Flowering and Seed Dispersal of Dwarfmistletoe (*Arceuthobium campylopodum*) in California

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ABSTRACT: Under the short growing season of the Sierra Nevada, both flowering and seed dispersal of *Arceuthobium campylopodum* occurred earlier in the fall and dispersal extended for a shorter duration than at lower elevations and along the coast of California. Also in years of above normal summer temperatures, flowering and seed dispersal occurred earlier in the season than in years of below normal temperature.

The periods of flowering and seed dispersal of the various forms of dwarfmistletoe (Arceuthobium campylopodum Engelm.) have not been carefully investigated. Knowing when these processes occur may provide information useful in controlling the spread and buildup of this widely distributed parasite.

Unlike other North American species of dwarfmistletoe, A. campylopodum flowers and disperses seed in late summer and fall. Reports in the literature indicate, however, that the time and duration of these processes is not the same for the various forms of the species growing in different areas. Only few reports concern the flowering period of A. campylopodum. Gill[2] (p. 144) indicated that it blooms in August and September. Peirce[3] on the other hand, reported that A. campylopodum growing on Monterey pine (Pinus radiata) along the coast of California flowers from September to January.

Similarly, apparently conflicting reports on seed dispersal are found in the literature. Peirce[3] observed that dispersal of the parasite on Monterey pine occurred during November and December. Gill[2] reported that except under mild weather conditions the fruit matures in autumn and seeds are all disseminated by the end of October. Weir[4] investigating several forms of A. campylopodum

[1]Appreciation is expressed to C. R. Quick, Pacific Southwest Forest and Range Experiment Station, and to D. R. Miller, California Region, U. S. Forest Service, for their assistance in making field observations on flowering and seed dispersal of dwarfmistletoe.

[2]Gill, Lake S. Arceuthobium in the United States. Conn. Acad. Arts & Sci., Trans. 32: 111-245. 1935.

[3]Peirce, G. J. The dissemination and germination of *Arceuthobium occidentale*, Eng. Ann. Bot. 19: 99-113. 1905.

[4]Weir, James R. Experimental investigations on the genus *Razoumofskya*. Bot. Gaz. 66(1): 1-31. 1918.

and Roth[5] working with the form on ponderosa pine, both found the dispersal period corresponded rather closely with that reported by Gill[2].

The aim of the study reported in this note was to investigate the approximate time and duration of flowering and seed dispersal of A. campylopodum forma abietinum on red fir (Abies magnifica) and white fir (A. concolor); forma campylopodum on Digger pine (Pinus sabiniana), Monterey pine, and ponderosa pine (P. ponderosa); and forma blumeri on sugar pine (P. lambertiana). The relationship of flowering and seed dispersal to climatic conditions was also investigated.

METHODS

Field observations of flowering and seed dispersal were made from 1958 to 1963. In general, annual observations were made of both flowering and seed dispersal of the parasite on firs; only annual observations of seed dispersal were made of dwarfmistletoe on Digger pine. The form growing on firs was located on the Plumas National Forest in northern California and on the Stanislaus National Forest in the central Sierra Nevada. The form on Digger pine was located on Mt. Diablo in the Coast Range, about 40 air miles east of San Francisco. Additional observations on flowering and seed dispersal of the parasite on Digger pine, sugar pine, Monterey pine, and ponderosa pine were made in several different areas of California over the 6-year period. All areas examined in the Sierra Nevada were west of the summit and subject to west-side climatic conditions. For any one observation in a given area several dwarfmistletoe plants were examined carefully in order to ascertain the stage of flowering or fruiting.

The flowering period was considered to extend from the first appearance of open staminate flowers (fig. 1) to the period when flowers were either dried up or no longer present. The approximate percentage of male flowers in bloom and the condition of the flowers were the main criteria used to judge stage of flowering.

The period of seed dispersal was considered to extend from first signs of natural seed discharge until fruits (fig. 2) were no longer present on the shoots. Stage of seed dispersal was judged by ripeness of the fruits as shown by the approximate percentage of seeds discharged when shoots were shaken and by the percentage of fruits remaining on unshaken shoots.

Using data from these examinations, the beginning and end of flowering and seed dispersal periods were estimated to the closest calendar week.

RESULTS

FLOWERING AND SEED DISPERSAL

The duration of flowering of dwarfmistletoe on true firs generally extended for about 6 to 7 weeks (fig. 3). Flowering of the fir

[5]Roth, L. F. Natural emplacement of dwarfmistletoe seed on ponderosa pine. Forest Sci. 5: 365-369. 1959.

