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— Short Note on Methodology —

POLLINATOR EXCLUSION DEVICES PERMITTING EASY ACCESS TO FLOWERS OF SMALL HERBACEOUS PLANTS

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Abstract—Pollinator exclusion bags for small herbaceous plants are much more convenient to apply and remove if their bottom edge is made in the form of a cloth tunnel loaded with sand to conform to the terrain. Damage and inadvertent selfing of flowers are minimized.

Many experiments in pollination ecology require that pollinators be excluded from flowers. "Pollination bags" are usually used for this: an open-ended bag of fabric is slid over a shoot and closed by pulling a drawstring or gathering the fabric and using something like a wire tie to keep it snug around the stem. Kearns & Inouye (1993, pp. 13-19) discuss this method and some of its problems. There is an acknowledged trade-off involving the mesh size of the fabric: more open weaves may not exclude small visitors such as thrips, but less permeable fabrics tend to cause overheating or condensation. Nevertheless, this technique is widely used. Our lab has adopted polyolefin soil sample bags (Hubco, Inc.; Hutchinson, Kansas, USA) as our standard choice in the cool, dry habitats where we mostly work: they are available in several sizes, have integral drawstrings, shed rain, and retain good breathability while excluding the tiniest insects.

One problem they do not solve is the physical disturbance and wasted time of securing and removing the bags. In applications where a bag is placed over buds once and left there until fruits are set, the method of securing the bag is not very important. In certain experiments, however, one needs to open and close the bags frequently to conduct pollinations, make observations, sample nectar, etc. These operations are especially frustrating in plants whose flowers are borne on short pedicels above a rosette of leaves. To reduce handling time and the attendant damage to flower parts, we have designed a speedier variant that has proved its worth in field trials with small herbs, including violets and gentians.

Our inspiration comes from the stiff acetate cones used by Hocking (1968) and Kevan (1972). Cones are elegant because they nest for transport, and they can be simply set in place over the entire plant and lifted away as needed for operations on the flowers. Unfortunately, they are hard to seal at the base, and they also need to be secured to firm supports to prevent their being dislodged by wind. Detaching and reattaching the supports is time-consuming. Our redesign uses a flexible fabric bag, but the open end is not intended to be gathered around the stem. Instead, it is fitted with a wide bottom hem (similar to a wide drawstring tunnel) that is filled with sand or fine gravel. The sandbag-style bottom edge of the bag has a double function: its mass anchors the bag in place, and its flexibility provides for automatic sealing by conforming to irregular contours at the ground surface (Fig 1). It can be lifted off in an instant and replaced almost as fast, with virtually no disturbance to the plant.

FIG. 1. A Bioquip Products entomological net converted to a sandbag-style exclusion bag and deployed with a wire support over a plant of *Viola praemorsa*

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Suitable bags may be easily sewn from scratch, or existing bags can be given a wide hem to serve as the tunnel for sand. A funnel is essential for easy filling. Tunnels can be sewn shut after filling, or fitted with Velcro closures if they will be emptied and refilled. Bags can be stuffed compactly into a backpack for transport in the field, although they are heavy if filled. In many situations, bags could be transported empty and filled with indigenous material at the study site.

If the fabric is stiff and if rain is not a consideration, these bags may be sufficiently self-supporting to use without further modification. In most cases, however, it will be better to provide support. Two pieces of stiff wire, each bent into the shape of a round-topped croquet hoop, and stuck into the ground at right angles serve well; other shapes can also be used (Fig. 1). Such hoops act as stand-offs that prevent the bag from contacting the flowers or collapsing when wet.

Our most extensive use of this design used commercial insect nets (Bioquip Products, Rancho Dominguez, California, USA), the construction of which includes a suitably sized tunnel intended to receive the round wire frame of the net. Although more expensive than hand-sewn bags, these nets greatly speeded our operations. They are sturdy and they sealed well. The only drawback we encountered was that nets on very late-season gentians near the Rocky Mountain Biological Laboratory were broached by rodents seeking to eat developing fruits. Vole populations were near outbreak levels at this time; such raids might not be a risk in other sites or years.

Peter Kevan (pers. comm.) suggests correctly that the sandbag-hem design could be combined with variation in the mesh size of the exclusion fabric. Such designs allow the selective exclusion of particular pollen vectors: animals versus wind (e.g., Meléndez-Ramírez 2004), honeybees versus smaller insects (e.g., Mazer and Meade 1998); hummingbirds versus insects (e.g., Fenster and Dudash 2001). To some extent, such use entails an intrinsic tradeoff in design features: maintaining consistently large openings is best served by a stiff mesh, such as steel "hardware cloth" or poultry wire, but the sandbag hem works best with a limp fabric bag that allows maximum conformability to irregular contours. In practice, this tradeoff can be circumvented. First, irregular substrates can be leveled off to allow a better ground seal. Second, a wider hem, loosely filled, can allow conformability even when the bag is a stiff cage. Third, because large mesh is usually intended to *permit* access by smaller vectors, small gaps at ground level will not compromise the experiment.

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