

# A SUBDIOECIOUS POPULATION OF *PINUS CEMBROIDES* IN SOUTHEAST ARIZONA<sup>1</sup>

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In the Chiricahua Mountains, Cochise County, Arizona, (Latitude 31° 40' to 32° 10' N., Longitude 109° 29' W.) Mexican piñon (*Pinus cembroides* Zuccarini) occurs on a variety of sites from 1430 to 2530 m (4700 to 8300 ft) above mean sea level. The species is most frequent in broad valleys situated between the elevations of 1525 and 2285 m, on north-facing slopes from 1615 to 2513 m, and on a few south-facing slopes at elevations as high as 2530 m. The Chiricahua population is isolated from neighboring populations in the surrounding mountain ranges by 15 (east) to 35 km (west) or more.

Monographic studies of the genus *Pinus* (Engelmann, 1880; Gordon, 1880; Sargent, 1897; Shaw, 1914; Gaussen, 1960) and the works pertinent to the Group *Cembroides* (Parry and Engelmann, 1862; Engelmann, 1878; Martínez, 1948), describe only the monoecious flowering habit of pines. There are, however, previous reports of two species that exhibit dioecism, but the trees involved are found at timberline where they are subjected to severe environmental stress. The species are: *Pinus culminicola* Andresen & Beaman at timberline on the highest mountain in northeastern Mexico, Cerro Potosí (ca. 3600 m) (Andresen and Beaman, 1961), and *P. flexilis* James at timberline in the Rocky Mountains of north-central Colorado (Kiener, 1935). In his discussion, Kiener cited an earlier report by Schroeter (1926) in which *Pinus montana* Miller allegedly was described as possessing a dioecious habit. A review of Schroeter's paper by the present authors, however, revealed that the specimens of *P. montana* he described were predominantly staminate or ovulate, not dioecious. Schroeter did illustrate and describe branches with a definite verticillate appearance from predominantly staminate trees.

In the Chiricahuas the great majority of individuals of *Pinus cembroides* is dioecious. The term "subdioecious," as used in the title of this paper, signifies that a few monoecious individuals occur within the predominantly dioecious population. In closed stands, piñon crowns are small and situated well above eye level, so that the trees have a uniform appearance; but in open-grown individuals there is a striking difference between the habits of staminate and ovulate trees. So conspicuous is this dimorphism that upon cursory examination several observers considered ovulate trees to be *P. cembroides* and staminate trees growing beside them to be *P. edulis*.

Mature piñons in the Chiricahuas generally are 6 to 9 m tall, have a crown spread of about 6 m, and are 15 to 25 cm in diameter at breast height, but in the southern portion of the Mountains, they may attain heights of 13.5 to 18 m and diameters of 30 to 45 cm. Open grown trees are branched from near the base, so that the crown extends from ground level to tree top. The foliage of ovulate trees is dense and the crowns have a full and even appearance, but staminate trees have much less dense foliage and individual branches are more obvious.

Leaves of *P. cembroides* may persist for seven years. Counts of leaves on branches from 17 randomly selected trees indicated that only about 10 per cent of the leaves of a given year drop before the second summer, an additional 70 to

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80 per cent drop by the end of the third year, and scattered leaves, comprising less than 1 per cent of the original seasonal leaf complement, or none, remain on six and seven year old twig sections. No leaves were found during the spring of 1961 that were more than seven years old (i.e., found on 1954 twigs). On branches of ovulate trees, fascicles of leaves, which inclined toward the apex, uniformly covered twig sections which grew during the current and past seasons and, on many trees, also covered the third oldest twig sections. Remains of the short peduncles of the solitary, sub-sessile ovulate cones caused no noticeable interruptions in the foliage. In contrast, the staminate strobili, which occur in clusters of 7 to 50, leave prominent discontinuities in the foliage. Thus, the foliage on a staminate tree is interrupted at regular intervals by 1 to 4 cm long sections of exposed twig on which ephemeral staminate cones were borne in past seasons. These naked sections are accentuated by the habit of leaves of staminate trees to spread at right angles to the twig.

