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## RANGE EXTENSIONS FOR TWO DWARF MISTLETOES (*ARCEUTHOBIUM* SPP.) IN THE SOUTHWEST

Robert L. Mathiasen<sup>1</sup> and Kenneth H. Jones<sup>2</sup>

ABSTRACT.— A second small population of white fir dwarf mistletoe, *Arceuthobium abietinum* f. sp. *concoloris*, is reported from the Santa Catalina Mountains in southern Arizona. The discovery of a second population of this mistletoe in southern Arizona supports the contention that it once had a more southern distribution but has survived past climatic changes in only a few locations in the southwestern United States. The distribution of the Western spruce dwarf mistletoe, *Arceuthobium microcarpum*, is extended to the Sacramento Mountains of south central New Mexico, a range extension of approximately 170 miles. The mistletoe is restricted to an area of about 300 acres, but its potential for further spread is high. The possible implications of this range extension to the biosystematics of *Picea* spp. and the evolution of *A. microcarpum* are discussed.

White fir dwarf mistletoe, *Arceuthobium abietinum* Engelm. ex Munz f. sp. *concoloris* Hawksw. & Wiens, is a serious pathogen of white fir, *Abies concolor* (Gord. & Glend.) Lindl., in the western United States (Scharpf 1964, Scharpf and Parmeter 1967). Hawksworth and Wiens (1972) list the distribution of this dwarf mistletoe from southern Washington southward through the Cascade Range and Sierra Nevada to the San Bernardino Mountains in southern California, with four isolated populations known: the Charleston Mountains and Spring Creek Mountains, Nevada; Kane County in southwestern Utah; and Grand Canyon National Park, Arizona. More recently it has been reported from the Chiricahua Mountains of southeastern Arizona, nearly 300 miles south of the Grand Canyon populations (Mathiasen 1976).

Western spruce dwarf mistletoe, *Arceuthobium microcarpum* (Engelm.) Hawksw. & Wiens, severely parasitizes Engelmann and blue spruce, *Picea engelmannii* Parry and *P. pungens* Engelm., in the southwestern United States (Hawksworth and Graham 1963, Hawksworth and Wiens 1972). In Arizona it is known from the Kaibab Plateau, the San Francisco Peaks and Kendrick Peak, the White Mountains, and the Pinaleno Mountains (Hawksworth and Wiens 1972). In New Mexico it has only been reported from the Mogollon Mountains in the west central part of the state (Hawksworth and Wiens 1972).

This paper reports isolated populations of *A. abietinum* from the Santa Catalina Mountains in south central Arizona and of *A. microcarpum* from the Sacramento Mountains in south central New Mexico.

In 1979 a very small population of *A. abietinum* was discovered parasitizing white fir in the Santa Catalina Mountains of Pima County, Arizona (Fig. 1). The population occurs in an area of about 10 acres in Marshall Gulch (T. 12 S., R. 16 E., Section 6) near the center of the mountain range at elevations of 2,310 to 2,340 m. The predominant tree species in the infested stand are white fir, Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco), and southwestern white pine (*Pinus strobiformis* Engelm.). Douglas fir dwarf mistletoe (*Arceuthobium douglasii* Engelm.) also occurs in the stand on Douglas fir. Douglas fir dwarf mistletoe has rarely been collected on white fir and can easily be distinguished from white fir dwarf mistletoe using shoot morphology (Hawksworth and Wiens 1972). This is the second report of a small, isolated population of *A. abietinum* from southern Arizona. The first was reported in the Chiricahua Mountains, approximately 100 miles southeast of the Santa Catalina population (Mathiasen 1976). The Santa Catalina population of *A. abietinum* is nearly 260 miles south of the Grand Canyon population of this taxon, and no other populations of *A. abietinum* are known between these localities (Mathiasen 1976).

