are typical of *T. filifolium*, possessing sulphur-yellow rays (vs yellow, the disc florets brownish to purplish-brown (vs yellow), not to mention the habital differences.

Finally, it should be noted that *Thelesperma flavodiscum* is relatively rare in eastern Texas, and presumably becoming more so. Attempts to collect again from two previously collected populations of the species in Wilson County Texas (Melchert, in 1962; Turner, in 1965) proved futile in the spring of 2007. Indeed, attempts to re-collect from a population of the species obtained in 1988 from Medina County by Orzell & Bridges (6728 TEX) also proved profitless, this from a well documented locale (roadside park along IH 35 in Carrizo sands). Perhaps *T. flavodiscum* was rare at these several sites to begin with, but I suspect that continual mowing of the roadsides by the Highway Dept. of the State of Texas over the years concerned has been a factor in their disappearance.

ACKNOWLEDGEMENTS

I am grateful to my son Matt Turner and his partner, Paul Waller, for assisting me with field work during the spring of 2007.

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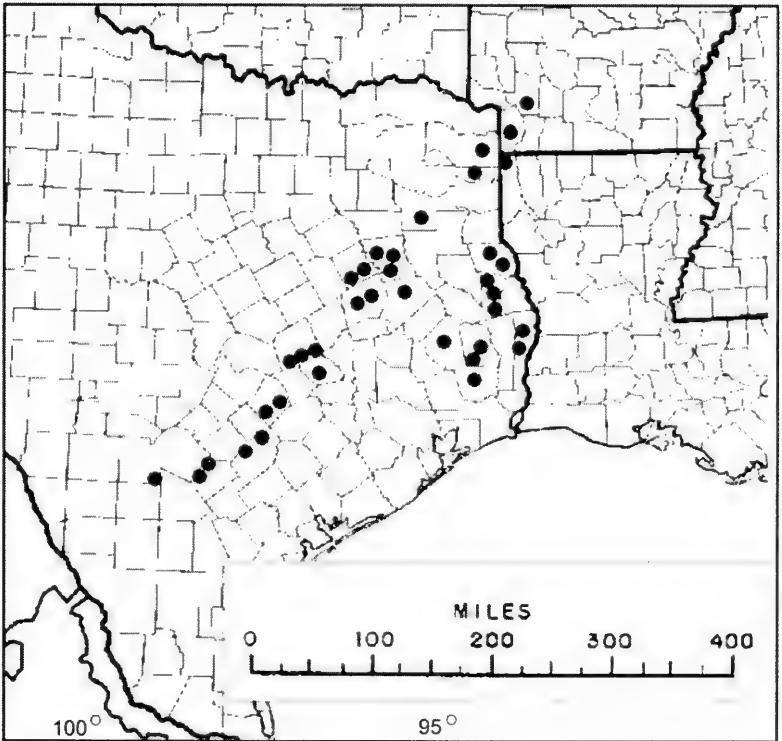


Fig. 1. Distribution of *Thelesperma flavodiscum*.

**KEYS TO THE FLORA OF FLORIDA - 17, *RUELLIA*
(ACANTHACEAE)**

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ABSTRACT

Ruellia (Acanthaceae) is represented in Florida by 8 species. *Ruellia heteromorpha* and *R. succulenta* are endemic to the state, while *R. brittoniana* and *R. ciliatiflora* are introduced and naturalized. *Ruellia noctiflora* is rated as endangered. *Ruellia brittoniana* has been designated an "invasive" species and is rapidly spreading along Florida waterways. A nomenclatural justification is provided for use of *R. brittoniana*, rather than *R. tweediana*, as the correct name for the Mexican Petunia. Five species, elsewhere reported for the state, are here excluded. An amplified key is given to the Florida taxa.

KEY WORDS: *Ruellia*, Acanthaceae, Florida flora.

The genus *Ruellia* (Acanthaceae) in eastern North America was well treated by M. L. Fernald (Rhodora 47: 1-38, 47-63, 69-90. 1945), and his documented record of collections, morphology, and range remains the basis for all later work.

Ruellia then became the subject of intense study -- in the field, the test garden, and the laboratory -- by Robert W. Long (USF). His insightful reports have gone far to bring understanding to the Florida species: transplant studies of *R. caroliniensis* and related taxa in South Florida (Amer. Jour. Bot. 51: 842-852. 1964); the first Florida report of *R. ciliatiflora* (Rhodora 68: 432-434. 1966); the misapplication of *R. humilis* (Bull. Torrey Bot. Club 95: 16-27. 1968); the polymorphic *R. caroliniensis* (J. Arnold Arbor. 51: 257-309. 1970); and the distribution

and genetic relationships of the very different (and endangered) *R. noctiflora* (Bull. Torrey Bot. Club 98: 16-21. 1971); among others.

Yet Long's untimely death in 1976 left still other issues unsettled. Perhaps the most regretted uncertainty centers on the variation observed in south peninsular Florida. Fernald (1945) believed herbarium materials justified recognition of two species endemic to southern peninsular Florida, *R. heteromorpha* and *R. succulenta*, while restricting *R. caroliniensis* and *R. ciliosa* to north Florida and the upper peninsula. Long (1964), after cultivation of plants from 25 Florida populations, interpreted the observed variation to represent only a single species, *R. caroliniensis*. But, following further opportunity to observe the Florida plants, Long (1970) partitioned the single species into two subspecies -- ssp. *caroliniensis* which he divided into var. *caroliniensis* and var. *succulenta*; and ssp. *ciliosa*, in turn divided into var. *ciliosa* and var. *heteromorpha*. D. C. Wasshausen (Castanea 63: 99-116. 1998), in a careful synopsis of southeastern species, accepted Long's analysis.

Other Florida authors have followed somewhat different pathways. Wunderlin & Hansen (2003) recognized *Ruellia caroliniensis* and *R. ciliosa* as distinct; they also recognized *R. succulenta* into which they merged *R. heteromorpha* without distinction. As indicated by the following key, the present author views the four taxa as worthy of specific recognition, returning to the interpretation of Fernald.

One species, *Ruellia brittoniana*, has become popular in garden and patio cultivation and is now known in diverse flower colors. What apparently is the original blue-violet flowered Mexican species has become extensively naturalized and invasive along Florida waterways to such an extent that effort is being made to find biological controls, a task made more difficult by the potential threat posed to a commercially valuable horticultural species.

The Mexican species has been known as *Ruellia brittoniana* Leonard since 1945 when its convoluted nomenclatural history was

fully elucidated (ca. 1800 words, including quotation of all relevant original sources) by Fernald (1945). In outline: Nees (1847) briefly described *Cryphiacanthus angustifolius*; he cited two collections, one by Galeotti from Jalapa, Mexico, the other by Tweedie from Entre Rios, Argentina. These collections have since been consistently interpreted as representing distinct species, leading Grisebach (1879) to rename the Argentine plant *Ruellia tweediana*, with a brief description. (In modern parlance, Grisebach followed the spirit of I.C.B.N., Art. 9A.5, in segregating one of the elements as another taxon, and thus by implication designated the "residue" as the lectotype of *C. angustifolius*.) Britton (1893), addressing the plants of Paraguay, in recognition that the original epithet, "*angustifolius*," was a later homonym in *Ruellia* (not *R. angustifolia* Sw., 1788) and thus unavailable and seemingly unaware of Grisebach's assignment of the name *R. tweediana*, again renamed the South American plant, as *Ruellia spectabilis*. Leonard (1941), noting that Nees's "*angustifolius*," as well as Britton's "*spectabilis*", had already been used in *Ruellia*, and needing a name for the Mexican plant, formed still another name, *Ruellia brittoniana*. Fernald (1945) then re-described the Mexican and Argentine plants in full (Latin) detail, and used *R. brittoniana* and *R. tweediana* as their names.

A recent statement (30 words) by Wunderlin (1998: 662) that the Florida plant should be known as *Ruellia tweediana* is incorrect. He noted that *R. tweediana* Griseb. predates *R. brittoniana* Leonard; it does indeed, but the first is the South American species, while the second is the related but clearly distinct North American taxon. He remarked *inter alia* that *R. brittoniana* is illegitimate since it is based on the same type as *R. tweediana*; it is not, for the two names are based on the two different specimens, treated together by Nees but segregated by Grisebach.

Though Fernald's descriptions are the first to establish a proper understanding of the morphology of these two species, the diagnoses by Nees and Grisebach, though scant, coupled with the unambiguous collections cited, are nomenclaturally sufficient to form legitimate names. The types on which the names are based have not been changed

(Art. 47.1), and the oft-used author citation, "Leonard ex Fernald," for *R. brittoniana* is inappropriate. [Though not a responsibility of Florida botanists, the present I.C.B.N. (Rec. 60C.1) indicates the Argentine plant, in honor of James Tweedie (1775-1862), is properly spelled *R. tweediana*.]

RUELLIA L. Wild Petunias ¹

1. Cauline leaves linear to narrowly linear-lanceolate, to 25 cm. long and 2 cm. broad, sessile; inflorescence of elongate axillary peduncles; flowers 1-several, terminal; corollas 3-4 cm. long, blue-violet. Perennial herb, to 1 m. tall. Stream banks, pond margins. Rare in panhandle, frequent throughout peninsula. Spring-fall. **INVASIVE.** [*Ruellia coerulea*, misapplied; *Ruellia malacosperma*, misapplied; *Ruellia tweediana*, misapplied]
MEXICAN PETUNIA. * ***Ruellia brittoniana* Leonard**
1. Cauline leaves broad, variously petiolate.
 2. Leaves broadly ovate, the blades abruptly truncate at base, to 10 cm. long and 5 cm. broad, with petioles to 2 cm. long; inflorescence a terminal panicle, densely glandular-pubescent; corollas pale blue-violet, pubescent. Perennial herb, to 1 m. tall. Waste areas, margins of cultivated fields. Central and south peninsula (Hillsborough, Dade counties); rare. Spring-fall. [*Ruellia lorentziana* Griseb.]
 * ***Ruellia ciliatiflora* Hook.**
 2. Leaves, if ovate, with blades not abruptly truncate at base, and petioles under 1 cm. long; inflorescence not a terminal

1. This paper is a continuation of a series begun in 1977. The "amplified key" format employed here is designed to present in compact form the basic morphological framework of a conventional dichotomous key, as well as data on habitat, range, and frequency. Amplified keys are being prepared for all genera of the Florida vascular flora; the present series is restricted to genera where a new combination is required or a special situation merits extended discussion.

panicle, not densely glandular-pubescent; corollas not pubescent.

3. Flowers terminating simple to sparingly branched elongate near-leafless axillary peduncles; corollas blue-purple, to 4 cm. long. Perennial herb, to 30 cm. tall. Bogs, seasonally wet pinelands. Central panhandle (Gadsden, Liberty, Washington counties); rare. Summer. [*Ruellia pedunculata* Torr. & Gray ssp. *pinetorum* (Fern.) R. Long] **Ruellia pinetorum** Fern.

3. Flowers subsessile or in short-peduncled glomerules, in axils of uppermost leaves.

4. Corollas white, 6-10 cm. long, opening at dusk. Perennial herb, to 50 cm. tall. Wet pinelands. Central panhandle (Jackson, Franklin, Wakulla counties), disjunct to northeast Florida (Clay, Duval, Nassau, St. Johns counties); rare. Summer. ENDANGERED (State listing)

NIGHT-FLOWERING WILD PETUNIA.

Ruellia noctiflora (Nees) Gray

4. Corollas lavender or bluish, sometimes with white lobes, 4-6 cm. long, opening in daytime.

5. Stems very short, usually under 10 cm. tall; leaves crowded, with narrowed bases and rounded tips, the veins white-villous. Perennial herb, to 10 cm. tall. Dry pinelands, sandhills. North Florida (s. in peninsula to Hernando, Lake counties); frequent in panhandle, infrequent southward. Summer-fall. Occasional plants with stems elongate, the leaves spatulate, remote, are apparent hybrids with *R. caroliniensis*. [*Ruellia humilis*, misapplied; *Ruellia caroliniensis* (Walt. ex Gmel.) Steud. ssp. *ciliosa* (Pursh) R. Long]

DWARF WILD PETUNIA. **Ruellia ciliosa** Pursh

5. Stems normally elongate, above 20 cm. tall; leaves well-separated, ovate to elliptic with blunt to acute tips, usually with short but distinct petioles, the surfaces variously pubescent to glabrous, the veins not notably more so.

6. Plant glabrous or nearly so, upright, the leaves thick, somewhat fleshy, often purple-tinged. Perennial herb, to 30 cm. tall. Moist to dry soils, occasionally in rocklands. South peninsula (Collier, Dade, Monroe counties); infrequent. All year. Endemic. [*Ruellia caroliniensis* (Walt. ex Gmel.) Steud. var. *succulenta* (Small) R. Long]

***Ruellia succulenta* Small**

6. Plant variously pubescent, upright or with long-spreading lower stems, the leaves thin, full green.
7. Stems upright, either simple or with short lateral branches, sparingly pubescent. Perennial herb, to 80 cm. tall. Mesic hammocks, brushy margins. Throughout; common north and central, rare south. Spring-fall. [*Ruellia parviflora* (Nees) Britt.] COMMON WILD PETUNIA.

***Ruellia caroliniensis*
(Walt. ex Gmel.) Steud.**

7. Stems in early season upright, in mid to late season forming long trailing horizontal branches from lower nodes, hirsute to villous. Perennial herb, to 40 cm. tall. Dry sandy soils, pinelands, occasional weed in plantings. South peninsula (n. to Lee, Brevard counties); frequent. All year. Endemic. [*Ruellia caroliniensis* (Walt. ex Gmel.) Steud. var. *heteromorpha* (Fern.) R. Long; *Ruellia hybrida*, misapplied]

***Ruellia heteromorpha* Fern.**

Excluded names:

***Ruellia humilis* Nutt.**

Northern. Reported for Florida by Small (1933), who had this plant confused with the coastal plain *R. ciliosa* (Long, 1970).

***Ruellia malacosperma* Greenm.**

Reported for Florida by Small (1933), apparently based on specimens of *R. brittoniana*. Cultivated in the state, but not known to escape.

Ruellia nudiflora (Gray) Urban

Western. Reported to occur in "pinelands," Dade County, by Lakela & Craighead (1965); omitted without comment by Long & Lakela (1971).

Ruellia strepens L.

Northern and western. Reported for Florida by Small (1933). No documenting specimens are known.

Ruellia tuberosa L.

An occasional weed in shadehouses, Dade County, but yet unknown outside.

**WHAT IN THE WORLD DID THOMAS WALTER MEAN BY
Xxxxx/yyyy? PART TWO: THE QUITE DOUBTFULS**

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ABSTRACT

Flora Caroliniana, published by Thomas Walter in 1788, was the first treatment of American plants to employ the binomial nomenclature and sexual classification system of Linnaeus. Many of its species were new to science, and their names remain important in documentation of the southeastern American flora. But Walter kept no herbarium, and certain of his plants have not been confidently matched with modern names. Assistance of select readers is requested to determine to the extent possible what plants Walter must have had in hand when he named and described 33 of his insecurely identified new species.

REQUEST FOR TAXONOMIC ASSISTANCE

Thomas Walter published over 400 new names in his pioneer *Flora Caroliniana* (1788). Many of these names were accompanied by clearly written descriptions, and represent familiar species in the Southeastern flora. But the descriptions of others were so brief or cryptic that later generations of botanists have remained uncertain of what Walter had intended. A small number have remained unidentified even to genus (Ward, 2007a). A larger number, addressed here, strongly indicate the genus to which they belong but are unclear as to species.

An annotated index of all of Walter's new species is now in preparation. The majority of Walter's names have been adequately identified. A few will inevitably remain intransigent and will be termed

irretrievably ambiguous and unusable for most nomenclatural purposes. But others, though not immediately suggesting the plant Walter intended, can be salvaged at least to the level of being assigned appropriate synonymic status.

The following tabulation of 33 species described by Walter includes (a) Walter's original name, (b) Walter's Latin description, (c) known species, of the same or related genera (Walter's name is in quotes if different from the modern name), (d) the modern name, as best can be ascertained, and (e) comments and information that may aid in identification. "Spm." references are to specimens in the Fraser/Walter herbarium, London (Ward, 2006a).

As in the preceding tabulation of especially intractable names (Ward, 2007a), the request is made that persons familiar with the Southeastern flora review this listing of these somewhat less refractory names and report ANY DESCRIPTIONS THAT CAN BE IDENTIFIED. Your speculations and suggestions will be appreciated. [E-mail: DBW, c/o kperkins@flmnh.ufl.edu]

LIST OF SPECIES

Walter's name: **Actaea pentagyna** Walter (p. 151)

Walter's description: *floribus solitariis, pedunculis e sinu foliorum ortis; corollis petalis septem obovato-oblongis, albis; pericarpio lanceolato monospermo; foliis biternatis, foliolis obtusis tridentatis.*

Related species also listed: *Cimicifuga racemosa* ("Actaea monogyna"), *Aruncus dioicus* ("Actaea dioica")

Modern name: Perhaps **Cimicifuga americana** Michx.

Identified as *Cimicifuga americana* by I.K. (1893), but not accepted by American authors. The uncertain identification makes a neotype undesirable; were one selected, Walter's name might displace that of Michaux (1803). *Cimicifuga americana* is frequent in western NC mountains, unknown in SC.

Walter's name: **Aira aegilopsoides** Walter (p. 78)

Walter's description: *spicis secundis; corollarum glumae valvula altera ovata, acuminata, altera columnari, obtusa.*

Related species also listed: *Triplasis purpurea* ("Aira purpurea"),
Melica mutica, *Cenchrus incertus* ("Cenchrus carolinianus")

Modern name: Perhaps **Chloris petraea** Sw.

No type of *Aira aegilopsoides* Walt. is known. Spm. 112-A was labeled "*Aegilops an Aira ?*" by Walter; it was tentatively identified as *Chloris petraea* by Hitchcock (1905: 47). *Chloris petraea* is occasional along the SC coast.

Walter's name: **Anonymos ciliat[a]** Walter (p. 197); nom. illegit.

Walter's description: *caule laevi 3-pedali, foliis linearibus ciliatis, floribus pedunculis brevibus subimbricatis purpureis spicatum positis, calycibus multifloris squamis minus obtusis minus conniventibus, caulibus simplicibus.*

Related species also listed: ?*Liatris* sp. ("*Anonymos pilosa*"), ?*Liatris* sp. ("*Anonymos ramosa*"), *Carphephorus paniculatus* ("*Anonymos paniculata*"), *Carphephorus tomentosus* ("*Anonymos uniflora*"), *Carphephorus odoratissimus* ("*Anonymos odoratissima*")

Modern name: Probably **Liatris** sp.

No type of *Anonymos ciliata* Walt. is known. No neotype should be selected.

Walter's name: **Anonymos erect[a]** Walter (p. 170); nom. illegit.

Walter's description: *foliis linearibus pedunculo brevioribus, floribus axillaribus purpureis.*

Related species also listed: *Agalinis purpurea* ("*Anonymos purpurea*"),
Agalinis setacea ("*Anonymos setacea*")

Modern name: Possibly **Agalinis obtusifolia** Raf.

No type of *Anonymos erecta* Walt. is known. No neotype should be selected. Pennell (1935) concluded he was unable to identify Walter's *Anonymos erecta* [= *Agalinis erecta* Walt. ex Pennell]. He replaced it with *Agalinis obtusifolia* Raf. (a name of equally dubious antecedents), and other authors have followed. *Agalinis obtusifolia* is

infrequent in eastern SC.