Fascicles of leaves of the current season are located on the apical two-thirds of the current section of staminate twigs. The lower third of the section is naked and marked by raised scars of the deciduous staminate cones. Leaves of the previous and current year are separated by this gap. This pattern is continued on the twig section formed two years previously and occasionally on that formed three years previously if sufficient leaves are present. Thus, the staminate trees have a banded, or verticillate appearance. The paucity of leaf-fascicles on twig sections older than three years obscures the regularity of these gaps in foliage.

This verticillate habit also has been described in other species of pine. It is so pronounced in some segregates of *Pinus montana* in which the leaves persist for eight years, that the name *Pinus montana* var. *equisetiformis* Beissner was proposed in 1898. This variety, however, has been reduced to synonymy with *P. montana* (Beissner and Fitschen, 1930: 428). *Pinus sylvestris* var. *monticola* Schröter, a questionably recognized variety which occurs in Germany and Switzerland, was likened by Beissner and Fitschen (1930: 422) to *Sciadopitys verticillata* Siebold and Zuccarini because of the "whorled" foliage of the upper parts of staminate branches.

Analyses were made of the ratio of staminate to ovulate trees in stands of *P. cembroides* at three locations in the Chiricahua Mountains (table 1). Near Paradise, in the central portion of the Mountains, 183 trees were examined in a dense, nearly pure piñon stand situated at an elevation of approximately 1700 m on a north-facing slope. Of these, 48.6 per cent were ovulate, 48.1 per cent were staminate, and 3.3 per cent were monoecious. In an open stand on a north-facing slope at 1675 m in Rucker Canyon, in the southern portion of the Mountains, approximately 2.9 km west of Devils Canyon, 58 per cent of 100 trees examined were ovulate, 42 per cent were staminate, and none were monoecious. The third stand studied was at 1815 m on a north-facing slope of Limestone Mountain in Tex Canyon, about 12.9 km northwest of the Krentz Ranch, also in the southern portion of the mountains. Of 100 trees examined, 51 per cent were ovulate, 47 per cent were staminate, and 2 per cent were monoecious. A total of 383 trees was examined in the three stands and, of these, 51.7 per cent were ovulate, 46.2 per cent were staminate, and 2.1 per cent were monoecious.

Monoecious trees, without exception, bore a crop of cones in which strobili of one type predominated. In habit, the trees resembled dioecious trees of the predominant cone type. Predominantly-ovulate trees with a few clusters of staminate cones were observed more frequently than predominantly staminate trees with scattered ovulate cones. In all monoecious individuals, however, strobili of only one type were found on any single annual twig section, although staminate and ovulate cones did occur on twig sections of different season's growths on one axis of a branch and on twig sections of the same season on different axes of a single branch. For example, on the primary axis of one branch of a pre-

dominantly staminate tree, there was a 1959 ovulate cone, but the 1960 cones were staminate and the 1958 twig section bore scars of staminate cones. On another branch of the same tree, the 1960 growth resulted in a continuation of the main axis, on which there were two small ovulate cones, and a single lateral branch which bore a cluster of staminate strobili on 1960 growth.

Five staminate, six ovulate, three predominantly-staminate, and two predominantly-ovulate monoecious trees were selected randomly from various places in the Chiricahuas and at sites which ranged from 1675 to 2500 m in elevation. From each tree, 100 fascicles of needles were selected at random. In addition, 50 leaves were selected from each of two other predominantly-staminate monoecious trees. The length of the longest leaf in each fascicle was measured and the number of leaves in each fascicle was recorded.

