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THE POLLINATION OF *Illicium parviflorum* (ILLICIACEAE)

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Abstract: *Illicium parviflorum* is a small evergreen shrub restricted to the drainage of the upper St. Johns River, Florida. The flowers are pollinated by a wide variety of small insects, particularly Diptera, that emerge from the litter and other habitats. Asexual reproduction is the chief means of reproduction as the plants are self-incompatible, and the fruit set is low.

Key Words: *Illicium*; pollination; incompatibility; Diptera.

INTRODUCTION

Illicium, a group of shrubs and small trees, is the sole genus in the Illiciaceae (Cronquist, 1981) with 37 species in southeastern Asia and 5 in North America and in the West Indies (Smith, 1947). The genus is sharply divided into two sections (*Badiana* and *Cymbostemon*) by perianth characters (Smith, 1947) though the fruits are similar (Fig. 1).

Illicium floridanum Ellis is a relictual species growing along the northern coast of the Gulf of Mexico from Louisiana to the panhandle of Florida. The flowers of *I. floridanum* (section *Badiana*; Fig. 1) are pollinated by myriad insects that emerge from the leaf litter and streams during the spring (Thien et al., 1983). As the insects walk and feed on the usually upright flowers, pollen is deposited on their legs and on other regions of the body. This study determines the mode of pollination of *I. parviflorum* Michx. ex Vent. (section *Cymbostemon*; Fig. 1) to compare it with *I. floridanum.*

Illicium parviflorum is a rare, evergreen, understory shrub or small tree occurring only in eastern Florida along the upper St. Johns River (Smith, 1947). Other extant members of the family display a similar relictual pattern of distribution (Smith, 1947); however, the fossil record of the family indicates a widespread geographical range in the boreal-tropical regions of Europe and eastern North America (Wolfe, 1975; Tiffney and Barghoorn, 1979).

METHODS

The study area was located at Alexander Springs, Florida, within Ocala National Forest. *Illicium parviflorum* and *Persea palustris* are common understory plants in peaty soils around the spring and along spring-fed streams. The forest at Alexander Springs contains a curious mixture of sub-tropical and temperate trees (Mohlenbrock, 1976) with a canopy of 25–35 m. The dominant forest trees are

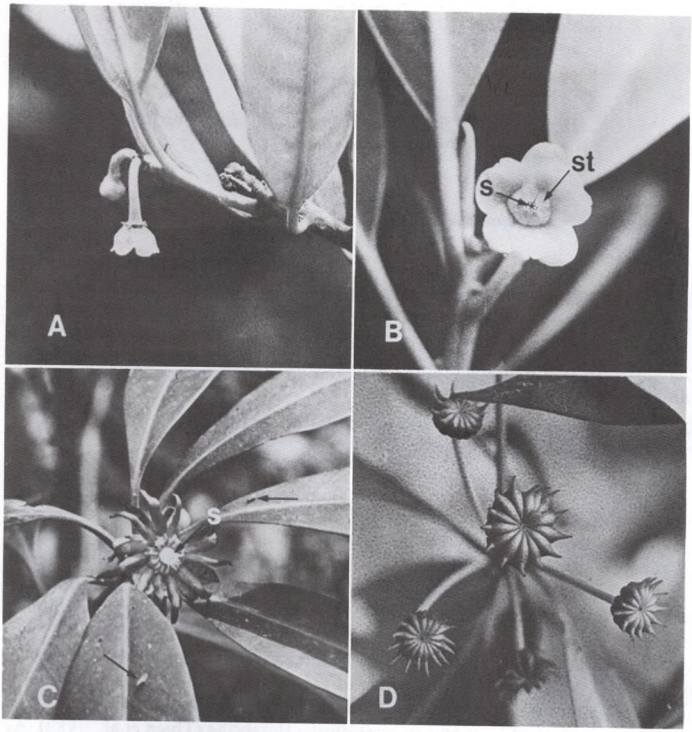

FIG. 1. Reproductive structures of *Illicium parviflorum* and *I. floridanum*. A. Pale yellow, pendant, male phase flower and bud of *I. parviflorum* (1×). B. Face view of A (2×). S = stigmas; St = stamens. C. Flower (red) of *I. floridanum*. Two unlabeled arrows show dipterans resting on leaves (½×). D. Fruits or circle of swollen carpels of *I. floridanum* (¾×).

Sabal palmetto, Magnolia grandiflora, Liquidambar styraciflua, Nyssa biflora, Fraxinus caroliniana, and *Carya aquatica* (Mohlenbrock, 1976).

In the study site, individuals of *I. parviflorum* were ranked into height classes of 50 cm within 5 × 10 m plots. In addition, flowering and fruiting times were noted. Insects on flowers were observed during day and night hours and the movements of the flower parts photographed. Insects captured on flowers were preserved in 70% alcohol for identification.

Several plants of *I. parviflorum* grow on the Tulane University campus. These individuals were planted adjacent to one another and form a hedge about 25 years old. Insect behavior, flower movements, and fruit set were also monitored in this naturalized population.

Voucher specimens of flowering and fruiting branches of *I. parviflorum* from both the natural and naturalized populations are deposited in the Herbarium of

Tulane University. The United States Department of Agriculture, Insect Identification and Beneficial Insect Introduction Institute provided names for the insects. Insect vouchers are deposited in the Department of Biology, Tulane University.

