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Seed Dispersal in *Mimulus guttatus* by Wind and Deer

ABSTRACT: Dispersal of monkey flower (*Mimulus guttatus* Fischer ex D.C.) seeds by wind was studied by placing flats of sterilized soil in rows up-canyon from clumps of monkey flowers in the Red Butte Canyon Natural Area, Salt Lake Co., Utah. Seeds were abundantly dispersed over the 1st meter and as far as 4.75 m. Scat of deer and moose were tested for seeds also. One deer sample produced *M. guttatus* plants that fortuitously exhibited a genetic marker known from only a single population over a kilometer away.

INTRODUCTION

Mimulus guttatus seeds can be dispersed by birds (Lindsay, 1964), wind and water (Waser *et al.*, 1982). Bird and wind dispersal have been demonstrated in the laboratory whereas dispersal by streams has been shown in the field. Levin and Kerster (1974) observed that water dispersal is also highly effective. We recorded water dispersal distances of hundreds of meters (Waser *et al.*, 1982), but dispersal is downstream only. Can *Mimulus guttatus* seeds be dispersed upstream by wind or animals?

EXPERIMENTAL DESIGN

To field-test the possibility of wind dispersal of *Mimulus* seeds upstream, three experiments were set up in successive years in the Red Butte Canyon Natural Area, Salt Lake Co., Utah. In each experiment, flats (23 cm x 30 cm, *i.e.*, with an area of ca. 700 cm² each) of sterilized soil were placed in a row up-canyon from large clumps of flowering *M. guttatus*. In the 1981 experiment four flats were placed at intervals of 0.5 m, 1 m, 2.5 m, 5 m, 10 m, 25 m, 50 m and 100 m (Table 1) up-canyon from the three clumps of monkey flowers. The flats were left in place for 36 days (30 June-6 August) by which time the *M. guttatus* plants had ripened and shed the large majority of their seeds. The flats were brought in to the Biology Department isolation greenhouse where they were regularly watered, thus initiating germination. Germination, which has no other special requirements in *M. guttatus*, began in 5 days. The number of seedlings in each flat was recorded daily for 2 weeks and at longer intervals for the next 2 months, by the end of which time germination had essentially ceased (Table 1). In previous artificial wind experiments (Waser *et al.*, 1982), 63% of the seeds landed less than .5 m from the seed source (a plant with numerous ripe capsules) at electric fan-created wind velocities of 4 m/sec and 11 m/sec; but 1% attained distances of 10 m at 4 m/sec and 4% attained distances of 25-30 m at 11 m/sec. An automatic recorder showed that 4 m/sec winds occurred both up-canyon and down-canyon 1% of the time at the study site during the study period (Ehleringer, pers. comm.) with occasional gusts of 11 m/sec up to 25 m/sec (our measurements—the automatic recorder averaged the velocities each minute and thus understated gusts). In view of these results, the 1982 experiment was designed to observe short-range dispersal distances in more detail. Solid lines of flats (23 cm x 30 cm) spaced four to the meter were placed up-canyon for 2.5 m from each of four clumps of flowering *M. guttatus* plants. Thus, a continuous record of dispersal was obtained in the direction sampled. The flats were left in place from 14 July through 12 August by which time approximately 90% of the seeds of the *M. guttatus* plants had ripened and been dispersed. The flats were removed to the isolation greenhouse, watered and germination scored as before (Table 1). The 1983 experiment was planned to obtain more detailed data on the distance of dispersal. Solid lines of 40 flats were placed for 10 m up-canyon from each of two clumps of monkey flowers. The experiment lasted from 15 July through 17 August. As before, the flats were returned to the isolation greenhouse, watered and germination scored (Table 1).

To test the possibility of dispersal by large animals (Janzen, 1984), two experiments were done. In 1982, approximately 1 liter of deer scat from the streamside—approximately 10 m from the *Mimulus guttatus* population at the old Beaver Dam at 1970 m elevation in Red Butte Canyon—was gathered. It was spread out on flats of sterilized soil in the isolation greenhouse, watered regularly and germination recorded. The experiment was repeated in 1983 with both deer and moose scat from the same locality, because in the meantime a family of moose had moved into the canyon and moose are known to browse on aquatic plants (Grzimek, 1972). Approximately 1 liter of each type of scat was spread on flats of sterilized soil in the isolation greenhouse, watered regularly and the germination results scored as before.