Statistical analyses of measurements of length and counts of leaves of these 1660 fascicles indicated that there was no significant difference ( $P < 0.05$ ) between staminate, ovulate, and monoecious trees in either parameter. Therefore, all data were combined to derive a general description of the local population. Mexican piñon leaves occur in fascicles of from one to five leaves, but the majority (72 per cent) of the fascicles examined was three-leaved. Two leaves occurred in 19.5 per cent, one leaf in 5 per cent, four leaves in 3.5 per cent, and five leaves in 0.6 per cent (one fascicle) of the 1660 fascicles examined. The lengths of the

TABLE I  
Summary of cone types of individuals composing three stands of  
*Pinus cembroides* in the Chiricahua Mountains

Stand	Elevation in meters	Number of trees	Ovulate trees %	Staminate trees %	Monoecious trees %
1.	1700	183	48.6	48.1	3.3
2.	1675	100	58.0	42.0	0.0
3.	1815	100	51.0	47.0	2.0
Averages			51.7	46.2	2.1

longest needle in a fascicle ranged from 6 to 54 mm; the arithmetic mean and median measurements were 35.6 and 36.0 mm, respectively, and half of the measurements ranged between 34 and 43 mm. There was an apparent positive correlation between leaf length and elevation above sea level, although the data were not conclusive. The mean length of the longest leaf in 1097 fascicles from piñons growing between the elevations of 1675 and 2010 m was 34.3 mm. In contrast, the mean length of the longest leaves in 503 fascicles from piñons growing at elevations above 2130 m was 38.6 mm.

Several other superficial features, as well as the more basic aspects of sex-correlated variation in *P. cembroides* invite study. For example, the twigs of ovulate trees appeared to be thicker than comparable portions of the twigs of staminate trees and appeared to develop longer internodes. The diameter and height growth of ovulate trees seems to be more rapid than those of staminate trees, on the basis of only eight increment cores. It is not known whether there are differences in fertility between gametes produced from the dioecious trees and from monoecious trees or whether seeds produced on monoecious trees differ in germinative ability from those produced on ovulate trees. Neither is it known whether or not gametes produced on monoecious trees in this predominantly dioecious population are self-sterile. Genetic and/or physiologic mechanisms controlling the development of the reproductive mechanisms in this piñon and the

geographic range of the dioecious condition in *P. cembroides* are unknown. The condition does not appear to have been mentioned previously in the literature, but Dr. Marion T. Hall (personal communication, 1962) states that he has observed a spotty occurrence of dioecious piñon populations in central New Mexico, from the Sacramento Mountains northward to the Sandia Range. Dr. Hall considers the trees in this region to be introgressants of *P. edulis* and *P. cembroides* and that dioecism is positively associated with the degree of introgression.

Of the reported observations of dioecism in the Genus *Pinus* (Andresen and Beaman, 1961; Kiener, 1935), the phenomenon is apparently restricted to the wingless-seed groups *Cembroides* and *Flexiles* of the Sub-genus *Haploxylon*. Under most conditions, extended seed dissemination of these pines is dependent upon an avian or mammalian vector (Baldwin, 1942: 25).

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#### SUMMARY

In the Chiricahua Mountains, Cochise County, Arizona, *Pinus cembroides* grows on various sites between the elevations of 1430 and 2530 m. Only about 2 per cent of the individuals in the local population are monoecious. Staminate trees of the dioecious component of the population can be distinguished readily from ovulate trees by the verticillate aspect of their foliage. Whereas leaves on twigs of ovulate trees form a relatively continuous cover on twig sections which grew during the current and past seasons, the foliage of staminate trees is interrupted by 1- to 4-cm long sections of bare twig on which ephemeral staminate cones were borne. No variations correlated with spore type were found in leaf length or in the number of leaves per fascicle. The majority of strobili on monoecious trees were either staminate or ovulate. Strobili of the other type were borne on only a few branches. The habit of monoecious trees resembled dioecious trees of the spore type predominant in the monoecious individual.

From measurements and counts of 1660 fascicles from 18 randomly selected trees, it was found that the number of leaves per fascicle varied from one to five and that the longest leaf of a fascicle ranged from 6 to 54 mm, with a median length of 36.0 mm. Some leaves were found to persist for seven years, although 80 to 90 per cent are deciduous by the end of their third year.

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