Pollination

Flexible style that encourages outcrossing

Despite the convenience of self-pollination (selfing) in flowering plants, the detrimental effects of inbreeding that follow repeated selfing have promoted strong natural selection for mating systems that ensure successful cross-fertilization (outcrossing). Here we describe a mechanism deployed by some tropical ginger flowers to avoid self-pollination — the flower moves its stigma (style), which normally acts as the pollen receptor, out of the way while its anther is releasing pollen. This cunning evasion adds to the diversity of pollination strategies that have contributed to the evolutionary success of flowering plants.

Alpinia is an Asian genus in the ginger family (Zingiberaceae) containing more than 250 species. These are perennials with the flower parts behaving in nine species of Alpinia, for only a day. We have monitored how the flower parts behave in nine species of Alpinia, both native and introduced, in a tropical seasonal rainforest in Xishuangbanna, Yunnan, in southwest China.

Each species of Alpinia has two phenotypes that coexist in all populations and which differ in the movement of the flower stigma (the phenotypes are termed cataflexistyled and hyperflexistyled flowers, depending on the direction of stigma movement during flowering). When cataflexistyled flowers are fully open (06:00–06:30), the stigma is held above the open (dehisced) anther from which pollen is being released (Fig. 1a). At the same time of day, the receptive stigma of hyperflexistyled flowers is curved downwards, below the indehiscent anther from which pollen has not yet been shed (Fig. 1b). Flowers of both types retain these respective stigma positions until about midday, when the stigma of the hyperflexistyle flower no longer directs all stigmas of the same phenotype have moved out of the receptive position (Fig. 2). It is likely that successful pollination only occurs between the two different forms, with the two phenotypes being associated with two genotypes (for example, in a natural population of A. kwangsiensis the ratio of individuals of the two phenotypes is about unity: 86:78; \( \chi^2 = 0.39, P = 0.5 \)).

We artificially manipulated different pollination combinations within and between phenotypes of A. kwangsiensis in the field. Our results indicate that fruit set resulting from cross-pollination between the two phenotypes is not significantly different (\( F = 1.393, d.f. = 1, P = 0.242 \)) and that for the same treatments (self-pollination, cross-pollination, open pollination or controls), fruit-set rates did not differ significantly between the two phenotypes (\( F = 2.251, d.f. = 4, P = 0.072 \)), indicating self-compatibility of the species. However, there was a significant difference between the treatments within the same phenotype (\( F = 69.163, d.f. = 6, P < 0.001 \)); in both forms and during both gender phases, cross-pollination had a significantly higher fruit set than self-pollination, indicative of an inbreeding depression effect.

The floral strategy described here not only prevents self-pollination in a flower and within the same individual, but also among individuals of the same phenotype. It decreases inbreeding and promotes outcrossing in the plant by temporally and spatially separating the presentation of pollen and receptive stigmas through active floral movement. This mechanism, which we call flexistyly, differs from other passive out-breeding devices, such as dichogamy, herkogamy, enantioisty and heterostyly, in that it combines some features of all of these mechanisms with the unique movement of floral parts.

We observed flexistyly in all nine Alpinia species we studied. In a molecular analysis of the phylogenetic relationships within the Zingiberaceae family (W. J. K. et al., unpublished data), these nine species are distributed in three separate clades in the Alpinae, indicating that flexistyly either evolved independently several times in this Alpinae group or that it is widespread (though as yet unrecorded) in many taxa in the group (in Amomum, for example).