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# Resistance of Ponderosa Pine to the Gouty Pitch Midge (*Cecidomyia piniinopis*)

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## RESEARCH SUMMARY

Individuals of a family test of ponderosa pine were scored for the amount of damage caused by infestation by gouty pitch midge. The percentage of dead or dying tips varied from 0 to 57 percent for individuals and from 0 to 20 percent for families. Heritability based on individuals was 0.48 and for families 0.60. Selection for resistance could yield a family gain of 10 percent and an individual gain of 8 percent for each unit of *i*. Use of these data in tree improvement programs is discussed.

## THE AUTHOR

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# Resistance of Ponderosa Pine to the Gouty Pitch Midge (*Cecidomyia piniinopis*)

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## INTRODUCTION

In 1985 a heavy infestation of the gouty pitch midge (*Cecidomyia piniinopis*) was found in a plantation of ponderosa pine (*Pinus ponderosa*) in northern Idaho. The trees had been planted in rows of four trees, each row representing one family. It thus became apparent that some families were heavily damaged while others were not damaged at all.

The purpose of this paper is to document severity of infestation, and inheritance of resistance to midge attack in a ponderosa pine plantation in the Inland Northwest.

The gouty pitch midge is a native pest of forests of Eastern and Western North America. In the West, the pest is especially injurious to ponderosa pine where the level of infestation becomes high enough to kill trees (Eaton and Yuill 1960). Natural controls such as weather, host resistance, and parasites normally keep it in check (Eaton and Yuill 1960). The midge lays its eggs on rapidly growing branch and leader tips. After hatching, the larva bores through the surface until it is completely embedded in the vascular tissue. The larva feeds there until the following spring, then works to the surface to pupate. The adult emerges in 10 to 14 days. Damage occurs during larval feeding, the result of disruption of vascular tissue.

The level of midge infestation appears to be associated with the characteristics of the new shoots (Austin and others 1945). Shoots that are smooth or are covered with a waxy bloom are less infested than shoot surfaces that are sticky and resinous. Further, Duffield (1985) reported evidence that the nature of the new shoot surface was inherited and that two genes were involved.

## MATERIALS AND METHODS

In 1974 the Northern Region of the Forest Service established two progeny tests of ponderosa pine in northern Idaho and one in western Montana. Other members of the Inland Empire Tree Improvement Cooperative also established tests the same year. Altogether there are six plantations. In 1985 the plantation at the Lone Mountain tree improvement site in northern Idaho exhibited high infestation by the gouty pitch midge (fig. 1).

The Lone Mountain tree improvement site is located 40 km north of Coeur d'Alene, ID. The site is flat, with only slight undulations, at an elevation of 758 m. The entire 65-ha site is surrounded by naturally regenerated ponderosa pine and lodgepole pine (*Pinus contorta*), with lesser

amounts of grand fir (*Abies grandis*), Douglas-fir (*Pseudotsuga menziesii*), and western larch (*Larix occidentalis*). This natural stand has an overstory of mature scattered trees (remnants of harvest) and an understory of pole-sized trees 6 to 9 m tall. Many ponderosa pine of all ages were infested with the gouty pitch midge.

Open-pollinated seed of 234 families were collected from 48 stands located in northeastern Washington and in Idaho north of the Salmon River. The number of trees per stand was usually five, sometimes four. The seedlings were grown at a Forest Service nursery near Coeur d'Alene, ID, in bare-root beds for 2 years, then lifted and planted at the Lone Mountain site in April 1974. The experimental design was a randomized complete block design with five blocks. Four progeny of each family were planted per block as a four-tree row plot.