Walter's name: **Anonymos pilos[a]** Walter (p. 197); nom. illegit.

Walter's description: *caule piloso 3 ad 5-pedali, foliis lineari-acerosis utrinque pilosis, floribus sessilibus subimbricatis spicatum positis purpureis. Calycibus multifloris squamis adpressis, caulibus simplicibus.*

Related species also listed: ?*Liatris* sp. ("*Anonymos ciliata*"), ?*Liatris* sp. ("*Anonymos ramosa*")

Modern name: Probably **Liatris** sp.

No type of *Anonymos pilosa* Walt. is known. No neotype should be selected.

Walter's name: **Anonymos ramos[a]** Walter (p. 198); nom. illegit.

Walter's description: *caule subramoso 4-pedali, pubescente, foliis lanceolatis, floribus subsessilibus purpureis spicatum positus, calycibus multifloris squamis obtusis subconniventibus.*

Related species also listed: ?*Liatris* sp. ("*Anonymos ciliata*"), ?*Liatris* sp. ("*Anonymos pilosa*")

Modern name: Possibly **Liatris** sp.

No type of *Anonymos ramosa* Walt. is known. No neotype should be selected.

Walter's name: **Cineraria caroliniensis** Walter (p. 207)

Walter's description: *floribus paniculatis, foliis petiolatis oblongis denticulatis laevibus, caule herbaceo.*

Related species also listed: *Conyza canadensis* ("*Cineraria canadensis*")

Modern name: Perhaps **Conyza parva** Cronq. [= *Conyza canadensis* (L.) Cronq. var. *parva* Cronq.; *Erigeron canadensis* L. var. *pusilla* (Nutt.) Ahles]

No type of *Cineraria caroliniensis* Walt. is known.

Identification here is partially based on Walter's separate recognition of *Conyza canadensis* (as *Cineraria canadensis*). Both it and *Conyza parva* are common throughout. *Conyza parva* and *C. canadensis* are similar and often occur together, but seem not to intergrade; they merit specific status. Walter's name is prior to that of Cronquist (1943),

though not to that of Linnaeus (1753). The only possible specimen (spm. 13-B) appears to be *C. canadensis*. *Conyza parva* is common throughout.

Walter's name: **Collinsonia serotina** Walter (p. 65)

Walter's description: *fol. magnis oppositis ovatis, petiolis longis, supremo pari unice sessili, cordato; panicula terminali ramosissima.*

Related species also listed: *Collinsonia canadensis* ("*Collinsonia praecox*")

Modern name: **Collinsonia** sp.

No type of *Collinsonia serotina* Walt. is known. The name was rejected as ambiguous by Peirson et al. (2006).

Walter's name: **Cucubalus polypetalus** Walter (p. 141)

Walter's description: *foliis oppositis, ovato-lanceolatis; floribus polypetalis.*

Related species also listed: *Silene antirrhina*, *Silene catesbaei*

Modern name: Perhaps **Silene cucubalus** Wibel

A single crumpled flower in the Fraser/Walter herbarium was identified as "Walter's type" of *Cucubalus polypetalus* Walt., by Fernald & Schubert (1948: 198; plate 1105). Corrected to lectotype, by Ward (2007b). But Walter's description of *C. polypetalus* suggests another species, perhaps *Silene cucubalus* A. W. Wibel (1799). See discussion elsewhere (Ward, 2006b). *Silene cucubalus* is frequent in the mountains of western NC, but is unknown in SC.

Walter's name: **Dianthera ensiformis** Walter (p. 63)

Walter's description: *spicis subcapitatis, pedunculo longo solitario, flor. rubris, fol. ensiformibus.*

Related species also listed: *Justicia ovata* ("*Dianthera ovata*")

Modern name: Possibly **Justicia americana** (L.) Vahl [= *Dianthera americana* L.]

No type of *Dianthera ensiformis* Walt. is known. Elliott (1816:) renamed it *Justicia ensiformis* (Walt.) Ell. I.K. (1893) listed Walter's name as synonym of *Dianthera americana*. Yet the flowers of

D. americana are white and pale lavender, not red. *Justicia americana* is absent on the SC coastal plain, rare inland.

Walter's name: **Dianthus carolinianus** Walter (p. 140)

Walter's description: *floribus aggregatis pedunculis longis, squamis tubo dimidio minoribus.*

Related species also listed: *Arenaria caroliniana*

Modern name: Perhaps **Dianthus armeria** L.

No type of *Dianthus carolinianus* Walt. is known. *Dianthus armeria* is unknown in eastern SC, but frequent to west.

Walter's name: **Eupatorium Marrubium** Walter (p. 199)

Walter's description: *foliis ovato-deltoidibus obtuse serratis pubescentibus glabris sessilibus.*

Related species also listed: *Eupatorium fistulosum* ("*Eupatorium trifoliatum*"), *Eupatorium purpureum* ("*Eupatorium fuscorubrum*"), *Eupatorium sessilifolium*, *Eupatorium album*, *Eupatorium hyssopifolium* ("*Eupatorium linearifolium*"), *Eupatorium pilosum*, *Eupatorium rotundifolium*, *Eupatorium capillifolium* ("*Eupatorium Foeniculoides*"), *Eupatorium compositifolium*, *Eupatorium aromaticum* ("*Eupatorium cordatum*"), *Eupatorium perfoliatum*, *Eupatorium ?rugosum* ("*Eupatorium odoratum*"), *Conoclinium coelestinum* ("*Eupatorium coelestinum*"), *Fleischmannia incarnata* ("*Eupatorium incarnatum*")

Modern name: Perhaps **Eupatorium rotundifolium** L.

No type of *Eupatorium Marrubium* Walt. is known. Elliott (1822: 300) said of *Eupatorium rotundifolium*, "I have always suspected this plant to be the *E. Marrubium* of Walter." *Eupatorium rotundifolium* is common in eastern SC.

Walter's name: **Festuca multiflora** Walter (p. 81)

Walter's description: *repens, paniculis erectis ovatis, spiculis 8 ad 40-floris, acutis, foliis angustis, acutis, fauce subplumosis.*

Related species also listed: *Festuca ?sciurea* ("*Festuca quadriflora*"), *Festuca octoflora*, *Bromus* sp. ("*Bromus ciliatus*")

Modern name: Possibly **Distichlis spicata** (L.) Greene

No type of *Festuca multiflora* Walt. is known. Hitchcock (1905: 52) suggested Walter's description was of *Leptochloa fascicularis* (Lam.) Gray -- unlikely since that species is unknown in SC. He later (1951: 856) considered it a tentative synonym of *Distichlis spicata* (L.) Greene, common along the SC coast.

Walter's name: **Gratiola inaequalis** Walter (p. 61)

Walter's description: *fol. oblongis obtusis subdentatis. Cor. labio superiore brevior suberecto; flor. pedicellatis, subcaeruleis.*

Related species also listed: *Mecardonia acuminata* ("*Gratiola acuminata*"), *Gratiola ramosa*, *Gratiola virginiana*, ?*Gratiola* sp. ("*Gratiola Peruviana?*"), *Bacopa monnieri* ("*Gratiola Monniera*")

Modern name: Perhaps **Lindernia anagallidea** (Michx.) Pennell

No type of *Gratiola inaequalis* Walt. is known. The name has not been identified with confidence. Pennell initially (1920: 246), on the basis of its distribution in the Carolinas, considered *Lindernia anagallidea* to be represented by Walter's name; he noted Elliott had so interpreted the name. Later, Pennell (1935) analyzed Walter's description and concluded, "I think that we may leave the identification of Walter's plant as permanently doubtful." *Lindernia anagallidea* is frequent in eastern SC.

Walter's name: **Hamamelis monoica** Walter (p. 255)

Walter's description: *floribus monoicis.*

Related species also listed: *Hamamelis virginiana* ("*Hamamelis dioica*," "*Hamamelis androgyna*")

Modern name: Perhaps **Fothergilla gardenii** Linnaeus in Murray

No type of *Hamamelis dioica* Walt. is known. The leaves of *Fothergilla* are similar to *Hamamelis*, and Walter's epithet, *monoica*, may be his indication of the usually bisexual flowers. *Fothergilla gardenii* is frequent in eastern SC.

Walter's name: **Ilex** ----- #2 (*unnamed*) Walter (p. 241)

Walter's description: *baccis flavis.*

Related species also listed: *Ilex opaca* ("*Ilex Aquifolium*"), *Ilex cassine* ("*Ilex Dahoon*"), *Ilex myrtifolia*, *Ilex decidua*, *Ilex vomitoria* ("*Ilex Cassine*")

Modern name: **Ilex** sp.

No type of this *Ilex* is known. No neotype should be selected. Though no other description was given, this may be a yellow-fruited form of *Ilex opaca*, which it immediately follows.

Walter's name: **Lechea juncifolia** Walter (p. 83)

Walter's description: *foliis radicalibus teretibus, calyce nullo.*

Related species also listed: *Lechea minor*, *Lechea ?villosa* ("*Lechea major*")

Modern name: Possibly **Lechea tenuifolia** Michx.

No type of *Lechea juncifolia* Walt. is known. *Lechea tenuifolia* is absent from SC coastal plain, common on the piedmont. Elliott (1816: 185) tentatively equated these two names, and was followed by Hodgdon (1938: 90). Torrey & Gray (1838: 1: 154), however, called it "wholly unknown."

Walter's name: **Ludwigia ramosissima** Walter (p. 89)

Walter's description: *caule erecto, ramosissimo, rubro; fol. alternis, lineari-lanceolatis, longis; flor. axillaribus, pedicellatis; capsulis turbinato-cubicis angulis membranaceo-alatis.*

Related species also listed: *Ludwigia glandulosa*, *Ludwigia palustris* ("*Ludwigia apetala*"), *Ludwigia alternifolia*, *Ludwigia linearis*, *Ludwigia decurrens*, *Ludwigia pilosa*, *Ludwigia arcuata*, *Ludwigia ?sphaerocarpa* ("*Ludwigia rudis*"), *Ludwigia suffruticosa*

Modern name: Perhaps **Ludwigia alternifolia** L.

No type of *Ludwigia ramosissima* Walt. is known. Munz (1944: 158) suggested it was a second description of *Ludwigia alternifolia* L. (which Walter described under that name immediately preceding), though no argument was put forward to exclude other Carolina *Ludwigia* not recognized by Walter. *Ludwigia alternifolia* is common throughout.

Walter's name: **Melanthium spicatum** Walter (p. 125)

Walter's description: *spica nutante, flor. hermaph. radice fibrosa, fol. caulinis subovatis.*

Related species also listed: *Zigadenus glaberrimus* ("Melanthium virginicum"), *Melanthium hybridum*, *Veratrum virginicum* ("Melanthium monoicum"), *Zigadenus muscaetoxicum* ("Melanthium Muscaetoxicum"), *Chamaelirium luteum* ("Melanthium dioicum"), *Tofieldia racemosa* ("Melanthium racemosum?")

Modern name: Possibly **Xerophyllum asphodeloides** (L.) Nutt. [= *Xerophyllum setifolium* Michx.]

No type of *Melanthium spicatum* Walt. is known. Suggested by I.K. (1894) to be *Xerophyllum setifolium* (now *X. asphodeloides*). But Walter stated cauline leaves to be "subovatis," while *X. asphodeloides* leaves are linear, almost acicular. *Xerophyllum asphodeloides* is very rare in western NC and SC.

Walter's name: **Menispermum carolinianum** Walter (p. 248)

Walter's description: *caule fruticoso volubili, foliis lobato-cordatis, racemis axillaribus.*

Related species also listed: *Menispermum canadense* ("Menispermum virginicum")

Modern name: Perhaps **Calycocarpum lyonii** (Pursh) Gray

No type of *Menispermum carolinianum* Walt. is known. Walter synonymized his plant with *Cissamp[elos] smilacina* L. But Walter's description is of *Calycocarpum lyonii*. That species, though it ranges both north and south, is unknown in the Carolinas. Perhaps a Fraser discovery, but from where? Walter's name is original (even though not italicized); he was not describing nor intending *Menispermum carolinum* L.

Walter's name: **Ophrys trifolia** Walter (p. 221)

Walter's description: *bulbis fasciculatis, foliis radicalibus ovatis submagnis planis, scapo trifolio, floribus albo-viridibus adscendentibus, nectarii labio integro lato subtriangulari.*

Related species also listed: *Platanthera cristata/ciliaris* ("*Ophrys fimbriata*"), *Calopogon barbatus/pulchellus* ("*Ophrys barbata*")

Modern name: Perhaps **Liparis liliifolia** (L.) Richard
No type of *Ophrys trifolia* Walt. is known. *Liparis liliifolia* is frequent in NC and western SC, unknown in eastern SC.

Walter's name: **Orchis lata** Walter (p. 220)

Walter's description: *alba, bulbis individuis, nectarii labio integro lato revoluto, cornu sublongo tenui.*

Related species also listed: *Habenaria ciliaris/blephariglottis* ("*Orchis ciliaris*"), *Pogonia ophioglossoides* ("*Orchis ophioglossoides*"), *Platanthera lacera* ("*Orchis habenaria?*")

Modern name: Perhaps **Habenaria nivea** (Nutt.) Spreng.
No type of *Orchis calcarata* Walt. is known. The white flowers suggest *Habenaria nivea*, which is infrequent in eastern SC.

Walter's name: **Origanum clinopodioides** Walter (p. 165)

Walter's description: *capitulis rotundatis verticillatis terminalibusque, floribus sessilibus, foliis cordato-ovatis subpetiolatis glabris.*

Related species also listed: *Pycnanthemum incanum* ("*Origanum incanum*"), *Pycnanthemum flexuosum* ("*Origanum flexuosum*")

Modern name: **Pycnanthemum** sp.

No type of *Origanum clinopodioides* Walt. is known. Perhaps *Pycnanthemum aristatum* Michx., as suggested by I.K. (1894), though not reported by that name in Carolina floras. Apparently not *Pycnanthemum clinopodioides* Torr. & Gray, which does not reach the Carolinas.

Walter's name: **Panicum speciosum** Walter (p. 73)

Walter's description: *panicula longa erecta geniculata, ramiis 4, 6, s.8 verticillatis simplicibus brevibus, e singulis nodis radiatis; flor. solitarii subsessilibus, suscis, longitudine eorum remotis.*

Related species also listed: *Panicum virgatum* ("*Panicum coloratum*"), *Agrostis hyemalis* ("*Cornucopiae hyemalis*")

Modern name: Possibly **Sporobolus junceus** (Beauv.) Kunth

No type of *Panicum speciosum* Walt. is known. Hitchcock (1905: 38) considered it possible that Walter was addressing *Sporobolus junceus*, which is frequent in SC. A neotype is not to be desired, since that action would displace *Heleocholea juncea* Beauv. (1812), the basionym of the familiar later name. *Sporobolus junceus* is rare on SC coastal plain, common inland.

Walter's name: **Plantago caroliniana** Walter (p. 85)

Walter's description: *spica floribus confertis*.

Related species also listed: *Plantago virginica*

Modern name: Perhaps **Plantago lanceolata** L.

No type of *Plantago caroliniana* Walt. is known. Walter's "flowering spike crowded" well matches *Plantago lanceolata*. That species is introduced, but was likely familiar in pioneer days, now common throughout.

Walter's name: **Prasium coccineum** Walter (p. 166)

Walter's description: *foliis subovatis, floribus coccineis*.

Related species also listed: *Physostegia virginiana* ("*Prasium incarnatum*"), *Physostegia purpurea* ("*Prasium purpureum*")

Modern name: Perhaps **Calamintha coccinea** (Hook.) Benth. in DC.

No type of *Prasium coccineum* Walt. is known. Identification is uncertain, but scarlet flowers ("*floribus coccineis*") limit the possibilities. *Calamintha coccinea* is not known north of GA.

Walter's name: **Ranunculus nitidus** Walter (p. 159)

Walter's description: *foliis caulinis nitidis trifidis, lobis obtusis, floribus luteis*.

Related species also listed: *Ranunculus recurvatus* ("*Ranunculus abortivus*")

Modern name: Perhaps **Ranunculus abortivus** L.

No type of *Ranunculus nitidus* Walt. is known. Elliott (1821) called this *Ranunculus abortivus* L. and I.K. (1895) tentatively agreed, although Walter had used that name for another species. Elliott may have believed this description fitted Linnaeus' *R. abortivus* better than Walter's *R. abortivus* which was perhaps *R. recurvatus*. *Ranunculus abortivus* is unknown on the SC coastal plain, common inland.

Walter's name: **Schoenus umbellatus** Walter (p. 70)

Walter's description: *culmo subtriquetro folioso, floribus in umbellis compositis.*

Related species also listed: *Rhynchospora glomerata* ("Schoenus glomeratus"), *Rhynchospora corniculata* ("Schoenus umbellatus")

Modern name: Perhaps **Rhynchospora corniculata** (Lam.) Gray

No type of *Schoenus umbellatus* Walt. is known. Elliott (1816: 59) tentatively attributed Walter's name to *Rhynchospora longirostris* Ell., a synonym of *R. corniculata*. *Rhynchospora corniculata* is common throughout.

Walter's name: **Senecio Tussilaginoïdes** Walter (p. 208)

Walter's description: *corollis flosculosis, foliis crenatis, infimis cordatis petiolatis superioribus pinnatifidis lyratis.*

Related species also listed: *Erechtites hieracifolia* ("Senecio hieracifolius?")

Modern name: Possibly **Senecio smallii** Britt.

No type of *Senecio tussilaginoïdes* Walt. is known. I.K. (1895) interpreted this species to be *Senecio aureus* L., which the description fits quite well (lower leaves cordate and petiolate, upper leaves pinnatifid and lyrate). But Walter's description is not original; it is copied directly from that of Linnaeus for *Senecio aureus*. Yet that species is unknown in eastern SC, while *S. smallii* is common throughout.

Walter's name: **Silphium scabrum** Walter (p. 217)

Walter's description: *foliis alternis lato-lanceolatis serratis scabris ciliatis subsessilibus, caule bipedali glabro, pedunculis laevibus.*

Related species also listed: *Silphium compositum* ("Silphium laciniatum")

Modern name: Possibly **Silphium dentatum** Ell.

No type of *Silphium scabrum* Walt. is known. Spm. 98-C was labeled "*Silphium*" by Walter and "*Scabrum*" by Fraser. *Silphium asteriscus* L. is the more scabrous plant, but is essentially absent from SC. *Silphium dentatum* is common throughout.

Walter's name: **Tragia innocua** Walter (p. 229)

Walter's description: *foliis lanceolatis subdentatis pilosis, spica terminali.*

Related species also listed: *Tragia urens*

Modern name: Perhaps **Tragia urticifolia** Michx.

No type of *Tragia innocua* Walt. is known. *Tragia urticifolia* is frequent in eastern SC.

Walter's name: **Urtica filiformis** Walter (p. 230)

Walter's description: *foliis oppositis ovatis serratis trinerviis, amentis filiformibus sere longitudine foliorum.*

Related species also listed: *Laportea canadensis* ("*Urtica canadensis*"), *Boehmeria cylindrica*, *Pilea pumila* ("*Urtica pumila*")

Modern name: Perhaps **Parietaria praetermissa** Hinton [= *Parietaria floridana* Nutt.]

No type of *Urtica filiformis* Walt. is known. *Parietaria praetermissa* is rare along SC coast.

Walter's name: **Veronica caroliniana** Walter (p. 61)

Walter's description: *flor. solitariis, pedunculis brevibus; fol. radicalibus obovato-oblongis subincisis, caulinis oblongis subserratis obtusis oppositis; caule suberecto; flore albo.*

Related species also listed: *Veronica serpyllifolia*, *Veronica arvensis*

Modern name: Perhaps **Veronica officinalis** L.