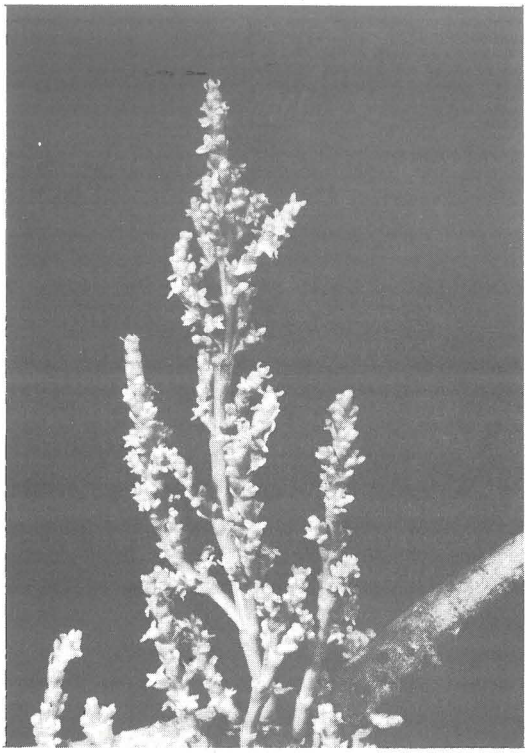

Figure 1.--Male plant of *A. campylopodum* f. *campylopodum* bearing staminate flowers, on Digger pine.

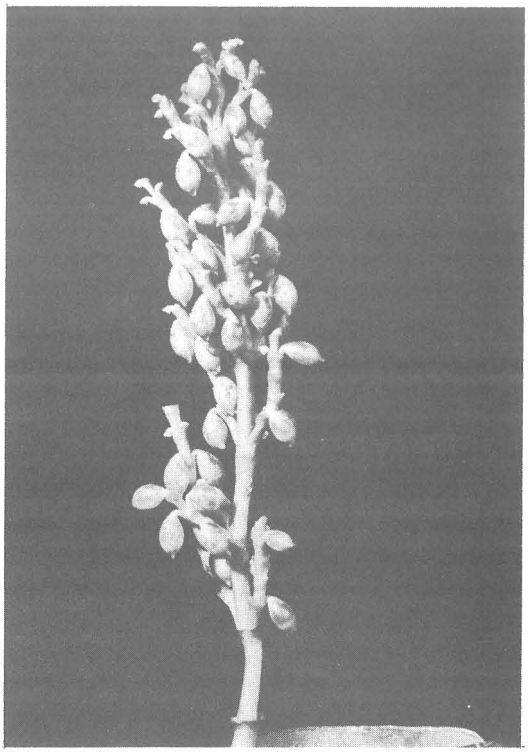

Figure 2.--Shoot of *A. campylopodum* f. *campylopodum* bearing mature fruits, on Digger pine.

form in a given area, however, did not always begin at the same time each year. It differed by as much as a month. On the other hand, no marked differences were noticed in the time of flowering between the parasite on red firs and the one on white firs in the same area in any one year. Furthermore, in the same year (1961), no obvious differences were noted in time of flowering of the fir form observed in different and widely separated areas (Plumas and Stanislaus National Forests).

Earliest flowering, recorded for dwarfmistletoe on sugar pine, began in mid-July and extended for about a month (fig. 4). Flowering on ponderosa pine and Digger pine began in late August to mid-September and extended for about 5 to 6 weeks.

Duration of seed dispersal of dwarfmistletoe on firs (fig. 5)--similar to that of flowering--extended for about 5 to 7 weeks. Dispersal began in September. The dwarfmistletoe on red fir generally dispersed seeds about a week earlier than the one on white fir. On the Stanislaus National Forest, differences were noted in the time of seed dispersal for fir dwarfmistletoe for the years 1958-63. On the Plumas National Forest, only time of beginning dispersal was recorded for dwarfmistletoe, and only then for the years 1958 and 1963. Observations showed, however, time of dispersal to be about the same as that on the Stanislaus National Forest in the same years.

On Digger pine in the Coast Range, seed dispersal of dwarfmistletoe began about a month later than on firs in the Sierra Nevada (fig. 6). Its duration on Digger pine was more than twice that of the fir form--extending from October to about mid-January. An unusual case was observed in 1961 in which a single plant on Digger pine bore fruits and was dispersing seeds in May.

Dispersal of dwarfmistletoe on ponderosa pine observed in 1958 and 1961 on the Stanislaus National Forest began 1 to 3 weeks later than on white fir; or about midway between beginning dispersal of the form on firs and the one on Digger pine. But duration of dispersal was about the same as that of the form on firs.

