POLLEN TRANSFER EFFICIENCY OF *APOCYNUM CANNABINUM* (APOCYNACEAE): A COMPARATIVE PERSPECTIVE

by Tatyana Livshultz, Sonja Hochleitner, Elizabeth Lakata

In the animal kingdom, extreme forms produce extraordinary performances; think of the lithe form of a cheetah, the fastest land animal, or the massive wingspan of an albatross, capable of soaring around the globe in less than 2 months. Plants, like animals, also perform to survive, grow, and reproduce, and like animals, plants with extreme forms can perform extraordinary feats. For example, the extremely low surface to volume ratio of a cactus allows it to live in arid climates where most other plants cannot survive.

One of the most important performances of a flowering plant's life is pollination, the movement of the male pollen from the anthers of one flower to the female stigma of another flower. This is the first essential step in a sequence of events that will allow the source flower to father the seeds produced by the recipient flower and pass its genes on to the next generation. For flowering plants that rely on animals for pollination, this performance is a *pas de deux*, and the animal partner is not particularly concerned with the execution since, from the animal's perspective, it is just collecting nectar and pollen for food. Not surprisingly, the process of animal mediated pollination is very inefficient. On average about 1% of pollen removed from flowers by animals is delivered to a stigma of the same species; the other 99% is lost in transit or eaten.

Two groups of plants: orchids (Orchidaceae) and milkweeds (Apocynaceae) have evolved extreme floral forms that turn their clumsy animal partners into pollen-delivering virtuosos: pollen transfer efficiency of these flowers averages about 25%, a 1 in 4 chance of successful delivery rather than 1 in 100. How do orchids and milkweeds achieve such extreme efficiency?

The flowers of dogbane don't look too unusual, but they command extraordinary performances from their pollinators, achieving unusually efficient pollen transfer. *Photo: Tatyana Livshultz*

Most flowers disperse their pollen as thousands or millions of microscopic grains. In contrast, individual orchid and milkweed pollen grains are packaged into a few much larger pollinia that are firmly attached to visiting animals by specialized structures called "translators", reducing the likelihood of loss in transit.

But besides pollinia, orchids and milkweeds have many other modifications of their flowers that may elevate pollen transfer efficiency. How much of the overall performance gain is contributed by pollinia and how much by other components of floral morphology?

To understand the contributions of floral structures other than pollinia, we measured pollen transfer efficiency in dogbane (*Apocynum cannabinum*), a milkweed relative in the same plant family (Apocynaceae), that shares many floral traits with milkweeds, but disperses its pollen in tetrads of four pollen grains fused together rather than pollinia of hundreds or thousands of pollen grains fused together. We predicted that, based on its morphology, the pollination mechanism of a dogbane flower should be less efficient than that of a typical milkweed but more efficient than an "average" flower that disperses its pollen as solitary grains.

We sampled dogbane flowers from natural populations and quantified the amount of pollen removed and deposited in each flower, calculating the pollen transfer efficiency.

We showed that the performance of dogbane flowers is less efficient than that of milkweeds, on average about 8% of removed pollen grains are delivered to stigmas of dogbane flowers, versus about 25% on average in milkweed flowers. On the other hand, dogbane flowers are more than twice as efficient as the currently-known most efficient flower that disperses its pollen as solitary grains, around 3.5%.

Our results suggest that other modifications of floral morphology, not just pollinia, can increase pollen transfer efficiency, but that pollinia increase efficiency even more.

Our next step is to study pollen transfer efficiency in other Apocynaceae flowers, especially ones that disperse their pollen as solitary grains, not tetrads like dogbane, to see if we can further dissect the contribution of individual structures to overall performance.

A bigger question is why only a few lineages of plants have evolved the extreme floral forms and extraordinary efficiencies we see in milkweeds and orchids? Perhaps, under most circumstances, such extreme forms decrease the performance that matters most in the game of evolution, passing genes to the next generation, despite improving the efficiency of one contributing component, pollen transfer.