No type of *Veronica caroliniana* Walt. is known. Walter's sectional description, "*planta tota tomentosa*," suggests *Veronica officinalis*, a species unknown in coastal plain SC but common in the western, higher part of NC. But that species has racemes of blue flowers, while Walter's plant had solitary white flowers ("*flor. solitariis...albo*"). Perhaps not a *Veronica*.

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**HETEROSPERMA XANTI TRANSFERRED TO THE GENUS
BIDENS (ASTERACEAE: COREOPSIDEAE)**

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Bidens xanti* (A. Gray) B.L. Turner, **comb. nov.*

Based upon *Heterosperma xanti* A. Gray, Proc. Amer. Acad. Arts 5:
162. 1861.

Bidens coreocarpoides Sherff

Bidens xantiana Rose ex Vasey & Rose

Heterosperma brandegeei Sherff

Heterosperma coreocarpoides (Sherff) Sherff

Heterosperma microglossum Sherff

As indicated in the above synonymy, this species was included in the genus *Heterosperma* by several authors. Gray, in his original description, stated, "The disk-achenia, and indeed the whole structure, except the fertile achenia, accord with *Bidens*." Vasey and Rose (1890) in their description of *Bidens xantiana*, and Sherff (1935) in his description of *B. coreocarpoides*, also retained the taxon in *Bidens*, albeit with mistaken identifications. Sherff (1955) subsequently placed *Heterosperma xanti* in the genus *Heterosperma* where it was retained by most workers until Clement (by annotation, TEX) and Melchert (also by annotation, TEX) again placed it in the genus *Bidens*, this in agreement with Melchert's forthcoming treatment of *Bidens* for Mexico (in prep.). Clement never published the new combination concerned, nor did Melchert.

Heterosperma (and the genus *Coreocarpus*) is distinguished from *Bidens* largely by its heteromorphic achenes, those of the disc florets differing from those of the ray florets, as noted by Panero (2007), in his key to genera of the tribe Coreopsidae. Regardless, I have included *Heterosperma xanti* in *Bidens* because it will not fit comfortably, all characters considered, within the former genus nor in

Coreocarpus, in spite of the fact that the plants concerned possess heteromorphic achenes. Indeed, Melchert and Turner (1990) transferred two species of the genus *Coreocarpus* (*C. gracillima* and *C. hintonii*), as conceived by Smith (1989), into *Bidens*, and Melchert intended to transfer *Heterosperma xanti* into the latter genus, as judged by his annotations on herbarium sheets at TEX. In short, the presence of dimorphic achenes in this or that species of *Bidens* is to be expected. This is also implicit in the work of Kimball and Crawford (2003) and Kimball et al. (2003) whose DNA studies confirm the position of *Coreocarpus hintonii* within *Bidens*, and that of *Coreopsis cyclocarpa* (having heteromorphic achenes) in the genus *Heterosperma*. *Bidens xanti* does, however, possess radial achenes similar to those of *Heterosperma*, if not *Coreocarpus*; the former, however, has floral traits like those of *Bidens*, hence the above transfer.

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**VASCULAR FLORA OF A LONGLEAF PINE UPLAND IN
SABINE COUNTY, TEXAS**

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ABSTRACT

We describe the vascular flora of select plots within longleaf pine uplands at Fox Hunter's Hill in the Sabine National Forest in eastern Texas. The eight established 0.1 ha plots contained a total of 196 species and averaged 87.25 species (range 71 to 112) per plot; sixteen 0.001 ha plots averaged 28.75 species (range 17 to 46); and sixteen 0.0001 ha plots averaged 12.44 species (range 5 to 25). A comparison between longleaf pine uplands in central Louisiana and Fox Hunter's Hill shows that they have similar floristic composition.

KEY WORDS: longleaf pine, *Pinus palustris*, longleaf pine uplands, Sabine National Forest, Sabine County, Texas.

Longleaf pine uplands are among the most extensively studied and best known ecosystems in the southeastern United States (Marks and Harcombe 1981, Platt et al. 1988, Frost 1993, Peet and Allard 1993, Ware et al. 1993, Streng et al. 1993, Glitzenstein et al. 1995, Noel et al. 1998, Platt 1999, Christensen 2000, Conner et al. 2001). Surprisingly, considering the amount of attention given to this ecosystem and its eponym, relatively little is known about the

herbaceous layer. Either little or no information has been collected or only partial descriptions are available. This is especially true of longleaf pine communities in the West Gulf Coastal Plain (Streng and Harcombe 1982, Bridges and Orzell 1989, Orzell 1990, Harcombe et al. 1993, MacRoberts and MacRoberts 1998, Turner et al. 1999, Haywood et al. 1998, 2001, Haywood and Harris 1999, Van Kley 1999a, 1999b, 2006, MacRoberts et al. 2004a, Lester et al. 2005, Diggs et al. 2006), where far less research has been done than in the Atlantic and East Gulf Coastal Plain (Peet and Allard 1993, Platt 1999, Christensen 2000). In our search of the literature, we were able to find only one detailed study of the floristic composition of longleaf pine uplands in the West Gulf Coastal Plain (MacRoberts et al. 2004a).

If management of longleaf pine communities is to be undertaken effectively, more than just eliminating offsite woody vegetation and reintroducing fire may be needed. At a minimum, the herbaceous layer must be known, for historical evidence indicates that many currently rare species were more common prior to recent anthropogenically influenced declines, and if current trends continue, today's common species may become rare in the near future (Glitzenstein et al. 2001). In order to reconstruct any plant community, whether by adding rare species to intact communities or by restoring badly degraded sites, one must know what was there initially and, while we cannot go back to pre-settlement vegetation, we can at least begin by studying or by documenting today's best managed sites.

Gathering information on the herbaceous layer of longleaf pine uplands is not always easy, since virtually all West Gulf Coastal Plain longleaf pine was cut during the last two centuries (Noss 1988, Frost 1993, Outcalt 1997, Platt 1999, Diggs et al. 2006). At best, second growth exists but even where there is second growth, there is seldom much, if any, herbaceous layer because of shading by shrub growth resulting from fire suppression (Platt et al. 1988, Streng et al. 1993, Olson and Platt 1995, Brewer 1998, Frost 1998, Platt 1999, Haywood et al. 1998, 2001, Drewa et al. 2002).

In pre-European North America, longleaf pine extended from Virginia to Texas (Schwarz 1907, Ware et al. 1993, Platt 1999, Conner et al. 2001). In the West Gulf Coastal Plain, it occurred in Louisiana

and Texas. In central and southwestern Louisiana and southeastern Texas there were large tracts of longleaf pine (Eldredge 1934, Smith 1991, Evans 1997, Outcalt 1997), which were cut in the late 19th and early 20th centuries. Over the total original range of longleaf pine, less than 3 percent remains in a semi-natural condition, and most of this is on public land (Frost 1993, Peet and Allard 1993, Bezanson 2000, Van Kley 2006).

Information about longleaf pine uplands before the arrival of Europeans can be gleaned from historical descriptions, lumber company records, and from the few acres that have miraculously survived logging, for example, the Wade Tract in Georgia (Evans 1997, Platt 1999). Early travelers write of monospecific longleaf pine uplands in central Louisiana and eastern Texas (MacRoberts et al. 2004a, Diggs et al. 2006). They depict a landscape with widely spaced uneven aged pines, an open canopy with frequent gaps, and a rich herbaceous layer of grasses, composites, and other forbs. There was little or no midstory and little or no woody vegetation. Every one to three years low intensity fires moved through these pinelands, usually in the spring and summer.

Since documentation of floristic composition can be found only for a small portion of this community --- notably lacking is documentation for the herbaceous layer --- it was the purpose of this study to locate a longleaf pine upland where the understory appeared to be intact and to obtain a floristic list. While the aim was to gather baseline data, the question of the quality of longleaf pine uplands in the West Gulf Coastal Plain is also briefly addressed (see Conner et al. 2001 for detailed discussion).

STUDY SITE

Previous surveys of the Texas National Forests and Grasslands in Texas, notably the Sabine National Forest and Angelina National Forest, have pinpointed several high quality longleaf pine uplands (Orzell 1990). One of these is Fox Hunter's Hill in southern Sabine County, Texas.

Fox Hunter's Hill is situated in the Mayflower Uplands Landtype Association (LTA). This LTA is associated with the Catahoula formation overlain with sandstones, sandy clays, and volcanic tuffs. Clay outcrops are present as are deep sands and loams. The topography is generally a rolling hill landscape with some steep hills. The LTA is noted for the longleaf-little bluestem herbaceous community, Catahoula barrens (glades), and hillside seeps/bogs (Figure 1).

However, Fox Hunter's Hill, like the remainder of longleaf pine uplands in the West Gulf Coastal Plain, is not pristine. Pine stands are generally young, over-stocked, and even-aged; the canopy is dense, with insufficient gaps, and there is often too much shrub and mid-story woody vegetation. Forest Service records indicate that prescribed fire has been introduced mainly in the non-growing season (however, recent



Figure 1. Shingle Branch Bog occurs within Fox Hunter's Hill

burns have been applied as late as May) and often with long intervals (2-4 years) between ignitions. In spite of these problems, Fox Hunter's Hill (Figure 2) has a diverse ground layer in many places.

Community types at Fox Hunter's Hill include extensive areas of arenic dry uplands, loamy dry mesic uplands, and small patches of xeric sandylands and glades. Along creeks are herbaceous seeps, particularly bogs and baygalls (Orzell 1990, Diggs et al. 2006, Van Kley 2006). High-quality longleaf pine upland is habitat for such



Figure 2. Upland Longleaf Community at Fox Hunter's Hill

federally listed animals as the Red-cockaded Woodpecker and the Louisiana Pine Snake (Connor et al. 2001), and rare plants such as *Liatris tenuis* Shinnery (Figure 3), *Silene subciliata* B.L. Robins., and *Rudbeckia scabrifolia* L. Brown (Carr 2004).

Few logging and other silvicultural activities have been conducted at Fox Hunter's Hill in the recent past. In the past 17 years, two prescriptions have been written for the area (S. Walker unpubl. data); however, one of the projects was not carried out and the other project included only a small area of patch clear-cut that was necessary due to scorch from a prescribed burn. That area was replanted with longleaf pine. Prescribed fire has been the main management tool used in Fox Hunter's Hill for the past 15 years. With the exception of 2000-



Figure 3. *Liatris tenuis* Shinnery

2003, when no prescribed burning occurred, Fox Hunter's Hill has been burned on a 2-3 year rotation (T. Zimmerman pers. comm.). The timing of burns alternated between fall and late winter to early spring. However, the latest prescribed burn applied to Fox Hunter's Hill occurred in May 2006 because of a desire to implement a growing season fire pattern.

METHODS

We established eight 20 m x 50 m (0.1 ha) plots in areas representative of the various longleaf pine upland habitats (Figure 4). Included were extensive areas of arenic dry uplands and loamy dry mesic uplands. Plots 1, 3, and 5 were mostly herbaceous and plots 2, 4, 6, and 8 were mostly shrubby. Plot 6 contained a small area of xeric sandylands; plots 3 and 7 had Catahoula glade elements. Within each 0.1 ha plot, we established two nested 3.16 m x 3.16 m (0.001 ha) plots

and two 1 m x 1 m nested (0.0001 ha) plots (see Peet et al. [1998] for plot design). We surveyed these plots on 21 and 22 June 2005, 12 July 2005, 26 and 27 October 2005, and 5 and 6 April 2006, and recorded all species in each. We estimated canopy cover for each 0.1 ha plot.

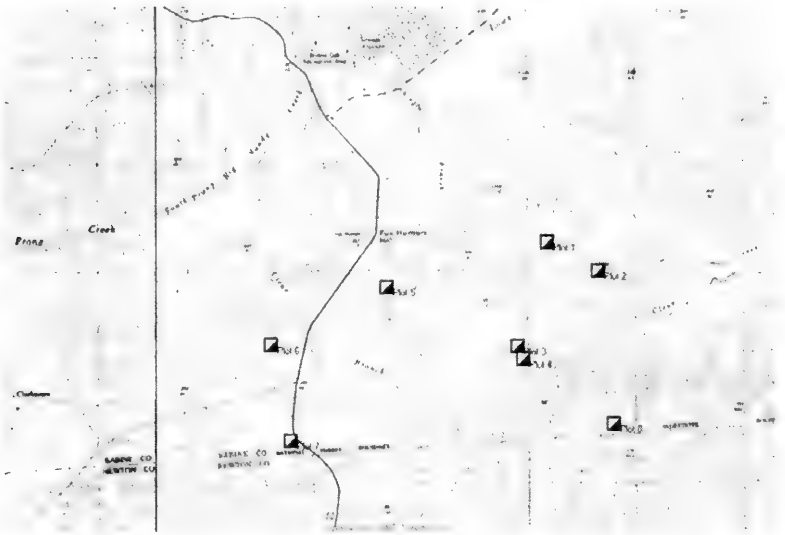


Figure 4. Plot locations at Fox Hunter's Hill

Throughout this paper, plant nomenclature follows Kartesz and Meacham (1999), Diggs et al. (2006), or USDA (2006).

RESULTS

Table 1 lists the vascular flora of the eight 0.1 ha plots. 1-8 refer to the 0.1 ha plot in which the species occurred.

Table 1: Fox Hunter's Hill Plant Species List 2005-2006

ACANTHACEAE

Ruellia humilis Nutt. (1)(2)(4)(5)(6)

ACERACEAE

Acer rubrum L. (1)(2)(4)

AGAVACEAE

Yucca louisianensis Trel. (2)(8)

ANACARDIACEAE

Rhus copallinum L. (1)(2)(4)(5)(6)(8)

Toxicodenron pubescens P. Mill. (1)(2)(3)(4)(5)(6)(7)(8)

ANNONACEAE

Asimina parviflora (Michx.) Dunal (1)(2)(5)(6)

APIACEAE

Eryngium yuccifolium Michx. (1)(5)(6)(7)

AQUIFOLIACEAE

Ilex opaca Ait. (2)(6)(8)

Ilex vomitoria Ait. (1)(2)(3)(4)(5)(6)(8)

ARISTOLOCHIACEAE

Aristolochia reticulata Jacq. (1)(2)(3)(5)(6)

Aristolochia serpentaria L. (1)(4)(5)

ASCLEPIADACEAE

Asclepias amplexicaulis Sm. (6)

Matelea cynanchoides (Engelm.) Woods. (6)

ASTERACEAE

Ambrosia artemisifolia L. (1)(2)(5)(8)

Baccharis halimifolia L. (1)(5)

Berlandiera pumila (Michx.) Nutt. (1)(2)(5)(6)

Bigelowia nuttallii L.C. Anders. (3)(4)

Boltonia diffusa Ell. (2)(4)

Chrysopsis pilosa Nutt. (1)(3)(4)(5)(6)(7)(8)

Cirsium sp. (6)

Croptilon divaricatum (Nutt.) Raf. (6)

Echinacea pallida (Nutt.) Nutt (7)

Elephantopus tomentosus L. (4)

- Erigeron strigosus* Muhl. ex Willd. (1)(6)(8)
Eupatorium capillifolium (Lam.) Small (5)(6)
Eupatorium compositifolium Walt. (1)(2)(5)(6)
Eupatorium rotundifolium L. (1)(2)(3)(4)(5)(6)
Eurybia hemisphaerica (Alex.) Nesom (7)
Gaillardia aestivalis (Walt.) H. Rock (1)(5)(6)
Helianthus angustifolius L. (1)(2)(3)(4)(5)(7)(8)
Helianthus hirsutus Raf. (4)
Hieracium gronovii L. (1)(2)(3)(4)(5)(6)(7)(8)
Hymenopappus artemisiifolius var. *artemisiifolus* DC. (1)(2)(5)(6)
Ionactis linariifolius (L.) Greene (1)(3)(4)(5)(6)(7)
Krigia sp. (6)
Lactuca canadensis L. (1)(2)(5)
Liatris elegans (Walt.) Michx. (1)(2)(5)(6)(8)
Liatris pycnostachya Michx. (6)
Liatris squarrosa (L.) Michx. (4)(5)(8)
Liatris tenuis Shinnars (3)(4)(7)
Pityopsis graminifolia (Michx.) Nutt. var. *graminifolia*
 (1)(2)(3)(4)(5)(6)(7)(8)
Pseudognaphalium obtusifolium (L.) Hilliard & Burt (5)(6)
Rudbeckia grandiflora (D. Don) J.F. Gmel ex DC. (1)
Rudbeckia hirta L. (1)(2)(3)(4)(5)(6)(7)(8)
Silphium gracile Gray (1)(2)(5)(6)
Solidago nitida Torr. & A. Gray (1)(2)(6)(7)
Solidago odora Ait. (1)(2)(3)(4)(5)(6)(7)(8)
Solidago petiolaris Ait. (2)(3)(5)(8)
Symphyotrichum dumosus (L.) Nesom (3)(4)(6)(7)
Symphyotrichum patens (Ait.) Nesom var. *patens* (1)(2)(3)(6)(7)(8)
Symphyotrichum pratensis (Raf.) Nesom (3)(4)(7)
Vernonia texana (A. Gray) Small (1)(2)(3)(4)(6)(7)(8)

BIGNONIACEAE

- Bignonia capreolata* L. (1)(7)

BORAGINACEAE

- Lithospermum caroliniense* (Gmel.) MacM. (1)(2)(5)(6)

CAMPANULACEAE

- Lobelia appendiculata* A. DC. (6)

Lobelia puberula Michx. (1)(2)(3)(4)(5)(6)

CAPRIFOLIACEAE

Viburnum rufidulum Raf. (8)

CISTACEAE

Helianthemum georgianum Chapm. (1)(6)

Lechea mucronata Raf. (1)(3)(4)(5)(7)

Lechea tenuifolia Michx. (3)(5)

CLUSIACEAE

Hypericum crux-andreae (L.) Crantz (3)(4)

Hypericum gentianoides (L.) B.S.P. (3)(6)(7)

Hypericum hypericoides (L.) Crantz (1)(3)(4)(5)(6)(7)(8)

COMMELINACEAE

Commelina erecta L. (1)(2)(5)(6)

Tradescantia reverchonii Bush (1)(5)(6)

CONVOLVULACEAE

Ipomoea pandurata (L.) G.F.W. Mey. (5)

CORNACEAE

Cornus florida L. (1)(2)(4)(5)(6)(8)

Nyssa sylvatica Marsh. (2)(3)(4)(5)(7)(8)

CYPERACEAE

Carex caroliniana Schwein. (4)

Cyperus echinatus (L.) Wood (1)(2)(5)(6)(8)

Cyperus filiculmis Vahl. (6)

Cyperus retrofractus (L.) Torr. (5)

Rhynchospora globularis (Chapm.) Small. (3)(4)(7)(8)

Rhynchospora grayi Kunth (1)(2)(3)(4)(8)

Scleria ciliata Michx. (2)(3)(4)(5)(6)(8)

Scleria oligantha Michx. (8)

Scleria triglomerata Michx. (1)(5)(6)

DENNSTAEDTIACEAE

Pteridium aquilinum L. (1)(7)(8)

DROSERACEAE

Drosera brevifolia Pursh (3)(4)(7)(8)

EBENACEAE

Diospyros virginiana L. (4)(7)

ERICACEAE

Vaccinium arboreum Marsh. (1)(2)(3)(4)(5)(7)(8)

Vaccinium corymbosum L. (1)(2)(3)(4)(6)(7)(8)