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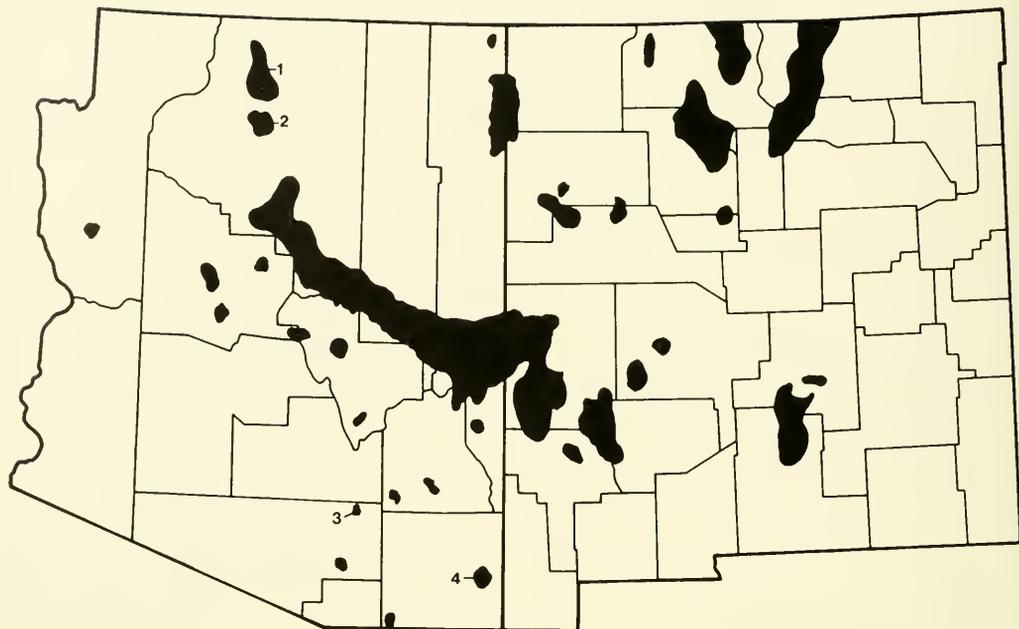


Fig. 1. Distribution of *Abies concolor* and *Arceuthobium abietinum* (1-4) in Arizona and New Mexico. Numbers 3 and 4 represent the *A. abietinum* populations in the Santa Catalina and Chiricahua mountains, respectively.

The discovery of a second population of *A. abietinum* in southern Arizona supports the suggestion that *A. abietinum* had a more widespread southern distribution in the past and only relict populations now exist where climatic conditions have remained favorable for its survival in the southwestern United States (Mathiasen 1976). Both of the southern Arizona populations of *A. abietinum* occur on mesic, north-facing slopes of narrow canyons at approximately the same elevational range, and near the lower elevational limits of white fir in the Southwest. The occurrence of an extremely isolated population of the white fir true mistletoe, *Phoradendron densum* Torr. ex Trel. subsp. *pauciflorum* (Torr.) Wiens, parasitizing white fir in the Santa Catalina Mountains, may indicate this mistletoe had a more southern past distribution also. *Phoradendron densum* subsp. *pauciflorum* has not been found on white fir in other mountain ranges in Arizona, but it does occur in the Sierra San Pedro Mártir in Baja California, which is farther south than the Santa Catalina populations (Wiens 1964). Therefore, it may be possible that both of these white fir parasites migrated to southern Arizona along a southern route when Baja California and the present mainland of Mexico

were continuous (Hamilton 1961). However, *A. abietinum* has not been reported from Baja California, but may not have survived there for the same reasons it has not been reported from more localities in the southwestern United States. The discovery of additional relict populations of *A. abietinum* and *P. densum* subsp. *pauciflorum* in Mexico or in the mountain ranges with white fir populations between the Grand Canyon and southern Arizona would provide more evidence concerning the past distribution of these taxa and their probable migration routes into the Southwest.

In 1980, a small population of *A. microcarpum* was discovered parasitizing *Picea engelmannii* in the Sacramento Mountains of Otero County, New Mexico (Fig. 2). This population is approximately 170 miles east and slightly south of the nearest known population of *A. microcarpum* in the Mogollon Mountains of west central New Mexico. Our surveys over the last two years indicate the infestation of *A. microcarpum* in the Sacramento Mountains is restricted to three small populations totaling about 300 acres occurring on northern exposures in the general vicinity of upper Hay Canyon (T. 17 S., R. 12 E., Sections 33-34; T. 18 S. R. 12 E., Sections

