

EFFECTIVENESS OF THE SEED WING OF *PINUS FLEXILIS* IN WIND DISPERSAL

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ABSTRACT.— Limber pine (*Pinus flexilis* James) seeds are usually wingless but occasionally have short, stubby wings. To determine the effectiveness of these wings in slowing seed descent, rates of fall were determined before and after wing removal. A similar experiment was conducted with seeds of Himalayan blue pine (*P. griffithii* McClelland), a white pine with typically long seed wings. The short wings of limber pine seeds were found to influence rate of seed fall far less than the wings of Himalayan blue pine. This is consistent with evidence suggesting that limber pine seeds are not effectively dispersed by wind but are dependent for dispersal on Clark's Nutcracker (*Nucifraga columbiana*).

The seeds of limber pine (*Pinus flexilis* James) are usually described as lacking the membranous wing typical of most Pinaceae or as having only rudimentary wings (Sargent 1891–1902, Harlow et al. 1979, Dallimore & Jackson 1961, Lanner 1984). During the course of recent research, numerous limber pine seeds from throughout Utah, Wyoming, and Montana have been examined in this laboratory. Winged seeds were occasionally found in cones collected in all three of these states, though they are scarce. The outer cone-scale tissue from which seed wings are formed is maternal in origin, and therefore of uniform genotype. Thus, all the seeds of a tree bearing winged seeds are winged, and all the seeds from a tree bearing wingless seeds are wingless.

Limber pine and some other western American wingless-seeded pines (*P. edulis* Engelm., *P. monophylla* Torr. & Frém., *P. albicaulis* Engelm.) have recently been found to be at least partially dependent on corvids, principally Clark's Nutcracker (*Nucifraga columbiana*) and the Piñon Jay (*Gymnorhinus cyanocephalus*), for dispersal of their seeds and establishment of their seedlings (Vander Wall and Balda 1977, Lanner 1980, Lanner and Vander Wall 1980, Hutchins and Lanner 1982). In brief, the corvids harvest conifer seeds from cones and bury them in the soil as food stores which, if not retrieved, often germinate. There is strong evidence that whitebark pine (*P. albicaulis*) is systematically dis-

persed and established only by Clark's Nutcracker, all other potential disperser-establishers being ineffective (Hutchins and Lanner 1982). Limber pine has not received thorough enough study to determine whether this is also true of its regeneration, but the similarity of its potential dispersing fauna to that of whitebark pine suggests this may be so. However, the occasional presence of seed wings in limber pine raises the possibility that a limited amount of wind dispersal also occurs. If so, the hypothesis of dependence on corvids, or other animals that may subsequently be found effective, would fail. The purpose of the experiment reported here was to determine whether the rudimentary wings of limber pine seeds are aerodynamically capable of effecting seed dissemination by the wind.

METHODS

Limber pine cones from the Beartooth Mountains, Montana, were allowed to open naturally in the laboratory. Cones from several trees (trees 1, 2, and 3) bore seeds with wings at least as long as any hitherto encountered and were selected for study. These wedge-shaped wings were up to 5 mm long. Seeds were individually dropped 9 m down a stairwell in still air. Descent time was determined with a stopwatch. Seeds were retrieved and dropped again after removing the wing. A "slowdown factor" was com-

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TABLE 1. Rates of fall (meters sec⁻¹) of winged and de-winged *Pinus flexilis* seeds from three trees from the Beartooth Mountains, Montana, during a 9-m descent.

	Tree 1		Tree 2		Tree 3	
	Winged	De-winged	Winged Rate of fall, meters sec ⁻¹	De-winged	Winged	De-Winged
Mean	4.21	4.67	4.12	4.61	4.20	4.56
S.D.	0.40	3.7	0.50	0.54	0.16	0.84
n	7	6	7	7	10	10

puted by dividing the rate of fall of de-winged seeds in meters per second by the rate of fall of winged seeds. A similar experiment was performed with seeds of Himalayan blue pine, *P. griffithii* McClelland, but these long-winged seeds tended to drift easily and thus were dropped to the floor of a laboratory from a height of 2.9 m.

RESULTS

Limber pine seed descent was linear, with little tendency to autorotate, whether wings were present or absent. The mean rate of descent of limber pine seeds before wing removal was 4.18 meters sec⁻¹; and after removal of wings the rate was 4.61 meters sec⁻¹ (Table 1). The slowdown factor for individual trees' seeds ranged from 1.09 to 1.12, with a mean of 1.10. Therefore, winged seeds required 1.1 times as long to fall one meter as did de-winged seeds.

Himalayan blue pine seeds immediately began to autorotate when released and drifted in response to even very slight air movements. Winged seeds fell at an average rate of 1.12 meters sec⁻¹ (filled) and de-winged seeds fell 4.06 meters sec⁻¹ (Table 2). The slowdown factor for filled seeds was therefore 3.63, meaning that the long membranous wings of these seeds delayed their fall by a time factor of 3.63. Empty seeds fell somewhat more slowly, both with and without wings, and had a slowdown factor of 3.94.

DISCUSSION AND CONCLUSIONS

The winged seeds of Himalayan blue pine are typical of the white pines. According to USDA Forest Service (1974), they weigh about 9100 per pound, or roughly .05 gm each. Limber pine seeds weigh about .09 gm each, according to the same source. The

wings of samaras, which these seeds are in functional terms, initiate autorotation, thus slowing descent and allowing wind currents to exert lateral force on seed flight; so it can be assumed that a wing that is highly effective in slowing the rate of descent is adaptive in the context of wind dispersal. It is apparent that if the slowdown factor of Himalayan blue pine seed wings is taken as typical for the white pine group, of which limber pine is also a member (Critchfield and Little 1966), then the rudimentary wing of limber pine seeds is a comparatively ineffective braking mechanism. It therefore appears that wind dispersal of limber pine seeds is unlikely to be effective beyond the crown projection of the individual seed tree and that dispersal by corvids, especially Clark's Nutcracker, is of far greater ecological significance.

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