Vaccinium stamineum L. (1)(2)(3)(4)(5)(7)(8)

EUPHORBIACEAE

Acalypha virginica L. (5)(6)

Cnidocolus texanus (Muell.-Arg.) Small (5)(6)

Croton argyranthemus Michx. (1)(3)(4)(5)(6)

Croton willdenowii G.L. Webster (3)(6)

Croton michauxii G.L. Webster (7)

Euphorbia sp. (8)

Euphorbia corollata L. (1)(2)(3)(4)(6)(7)(8)

Stillingia sylvatica L. (2)(5)(6)(8)

Tragia smallii Shinnery (1)(2)(5)(6)(8)

Tragia urens L. (1)(2)(5)(6)(8)

Tragia urticifolia Michx. (1)(2)(5)(6)(8)

FABACEAE

Baptisia bracteata Muhl. ex Ell. var. *laevicaulis* (Gray ex Canby) Isely (1)(3)(4)(6)

Centrosema virginiana (L.) Benth. (2)(5)(6)

Chamaecrista fasciculata (Michx.) Greene var. *fasciculata* (1)(3)(5)

Clitoria mariana L. (5)

Crotalaria sagittalis L. (1)(5)(6)

Desmodium sessilifolium (Torr.) T.&G. (2)(3)(4)(5)(6)(7)(8)

Desmodium ciliare (Muhl. ex Willd.) DC. (1)

Erythrina herbacea L. (6)

Galactia volubilis (L.) Britt. (1)(2)(3)(5)(6)(7)(8)

Lespedeza sp. (5)(6)

Lespedeza procumbens Michx. (3)

Lespedeza repens (L.) Barton (7)

- Lespedeza virginica* (L.) Britt. (3)
Mimosa hystricina (Small) B.L. Turner (5)(7)
Rhynchosia latifolia Nutt. ex. Torr. & Gray (1)(6)
Rhynchosia reniformis DC. (1)(2)(3)(5)(6)
Strophostyles umbellata (Muhl. ex Willd.) Britt. (1)(2)(3)(5)(6)
Stylosanthes biflora (L.) B.S.P. (3)(4)(5)(6)(7)(8)
Tephrosia onobrychoides Nutt. (1)(2)(3)(4)(5)(6)(7)
Tephrosia virginiana (L.) Pers. (1)(2)(3)(4)(5)(6)(7)(8)

FAGACEAE

- Quercus alba* L. (3)(4)(8)
Quercus falcata Michx. (1)(2)(3)(6)(7)(8)
Quercus incana Bartr. (2)(5)(6)
Quercus marilandica Muenchh. (1)(3)(4)(6)(7)(8)
Quercus nigra L. (2)(8)
Quercus stellata Wang. (3)(4)(7)(8)

GENTIANACEAE

- Sabatia campestris* Nutt. (6)

HAMAMELIDCEAE

- Liquidambar styraciflua* L. (2)(3)(4)(5)(6)(7)(8)

IRIDACEAE

- Alophia drummondii* (Graham) Foster (1)(5)(6)(8)
Sisyrinchium albidum Raf. (3)(4)(7)(8)

JUGLANDACEAE

- Carya alba* (L.) Nutt. ex Ell. (6)
Carya texana Buckl. (1)(2)(6)(8)

LAMIACEAE

- Monarda fistulosa* L. (6)
Pycnanthemum albescens Torr. & A. Gray (4)(5)(6)
Salvia azurea Michx. ex Lam (8)
Scutellaria sp. (3)
Scutellaria cardiophylla Engelm. & A. Gray (6)(8)
Scutellaria parvula Michx. (3)

LAURACEAE

Persea palustris (Raf.) Sarg. (1)(2)(6)(8)

Sassafras albidum (Nutt.) Nees (1)(2)(5)(6)(7)

LILIACEAE

Allium canadense L. (4)

Hypoxis hirsuta (L.) Coville (5)

Nothoscordum bivalve (L.) Britt. (3)(4)(7)

LINACEAE

Linum medium (Planch.) Britt. (1)(3)(4)(5)

LOGANACEAE

Gelsemium sempervirens (L.) Ait. f. (1)(2)(3)(4)(5)(6)(7)(8)

MAGNOLIACEAE

Magnolia grandiflora L. (6)

Magnolia virginiana L. (1)

MYRICACEAE

Morella cerifera (L.) Small (1)(2)(3)(5)(7)(8)

OLEACEAE

Chionanthus virginicus L. (4)(7)(8)

OXALIDACEAE

Oxalis dillenii Jacq. (1)(2)(6)(7)

Oxalis violacea L. (1)

PASSIFLORACEAE

Passiflora lutea L. (2)

PINACEAE

Pinus echinata P.Mill. (1)(2)(3)(4)(6)(7)(8)

Pinus palustris P.Mill. (1)(2)(3)(4)(5)(6)(7)(8)

Pinus taeda L. (1)(2)(5)(6)(7)(8)

POACEAE

Agrostis sp. (1)(2)

- Andropogon gerardii* Vitman (2)(3)(6)(7)
Andropogon ternarius Michx. (1)(2)(6)(7)
Andropogon virginicus var. *virginicus* L. (1)(6)(7)
Aristida lanosa Muhl. ex Ell. (1)(3)(6)
Aristida longespica Poir (1)(2)(3)(6)(7)
Chasmanthium laxum (L.) Yates (4)(6)
Coelorachis cylindrica (Michx.) Nash (1)(5)(6)(8)
Dichantherium aciculare (Desv. ex Poir) Gould & Clark (3)(4)(5)(6)(7)
Dichantherium acuminatum (Sw.) Gould & C.A. Clark (1)(2)(4)(5)(8)
Dichantherium oligosanthes (J.A. Schultes) Gould (1)(6)
Dichantherium scoparium (Lam.) Gould (2)(3)
Dichantherium sphaerocarpon (Ell.) Gould (1)(3)(4)(5)(6)(8)
Digitaria cognata (J.A. Schult.) Pilger (8)
Eragrostis spectabilis (Pursh) Steud. (2)(4)(7)
Gymnopogon ambiguus (Michx.) B.S.P. (1)(2)(5)(6)
Panicum sp. (8)
Panicum anceps Michx. (4)
Paspalum floridanum Michx. (3)(4)(7)
Paspalum setaceum Michx. (2)(5)
Schizachyrium scoparium (Michx.) Nash (1)(2)(3)(4)(5)(6)(7)(8)
Sorghastrum elliottii (C. Mohr) Nash (3)(6)
Sporobolus junceus (Beauv.) Kunth (1)(2)(6)(8)
Tripsacum dactyloides (L.) L. (5)

POLEMONIACEAE

- Phlox pilosa* L. (1)(2)(3)(5)

POLYGALACEAE

- Polygala mariana* Mill. (3)
Polygala nana (Michx.) DC. (2)(3)(5)
Polygala polygama Walt. (8)

RANUNCULACEAE

- Delphinium carolinianum* subsp. *vimineum* (D. Don) Warnock (5)(6)

RHAMNACEAE

- Berchemia scandens* (Hill) K. Koch (4)
Ceanothus americanus L. (2)(3)(5)
Frangula caroliniana (Walt.) A. Gray (8)

ROSACEAE

- Crataegus brachyacantha* Sarg. & Engelm. (3)
Crataegus marshallii Egglest. (2)(3)(4)(7)(8)
Crataegus spathulata Michx. (4)(7)
Rubus argutus Link (2)(3)(4)(6)(7)(8)

RUBIACEAE

- Diodia teres* Walt. (3)(6)
Galium pilosum Ait. (1)(2)(3)(5)(6)
Hedyotis nigricans (Lam.) Fosberg (1)(2)(5)(6)
Houstonia micrantha (Shinners) Terrell (4)
Mitchella repens L. (4)(8)

SAPOTACEAE

- Sideroxylon lanuginosum* Michx. (2)

SCROPHULARIACEAE

- Agalinis homalantha* Pennell (4)(6)(7)(8)
Penstemon laxiflorus Pennell (4)(5)(8)

SMILACACEAE

- Smilax bona-nox* L. (2)(4)(7)
Smilax glauca Walt. (2)(3)(4)(6)(8)
Smilax rotundifolia L. (4)(7)
Smilax smallii Morong (4)(7)(8)

SOLANACEAE

- Physalis pumilla* Nutt. (1)(6)

SYMPLOCACEAE

- Symplocos tinctoria* (L.) L'Her. (8)

VERBENACEAE

- Callicarpa americana* L. (1)(2)(3)(4)(5)(6)(8)
Glandularia canadensis (L.) Nutt. (1)(2)

VIOLACEAE

- Viola pedata* L. (3)(4)(7)(8)

VITACEAE

Parthenocissus quinquefolia (L.) Planch. (1)(3)*Vitis aestivalis* Michx.(1)(2)(3)(5)(6)(8)*Vitis rotundifolia* Michx.(1)(2)(4)(6)

Table 2 gives information on species richness in the 0.1 ha, 0.001 ha, and 0.0001 ha plots.

Table 2. Number of species in plots

Plot No.	0.1 ha plot	Nested plots within 0.1 plots			
		0.001 ha plots		0.0001 ha plots	
		average	range	average	range
1	96	32.5	27-38	12.5	8-17
2	88	25.5	25-26	7.0	5-9
3	83	24.0	20-28	9.0	7-11
4	80	22.0	17-27	11.5	9-14
5	93	31.5	28-35	17.5	15-20
6	112	45.5	45-46	24.5	24-25
7	71	23.0	21-25	7.0	5-9
8	75	26.0	21-31	10.5	9-12

Canopy cover of the eight 0.1 plots were as follows: plot 7 (20 percent); plot 3 (40 percent); plots 1, 2, 4, 5, 6 (50 percent); plot 8 (70 percent). The average was 48 percent.

DISCUSSION

The eight 0.1 ha plots had 196 species and averaged 87.25 species (range 71 to 112); while the sixteen 0.001 ha plots averaged 28.75 species (range 17 to 46); and the sixteen 0.0001 ha plots averaged 12.44 species (range 5 to 25).

MacRoberts et al. (2004a) provide the most complete West Gulf Coastal Plain longleaf pine uplands data set for comparison with the Fox Hunter's Hill plots. They established four 0.1 ha plots in

longleaf pine uplands (arenic dry uplands) in the Winn and Catahoula ranger districts of the Kisatchie National Forest, Louisiana, about 150 km northeast of Fox Hunter's Hill, and recorded all species in them. Their plots had between 82 and 113 species (average 100). An Index of Similarity (Sorenson's) between the eight 0.1 ha plots at Fox Hunter's Hill and the four 0.1 ha plots Kisatchie National Forest gives a figure of 63, a relative high degree of similarity. This degree of similarity is interesting considering the small amount of area sampled in both studies (0.8 ha at Fox Hunter's Hill, 0.4 ha at Kisatchie), unequal sample size (196 species at Fox Hunter's Hill, 158 species at Kisatchie), the distance between study sites (150 km), and the fact that Fox Hunter's Hill included plots with dryer (xeric) and wetter (loamy dry-mesic uplands) elements than the Kisatchie sample (arenic dry uplands only). This suggests that longleaf pine uplands in the West Gulf Coastal Plain may be very similar floristically over their range.

Data on species richness in the West Gulf Coastal Plain are scanty. Open habitat such as bogs, prairies, xeric sandylands, and old fields average about 15-25 species in 0.0001 ha plots, 30-40 in 0.001 ha plots, and 75-120 in 0.1 ha plots (MacRoberts and MacRoberts 2001, MacRoberts et al. 2002). In closed (shaded) habitat, the numbers drop dramatically (Brewer 1998, MacRoberts et al. 2004b, MacRoberts unpublished data). The data for Fox Hunter's Hill are therefore encouraging, with averages of 12.44, 28.75, and 87.25 for 0.0001 ha, 0.001 ha, and 0.1 ha plots.

Recommendations for the future management of Fox Hunter's Hill would include more frequent fire mainly in the growing season, lower stocking in many places, the creation of gaps so that natural regeneration will occur, and the creation of an uneven distribution of pines.

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**TAXONOMIC REFLECTIONS ON THE PARASITIC
ANGIOSPERMS OF PAKISTAN**

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ABSTRACT

This is the first comprehensive listing of the flowering parasitic plants of Pakistan. A total of 50 plant species in 13 genera belonging to five plant families are reported from Pakistan. The largest number of parasitic plants are in Orobanchaceae (25 species) followed by Cuscutaceae (17 species). Scrophulariaceae had four species, Loranthaceae three and Balanophoraceae one. The majority of these parasitic plants occur in northern areas of Pakistan and Kashmir. Six species were found in Balochistan, and only two in Sindh. All the species of Scrophulariaceae, except *Centranthera hispida*, were found either in hilly areas or in the salt range.

KEY WORDS: Parasitic angiosperms, Pakistan

Approximately 1% (4000 species) of all angiosperms are parasitic, and attach themselves to other vascular plants by means of haustoria (Nickrent and Press, 1999). These plants have continued

to be the focus of multidisciplinary research owing to their importance as agronomically significant weeds and as models for studying developmental, physiological and molecular processes (Albrecht et al. 1999, Boone et al. 1995, Stewart and Press 1990). Because of their intimate and complex interrelationships with host plants, parasitic angiosperms display evolutionary modifications at the biochemical, cellular, anatomical, and ecological levels that are novel among angiosperms (Nickrent and Press, 1999).

Yoder (1999, 2001) and Yoder et al. (1999) have reported how plants communicate via chemical signals in the environment. In their studies on parasitic plants, they particularly focused on the genetic mechanisms governing the interaction of parasitic angiosperms and their plant hosts. Parasitic plants are interesting because their growth, development, and physiological behavior is modified in response to molecular signals exuded from neighboring plants (Estabrook and Yoder 1998, Matvienko et al. 2001, O'Malley and Lynn 2000). In addition, the study of parasitic plants is important because of the agricultural devastation caused by several of the more pernicious weedy species (Cubero and Moreno 1996, Habib and Rahman 1988, Press and Graves 1995, Torres et al. 2000). For example, the parasitic weed *Striga* Lour. is estimated to infect two thirds of crop plants on cultivated lands in sub-Saharan Africa where it can cause complete yield losses in critical staples such as maize, sorghum, millet and broad beans (Hausmann et al. 2001). The lives of over a 100 million Africans are negatively affected by this single plant pathogen alone (Hausmann et al. 2001). Although all parasitic plants have received much attention, the major emphasis has been on devastating crop pathogens such as *Striga* and *Orobanche* L. (Cubero and Moreno 1996). Press and Graves (1995) discussed modern topics such as the physiology of seed germination and haustorial initiation, mineral, carbon and nitrogen relations; and genome organization. However, there still exists a need to fully explore the cellular, biochemical and structural aspects of all parasitic plants.

More than 50% of Pakistan is mountainous, particularly its northern areas which includes high altitude mountain ranges, such as the Hindu Kush, Pamirs, Karakoram and Himalayas. These ranges are rich in flora and fauna, most of which are endemic, having temperate

paleo-arctic affinity, including species typical of the Sino-Japanese phytogeographical zone and Himalayas (Nasir and Rafiq 1995). Parasitic angiosperms have been mentioned in the *Flora of Pakistan* (Nasir and Ali 1972) and elsewhere (Nasir and Rafiq 1995). However, reports on their taxonomy, distribution and host plants are lacking. The present study was undertaken to compile a taxonomic list of parasitic plants and their distribution in Pakistan.

MATERIALS AND METHODS

This study is based on extensive on line and library and search study through MEDLINE, review articles and book reports to find out parasitic angiosperms of Pakistan (Nasir and Ali 1972, Nasir and Rafiq 1995). A list was compiled, and their taxonomic position determined. The distribution of these parasitic angiosperms in various parts of Pakistan is also described. The genera are arranged alphabetically within families. The nomenclature and classification follow Nasir and Ali (1972) and Nasir and Rafiq (1995), and author citations follow Brummitt and Powell (1992).

RESULTS AND DISCUSSION

This study is the first comprehensive survey of the parasitic angiosperms of Pakistan. A total of 50 species in 13 genera belonging to five families are reported from Pakistan (Table 1). It is interesting to note are all dicotyledonous. The largest is found in Orobanchaceae (25 species) followed by Cuscutaceae (17 species). Scrophulariaceae had four species, Loranthaceae, three and Balanophoraceae one species (Table 1). The majority of these parasitic plants occur in northern areas of Pakistan and Kashmir. Six species were found in Balochistan and only two in Sindh (Table 1). All the species of Scrophulariaceae, except *Centranthera hispida* R. Br., are found either in hilly areas or the salt range.

Parasitic plants often use secondary metabolites secreted from the roots as chemical messengers to initiate the development of invasive organs (haustoria) required for heterotrophic growth (Keyes et al. 2000). Some of the most devastating parasitic plants of important food crops such as maize, sorgham, millet, rice and legumes belong to

Orobanchaceae, which typically invades the roots of the plants depriving them of water, minerals and essential nutrients (Yoder 1999). The hemiparasitic Orobanchaceae are characterized by a distinctive suite of ecophysiological traits (Phoenix et al. 2005). These traits have important impacts on the host plants and non-host plants, and influence interactions with other trophic levels. Ultimately, they can affect community structure and functioning. Phoenix et al. (2005) reviewed these physiological traits and discussed their ecological consequences.

The root hemiparasitic Orobanchaceae forms a convenient subset of the parasitic angiosperms for study because they are the most numerous and widely distributed group of parasitic angiosperms. Their physiological characteristics have been well studied. They are important in both agricultural and (semi)natural communities, and are tractable as experimental organisms (Estabrook and Yoder 1998, Phoenix et al. 2005, Riopel and Timko 1995, Torres et al. 2000). Key traits include: high transpiration rates; competition with the host for nutrients; and haustorial metabolism of host-derived solutes, uptake of host-derived secondary metabolites; dual autotrophic and heterotrophic carbon nutrition; distinct carbohydrate biochemistry; high nutrient concentrations in green leaf tissue and leaf litter; and small (often hairless and non-mycorrhizal) roots (Chang and Lynn 1986, 1987, Stewart and Press 1990).

Impacts of parasitic angiosperms on their hosts are detrimental, which can alter competitive balances between hosts and non-hosts and thus result in community change. Further impacts may result from effects on the abiotic environment, including soil water status, nutrient cycling and leaf/canopy temperatures. However, for non-host species and for organisms that interact with these (e.g. herbivores and pollinators) or for those that benefit from changes in the abiotic environment, the parasites may have an overall positive effect suggesting that at the community level, hemiparasites may also be considered as mutualists (Matvienko et al. 2001, Phoenix and Press 2005). It is clear that through their distinctive suite of physiological traits, hemiparasitic plants in Orobanchaceae have considerable impact on community structure and function, can have both competitive and positive interactions with other plants, and can affect other trophic levels (Phoenix and Press 2005). Many community level effects of

parasitic plants can be considered analogous to those of other parasites, predators or herbivores.

The goal of this study was to bring together the state-of-the-art research on parasitic angiosperms. Unlike most of the past publications, the main focus has been on the taxonomic and distributional aspects of the parasitic angiosperms of Pakistan. The results presented here will be of broad interest for plant scientists, and will provide information to specialists working on different aspects of parasitic plant biology.

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Table 1. Parasitic angiosperms of Pakistan.