RESULTS AND DISCUSSION

In our Red Butte Canyon wind dispersal field trials, nearly half, 44.48% of the seeds (recovered as seedlings) landed in the first 0.25 m (Table 1) despite the fact that the seeds are so small (1 x 1/2 mm) and so light (0.002 mg). Some 23.92% of the seeds landed in the second 0.25 m for a total of 68.40% in the first 0.5 m which is in line with our earlier artificial wind experiments (*see* above). Some 23.33% of the seeds landed in the second 0.5 m for a total of 91.73% in the 1st m. A scant 8.20% went farther than 1 m and as far as 2.5 m. Only 3 out of 4256, *i.e.*, 0.07%, went as far as 4.5 and 4.75 m. Occasionally, seeds probably are carried much farther as observed in our artificial wind experiments and as determined in the Arctic by Savile (1972). However, the necessarily limited area sampled rendered it highly unlikely that we would observe such rare, longer dispersal events. Nevertheless it is clear from the wind dispersal distances observed that *Mimulus guttatus* could migrate slowly up a canyon, *e.g.*, along the moist banks of a stream, and in time colonize a whole drainage.

Of the three animal dispersal trials, one produced *Mimulus guttatus* seedlings. Three monkey flower plants grew from the deer scat tested in 1982. Fortuitously, two of these plants had a large (0.4-cm diam) red spot on the lowest petal lobe of their corollas instead of the usual cluster of 15-30 tiny (1-mm diam) red dots. This marker shows variable expressivity. In about half the flowers it is present and in the other half there are no spots at all, even the usual little ones. This prominent genetic marker (not in the population adjacent to the site of scat collection) is only known to occur in a single population in the Wasatch Mountains—based on the extensive collections of *M. guttatus* from this area in the herbaria of the University of Utah (UT), Utah State University (UTC) and the Brigham Young University (BRY). The unique population occurs along Pine Fork Creek 1 km farther up Red Butte Canyon from the old Beaver Dam area from which the scat was collected. Thus, it is clear that deer can and do transport *M. guttatus* seeds a kilometer, possibly much farther, and could transport the seeds from one drainage to another. Also, the deer excreted the seeds near a stream (perhaps while drinking) in a favorable habitat for monkey flowers to germinate, grow and establish a population.

Thus, field trials demonstrate that *Mimulus guttatus* seeds can be transported by wind and deer as well as by water. This diversity of dispersal mechanisms is surely important to a species that frequently establishes new populations and often loses old ones to competition, floods, shading or other agents that destroy their habitats, *i.e.*, *M. guttatus* is a typical fugitive species in the sense of Hutchinson (1951), White (1979) and Waser *et al.* (1982).

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TABLE 1.—Wind dispersal of *Mimulus guttatus* seeds in Red Butte Canyon Natural area, Salt Lake County, Utah. Values are of total *M. guttatus* germination per flat

Distance in meters	1981 series			1982 series				1983 series	
	A	B	C	A	B	C	D	A	B
0.25	—	—	—	125	52	1022	351	245	98
0.50	32	1	2	93	35	392	408	41	14
0.75	—	—	—	6	8	183	461	1	12
1.00	0	1	0	9	7	89	203	3	10
1.25	—	—	—	9	3	66	82	0	3
1.50	—	—	—	6	1	41	32	0	1
1.75	—	—	—	1	4	15	31	0	1
2.00	—	—	—	3	1	5	9	0	2
2.25	—	—	—	9	1	2	5	0	2
2.50	0	0	0	8	4	0	1	0	1
Total	32	2	2	269	116	1815	1583	290	144

Note—In the 1981 series there was no germination at 5 m, 10 m, 25 m, 50 m or 100 m, the other distances tested. In the 1983 series there was no germination at any of the .25 m intervals up to the 10 m tested except 1 in B at 4.5 m and 1 each in A and B at 4.75 m. Therefore, the grand total = 4256

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