Notes

Northwest Science Notes contains papers that are less than four pages long. There is no specific format or content required for articles, but all papers will be peer-reviewed and must be scientifically credible. Papers cover a wide range of topics and material of interest to our readers. The following inaugural article by Thomas N. Kaye is a good example of the kind of paper appropriate for Notes. Authors may contact the Editor about the suitability of manuscripts for this section.

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Obligate Insect Pollination of a Rare Plant, *Lupinus sulphureus* ssp. *kincaidii*

Fender's blue butterfly (*Icaricia icarioides* ssp. *fenderi* Macy) was presumed extinct until its rediscovery in 1989 near Corvallis, Oregon (Chambers 1990, Hammond 1991). This remarkable find has focused attention on the biology of its host plant, *Lupinus sulphureus* ssp. *kincaidii* [Smith] Phillips (Kincaid's lupine). Butterfly oviposition and larval development in the wild occur primarily on this rare plant. Occasionally, butterfly populations are also associated with *L. arbustus* Dougl. (spur lupine) and *L. albicaulis* Dougl. (sickle-keeled lupine), but only when *L. sulphureus* ssp. *kincaidii* is also present (Hammond and Wilson, 1993). Populations of *L. sulphureus* ssp. *kincaidii* are primarily restricted to grassland remnants in the Willamette Valley. Both the butterfly and the lupine are proposed for threatened or endangered species status by the U.S. Fish and Wildlife Service (Oregon Natural Heritage Program 1998). To develop conservation strategies for both organisms, research on the restoration of native prairie remnants and the biology of the lupine and the butterfly is underway (Schultz 1997, 1998; Wilson et al. 1997).

Excavations of caudices and root-systems suggest that *Lupinus sulphureus* ssp. *kincaidii*, a perennial, may spread vegetatively over limited distances (M.V. Wilson, pers. comm.), but sexual reproduction is necessary for population expansion and colonization of new sites. Any limit to seed production may restrict lupine population growth and, in turn, butterfly population success. If this lupine does not actively self-pollinate and self-fertilize, pollinating insects will be crucial for seed production. Also, seed production and dispersal may be limited by seed predators. The objective of this study was to determine if *L. sulphureus* ssp. *kincaidii* flowers set seed in the absence of insect pollinators and, secondarily, ascertain if seeds are killed by insects before seed dispersal.

Inspection of flowers (Kaye, personal observation) revealed a pump (or piston) arrangement for cross-pollination (as described by Knuth [1908]), in which a string of pollen is pushed through the tip of the keel by the stigma when the pistil comes under pressure during an insect visit. In this system, which is common in lupines, the stigma is protected from automatic self-pollination by a peristigmatic ring of hairs and possibly by protandry (Juncosa and Webster 1989). Most lupine flowers do not produce nectar, and

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insect visitors, normally bees, gather pollen (Knuth 1908). Flowers mature sequentially from the bottom to the top of each inflorescence, passing first through male then female phases. Lupine pollinators (such as bumblebees) often forage from bottom to top within an inflorescence (Haynes and Messler 1984). This system promotes outcrossing because insects laden with pollen from another plant contact female-phase flowers before traveling up to male-phase flowers where they collect pollen and depart.

The study population of approximately 75 plants was located in 1.5 ha of native prairie on a south-facing slope at Oregon State University's McDonald Forest, near Corvallis, Oregon. On 15 May 1990, single unexpanded racemes (all flowers in bud) were tagged on 30 individuals (plants typically produced 5-20 racemes). Fifteen racemes were selected at random and covered with a nylon mesh (0.5 mm) bag to exclude pollinators. The remaining 15 racemes were not covered and served as controls. The plants were checked biweekly during the course of the blooming season to observe pollinators (2-hr survey periods) and ensure that the racemes elongated normally in the bags. All marked racemes were gathered on 24 July 1990 when fruits were mature. The number of flowers and fruits per raceme were counted and fruits were inspected to determine ovule number and production of mature and damaged seed. Flower number was obtained from the number of pedicel scars on each raceme. Mean ovule and seed production per raceme were used for calculating mean and standard error (SE) for each treatment (n=15).

Lupinus sulphureus ssp. *kincaidii* did not set fruits or viable seed in the absence of pollinators. On average, open pollinated racemes displayed 75 flowers (range: 58-123, n=15), and bagged inflorescences had 73.2 flowers (range:44-99, n=15); there was no significant effect of bagging on flower production (t=-0.288, P=0.776). The average fruit on open pollinated racemes contained 4.5 ovules (range: 4-5). Fruit-set on open-pollinated (control) racemes was 4.3% (± 0.6% SE) and seed-set per fruit was 30.6% (± 2.5% SE). No fruits or seeds were produced on bagged inflorescences, apparently because mechanical or temporal barriers prevented self-pollination; genetic self-incompatibility is unknown in *Lupinus* (Arroyo 1981). Ovule predation (possibly by short-nosed weevil larvae) averaged only 6.1% (± 2.4% SE) per fruit in unbagged inflorescences. Overall, 46.7% of fruits were occupied by insect larvae. Therefore, predispersal ovule predation may not limit seed production or seedling recruitment at this site. At other sites, however, up to 85% of fruits can be damaged by insect larvae (K. Kuykendall, Oregon State University, pers. comm.).

The pump arrangement for pollination and the lack of fruit or seed formation in bagged racemes is strong evidence that insect pollinators are required for seed production in *Lupinus sulphureus* ssp. *kincaidii*. Studies of the annual *L. nanus,* a facultatively autogamous species, have also shown that excluding pollinators can reduce reproductive success (Karoly 1992). The present report of obligate insect pollination of *L. sulphureus* ssp. *kincaidii* does not explore whether or not this perennial is self-compatible. No gametic self-incompatibility system was found in *L. nanus* ssp. *latifolius* (Juncosa and Webster 1989), however, and selfing rates vary widely among species and populations of several annual lupines (Horovitz and Harding 1972; Harding, Mankinen, and Elliott 1974; Helenurm and Schaal 1996). Instead, floral anatomy and pollinator behavior and availability appear to play pivotal roles in promoting outcrossing in lupines (Juncosa and Webster 1989, Karoly 1992). This report documented the importance of insects as pollinators at only one site and in one year, and it is clear that the importance of insects can differ from site to site, at least in annual lupines (Karoly 1992). A genetic study (Liston et al. 1995) of *L. sulphureus* ssp. *kincaidii*, however, documented low inbreeding coefficients at several populations of this taxon, which is indicative of an outcrossed breeding system.

Conservation of *Icaricia icarioides* ssp. *fenderi* will require maintenance of viable lupine populations, which may require protection of populations of insect pollinators. The only insect observed visiting the lupine flowers at the study site was a single bumblebee (*Bombus* sp.). Average seed production was 1.3% of available ovules per raceme, despite a locally wet spring and apparently plentiful soil moisture, which is well below values reported for other lupine species (Wiens 1984). The reasons for this are not clear. Cool misty days, common in 1990 while flowers were at anthesis, may have impeded pollinator activity. Climate data from Corvallis, Oregon (Oregon Climate Service, w w.ocs.orst.edu/) show that June of 1990 had above average precipitation and

below average maximum temperatures. Alternatively, native pollinators may be infrequent at the study site. If bumblebees or other insects that work the inflorescences from bottom to top are the typical pollinators for this species at most populations of *Lupinus sulphureus* ssp. *kincaidii*, then outcrossing is likely to be the dominant breeding system in this perennial lupine.

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