Seed dispersal of dwarfmistletoe on Monterey pine along the California coast began late in the year, in early November in 1958-60. Although the duration of dispersal was not accurately determined, it was found to extend for at least 2 months and probably even longer.

CLIMATIC INFLUENCES

Climate influences flowering and seed dispersal of A. campylopodum in California. Climatic conditions at elevations above 6,000 feet in the Sierra Nevada are considerably more extreme than those at lower elevations and in much of the Coast Range. Because of these extreme climatic conditions in the high Sierra a short growing season prevails. Under such conditions the maturation period of flowers and fruit of A. campylopodum is shortened, and seed dispersal occurs over a limited period in autumn. In contrast, under the mild, nearly year-long growing conditions at low elevations in the Coast Range, both flower and fruit maturation occurs later in the year, and seed dispersal occurs over a period of several month.

Year to year differences in flowering and seed dispersal were also observed for the forms of A. campylopodum examined during the years 1958-63. For example, flowering of the form on firs, and seed dispersal of the form on firs and Digger pine, occurred earlier in the year in 1960-61 than in 1962-63. In view of these consistent differences among forms in different areas, an investigation was made to see if flowering and seed dispersal could be correlated with particular temperature conditions that prevailed during the growing season. Because of lack of summer rain temperature was considered to be the most critical climatic influence governing these processes.

For the purpose of this study, average monthly temperature records of the Mt. Diablo North Gate weather station were examined in the years 1960-63[6]. Because departures from long-term means were not available for the Mt. Diablo station, temperature records of the Livermore station, located about 20 miles to the south were used. For a general picture of temperature conditions in the Sierra Nevada the special monthly weather summaries were also examined for 1960-63.

[6]U.S. Weather Bureau. Climatological data, California, 1960-63.

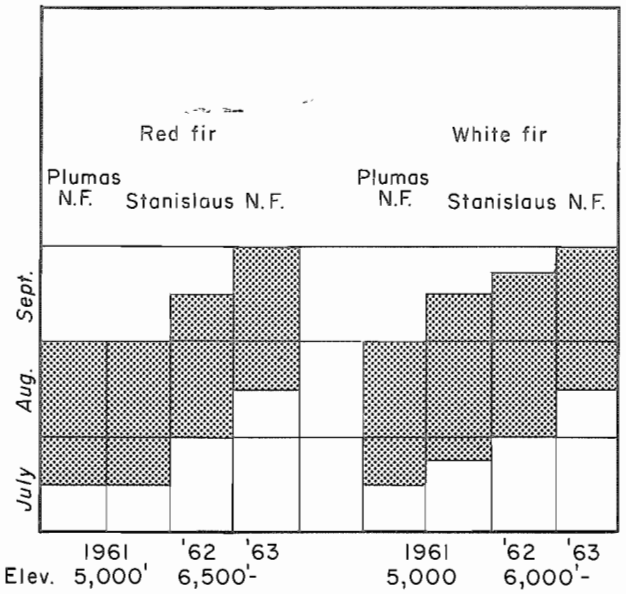

Figure 3.--Flowering periods of dwarfmistletoe on firs in California.

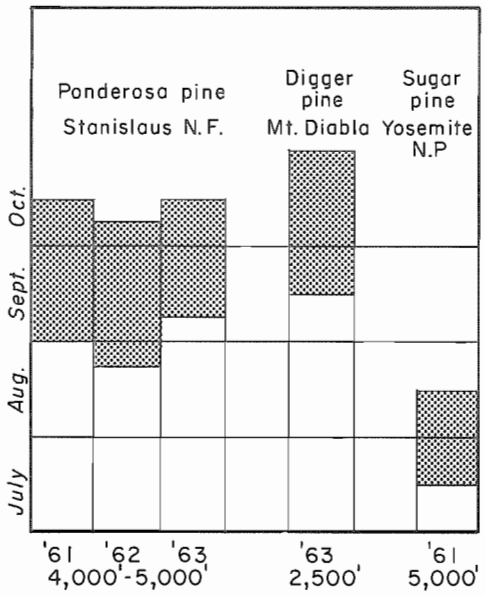

Figure 4.--Flowering periods of dwarfmistletoe on pines in California.