RESULTS

The average number of plants by size class in 5 × 10 m plots is as follows: 24 in 50 to 100 cm; 18 in 100–150 cm; 11 in 150–200 cm; 3 in 200–250 cm; 4 in 250–300 cm; 2 in 350–400 cm; 1 in 450–500 cm; 1 in 500–550 cm; and 1 in 700–750 cm. Few individuals smaller than 150 cm in height produce flowers; thus seeds are produced mainly by the large individuals. This pattern was also observed in *I. floridanum* (Thien et al., 1983). The plants may produce a large number of flowers and large individuals (250–500 cm tall) may yield 200 flowers per day.

The flowering season of *I. parviflorum* extends from late May until July. The protogynous, bisexual, light green-yellow flowers of *I. parviflorum* are pendant and produce a faint sweet odor. The individual flowers open at various times during the day and night and remain functional for 2–3 days. The perianth parts slowly and continuously unfold throughout the life of the flower; when unfolded, the perianth forms a small opening at the apex, giving the flower an "ericaceous" shape. The 10–13 stigmas (one on each carpel) are receptive at this stage and protrude through another opening formed by the tight fitting 6–7 stamens (Fig. 1). The tightly appressed glandular stamens form a funnel; they are the same color as the petals and dehisce introrsely via longitudinal slits. Pollen is shed after the first day and for the duration of anthesis. As noted, the apices of the anthers form a hole through which the stigmas protrude (Fig. 1), but upon dehiscence the anthers become appressed and no longer protrude through the opening, preventing self-pollination. In the pendant flowers pollen accumulates on the margins of the anther slits and falls through the opening formed by the tips of the anthers (functions like a hopper) upon the slightest movement of the flower or insect motion. This can be easily observed in darkness when a beam of light reflects from the falling grains. Observations indicate greatest insect activity on the flowers at dusk to several hours after sunset. The insects may remain on the flowers for long periods of time (30 min.) probing for small quantities of nectar produced at the base of the stamens. In the process pollen is showered upon the lower portion of the insect's body.

The stamens and perianth drop off after 2–3 days in 77% of the flowers; about 12% of the flowers function only one day. One to two weeks after the stamens dehisce the entire circle of unfertilized carpels drops via abscission of the pedicel. Fruit development takes 2–3 months to maturity. Such events as carpel drop and fruit development are similar to *I. floridanum* (Thien et al., 1983).

On the Tulane University campus 100 flowers were tagged and 5 produced mature fruits. A total of only 12 seeds developed when 50–65 seeds were possible had all carpels of the 5 flowers matured. Observations indicate a similar low fruit set in the Alexander Springs population.

The pollinators of *I. parviflorum* are a wide variety of small insects, particularly Diptera. *Clinodiplosis* spp., *Giardomyia* spp. and *Lestodiplosis* sp. in the family Cecidomyiidae are quite common; *Threticus* sp. (Psychodidae), *Forcipomyia fuliginosa* (Ceratopogonidae), undetermined Chironomidae, and several Orthocladiinae are less frequent pollinators. Other captured visitors included a homop-

teran, *Bothriocera datura* (Cixiidae); an orthopteran, *Cycloptilium* sp. (Gryllidae-Mogoplistinae); a thysanopteran in the Phlaeothripidae; two neuropterans, *Sisyra apicalis* (Sisyridae); and an unknown Coniopterygidae.

DISCUSSION

The mode of pollination in *I. parviflorum* and *I. floridanum* is similar although flower size, color, position, and structure are very different. In both species the pollinators are small insects that emerge from the litter and other habitats to mate and feed on nectar. In both pollination systems pollen is deposited on the lower portion of the insects, though in one by walking on relatively upright flowers (*I. floridanum*) and in the other by probing on pendant flowers (*I. parviflorum*). The population structure of the two species is very similar in that a high density of plants produces large quantities of flowers in the spring of the year.

Although the flowers of the species are very different in structure, both are adapted for pollination by small, delicate insects (Coleoptera are notably absent). Key features of this pollination mode are the small flower size, small quantity of pollen, limited quantities of nectar available at any given time, and plants bearing numerous flowers. Possibly the pendant, short-lived flowers of *I. parviflorum* are a response to greater rainfall; section *Cymbostemon* extends into more tropical areas than does section *Badiana* (Smith, 1947). Did the evolutionary development of the floral structures of these two species respond differently to the same mode of pollination? Is it possible the original pollinators of these two species have been lost? Study of the floral biology of the more tropical species (e.g., in Malaya) of the section *Cymbostemon* is needed to answer some of these questions.

In *I. floridanum* a gametophytic self-incompatibility mechanism has been described (Thien et al., 1983) which results in low fruit set. At Alexander Springs and in the naturalized population on Tulane University campus, *I. parviflorum* displays a similar low fruit set. It is difficult to quantify the role of self-incompatibility in *I. parviflorum* (although abscission of pollinated flowers and fruits indicates such a mechanism) because small rodents destroy most of the swollen fruits while still attached to the plants. This phenomenon was not observed in *I. floridanum* where only dispersed seeds on the ground were preyed upon by rodents. Low seed production is characteristic of both species of *Illicium* and root sprouting is now the chief means of reproduction.

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