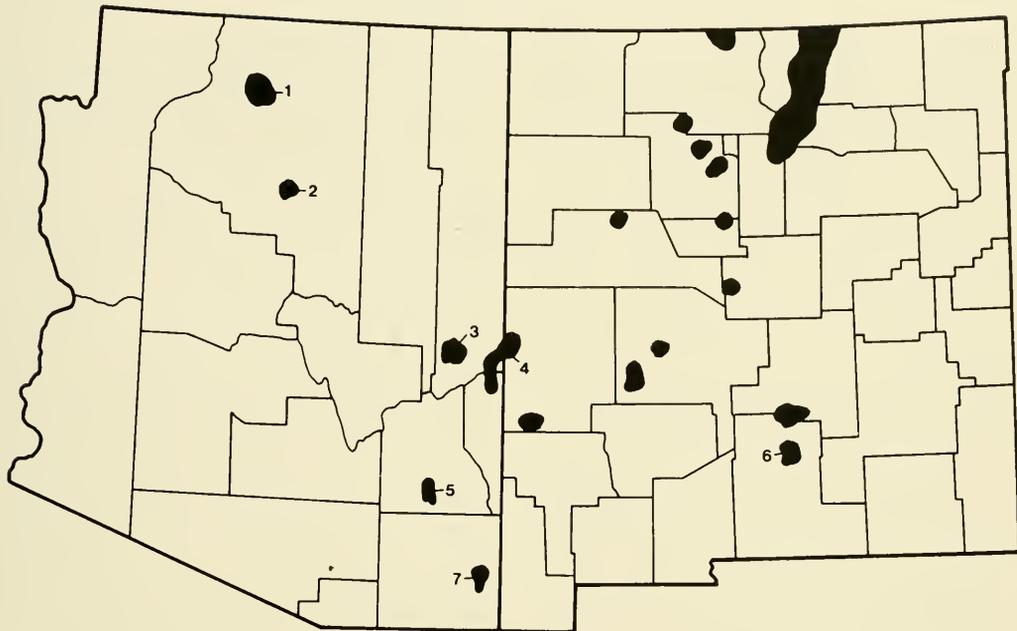


Fig. 2. Distribution of *Picea engelmannii* and *Arceuthobium microcarpum* (1-6) in Arizona and New Mexico. Numbers 5 and 6 represent the *A. microcarpum* populations in the Pinaleno and Sacramento mountains, respectively. Number 7 represents the Chiricahua Mountain population of *Picea engelmannii* var. *mexicana*.

3-4) at elevations ranging from 2,760 to 2,840 m. Our examinations of spruce stands in adjacent Spring, Hubbell, Wills, and Sacramento canyons have not detected additional populations of *A. microcarpum*. These canyons are similar in elevation and topography to Hay Canyon, and their north-facing slopes are dominated by a geographically restricted mixed conifer habitat type (*Picea engelmannii*/*Acer glabrum* HT) described by Moir and Ludwig (1979) in which Engelmann spruce and Douglas fir are co-dominant over-story species. In addition, all the areas surveyed in the Sacramento Mountains are well below the upper elevational limit of 3,100 m reported for *A. microcarpum* (Acciavatti and Weiss 1974, Hawksworth and Wiens 1972, Mathiasen and Hawksworth 1980). Therefore, the restriction of *A. microcarpum* to this small an area is anomalous because conditions for its spread into adjacent spruce stands appear to be favorable. The apparent confinement of this parasite to Hay Canyon may indicate it has arrived relatively recently in the Sacramento Mountains and did not accompany *P. engelmannii* at the time of this tree's migration into this range. Certainly if *A. microcarpum* had migrated there with *P. engelmannii*, additional populations should

have survived elsewhere in the Sacramento Mountains and in the other mountain ranges with large *P. engelmannii* populations in southwestern New Mexico (Little 1971) (Fig. 2). Therefore, the possibility of a more recent introduction of *A. microcarpum* into the Sacramento Mountains would appear more plausible than the relict population hypothesis, which seems more applicable to the disjunct populations of *A. abietinum* in southern Arizona.

A more recent introduction of *A. microcarpum* to the Sacramento Mountains may then be an example of long-range dissemination of a dwarf mistletoe by an avian vector. Hawksworth and Wiens (1972) cite examples of dwarf mistletoe distributions that might be best explained by seed dissemination by avian vectors, and certain infestation patterns of dwarf mistletoes in conifer stands are best explained by this means also (Hudler et al. 1979). One factor that must be considered when assessing the possibilities of long-range dissemination of dwarf mistletoes by birds is that *Arceuthobium* spp. are dioecious, and a male and female plant must become established in an isolated area for a successful infestation to occur. However, investigations of small satellite dwarf

mistletoe infection centers several meters from larger infestations have demonstrated that both male and female plants can become independently established in satellite centers (Hudler et al. 1979, Ostry 1978). In addition, Hudler et al. (1979) reported that they believe birds are the most likely agents of long-distance dispersal of dwarf mistletoes. Therefore, the possibility of the establishment of the Sacramento Mountains population of *A. microcarpum* by avian vectors should be considered.

The occurrence of *A. microcarpum* in southern New Mexico may be of interest in relation to recent studies of the taxonomic relationships of *Picea* spp. in the southwestern United States and northern Mexico. Engelmann spruce populations in the Sacramento Mountains (32° 48' N), the Pinaleno Mountains (32° 30' N), and the Chiricahua Mountains (31° 32' N) have been considered as the three most southern populations of this species in the United States (Little 1950, 1971, Daubenmire 1972, Taylor et al. 1975). However, Taylor and Patterson (1980) have shown that the *P. engelmannii* population from the Chiricahua Mountains differs slightly morphologically and chemically from more northern populations of this taxon and that the recently described *Picea mexicana* Martínez (Martínez 1961) is in their opinion not sufficiently different from *P. engelmannii* to warrant separation at the specific level. Therefore, they have reduced *P. mexicana* to a variety of *P. engelmannii* (*P. engelmannii* Parry var. *mexicana* (Martínez) Taylor & Patterson) and have included the Chiricahua Mountains population as representative of this combination (Fig. 2). Although Taylor and Patterson (1980) did not include samples of the *P. engelmannii* population from the Sacramento Mountains in their study, they did sample the *P. engelmannii* population in the Pinaleno Mountains and concluded it was representative of *P. engelmannii* var. *engelmannii*. We consider the spruce populations in the Hay Canyon vicinity to be morphologically representative of *P. engelmannii* var. *engelmannii* also (Daubenmire 1972, Jones 1977). In addition, the occurrence of *A. microcarpum* in the Sacramento Mountains may have taxonomic significance regarding the classification of this spruce population.