Parasitic Species	Distribution
Balanophoraceae	
<i>Balanophora involucrata</i> Hook. f. & Thomson	Kashmir
Cuscutaceae	
<i>Cuscuta approximata</i> Bab.	Chitral and Kashmir
<i>Cuscuta approximata</i> Bab. var. <i>urceolata</i> (Kunze) Yunck.	Murree and Kashmir
<i>Cuscuta australis</i> R. Br. var. <i>cesatiana</i> (Bertol.) Yunck.	Kashmir
<i>Cuscuta brevistyla</i> A. Braun ex A. Rich.	Chitral
<i>Cuscuta capitata</i> Roxb.	Astor and Kashmir
<i>Cuscuta chinensis</i> Lam.	Kashmir
<i>Cuscuta epithymum</i> (L.) L.	Skardu
<i>Cuscuta europaea</i> L.	Astor
<i>Cuscuta europaea</i> L. var. <i>indica</i> Engelm.	Chitral and Swat
<i>Cuscuta gigantea</i> Griff.	Kalat
<i>Cuscuta hyalin</i> Roth	Karachi
<i>Cuscuta kotschyana</i> Boiss.	Balochistan
<i>Cuscuta lehmanniana</i> Bunge	Chitral
<i>Cuscuta lupuliformis</i> Krock.	Kalat and Chitral
<i>Cuscuta monogyna</i> Vahl	Balochistan
<i>Cuscuta planiflora</i> Ten.	Chitral and Kashmir
<i>Cuscuta pulchella</i> Engelm.	Chitral
<i>Cuscuta reflexa</i> Roxb.	Karachi, Chitral, Dir, Gilgit and salt range
<i>Cuscuta tinei</i> Inzenga	Kashmir
Loranthaceae	
<i>Arceuthobium minutissimum</i> Hook. f.	Swat, Kagan,
<i>Viscum album</i> L.	Kurram, Chitral

<i>Viscum cruciatum</i> Sieber ex Spreng.	Khyber, Swat
Orobanchaceae	
<i>Aeginetia pedunculata</i> (Roxb.) Wall.	Murree
<i>Christisonia calcarata</i> Wight	Sindh
<i>Cistanche tubulosa</i> (Schrenk) Hook. f.	Sibi, Las Bella, Mianwali
<i>Lathraea squamaria</i> L.	Kaghan, Dunga Gali, Murree
<i>Orobanche aegyptiaca</i> Pers.	Quetta, Chaman, Ziarat, Dargai
<i>Orobanche alba</i> Stephan	Miranjani, Poonch
<i>Orobanche amethystea</i> Thuill.	Ziarat, Chitral
<i>Orobanche amoena</i> C. A. Mey.	Chitral
<i>Orobanche caesia</i> Rchb.	Murree and Kashmir
<i>Orobanche cernua</i> Loefl.	Quetta, Chitral
<i>Orobanche clarkei</i> Hook. f.	Kurram, Chitral
<i>Orobanche coelestis</i> (Reut.) Beck.	Balochistan
<i>Orobanche connata</i> K. Koch	Chitral
<i>Orobanche hansii</i> A. Kern.	Kurram, Chitral
<i>Orobanche hirtiflora</i> (Reut.) Tzvelev	Kalat
<i>Orobanche kashmirica</i> C. B. Clarke ex Hook. f.	Kashmir
<i>Orobanche kotschyi</i> Reut.	Chitral

<i>Orobanche lavandulacea</i> Rchb.	Baluchistan
<i>Orobanche orientalis</i> Beck	Ziarat and Kashmir
<i>Orobanche oxyloba</i> (Reut.) Beck	Baluchistan
<i>Orobanche psila</i> C. B. Clarke ex Hook. f.	Kashmir
<i>Orobanche solmsii</i> C. B. Clarke ex Hook. f.	Swat and Kashmir
<i>Orobanche stocksii</i> Boiss.	Kurram
<i>Orobanche vulgaris</i> Poir.	Kurram
<i>Xylanche himalaica</i> (Hook. f. & Thoms.) Beck	Kashmir
Scrophulariaceae	
<i>Centranthera hispida</i> R. Br.	Mirpur
<i>Striga asiatica</i> (L.) Kuntze	Salt range
<i>Striga gesnerioides</i> (Willd.) Vatke	Salt range
<i>Sopubia delphiniifolia</i> (L.) G. Don	Hilly areas

**XANTHISMA SPINULOSUM VAR. AUSTROTEXANUM
(ASTERACEAE: ASTEREA), AN ENDEMIC OF
SOUTHERNMOST TEXAS**

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ABSTRACT

Haplopappus texensis R.C. Jackson, heretofore ignored as a formal taxon within the *Machaeranthera pinnatifida* (Hook.) Shinnery complex by the present author, is now accepted as a good taxon within the genus *Xanthisma* as **X. spinulosum** var. **austrotexanum** (R.C. Jackson) B.L. Turner, **comb. & nom. nov.** The taxon was also ignored in the treatment of *Xanthisma* by Morgan and Hartman (2003) but placed in synonymy with *X. spinulosum* var. *spinulosum* in the treatment of Hartman (2006) for the Flora of North America.

KEY WORDS: Asteraceae, *Machaeranthera*, *Xanthisma*, Texas

According to DNA data the genus *Machaeranthera*, as conceived by Hartman (1990), is polyphyletic and has recently been reapportioned into four genera: *Arida*, *Dieteria*, *Machaeranthera*, and *Xanthisma*. Morgan and Hartman (2003) discussed the taxonomic implications of this fragmentation and have provided a nomenclature for the new phylogeny (Morgan and Hartman 2003; Hartman 2006). All four of these genera occur in Texas, and in the course of rearranging materials to accord with the new nomenclature I noted a group of plants from southernmost Texas belonging to the *Xanthisma spinulosum* complex that appeared to lack a formal name, hence the present paper.

Turner and Hartman (1976) treated *Xanthisma spinulosum* (= *Machaeranthera pinnatifida*) as having two allopatric subspecies: **subsp. gooddingii**, a western assemblage containing four intergrading

varieties; and a more eastern **subsp. spinulosum** containing three intergrading varieties. Within the latter subspecies, Turner and Hartman placed *Haplopappus texensis* R.C. Jackson in synonymy with *M. pinnatifida* var. *pinnatifida* noting, however, that the taxon concerned might be accorded varietal rank in due course, if not specific rank. At the time of its description, relatively few collections were known (mainly from the type locality). Regardless, in a numerical study of the *Machaeranthera pinnatifida* complex, Ramon (1968) demonstrated that topotypic material of *Haplopappus texensis* was "morphologically very distinct" from most other elements of the *Machaeranthera pinnatifida* complex. Indeed, he thought it deserving of specific rank. Nevertheless, by his data the taxon clustered with or near *M. p.* var. *pinnatifida*. Nevertheless, Hartman (2006) placed *Haplopappus texensis* in synonymy with *Xanthisma spinulosum* var. *spinulosum* without comment. Through some lapse, perhaps, he also excluded the distribution of var. *spinulosum* from Texas!

A number of new and old collections of the taxon concerned have been obtained in and about the region of *Haplopappus texensis* (Fig. 1). The characters (mainly stiffly erect unbranched habit, weakly incised leaves, and absence of glandular hairs) that distinguish it from its closest cohort, *M. p.* var. *pinnatifida*, hold up well, although the two taxa do appear to intergrade near regions of contact, hence my treatment of the taxon at the varietal level (putative intermediates between the taxa concerned are cited below).

Xanthisma spinulosum var. **austrotexanum** B.L. Turner, **stat. & nom. nov.** Based upon *Haplopappus texensis* R.C. Jackson, *Rhodora* 64:142. 1962. *Machaeranthera texensis* (R.C. Jackson) Shinnery, *Sida* 1:378. 1964. TYPE: U.S.A. Texas. **BROOKS CO.:** sandy soil along RR right-of-way, ca. 7.5 mi S of Falfurrias, 7 Aug 1959, R.C. Jackson 2938-1 (holotype: KANU).

I have taken up a new name for this varietal entity because of the well established *Xanthisma texensis* DC., which is a widespread species in Texas with several intergrading varieties. This should preclude future workers from becoming confused by the names concerned, and of course it will provide an epithet at species rank if

future workers were to re-elevate the taxon, as suggested by Ramon (1968) and its original author.

SPECIMENS EXAMINED: TEXAS. BROOKS CO: ca. 7.5 mi S of Falfurrias, 25 Aug 1957, along RR track embankment, *Jackson 2522* (SMU); 7 mi S of Falfurrias, 25 Aug 1957, *Jackson 2523* (TEX); 7 mi S of Falfurrias, 8 Aug 1959, *Jackson 2527* (TEX); ca. 8 mi W of Falfurrias along highway 285, 4 Jul 2005, *Richardson 3245* (TEX). **HIDALGO CO:** N of Dix, sandy soil, 13 Jul 1930, *Wolff 2363* (SMU). **JIM WELLS CO:** 12 miles N of Premont, 24 Nov 1954, *Johnston 542141* (TEX). **KLEBERG CO:** "Captains Pond," SW corner of Naval Air Station, Kingsville, 16 Sep 1991, *Carr 11426* (TEX); ca. 1.4 mi E of San Francisco Creek, Naval Air Station, Kingsville, 6 May 1993, *Carr 12716* (TEX); Kingsville, summer 1940, *Sinclair s.n.* (TEX).

I judge the following collections to be possible intermediates between the two varieties concerned: **TEXAS. JIM HOGG CO:** 15.4 mi S of Hebbronville, 9 Oct 1954, *Tharp & Johnston 541848* (TEX). **JIM WELLS CO:** Sandia, sandy roadside, 9 Aug 1959, *Turner 4586* (TEX).

ACKNOWLEDGEMENTS

I am grateful to my colleague Guy Nesom of BRIT for reviewing the paper and providing helpful comments.

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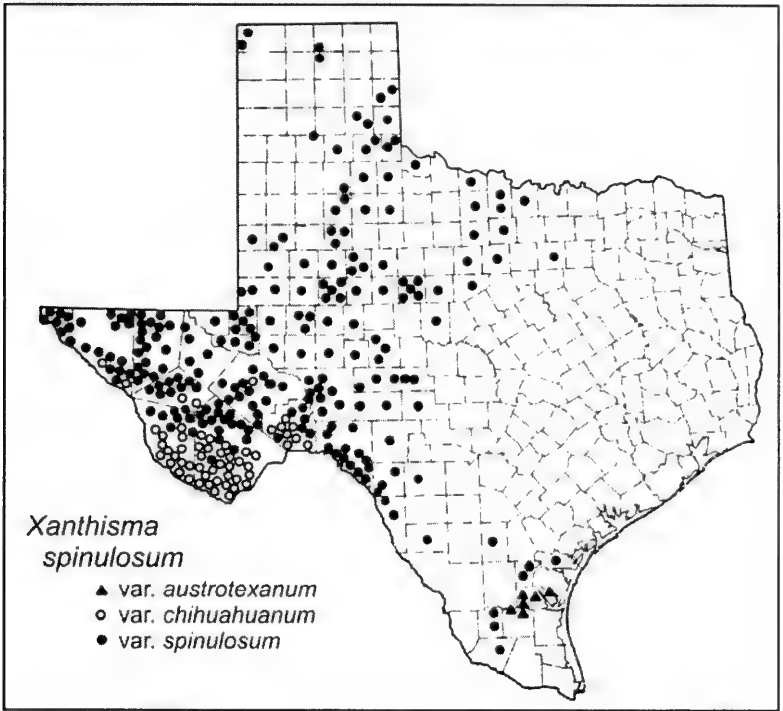


Fig. 1. Distribution of *Xanthisma spinulosum* var. *austrotexanum*, var. *chihuahuanum* and var. *spinulosum* in Texas.

A NEW SPECIES OF *VIGUIERA* (ASTERACEAE:
HELIANTHEAE) FROM OAXACA, MEXICO

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Routine identification of Mexican Asteraceae has revealed the following novelty:

***Viguiera paneroi* B.L. Turner, sp. nov.**

Viguierae sylvaticae Klatt similis sed differt capitulis majoribus (10-12 mm altis vs 5-7 mm), captulescentiis capitulis paucioribus (1-2 vs numerosis), et pappo magis prominenti (aristae laterales ca 5 mm longa vs ca 2 mm).

Perennial herb or shrublet to 1 m (?) high. **Stems** sparsely pilose with slender, multiseptate, appressed to spreading, hairs 3-5 mm long, beneath these a shorter array of recurved hairs ca 0.5 mm high. **Leaves** alternate along the upper stems, 10-14 cm long; petioles 2-4 cm long, grading into the blades; blades ovate, pubescent above and below with recurved hairs, their margins coarsely serrate, the under surfaces atomiferous-glandular with golden globules. **Capitulescence** of only 1 or 2 terminal heads on elongate peduncles. **Heads** ca 6 cm wide across the extended rays. **Involucre**s 10-12 mm high, the outer bracts subequal, linear-oblongate with somewhat ovate apices. **Receptacle** convex, ca 4 mm wide, paleate with stiff lanceolate bracts ca 14 mm long. **Ray florets** 13, neuter; tube sparsely pubescent, ca 1.5 mm long; ligules yellow, ca 3 cm long, 0.5-0.7 cm wide. **Disk florets** 40-60; corollas glabrous, the tube ca 0.5 mm long, the throat 4.5-5.5 mm long, markedly 5-nerved, their lobes ca 1 mm long. **Achenes** (immature) ca 5 mm long, densely appressed silky-white pubescent; pappus of two lateral, rigid awns, 5-6 mm long, between these 4-8 membranous scales 1-2 mm high.

TYPE: **MEXICO. OAXACA: Distrito Tehuantepec;** Mpio. San Pedro Huamelula, "noroestw [sic] de la laguna del Rosario Manglar, con Conocarpus erectus...Manglar. orilla de laguna." altitud ca 10 m, 15 Oct 2003, *Alfredo Saynes V. 3951* (con Silvia Salas). Holotype: TEX .

ADDITIONAL COLLECTIONS EXAMINED: **MEXICO. OAXACA: Distrito Tehuantepec:** Mpio. San Pedro Huamelula, 25 m, 2 Oct 2003, *M. Elorsa C. 7364* (TEX); 30 m, 29 Oct 2003, *M. Elorsa C. 7478* (Holotype: TEX).

To my knowledge this novelty has no close relatives in *Viguiera* (sensu Blake 1918), having a very distinctive 2-seriate involucre, the outer bracts longer than the inner and possessed of broad, oblanceolate apices. Vegetatively, it can be compared to *V. sylvatica* Klatt of the section *Diplostichis*, which has broad, ovate, markedly petiolate blades, the under surfaces of which contain golden-colored glandular punctations, similar to those found in *V. paneroi*.

Interestingly, the pales of *V. paneroi* resemble those found in species of *Simsia*, as do the peculiar long epidermal hairs found on its stems, these readily matched by the long epidermal hairs found on the stems of *Simsia foetida*. The achenes, however, both in shape and pappus, place the species in *Viguiera*, but not neatly into any of the series propounded by Blake (1918).

The species is named for my colleague, Prof. Jose L. Panero, long-time student of the genus *Viguiera* and exceptional teacher at The University of Texas, Austin.

ACKNOWLEDGEMENTS

I am grateful to Guy Nesom for the Latin diagnosis and for reviewing the paper. Jose L. Panero also reviewed the paper and kindly provided helpful suggestions.

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Fig. 1. *Vigiera paneroi* (Holotype: TEX).

NEW INFRAFAMILIAL TAXA IN ASTERACEAE

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ABSTRACT

Phylogenetic studies based on chloroplast DNA have recently identified several lineages that we recognize at the tribal and subfamily levels. Subfamilies Stifftioideae and Wunderlichioideae and tribes Hyalideae, Onoserideae, and Wunderlichieae are described.

KEY WORDS: Compositae, Stifftioideae, Wunderlichioideae, Mutisioideae, Hyalideae, Onoserideae, Wunderlichieae

Molecular studies using 10 loci of the chloroplast DNA and reported elsewhere (Panero & Funk submitted) reveal several clades that require naming to maintain a classification that recognizes only monophyletic groups. We describe the following new taxa formerly placed in Mutisioideae: Mutisieae. These names complement those already published in Panero & Funk (2002), based on the same molecular phylogenetic studies.

Stifftioideae (D. Don) Panero subfam. & comb. nov.; basionym: tribe Stifftieae D. Don, Trans. Linn. Soc. London, 16: 291, 1830. Type: *Stifftia* J. C. Mikan

Asteraceae subfamilia ad Mutisioideae similis sed differt (charactera in combinatione) foliis crasse coriaceis rare tenuibus in extremitatibus ramulorum fasciculatis, corollis grandibus tubis antherarum exsertis, capitulis phyllariis multiseriatis, stylis brachiis

glabris, cypselis plerumque 10-nervatis, et pappo aliquando vivide colorato.

Small trees, shrubs, vines. Leaves alternate, rarely opposite, petiolate, membranaceous to coriaceous, with margins entire, glabrous to pubescent. Capitula terminal, rarely axillary, solitary to large paniculiform cymes, rarely tightly grouped in glomerule-like cymes, homogamous, rarely heterogamous. Involucres narrowly cylindrical to hemispheric; phyllaries in 3-several series, imbricate, gradate. Receptacles epaleaceous. Florets hermaphrodite; corollas ligulate, bilabiate or actinomorphic, the lobes sometimes strongly coiled, white, yellow, pink, purple, orange or red; anthers 5, caudate, calcarate; anther appendages apiculate, rarely tapered; styles glabrous, style arms glabrous, rarely papillate or bullate on abaxial surface. Cypselae cylindrical; pappi of multiple capillary bristles, sometimes subplumose, mostly white or stramineous, rarely brightly colored, yellow-orange or pink.

The subfamily contains 10 genera: *Achnopogon* Maguire, Steyermark & Wurdack, *Dinoseris* Griseb., *Duidaea* S. F. Blake, *Eurydochus* Maguire & Wurdack, *Glossarion* Maguire, *Gongylolepis* R. H. Schomb., *Hyaloseris* Griseb., *Neblinaea* Maguire & Wurdack, *Quelchia* N. E. Br., and *Stiffia* J. C. Mikan.

Wunderlichioideae Panero & V. A. Funk, subfam. nov.,
Wunderlichieae Panero & V. A. Funk, tribus nov. Type:
Wunderlichia Riedel ex Benth. & Hook. f.

Asteraceae subfamilia ad Mutisioideae similis sed differt (charactera in combinatione) foliis crasse coriaceis aut deciduis, paginis abaxialibus foliorum aliquando dense pubescentibus albis in facie, corollis grandibus tubis antherarum exsertis, corollis plerumque actinomorphis rare bilabiatis aut ligulatis, capitulis phyllariis multiseriatis, antheris plerumque apiculatis, stylis brachiis papillatis aut laevibus, et cypselis plerumque cylindricis 10-nervatis.

Perennial herbs or shrubs. Leaves alternate, petiolate or sessile, coriaceous; blades linear, ovate to pandurate, obovate, with margins entire, undulate to tightly inrolled and then leaves (tubular,

cylindrical), sometimes densely ferruginous pubescent on abaxial surface. Capitula terminal, solitary, simple dichasia to paniculiform cymes, homogamous or heterogamous. Involucres cylindric to hemispheric; phyllaries in 3-several series, imbricate, gradate. Receptacles paleaceous or epaleaceous. Florets hermaphroditic; corollas bilabiate, actinomorphic, the lobes erect or rightly coiled, pink, white, purple, magenta, lavender, white or cream-colored; anthers 5, caudate, calcarate; anther appendages apiculate or tapered; styles glabrous, the arms glabrous, papillose or bullate abaxially. Cypselae cylindric, 10-ribbed; pappi in 3-4 series, sometimes plumose.