Data were taken by estimating the number of dead or dying branch or leader tips. The range of damaged tips was determined by spending a couple of hours counting damaged tips throughout the test on several trees. From this inspection a scoring system was developed that would encompass all trees. Then the level of infestation of each tree was noted and placed in one of the following classes:

0 = 0	infested branch or leader tips, average = 0
1 = < 5	infested branch or leader tips, average = 2.5
2 = 6-32	infested branch or leader tips, average = 18
3 = 33-67	infested branch or leader tips, average = 49
4 = 68-100	infested branch or leader tips, average = 84

Tree height varied from 1.1 to 7.0 m; to determine the proportion of tips damaged on a tree basis a regression of the actual number of tips per tree (healthy and damaged) by height was determined. A random sample of 224 trees (6 percent of total trees) was selected to develop the regression formula. The data used for analysis were the percentage damage per tree, determined as follows: percent damage = number of damaged tips/TT where  $TT = a + bx$ , and TT = estimated total tips,  $x$  = tree height,  $a$  and  $b$  = regression coefficients, number damaged = the average associated with the field damage category. Because percentage of damage varied widely, these data were transformed ( $\arcsin \sqrt{\text{percent}}$ ) (Steel and Torrie 1960).

The analysis of variance model and expected mean squares are shown in table 1. Heritabilities followed Namkoong (1979). The relationship of gouty pitch midge damage to 1985 height was determined by regression analysis, using the GLM procedure (SAS 1979).



Figure 1—Gouty pitch midge damage on ponderosa pine. Tree on left was not damaged. Tree on right was heavily damaged.

Table 1—Model for analysis of variance and expected mean squares

Source of variation	df	Expected mean squares
Block	4	$\sigma^2_E + \rho\sigma^2_{EE} + fpST_B$
Stand	47	$\sigma^2_E + \rho\sigma^2_{EE} + pb\sigma^2_{F/S} + pbf^*\sigma^2_S$
Family in stand	182	$\sigma^2_E + \rho\sigma^2_{EE} + pb\sigma^2_{F/S}$
Experimental error	916	$\sigma^2_E + \rho\sigma^2_{EE}$
Within plot	2,608	$\sigma^2_E$

where:  $b = 5$ ,  $S = 48$ ,  $f = 229$ ,  $f^* = 4.6$  harmonic mean of families in stands;  $p = 3.00$  harmonic mean of individuals within plots

## RESULTS

The regression of total tips per tree (TT) for the sample resulted in regression coefficients of  $a = -68.0$  and  $b = 74.1$  tips per meter,  $R^2 = 0.69$ .

The average level of damage by gouty pitch midge was 5 percent. Individuals varied from 0 to 57 percent, and families varied from 0 (15 families) to 20 percent. The frequency of damage classes by individual is summarized in table 2.

Differences among families within stands were highly significant (table 3). Variance components are listed in table 3. Heritability based on individuals was 0.48; for families 0.60.

There was very little relationship between the amount of damage caused by the gouty pitch midge and the heights of the trees in 1985.  $R^2$  for families was 0.02.

**Table 2**—Level of damage by gouty pitch midge on the new shoots of ponderosa pine

Infection class	Number of tips damaged		Test trees (progeny)
	Mean	Range	
0	0	0	46
1	2.5	< 5	20
2	18	6-32	23
3	49	33-67	10
4	84	68-100	2

**Table 3**—Analysis of variance and variance components of transformed data

Source of variance	df	MS	Variance component
Block	4	0.367	0.0005
Stand	47	.089	.0009
Family in stand	182	.300	.0012
Experimental error	916	.012	.0017
Within plot	2,608	.007	.0070

## DISCUSSION

Individuals and families of ponderosa pine vary in their response to infestation by the gouty pitch midge. The high individual and family heritabilities could result in fairly good genetic gains in resistance. The estimated gain that could be realized for one unit of  $i$  was 10 percent for family selection, 8 percent for individual selection.

Gouty pitch midge can be devastating to ponderosa pine. At the Lone Mountain tree improvement site the epidemic started in the mid-1980's. In 1986 many trees were dead, and on many others nearly all shoots were dead or dying. It will take a long time for this progeny test to recover.

Epidemics caused by the gouty pitch midge are rare in wildland forests. The biggest impact has been in test plantations, namely in a monoculture complicated by close spacing and foreign germ plasm. Nonetheless, a natural level of resistance should be maintained. It is probably not necessary to increase the level of resistance in the wildland population, unless the midge becomes a serious pest in forest plantings. The tree breeder should consider resistance in the selection scheme to make sure adequate resistance is maintained. This can be assured by carefully correlating shoot character and resistance to the midge.

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KEYWORDS: forest genetics, forest pathology, insect resistance, silviculture, reforestation

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