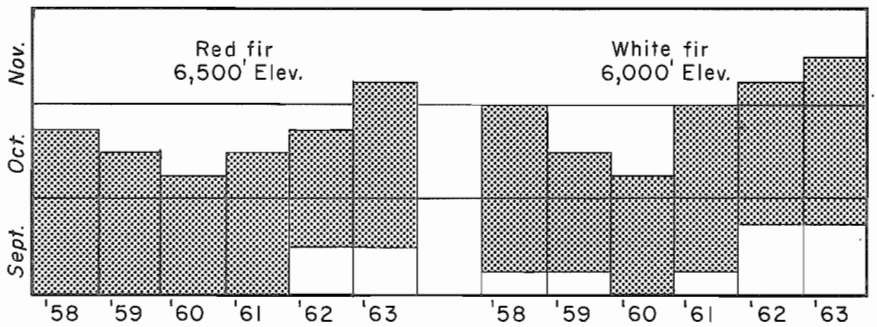

Figure 5.--Periods of seed dispersal of dwarfmistletoe on firs, Stanislaus National Forest.

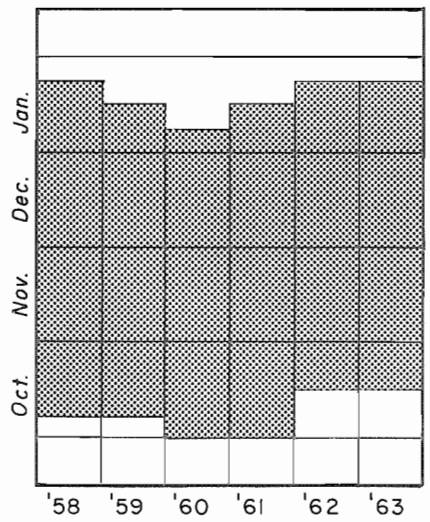

Figure 6.--Periods of seed dispersal of dwarfmistletoe on Digger pine, Mt. Diablo.

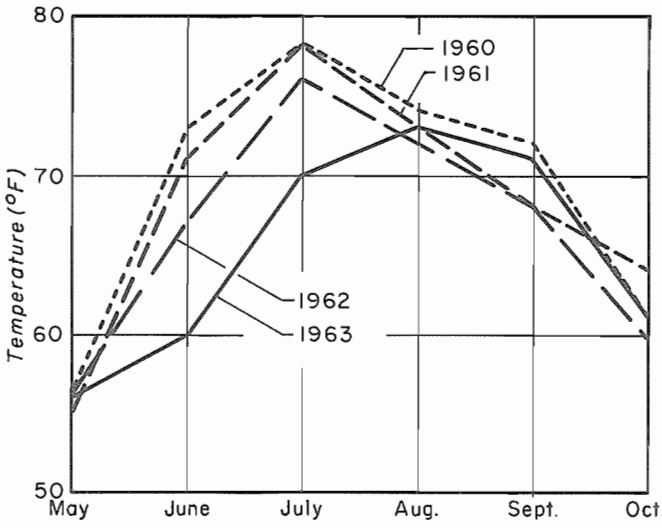

Figure 7.--Average monthly temperatures recorded on Mt. Diablo, May-October, 1960-63.

Table 1. *Temperature deviations from the long-term mean, Livermore station, U.S. Weather Bureau*

Year	Deviation (°F.)			
	June	July	August	September
1960	5.7	1.7	-0.6	-0.9
1961	3.2	1.9	.9	-2.0
1962	- .2	-1.8	- .8	-2.4
1963	-2.4	-3.9	-1.6	- .4

Examinations of weather records from Mt. Diablo and Livermore indicated that time of the year of seed dispersal of dwarfmistletoe on Digger pine was correlated with summer temperature conditions (figs. 6, 7, and table 1). For example, in 1960-61--years of rather early seed dispersal--average monthly temperatures were near or above normal for the months of June-September. On the other hand, in 1962-63--years of below normal summer temperatures --seed dispersal occurred somewhat later in the year.

For California in general, temperature conditions for the summers of 1960-63 were found to be similar to conditions that prevailed on Mt. Diablo and at Livermore. Above average temperatures occurred in 1960-61, and below average temperatures were recorded in 1962-63. The overall pattern of seed dispersal of dwarfmistletoe on firs matched the pattern for Digger pine (figs. 5, 6); dispersal occurred earlier in 1960-61 and noticeably later in 1962-63. Similarly on firs the pattern of flowering matched the pattern of seed dispersal in 1961-63 (figs. 3, 5).

CONCLUSIONS

In logging dwarfmistletoe-infected forest stands and in pruning and thinning trees to control the parasite, consideration should be given to the seed dispersal period to avoid infection from current year's seeds. The general climatic zone in which the host and parasite are growing and the general temperature conditions during the current year's growing season should be considered in judging the seed dispersal period and in timing dwarfmistletoe control operations.

The Author. . .

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