The subfamily contains 8 genera: *Chimantaea* Maguire, Steyerl. & Wurdack, *Ianthopappus* Roque & D. J. N. Hind, *Hyalis* D. Don ex Hook. & Arn., *Leucomeris* D. Don, *Nouelia* Franch., *Stenopadus* S. F. Blake, *Stomatochaeta* (S. F. Blake) Maguire & Wurdack, *Wunderlichia* Riedel ex Benth. & Hook. f.

Hyalideae Panero, tribus nov. Type: *Hyalis* D. Don ex Hook. & Arn.

Tribus subfamiliae Wunderlichioideae (in combinatione) distinctus appendicibus antherarum apiculatis, brachiis stylorum laevibus, et pappo et corollis conspicue exsertis supra involucra in speciebus plurimis.

Perennial herbs, shrubs, or small trees. Leaves alternate; leaf blades entire, linear to broadly obovate, sericeous to pannose white on abaxial surfaces, margins entire to slightly serrate. Capitula terminal, solitary or in small to compact paniculiform cymes, rarely corymbiform cymes, discoid or radiate. Involucres turbinate to campanulate; phyllaries in 3-multiple series, imbricate, gradate. Receptacles epaleaceous. Florets hermaphroditic; corollas ligulate, bilabiate with adaxial lobes strongly coiled, or actinomorphic, white, burgundy or pink; anthers 5, caudate, calcarate; anther appendages apiculate; styles glabrous; style arms glabrous. Cypselae cylindric to obovoid; pappi of multiple capillary bristles.

This tribe is placed in subfamily Wunderlichioideae and contains 4 genera: *Ianthopappus* Roque & D. J. N. Hind, *Hyalis* D. Don ex Hook. & Arn., *Leucomeris* D. Don, and *Nouelia* Franch.

Onoserideae (Bentham) Panero & V. A. Funk, tribus & comb. nov.
basonym: subtribe Onoseridinae Benth. & Hook. f., Gen. Pl. 2: 168,
215, 1873. Type: *Onoseris* Willd.

Tribus subfamiliae Mutisioideae (in combinatione) distinctus
corollis in morphologia similis et setis paleaceis dimorphis.

Annual or perennial herbs, shrubs, sometimes dioecious. Leaves alternate; blades entire, linear to ovate, rarely deltate, suborbicular or obovate. Capitula solitary, of a few dichasia or rarely forming large capitulescences with hundreds of capitula, radiate, rarely discoid. Involucre campanulate to hemispheric, with several series of imbricate phyllaries. Receptacles epaleate, rarely alveolate or fimbriate. Ray florets female; corollas bilabiate with a 3-toothed outer lobe and 1-2-toothed inner lobe, rarely absentred, orange, purple, pink, white or bicolored white-purple. Disc florets hermaphrodite, fertile or functionally staminate; corollas 5-lobed, the lobes short to long, straight or recurved, equal or unequal in length, sometimes with one lobe enlarged, red, yellow, greenish-yellow, purple, violet, white or pink; anthers 5, caudate, calcarate; styles glabrous, rarely papillose on abaxial surface of style arms. Cypselae cylindric to turbinate, glabrous to pubescent; pappi 2-4-seriate, mostly heteromorphic. Chromosome number, $x = 9$.

This tribe is placed in subfamily Mutisioideae and contains 6 genera including *Aphyllocladus* Wedd., *Gypothamnium* Phil., *Lycoseris* Cass., *Plazia* Ruiz & Pav., *Onoseris* Willd., and *Urmenetea* Phil.

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**JUNIPERUS COMPACTA (CUPRESSACEAE)
A NEW SPECIES FROM MEXICO**

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ABSTRACT

Recent nrDNA and trnC-trnD sequence data revealed that *J. monticola* and *J. m. f. compacta* are not monophyletic, and this prompted additional research using Single Nucleotide Polymorphisms (SNPs). The SNPs data clearly show that *J. monticola f. compacta* is not conspecific with *J. monticola f. monticola*. *Juniperus monticola f. compacta* Mart. is raised to the specific level as: ***Juniperus compacta* (Mart.) R. P. Adams, comb. et. stat. nov.**

KEY WORDS: *Juniperus jaliscana*, *Juniperus monticola*, *J. compacta*, *J. saltillensis*, nrDNA, trnC-trnD, SNPs, Cupressaceae

Adams (2004), in his monograph of *Juniperus*, followed traditional classifications in recognizing *J. monticola* Mart. f. *monticola*, *J. m. f. compacta* Mart. and *J. m. f. orizabensis* Mart. However, DNA sequencing of nrDNA and trnC-trnD for *Juniperus* (Schwarzbach, et al., 2008) has shed new light on the relationships within this group. One surprising finding was that *J. m. f. monticola* formed a clade with *J. jaliscana* whereas *J. m. f. compacta* formed a clade with *J. saltillensis* M. T. Hall. These clades were well separated.

To further investigate this problem, additional sequencings of nrDNA and the trnC-trnD cp DNA region were performed to obtain SNPs to reexamine the relationship of *J. monticola* to *J. m. f. compacta*.

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*, Adams 6898-6902, 12/21/1991, 3490 m, Cerro Potosi, Nuevo Leon, Mexico; putative *J. m. f. compacta*, S. Gonzalez et al. 7169a,b 6/17/2006, (=Adams 11221, 11222), 4000 m, Nevado de Colima, Jalisco, Mexico; *J. monticola* f. *monticola*, Adams 6874-6878, 12/20/1991, 2750 m, El Chico National Park, Hidalgo, Mexico; *J. saltillensis*, Adams 6886-6890, 12/21/1991, 2090m, on Mex. 60, 14 km E. of San Roberto Junction, Nuevo Leon, Mexico. Voucher specimens are deposited at BAYLU.

One gram (fresh weight) of the foliage was placed in 20 g of activated silica gel and transported to the lab, thence stored at -20° C until the DNA was extracted. DNA was extracted using the Qiagen DNeasy mini kit (Qiagen Inc., Valencia CA).

SNPs obtained from DNA sequencing

ITS (nrDNA) and trnC-trnD amplifications were performed in 50 µl reactions using 10 ng of genomic DNA, 3 units Qiagen Taq polymerase, 5 µl 10x buffer (final concentration: 50 mM KCl, 10 mM Tris-HCl (pH 9), 0.01% gelatin and 0.1% Triton X-100), 1.75 mM MgCl₂, 20 µl Q solution (2X final), 400 µM each dNTP, 1.8 µM each primer and 4%(by vol.) DMSO.

Primers (5'-3'):

ITS: ITSA = GGA AGG AGA AGT CGT AAC AAG G;

ITSB = CTT TTC CTC CGC TTA TTG ATA TG.

ITSA and ITSB primers from Blattner (1999).

trnC-trnD: CDFor: CCA GTT CAA ATC TGG GTG TC

CDRev: GGG ATT GTA GTT CAA TTG GT

CDFor, CDRev primers from Demesure et al. (1995).

CD10F: AAA GAG AGG GAT TCG TAT GGA

CD3R: AAC GAA GCG AAA ATC AAT CA

CD10F and CD3R primers from Andrea Schwarzbach (per. comm.).

The following PCR conditions were used: MJ Research Programmable Thermal Cycler, 45 cycles, 94°C (1 min.), 50°C (1 min.), 72°C (1 min.), with a final step of 72°C (5 min.). The PCR reaction was subjected to purification by agarose gel electrophoresis (1.5% agarose, 70 v, 55 min.). The nrDNA primers (ITSA, ITSB) produced a band of approx. 1120 bp. The internal trnC-trnD primers, CD10F-CD3R produced a band of approx. 850 bp. In each case the band was excised and purified by use of a Qiagen QIAquick gel extraction kit.

The gel purified DNA band with the appropriate primer was sent to McLab Inc. for sequencing. Sequences for both strands were edited and a consensus sequence was produced using Chromas, version 2.31 (Technelysium Pty Ltd.). Alignments were made using Clustal W and then manually corrected. Indels were coded with a "-" for the first nucleotide and "I" for succeeding nucleotides such that an indel was treated as a single mutation event. Overall sequences have been deposited in GenBank (Schwarzbach et al., 2008).

SNPs analyses

Aligned data sets (nrDNA and trnC-trnD) were analyzed by CLEANDNA (Fortran, R. P. Adams) to remove invariant data. Mutational differences were computed by comparing all SNPs, divided by the number of comparisons over all taxa (= Gower metric, Gower, 1971; Adams, 1975). Principal coordinate analysis was performed by factoring the associational matrix using the formulation of Gower (1966) and Veldman (1967). A minimum spanning network was constructed by selecting the nearest neighbor for each taxon from the pair-wise similarity matrix, then connecting those nearest neighbors as nodes in the network (Adams et al., 2003).

RESULTS AND DISCUSSION

Analyses of the nrDNA sequences revealed 13 SNPs among the taxa. PCO of the SNPs resulted in 3 eigenroots that accounted for 42, 22 and 19 % of the variation among the OTUs. Ordination (Fig. 1) shows 4

groups as *J. jaliscana*, *J. m. f. monticola*, *J. m. f. compacta* and *J. saltillensis*. Notice that the two alpine plants (NC1, NC2) from Nevado de Colima (4000 m) appear as somewhat intermediate between taxa.

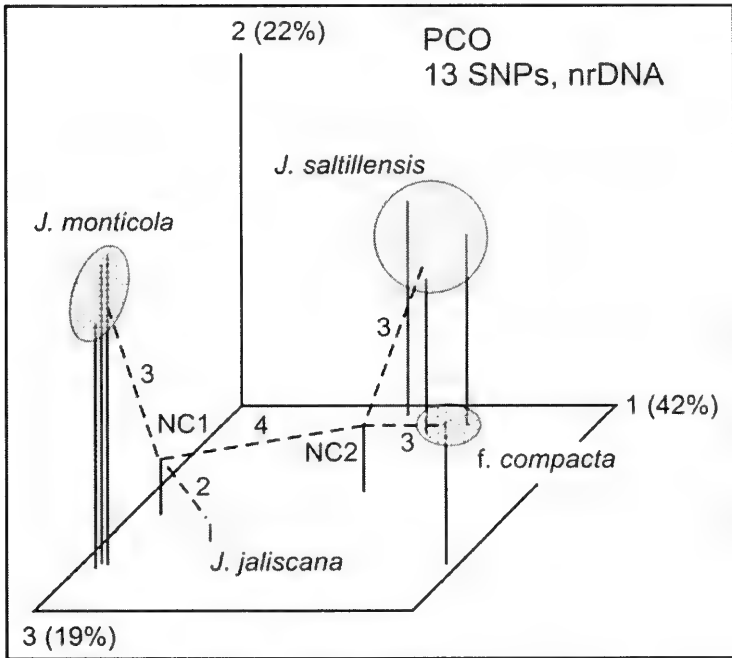


Figure 1. PCO ordination based on 13 SNPs from nrDNA. Dashed lines are the minimum spanning network with the number of nucleotide differences noted on the dashed line.

Clearly, *J. m. f. compacta* (Cerro Potosi) is quite different from *J. m. f. monticola*. No variation was found among the 3 individuals of *J. m. f. compacta* (Cerro Potosi), or among the 3 individuals of *J. jaliscana*. (a single stick is used in Fig. 1 to represent 3 individuals for these taxa).

Analyses of a portion of trnC-trnD revealed several indels, with a total of 15 SNPs. PCO ordination extracted 3 eigenroots that accounted for 66, 25 and 5% of the variation, implying that 4 groups were present

(Fig. 2). These four groups are the same groups as with the nrDNA: *J. jaliscana*, *J. m. f. compacta*, *J. m. f. monticola*, and *J. saltillensis*. However, the two alpine plants from Nevado de Colima (NC1, NC2) had no differences from *J. m. f. monticola* (- NC1) or from *J. jaliscana* (- NC2). It is possible that NC1 is of hybrid origin with pollen and cp DNA from *J. m. f. monticola* and that NC2 is of hybrid origin with pollen and cp DNA from *J. jaliscana*.

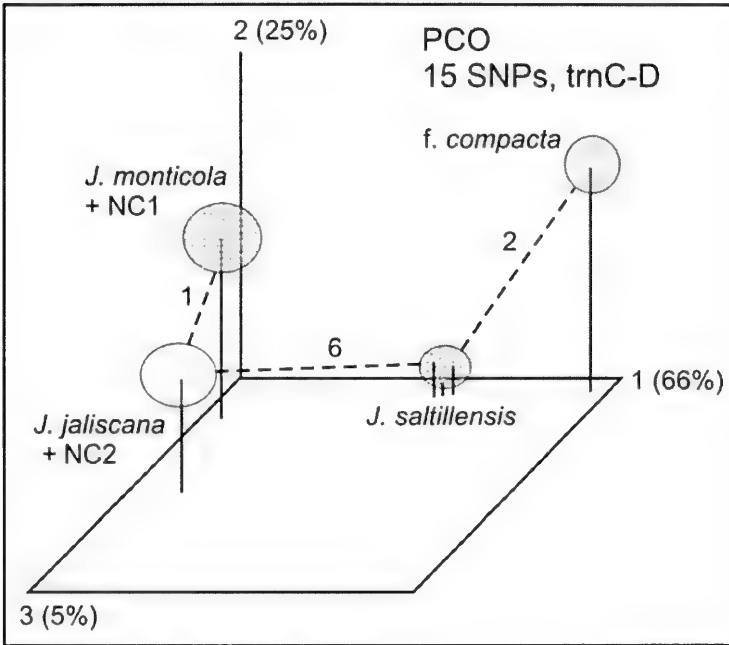


Figure 2. PCO ordination based on 15 SNPs from trnC-trnD. Dashed lines are the minimum spanning network with the number of nucleotide differences noted on the dashed line.

No variation was found within *J. jaliscana*, *J. monticola*, or *J. m. f. compacta*. However, the 3 individuals of *J. saltillensis* differed among themselves by a single nucleotide. This differs a little from the nrDNA where more variation within taxa was detected. It appears that in

this instance, the cp DNA has not accumulated mutations as quickly as nr DNA.

Zanoni and Adams (1976) analyzed leaf volatile oils from several locations of *J. monticola*, *J. m. f. compacta* and *J. m. f. orizabensis*. They reported that the oils from these taxa were rather uniform, except for the oil of *J. m. f. compacta* from Cerro Potosi.

Adams et al. (1980) compared the leaf terpenoids of *J. monticola* (El Chico), *J. m. f. compacta* (Nevada de Toluca) and *J. m. f. orizabensis* (Pico Orizaba). Table 1 shows an abbreviated summary of their results. Several compounds appear to discriminate between the three formas. These compounds include tricyclene, α -pinene, sabinene, α -terpinene, 4-terpineol, bornyl acetate, γ -terpinene, the eudesmols and 8- α -acetoxyelemol. It should be noted that the sample (average of 5 plants) of *J. m. f. compacta* was from Nevada de Toluca not Cerro Potosi (as used for the SNPs in this paper). Zanoni and Adams (1976) reported that the leaf oil from Cerro Potosi was quite different from *J. m. f. compacta* from Nevada de Toluca and Popocatepetl.

Table 1. Comparison of volatile leaf oils of *J. monticola* (El Chico), *J. m. f. compacta* (Nevada de Toluca) and *J. m. f. orizabensis* (Pico Orizaba). Several compounds that appear to separate the taxa are indicated in boldface. t = trace (<0.05%).

Compound	mont.	comp.	oriz.
tricyclene	0.6	t	0.9
α-pinene	25.8	8.8	6.0
camphene	0.8	t	1.2
verbenene	0.5	-	-
sabinene	t	26.9	t
β -pinene	0.8	t	t
myrcene	2.1	2.1	2.8
4-carene	3.3	0.9	2.1
α -phellandrene	t	t	t
3-carene	-	-	t
α-terpinene	-	1.8	t

p-cymene	t	0.5	t
camphene hydrate	0.5	t	1.3
borneol	4.0	2.5	1.7
4-terpineol	t	10.1	0.7
α -terpineol	t	t	t
piperitone	0.9	t	t
bornyl acetate	25.6	12.8	48.6
α -terpinyl acetate	t	t	t
thymol	t	t	t
(E)-caryophyllene	-	-	t
germacrene D	-	t	-
β -phellandrene	2.2	0.6	1.5
limonene	12.4	8.0	13.2
γ-terpinene	t	3.3	0.6
p-menth-1(7),3-diene	-	0.5	-
terpinolene	t	-	0.5
linalool	t	t	1.5
cis-sabinene hydrate	t	0.6	1.4
camphor	3.3	1.0	4.2
trans-sabinene hydrate	t	t	0.7
elemol	2.5	2.3	1.4
γ-eudesmol	1.0	0.6	t
β-eudesmol	3.3	1.4	t
α-eudesmol	1.6	0.5	t
8-α-acetoxylemol	1.4	0.8	t
manoyl oxide	t	3.0	t
manool	-	0.6	-

It is clear from SNPs of both nrDNA and trnC-trnD cp DNA that *Juniperus monticola* f. *compacta* is not allied with *J. monticola*. In fact, it is as different from *J. monticola* as several other recognized species (*J. jaliscana*, *J. saltillensis*, Figs. 1, 2). It is also different in its volatile leaf oils (Table 1) and its morphology (Adams, 2004; Zanoni and Adams, 1976, 1979), having tightly compacted foliage and being prostrate shrubs. Silba (2006) recognized it as a subspecies (*J. m.* subsp. *compacta* (Mart) Silba) but did not discern its affinity to *J. saltillensis* (due to cryptic variation in the morphology).

Based on the data presented in this paper, it is appropriate to recognize *Juniperus monticola* f. *compacta* as a distinct species:

Juniperus compacta (Mart.) R. P. Adams, **comb. et. stat. nov.**

Basionym: *Juniperus monticola* Martinez f. *compacta* Martinez, Bol. Soc. Bot. Mexico 7: 19 (1948). Compact mountain juniper. Type: Mexico, Volcan Popocatepetl, *Martinez 7003* (HOLOTYPE: MEXU!).

Distribution: 3000-4300 (-4500) m Sierra Mojada, Coahuila; Cerro Pelado and Ajusco, Distrito Federal; Nevado de Colima, Jalisco; Popocatepetl, Iztaccihuatl, Tlaloc and Nevado de Toluca, Mexico; Cerro Potosi, Nuevo Leon; Malinche, Tlaxcala; and Cofre de Perote, Vera Cruz, Mexico.

Synonyms: *Cupressus sabinooides* H.B.K., Nova Gen. et Sp. Pl. 2:3. 1817.

J. mexicana Sprengel, Syst. Veg. 3: #909 (1826), *nom. superfl. illeg.*

J. sabinooides (Kunth) Nees. Linnaea 19: 706 (1847), *non* Griseb., Spec. Fl. Rumel. 2: 352 (1846).

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J. monticola Martinez var. *monticola* f. *compacta* Martinez, Bol. Soc. Bot. Mexico 7:19 (1948).

J. monticola Martinez subsp. *compacta* (Martinez) J. Silba, J. Int. conifer Preserv. Soc. 13(1): 12 (2006).

Several questions remain unanswered concerning the alpine junipers of Mexico. What is the biological status of *J. monticola* f. *orizabensis*? Might all the disjunct alpine populations be variants of *J. compacta*? Do the large leaf oil differences correlate with more wide based genetic differences? Additional collections and analyses are being conducted to address these questions.