*Arceuthobium microcarpum* has not been reported on spruce in the Chiricahua Mountains (Hawksworth and Wiens 1972), but it is present on *P. engelmannii* in the Pinaleno Mountains, only 60 miles to the northwest, and is here reported on *P. engelmannii* from the Sacramento Mountains. Because dwarf mistletoes are relatively host specific parasites, the absence of *A. microcarpum* from the Chiricahua Mountains may be the result of the close phylogenetic affinities of that spruce population to the Mexican populations of *Picea* reported by Taylor and Patterson (1980). Hawksworth and Wiens (1972) reported that dwarf mistletoes have not been found parasitizing *Picea chihuahuana* Martínez in northern Mexico and there have been no reports of dwarf mistletoes on the Mexican populations of *P. engelmannii* var. *mexicana* (Hawksworth, F. G., pers. comm., 1982). Therefore, these taxa of *Picea* may have diverged from their northern relatives to the extent that they are less susceptible or immune to parasitism by extant species of *Arceuthobium* including *A. microcarpum*. If this is the case, then parasitism of the spruce populations in the Sacramento and Pinaleno mountains would help demonstrate their phyletic affinities to other *P. engelmannii* populations in the Southwest. The apparent absence of *A. microcarpum* from the Chiricahua Mountains does not indicate conclusively that *P. engelmannii* var. *mexicana* is less susceptible or immune to this mistletoe. Most varietal taxa of principal hosts of dwarf mistletoes are susceptible to parasitism when they occur within the mistletoes' geographic range (Hawksworth and Wiens 1972), and the absence of *A. microcarpum* from the Chiricahua Mountains may simply be a result of its geographic isolation from the spruce population there.

Hawksworth and Wiens (1972) suggested that *A. microcarpum* may have had a more northern distribution in the past, but has become isolated as relict endemic populations near the southern limits of its principal host ranges. They hypothesized that *A. microcarpum* may have evolved in a more northern area (possibly from the ancestor of *A. laricis* or *A. tsugense* since these taxa resemble *A. microcarpum* morphologically, our addition), migrated southward, and become isolated in

the Southwest. Recent studies of the dwarf mistletoe population parasitizing bristlecone pine, *Pinus aristata* Engelm., as a principal host on the San Francisco Peaks in north central Arizona have shown this mistletoe is *A. microcarpum* (Crawford and Hawksworth 1979, Mathiasen and Hawksworth 1980). However, this population differs morphologically and physiologically from other *A. microcarpum* populations (Mathiasen and Hawksworth 1980), and rarely parasitizes *Pinus strobiformis* and *Abies lasiocarpa* var. *arizonica* (Merriam) Lemm. (Hawksworth and Wiens 1972, Mathiasen and Hawksworth 1980). Therefore, *A. microcarpum* may have evolved in the Southwest from an ancestral species with a broader host range, including species of *Pinus* and *Picea*. The *A. microcarpum* population parasitizing *Pinus aristata* on the San Francisco Peaks would then be an extant population with close phyletic affinities to this hypothesized ancestral species and may indicate a relatively recent evolution of *A. microcarpum* with its radiation and specialization onto *P. engelmannii* and *P. pungens* in the southwestern United States. A more recent evolutionary origin for *A. microcarpum* would mean this species may still be migrating into areas where spruce populations are available for colonization. This may better explain its absence from the extensive spruce-fir forests of the central and northern Rocky Mountains than the hypothesis of a more northern evolutionary origin for *A. microcarpum*. It seems probable that *A. microcarpum* is not restricted to its present geographic range by climatic factors or host susceptibility, but that it evolved and specialized on *Picea* shortly before its potential host populations became isolated into small scattered populations in the higher mountain ranges of the Southwest. At present its further migration is severely hampered by its short dissemination range and hence its inability to spread over the long distances necessary for its migration into the central Rocky Mountains or into Mexico. However, the Sacramento Mountains population of *A. microcarpum* may indicate that this parasite can occasionally make an extremely large extension from its otherwise limited distribution. If it is occasionally possible for *A. microcarpum* to make a large jump, by

whatever means of dissemination, then, given enough time, *A. microcarpum* may eventually spread into the more northern and southern spruce populations of North America.

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