

Pollination ecology and floral visitor spectrum of turtlehead (*Chelone glabra* L.;
Plantaginaceae)

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The majority of flowering plants engage in pollination mutualisms with animals in order to sexually reproduce, exchanging food rewards such as nectar and pollen for the service of pollen transfer between flowers. However, many animals that feed at flowers do not pollinate, and are thus better thought of as antagonists rather than mutualists. Outcomes of these interactions among plants and animals are strongly dependent on abundance and diversity of flower visitors, as well as timing and quality of reward presentation. Despite the importance of plants to structure and function of ecosystems, the pollination ecology of many flowering plants is poorly known.

In this study we investigated the mating system, floral visitors and pollen limitation of turtlehead (*Chelone glabra* L.), an eastern North America wetland herb. We found that the plant reproduces sexually by both self-pollination and outcrossing, but requires pollinator visitation to set seed. We show that turtlehead flowers are protandrous, presenting separate male and female sex phases, and that nectar and pollen rewards available to pollinators vary greatly between phases. Half-black bumble bee (*Bombus vagans*), the most common flower visitor, made contact with anthers and stigmas while at flowers and transported pollen between them, suggesting it was an effective pollinator. The solitary bee *Hylaeus annulatus* also

made frequent visits to flowers, but contributed little to pollination due to morphological mismatch and because it avoided male-phase flowers. Despite high bee visitation rates, flowers were pollen limited for seed production, possibly indicating a negative effect of non-pollinating flower visitors on plant reproductive success. Our work demonstrates how interactions with mutualist and antagonist flower visitors combine to influence plant reproduction, and we project that outcomes of these processes have consequences for population dynamics of this wetland-dominant herb.



A bumble bee worker collects nectar and pollen from a turtlehead flower.