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TAXONOMIC REVIEW OF THE
XANTHISMA SPINULOSUM COMPLEX (ASTERACEAE: ASTEREAEE)

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ABSTRACT

A taxonomic review of the *Xanthisma spinulosum* complex is presented, with county-level (for the U.S.A.) dot maps documenting distribution of the taxa. *Xanthisma incisifolium*, *X. glaberrimum*, **X. paradoxum** (Turner & Hartman) Turner & Nesom, comb. et stat. nov., and **X. scabrellum** (Greene) Turner & Nesom, comb. nov., do not intergrade with other taxa of the complex and are treated at specific rank. In regions of sympatry, *X. spinulosum* var. *spinulosum*, var. *gooddingii*, var. *chihuahuanum*, and var. *austrotexanum* intergrade and are maintained here at varietal rank. **Xanthisma spinulosum** var. **hartmanii** Turner & Nesom, var. nov., is described from northern Coahuila, Mexico.

KEY WORDS: Asteraceae, *Xanthisma*, taxonomy

Xanthisma spinulosum (Pursh) Morgan & Hartman sensu lato is a species complex in the western United States composed of intergrading infraspecific taxa distributed within two subspecies, as treated by Turner and Hartman (1976, as *Machaeranthera pinnatifida*). Hartman (2006) treated the complex within the genus *Xanthisma* in his account for the Flora of North America, using recently modified generic circumscriptions as defined by Morgan and Hartman (2003). Nesom reviewed the complex in Mexico (1990) and in panhandle Texas (2003), in each case concluding that one of the taxa was

genetically isolated from the others and justifiably treated at specific rank. Turner (2007) added a taxon at varietal rank from southern Texas, citing collections that appear to represent intergrades with typical *X. spinulosum* in their region of contact. In the present study, we examine geographic distributions in detail and further evaluate biological integrity and taxonomic rank.

***Xanthisma glaberrimum* at specific rank.**

Xanthisma spinulosum var. *glaberrimum* (Rydb.) Morgan & Hartman was elevated to specific rank as *X. glaberrimum* (Rydb.) Nesom & O'Kennon (Nesom 2003). Hartman (2006), however, retained the taxon as a variety, noting that "it occurs sympatrically with variety *spinulosum* in the Texas panhandle, where the two taxa behave like biological species" but that "on the eastern plains of Colorado, however, hybridization and autopoloidy have been documented (D.B. Hauber 1986)."

Xanthisma glaberrimum (diploid, $2n = 8$) occurs from the southern panhandle region of Texas northwards into southern Manitoba, Canada (Fig. 1). Over most of this region it is confined to mid-grass regions of the central U.S.A. and only rarely comes in contact with populations of typical *X. spinulosum* (diploid, $2n = 8$), which appears to be largely confined to the more western short grass prairies. The two taxa are sympatric in westernmost Nebraska and adjacent Wyoming, southeastern Colorado, and panhandle Texas and adjacent areas of New Mexico and Oklahoma (Figs. 1, 2). Typical *X. glaberrimum* in southeastern New Mexico mostly grows on gypsum. In DeBaca and Chaves counties, N.M., some plants have a vestiture of barely perceptible tomentum but they contrast sharply in both vestiture and habit with many collections of typical *X. spinulosum* from the same area.

a. Stems usually unbranched until the upper third, the heads usually distinctly clustered; leaves strictly ascending, narrowly oblong in outline, 1-pinnatifid, midportion 1–2(–2.5) mm wide, lobes oblong-lanceolate to lanceolate or triangular, sometimes shallowly toothed, glabrous or less commonly lightly tomentose, eglandular or less commonly glandular; involucre cupulate.....**X. glaberrimum**

a. Stems branched from midstem or below to the upper third, the heads diffusely arranged; leaves loosely ascending to spreading, oblong to obovate in outline, especially the basal and lower cauline, 1–2-pinnatifid, midportion 0.5–1.0(–1.5) mm wide, lobes linear to lanceolate, usually shallowly toothed, and glandular to varying degrees, slightly to densely tomentose, rarely without eglandular hairs; involucre shallowly hemispheric.....var. **spinulosum**

Hauber (1986) noted that putatively hybrid tetraploids he investigated in Otero Co., Colo., show intermediacy toward the ascending stems with greatly reduced lateral branching characteristic of *X. glaberrimum* (vs. the spreading habit with strong lateral branching in var. *spinulosum*) as well as intermediacy in their degree of light tomentum. Nesom (2003) observed that in panhandle Texas, where *X. glaberrimum* and *X. spinulosum* occur as discrete entities in close proximity, the former is typical in morphology but *X. spinulosum* commonly shows genetic influence of *X. glaberrimum*. Morphological discontinuity and apparent isolation of the two taxa at local sites were emphasized in the decision to recognize each of the taxa at specific rank. It is plausible that a significant portion of the Texas panhandle populations of *X. spinulosum* are tetraploid (likely of hybrid origin, as in Hauber's study) and as such, effectively isolated from sympatric, diploid *X. glaberrimum*. Plants mapped as *X. glaberrimum* in Colfax Co., N.M. (Averett 345, TEX, Lucas 125, TEX) and in Weld Co., Colo. (Raven & Gregory 19521, TEX) also are intermediate between *X. glaberrimum* and *X. spinulosum*, but they probably indicate the close proximity of *X. glaberrimum*.

Hybridization occurs among well-marked species in many genera (e.g., among *Baptisia* species in Texas, Alston & Turner 1963) and, as in the case here with *Xanthisma*, the occurrence of hybrids does not necessarily make the case for specific negation.

***Xanthisma spinulosum* var. *paradoxum* as *X. paradoxum*.**

Xanthisma spinulosum var. *paradoxum* (Turner & Hartman) Morgan & Hartman is localized in distribution (Fig. 3) and restricted to the Four Corners region, occurring most abundantly in San Juan Co., Utah. It grows on low, rolling, sparsely vegetated hills formed from the Mancos or Fruitland shale formations (Cretaceous), which produce a

substrate of highly alkaline, gypsiferous clay. Common associates include *Atriplex corrugata*, *A. confertifolia*, *Frankenia jamesii*, and *Opuntia polyacantha*. At least three species are known to be endemic to this area: *Sclerocactus mesae-verdae* (Boissevain ex Hill & Salisbury) L. Benson, *Proatriplex pleiantha* (W. Weber) Stutz & Chu, and *Abronia bolackii* Atwood, Welsh, & Heil (NM Rare Plant Technical Council 1999).

Study of Four Corners Asteraceae by Nesom revealed that morphology of var. *paradoxum* is consistent and discontinuous from that of var. *spinulosum*, even where their distribution slightly overlaps (see couplet immediately below). Many collections of var. *paradoxum* have been made from the vicinity of Hatch Trading Post along Alkali Canyon in San Juan Co., Utah; from that locality, *Porter 1255* (SJNM 4260) is var. *paradoxa*, but *Porter 1255* (SJNM 7252) is var. *spinulosum*. The two Porter plants evidently were collected in close proximity.

a. Stems 6–15 cm; basal leaves persistent and dense, cauline mostly on proximal half of stems; heads on naked or bracteate peduncles 1–4 cm; involucre 15–25 mm.....**X. paradoxum**

a. Stems (10–)15–30 cm; basal leaves mostly deciduous by flowering, cauline relatively even sized upwards to near heads; heads on bracteate peduncles 0.5–2(–3) cm; involucre 8–12 mm wide.....var. **spinulosum**

Turner and Hartman (1976, p. 314) noted that var. *paradoxum* "is fairly well-marked and does not seem to intergrade with its more eastern allopatrich [var. *spinulosum*], ... it does appear to grade into var. *gooddingii* to the southwest, although not strikingly so." Var. *paradoxum* was compared in the original description to var. *gooddingii*, but as further study has shown, the two taxa are allopatric and do not have the opportunity to hybridize or intergrade. Thus, in parallel with *X. glaberrimum*, we observe that var. *paradoxum* is distinct and genetically isolated from *X. spinulosum* and propose (below) that it be treated at specific rank.

***Xanthisma spinulosum* var. *scabrellum* as *X. scabrellum*.**

Turner and Hartman (1976) observed that *Xanthisma spinulosum* var. *scabrellum* intergrades with *X. arenarium* (Benth.)

Morgan & Hartman to some degree and that *X. arenarium* might with justification also be treated within *X. spinulosum*, although they retained it at specific rank. Both taxa are densely glandular. *Xanthisma arenarium* is restricted to southern Baja California Sur and sympatric there with var. *scabrellum*, which is more widely distributed and extends northward into the adjacent state of Baja California. In southern Baja California var. *scabrellum* apparently is parapatric or slightly sympatric with var. *gooddingii*, which usually is eglandular in the zone of contact with var. *scabrellum*. The two also are conspicuously different in habit. In the current study, we find that neither var. *scabrellum* nor *X. arenarium* intergrades with *X. spinulosum* and, as Shinnars did earlier (1950). Consequently, we treat var. *scabrellum* at specific rank.

***Xanthisma incisifolium* at specific rank.**

Plants *Xanthisma spinulosum* var. *incisifolium* from a variety of habitats on the islands of San Lorenzo (Baja California) and San Esteban and Tiburón (Sonora) are consistent in morphology and distinct from other *X. spinulosum*. *Xanthisma spinulosum* var. *gooddingii* is the only expression of the species that approaches the geographic range of var. *incisifolium* and that is sympatric with it (on San Lorenzo and Tiburón). The insular endemic was recognized in a previous study (Nesom 1990) at specific rank as *X. incisifolium*.

***Xanthisma spinulosum* sensu stricto and varieties.**

We treat *Xanthisma spinulosum* as comprising five varieties. Even with recognition of these geographic variants, *X. spinulosum* var. *spinulosum* is variable, consisting of a panorama of individuals and/or local populations that have received formal taxonomic recognition. Variation within var. *spinulosum* may be complex even within a single county of Texas. For example, at one locality (Taylor Co., 7 mi SW of Merkel), plants of *X. spinulosum* may be found that are completely glabrous with once-pinnatifid leaves (Henderson 63-787, TEX), similar to those of *X. glaberrimum*, or that are cottony pubescent with similar leaves (Henderson 63-785, TEX). Additionally, plants referable to the "cotula" form (very glandular individuals lacking cottony pubescence) may also occur there, along with various intermediates between the latter and the previously mentioned expressions (LL, TEX). We have recognized all such individuals and/or population segregates in this area

as belonging to var. *spinulosum*. The distribution of densely glandular plants among the collections at LL,TEX is shown in Fig. 4.

Xanthisma spinulosum var. *spinulosum* intergrades with var. *chihuahuanum* (Fig. 5) in Mexico, southern Texas, southwestern New Mexico, and southeastern Arizona. In southern Arizona var. *spinulosum* may intergrade slightly with var. *gooddingii* (Fig. 7), but this needs detailed investigation. Var. *austrotexanum*, recently recognized as an endemic of the Rio Grande Valley in southern Texas (Turner 2007), apparently intergrades with var. *spinulosum* (Fig. 6). Var. *hartmanii*, first described in the present manuscript, occurs in north-central Coahuila, surrounded on all sides by var. *spinulosum* (Fig. 5), with which it may intergrade.

Status of subsp. *spinulosum* and subsp. *gooddingii*.

Turner and Hartman (1976) treated *Xanthisma spinulosum* (= *Machaeranthera pinnatifida*) as having two allopatric subspecies: subsp. *gooddingii*, a western assemblage including four varieties and a more eastern subsp. *spinulosum* with three varieties. Morgan and Hartman (2003) informally divided the species into the two subspecies but did not provide a valid combination for subsp. *gooddingii* in the new generic position. Because we have elevated three of the four original taxa of subsp. *gooddingii* to specific rank, and because we observe that var. *gooddingii* (Fig. 7) may intergrade with var. *spinulosum* and var. *chihuahuanum*, it no longer seems useful to formally recognize subspecies among the varieties of *X. spinulosum* treated here.

Key to the taxa of the *Xanthisma spinulosum* complex.

1. Plants eglandular to sparsely or densely glandular, stems usually at least slightly arcuate, with leaves reduced in size near the heads. (3)
1. Plants densely stipitate-glandular, stems stiffly erect, branches stiffly spreading-ascending, with leaves even-sized and evenly arranged to immediately below the heads. (2)

2. Densely stipitate-glandular, also sparsely to densely villous with eglandular hairs; leaves obovate, 5–9 mm wide; involucre 15–20 mm wide.....**X. arenarium**
2. Moderately stipitate-glandular, sometimes with a few eglandular hairs; leaves narrowly obovate-oblong, 2–4 mm wide; involucre 9–15 mm wide.....**X. scabrellum**
3. Plants glabrous or less commonly lightly tomentose, eglandular or less commonly slightly glandular; stems usually unbranched until the upper third, the heads usually distinctly clustered.....**X. glaberrimum**
3. Plants usually glandular to varying degrees, slightly to densely tomentose, rarely without eglandular hairs; stems branched from mid-stem or below to the upper third, the heads more diffusely arranged. (4)
4. Involucre mostly 8–15 mm wide (12–22 in var. *gooddingii*); leaves mostly cauline (if basal persistent, then involucre relatively small). (6)
4. Involucre 15–25 mm wide; leaves mostly basal or basal and lower cauline. (5)
5. Leaf lobes lanceolate to oblanceolate; heads held barely above the level of the leaves, on short, bracteate peduncles; subshrubs with woody, ascending, caudex-like branches.....**X. incisifolium**
5. Leaf lobes linear; heads above leaves on naked or bracteate peduncles 15–40 mm long; perennial herbs without caudex branches.....**X. paradoxum**
6. Leaves evenly arranged along entire stem, lobes linear, 4–8 mm long, and usually falcate-recurving; heads epedunculate, usually immediately subtended by leaves; stems 30–50 cm high; stems and leaves inconspicuously granular-glandular, without other vestiture.var. **hartmanii**
6. Leaves usually mostly on proximal 2/3, serrate or with lobes of varying length; heads pedunculate or pedunculate; stems 10–70 cm high; vestiture various. (7)

7. Plants evidently coarsely or minutely stipitate-glandular, usually without other pubescence; stems with leaves reduced distally, heads pedunculate; involucre mostly 12–22 mm wide. (9)
7. Plants eglandular or very sparsely and inconspicuously glandular, variably villous; stems relatively uniformly leafy up to heads, heads epedunculate; involucre mostly 8–12 mm wide. (8)
8. Stems mostly 10–40 cm tall, ascending from the base, intricately branched at midstem; midcauline leaves deeply toothed to divided; persistently thinly floccose tomentose; widespread...var. **spinulosum**
8. Stems 30–70 cm tall, stiffly erect from the base, usually branched only near the heads; midcauline leaves shallowly serrate; glabrescent and often glabrous; Brooks, Hidalgo, Kleberg, and Jim Wells counties, Texas.....var. **austrotexanum**
9. Entire plants usually densely and coarsely stipitate-glandular; leaf surfaces dull-textured, lobes and teeth antrorse, not falcate; involucre mostly 12–16 mm wide.....var. **chihuahuanum**
9. Plants minutely stipitate- to granular-glandular (U.S.) to eglandular (Baja California); leaf surfaces shiny, lobes and sometimes blades (distal cauline) commonly falcate; involucre 12–22 mm widevar. **gooddingii**
1. **XANTHISMA GLABERRIMUM** (Rydb.) Nesom & O'Kennon, Sida 20:1586. 2003. *Sideranthus glaberrimus* Rydb. [1900].
Machaeranthera pinnatifida var. *glaberrima* (Rydb.) Turner & Hartman. *Xanthisma spinulosum* var. *glaberrimum* (Rydb.) Morgan & Hartman. *Sideranthus laevis* Woot. & Standl. [1913]; *Haplopappus spinulosus* subsp. *laevis* (Woot. & Standl.) Hall; *Machaeranthera laevis* (Woot. & Standl.) Shinnors.
2. **XANTHISMA INCISIFOLIUM** (I. M. Johnston) Nesom, Sida 20:1585. 2003. *Aplopappus arenarius* var. *incisifolius* I.M. Johnston; *Machaeranthera pinnatifida* var. *incisifolia* (I.M. Johnston) Turner & Hartman; *Machaeranthera incisifolia* (I.M. Johnston) Nesom.
3. **XANTHISMA PARADOXUM** (B. L. Turner & Hartman) Nesom & B. L. Turner, **comb. et stat. nov.** Based on *Machaeranthera pinnatifida* var. *paradoxa* B. L. Turner & Hartman, Wrightia 5:314. 1976.

Type: USA. Colorado. Montrose Co.: Paradox, 21 Jun 1912, *E.P. Walker 147* (holotype: NY!, internet image!; isotypes: DS!, GH!, US! internet image!). *Xanthisma spinulosum* var. *paradoxum* (B. L. Turner & Hartman) Morgan & Hartman.

Stems numerous from base, ascending, 6–15 cm high, stems and leaves thinly tomentose-puberulent, eglandular. Leaves: basal persistent and dense, cauline mostly on proximal half of stems, basal and cauline deeply dissected, lobes linear, spreading-ascending. Heads on naked or bracteate peduncles 15–40 mm long; involucre cupulate, mostly 15–25 mm wide; phyllaries linear-lanceolate, minutely puberulent and finely granular-glandular.

Washes, clay hills, sandstone, disturbed sites, desert scrub, pinyon-juniper. Arizona, Colorado, Utah; 1400–1800 m; (Mar–)Apr–Oct; Arizona, Colorado, Utah.

4. **XANTHISMA SCABRELLUM** (Greene) Nesom & B. L. Turner, **comb. nov.** Based on *Eriocarpum scabrellum* Greene, *Erythea* 2:108. 1894. Type: Mexico. Baja California: Los Angeles Bay, 1887, *E. Palmer 539* (holotype: ND-G?; isotypes: US-2 sheets! internet images!). *Machaeranthera scabrella* (Greene) Shinnery; *Xanthisma spinulosum* var. *scabrellum* (Greene) Morgan & Hartman; *Machaeranthera pinnatifida* var. *scabrella* (Greene) B. L. Turner & Hartman.

Plants with a woody caudex; stems, leaves, and phyllaries densely stipitate-glandular. Stems usually spreading from the base, (6-) 15–35(–45) cm tall. Leaves oblong oblanceolate, 5–25 mm long, 1–3 mm wide, relatively even-sized along the stems (smaller immediately beneath heads), shallowly but coarsely toothed. Heads on peduncles 0–5(–10) mm long; phyllaries usually spreading to recurving at apex. $2n = 8, 16$.

Sandy roadsides, rocky slopes, shrublands, thorn-forests, short-tree woodlands, 10–400 m; most commonly Jan–Apr but sporadically all seasons; Baja California Sur, Baja California.

5. **XANTHISMA SPINULOSUM** (Pursh) Morgan & Hartman, *Sida* 20:1406. 2003. *Amellus spinulosus* Pursh (not *Machaeranthera spinulosa* Greene).
- 5a. Var. **AUSTROTEXANUM** B. L. Turner, *Phytologia* 89:350. 2007 [nom. nov.]. Based on *Haplopappus texensis* R.C. Jackson; *Machaeranthera texensis* (R.C. Jackson) Shinnars.
- 5b. Var. **CHIHUAHUANUM** (B. L. Turner & Hartman) Morgan & Hartman, *Sida* 20:1408. 2003. *Machaeranthera pinnatifida* var. *chihuahuana* Turner & Hartman
 $2n = 8, 16$.
- 5c. Var. **HARTMANII** B. L. Turner & Nesom, **var. nov.** TYPE: Mexico. Coahuila. 85 mi from San Miguel on Muzquiz road, common along road beneath *Acacia* - with *Hymenoxys*, *Sorghum*, *Verbena*, *Lantana*, *Aristida*, 24 May 1972, R.L. Hartman 3333[c] (holotype: TEX!; isotypes: TEX, RM).

A Xanthismo spinuloso var. *spinuloso* distinctus foliis profunde dissectis lobis linearibus falcato-recurvatis.

Stems and leaves inconspicuously granular-glandular, otherwise glabrous. Leaves relatively even-sized and similar in morphology from base of stem to heads, 2(-3)-pinnately parted with linear and usually falcate-recurving lobes. Heads usually immediately subtended by leaves.

Additional collections examined. Mexico. Coahuila. 1 mi W of La Rosita on road to Muzquiz, common in stream bed, 24 May 1972, Hartman 3334 (LL, RM). 3 mi W of Rancho La Rosita, 43 mi NW of Muzquiz, E of Sierra de la Encantada, 22 May 1968, Powell, Patterson & Ittner 1577 (TEX - 2 sheets).

These plants have been collected from only a single small area in north-central Coahuila -- they are highly distinct in a morphology not seen anywhere else in the range of the species. Three separate collections indicate the morphology is consistent. Collections of *Xanthisma spinulosum* from around the city of Muzquiz (Marsh 196-

TEX, Marsh 1196-TEX), about 55 kilometers southeast of typical var. *hartmanii*, have leaves more deeply dissected than normal and it is possible that these plants show genetic influence of var. *hartmanii*. On the other hand, their leaves are smaller and less dissected than in var. *hartmanii* and their vestiture is densely tomentose. Otherwise, plants surrounding var. *hartmanii* in all directions in Coahuila are var. *spinulosum*. It is plausible that further field study may show that var. *hartmanii* would be appropriately treated at specific rank.

5d. Var. **GOODDINGII** (A. Nels.) Morgan & Hartman, Sida 20:1408. 2003. *Sideranthus gooddingii* A. Nels.; *Machaeranthera pinnatifida* var. *gooddingii* (A. Nels.) B. L. Turner & Hartman

Baja California plants are slightly tomentose but completely eglandular or nearly so, while those of Sonora northward into the U.S.A. are minutely stipitate- to granular-glandular and have consistently narrower leaves. The tall and erect stems, large heads, linear leaves with long, sharp teeth, and distinctive vestiture of var. *gooddingii* are distinctive. It is maintained here within *Xanthisma spinulosum* because of putative intergrades with var. *spinulosum*, but these two taxa may prove to be isolated. $2n = 8$.

5e. Var. **SPINULOSUM**

Diplopappus pinnatifidus Hook.; *Machaeranthera pinnatifida* (Hook.) Shinnars.

Sideranthus cotula Small; *Haplopappus spinulosus* subsp. *cotula* (Small) H.M. Hall

$2n = 8, 16$.

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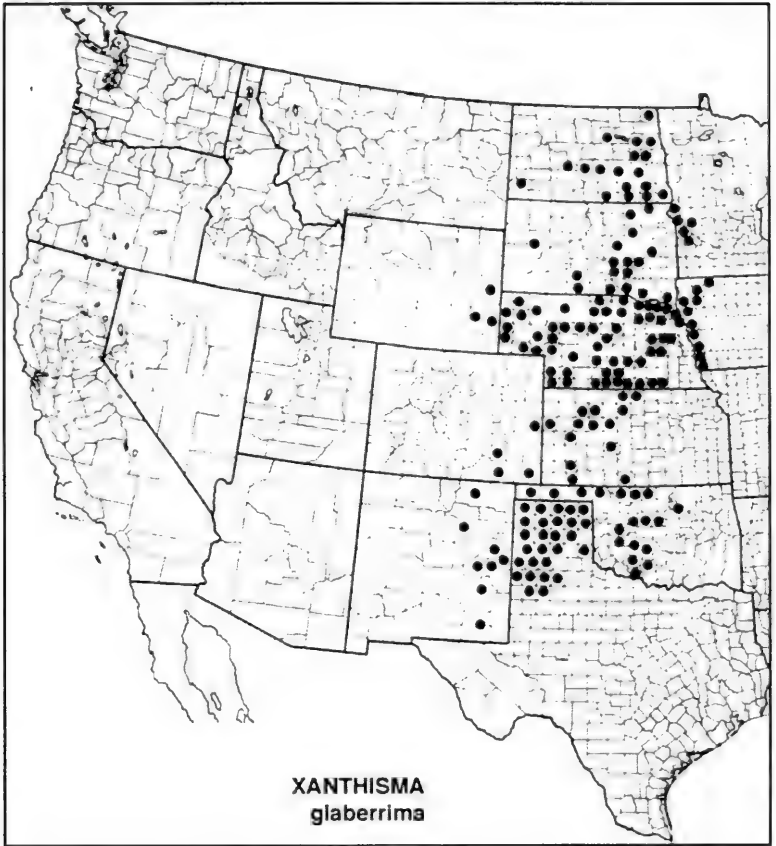


Fig. 1. Distribution of *Xanthisma glaberrimum* by county in the U.S.A.

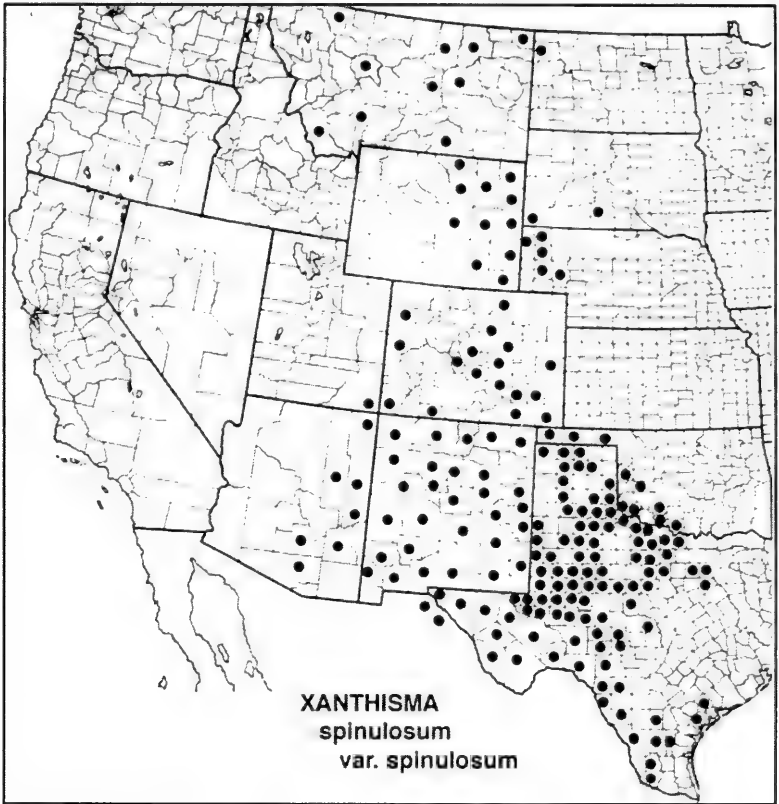


Fig.2. Distribution of *Xanthisma spinulosum* var. *spinulosum* by county in the U.S.A.

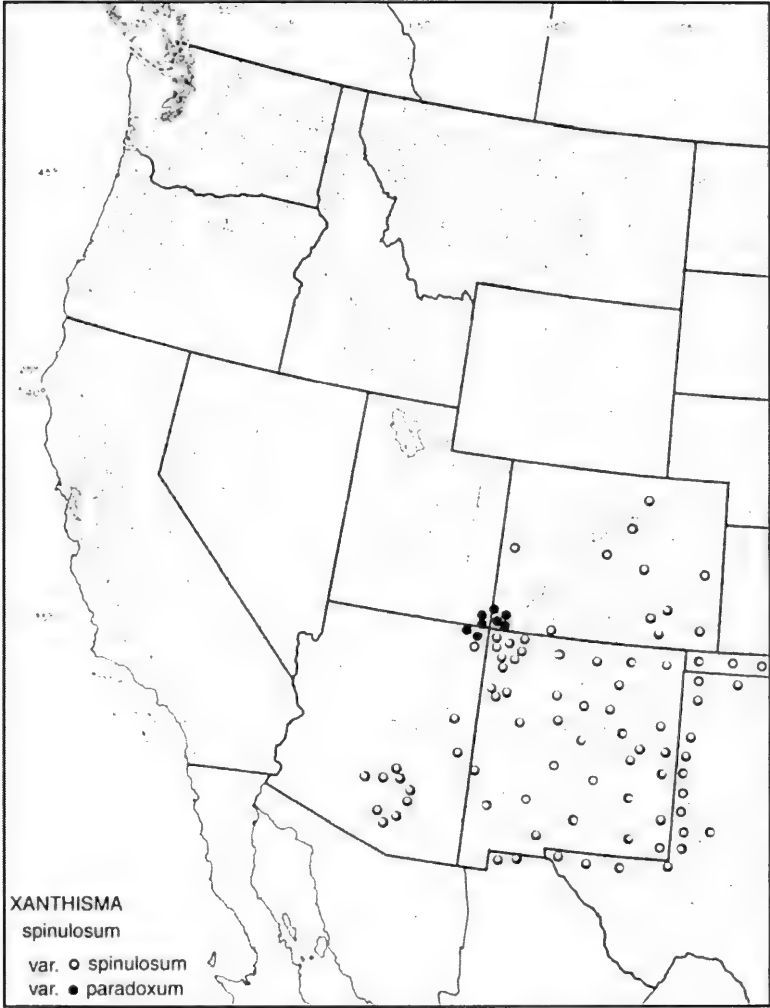


Fig.3. Distribution of *Xanthisma spinulosum* (open circles) and *X. paradoxum* (closed circles) in the Four-Corners region of the southwestern U.S.A.

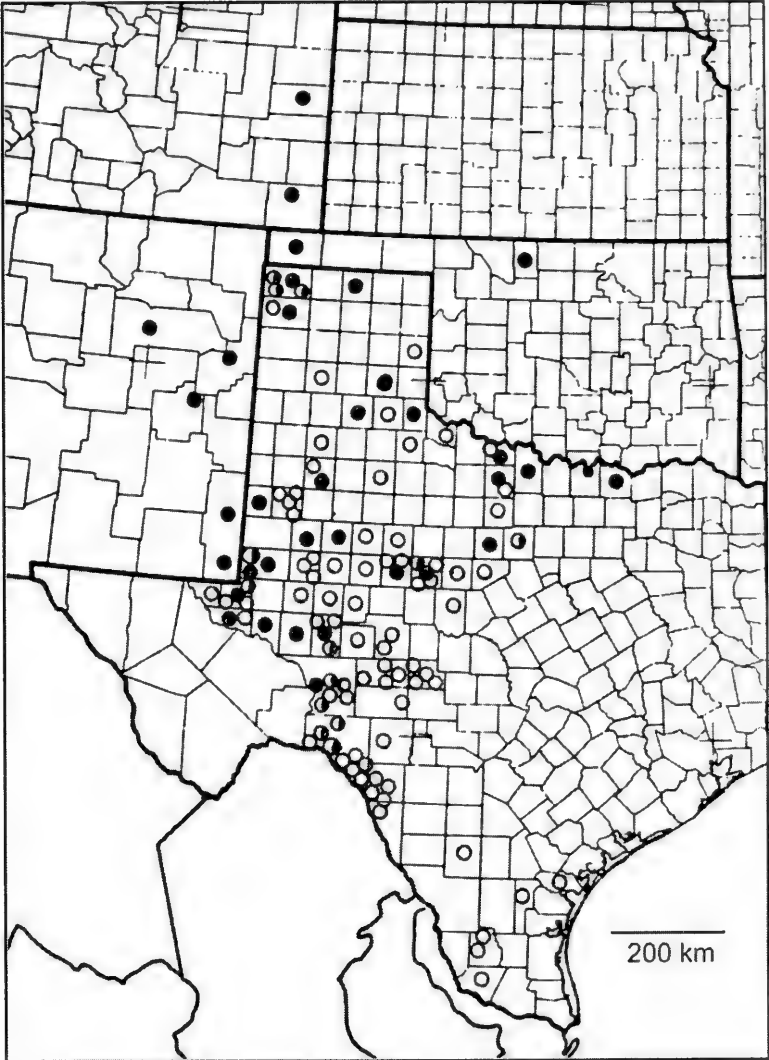


Fig.4. Distribution of plant and/or population forms of *Xanthisma spinulosum* in the southcentral U.S.A.: *var. spinulosum* (open circles); "cotula" form (closed circles); intermediates (half circles).

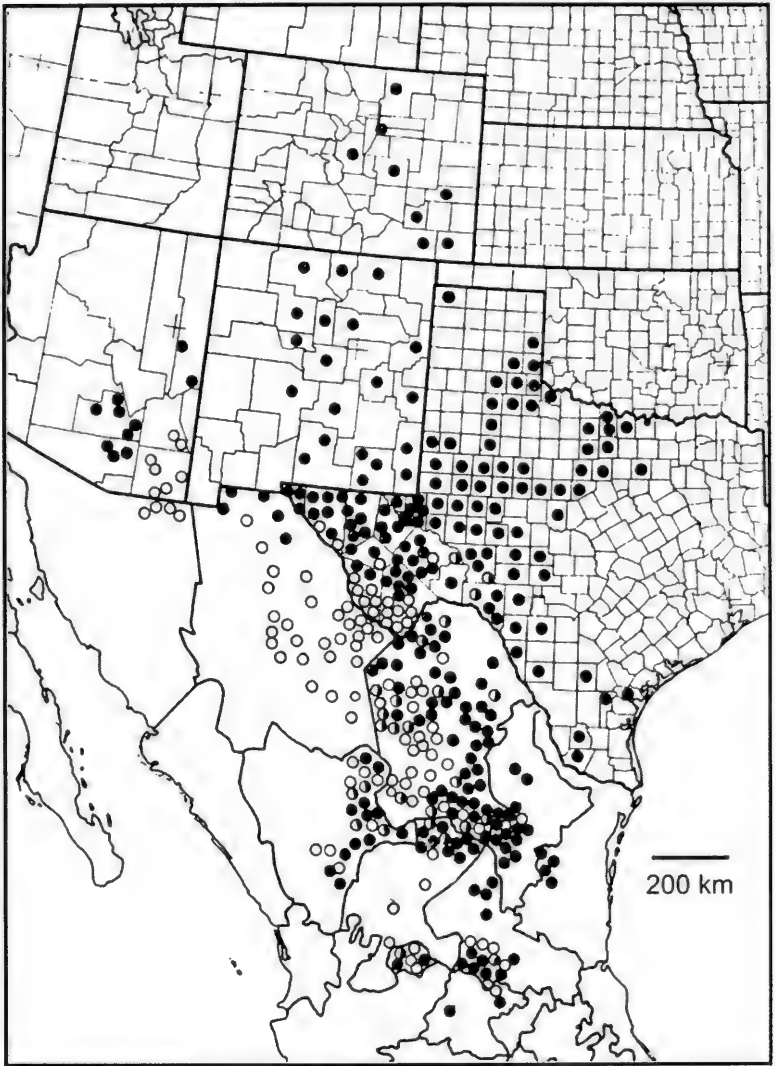


Fig.5. Distribution of *Xanthisma spinulosum* in the southwestern U.S.A. and closely adjacent Mexico: var. *chihuahuanum* (open circles); var. *spinulosum* (dotted circles). Var. *hartmanii* is not mapped.

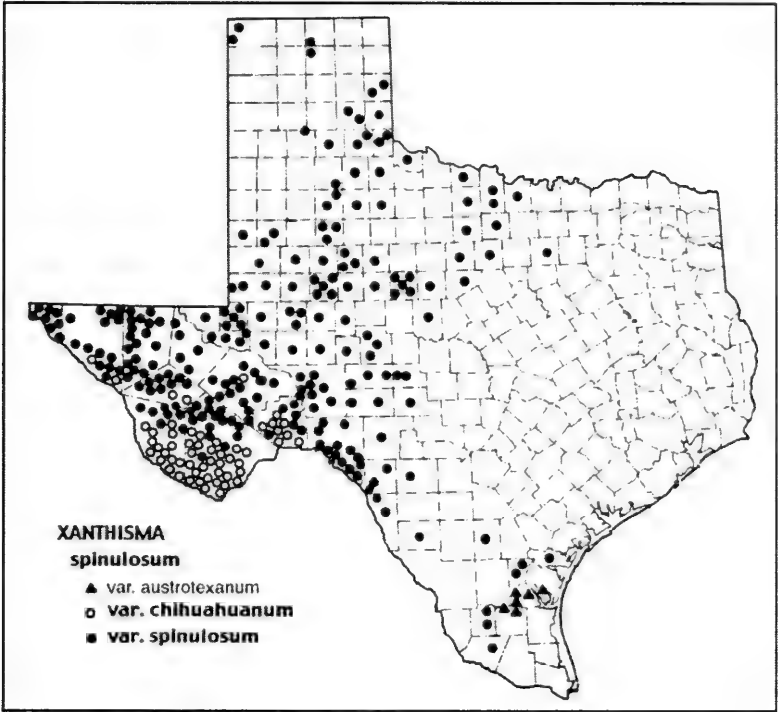


Fig.6. Distribution of *Xanthisma spinulosum* in Texas: var. *austrotexanum* (triangles); var. *chihuahuanum* (open circles); var. *spinulosum* (closed circles).

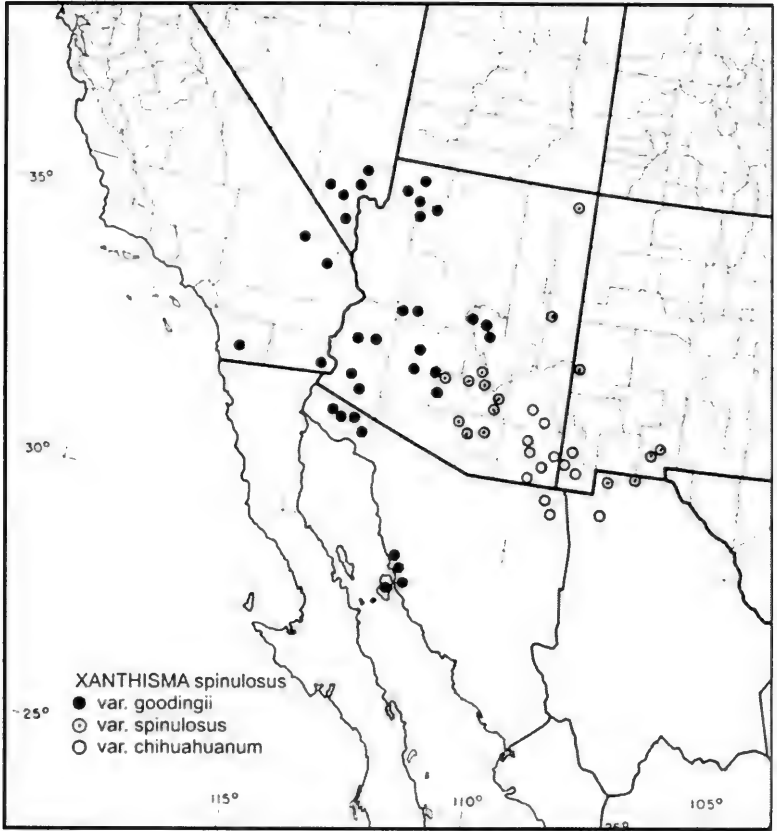


Fig. 7. Distribution of *Xanthisma spinulosum* var. *goodingii* (closed circles).

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ERRATA (Vol. 38)

Issue 1, p. 75: The genus *Physaria* misspelled as *Phasaria* in title and text.

p. 91: G.B. Hinton (deceased) listed as author of var. **intermedia**; this should be G.S. Hinton.



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