Georgia Journal of Science

Volume 71 *No. 2 Scholarly Contributions from the Membership and Others*

Article 9

2013

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SPADIX FUNCTION IN THE JACK-IN-THE-PULPIT, *ARISAEMA TRIPHYLLUM*

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ABSTRACT

Aroids are perennial herbs characterized by inflorescences consisting of a finger-like spadix surrounded by a vase-like spathe. A prominent aroid in Georgia is the Jack-in-the-pulpit, *Arisaema triphyllum*. We assessed the role of the spadix in attracting insect visitors to *Arisaema triphyllum*. Two study sites near Dahlonega, Georgia, were chosen: one along an unnamed first-order stream and the other along third-order Cane Creek. Plants received either ablation of the distal appendix, removal of the spadix tip, or a sham ablation. Arthropod visitors were captured with a small sticky trap placed inside the spathe. Despite the treatment applied, the number of Diptera captured was not affected. In contrast, ablation reduced the number of Collembola captured to just 29 % of that of the other two treatments (interaction of taxon and treatment after square root transformation: $F_{10,480} = 2.761$, $P = 0.003$). Pollination in *A. triphyllum* has previously been attributed to fungus gnats (Diptera) and *Heterothrips arisaemae* (Thysanoptera). Our results suggest that Collembola, which do not fly, may play a role in pollination, perhaps within clustered plants in which long-distance travel is not necessary.

Key words: *Arisaema triphyllum*, Jack-in-the-pulpit, spadix, osmophore, aroid, Araceae, Collembola, springtail.

INTRODUCTION

Plants in the clade Araceae possess a characteristic inflorescence consisting of a vase-like, ensheathing modified leaf or spathe that surrounds a slender finger-like spadix. The spadix often consists of a proximal reproductive zone and a distal, sterile appendix. The distal appendix of many aroids releases volatiles that attract pollinators (1,2).

A conspicuous aroid in mesic temperate forests of North America is the Jack-in-the-pulpit, *Arisaema triphyllum* (L.) Schott (Figure 1). In this species, sex is determined by resource availability (3,4). For plants to reproduce as females, resource conditions must be optimal. The same plants may also exist as males or in a vegetative state if conditions are poor. Another peculiar characteristic of *A. triphyllum* is its prolonged anthesis. While many aroids

remain anthetic for just 1-2 d, anthesis in *A. triphyllum* lasts approximately 20 d (5). During this period, odor is released intermittently, and is correlated with insect visitation (5). In Jack-in-the-pulpits, it is not known if the odor is released by the spadix, spathe, or both.

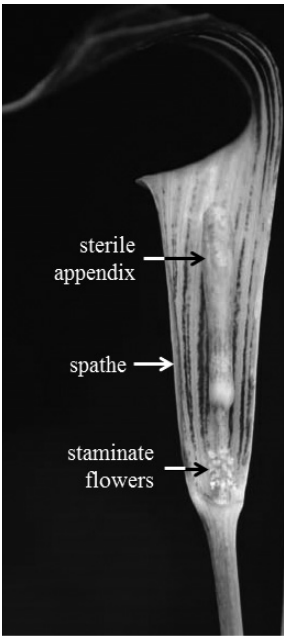

Figure 1. Typical inflorescence of a male Jack-in-the-pulpit composed of the finger-like spadix enclosed by a vase-shaped spathe. The spadix is composed of a distal sterile appendix and a proximal reproductive region. Photograph courtesy of Alan Galloway.

The spadices of Jack-in-the-pulpits do not generate heat during flowering, unlike aroid species with a brief anthesis (5). Heat generated by other aroids is thought to volatilize odorants that attract pollinators (1). Since *A. triphyllum* spadices do not generate heat, we sought to assess the importance of the spadix in attracting visitors.

MATERIALS & METHODS

The study was conducted throughout April and May in 2012. Two study areas were chosen along low-order streams in the north Georgia mountains near Dahlonega (Lumpkin County). Site 1 (34° 33' 02" N, 84° 00' 13" W, coordinates from Google Earth) was located along the floodplain of an unnamed first-order stream that was surrounded by dense herbal undergrowth. The ground vegetation was varied and temperate forest provided a moderately

closed canopy, yielding soil conditions we considered moist-to-wet, based on visual inspection. The second site (34° 31' 03" N, 84° 00' 13" W) was located along the floodplain of Cane Creek, a third-order stream. The soil there was drier than at Site 1 and the hardwood canopy was more open. Ground vegetation at Site 2 was less dense than that at Site 1.

Jack-in-the-pulpits were identified to the subspecies *Arisaema triphyllum triphyllum* according to the criteria of Huttleston (6). Only male plants were included in the study, as sex of plants is determined by resource availability and females were uncommon. Plants received one of three treatments, a full ablation of the sterile, distal appendix above the male region or one of two control procedures. One control procedure consisted of a sham ablation in which the tip of a small scissors was lightly drawn across the surface of the spadix just above the male region, leaving the spadix undamaged. The other entailed the removal of a few millimeters of tissue from the tip of the appendix (tip snip). Plants were assigned to treatments by an Excel® random number generator. Forty-one individuals received a full ablation of the spadix, 30 received a tip snip, and 31 received a sham ablation. Each treated plant had a 5 mm x 20 mm Agralan® (Swindon, United Kingdom) pot-plant sticky trap placed in the back side of the spathe chamber to collect visitors. Inflorescences were collected at senescence and arthropod visitors captured by the sticky traps were identified.

RESULTS

We captured 482 visitors from the 102 inflorescences harvested in the study. An average of 2.24 visitors/week was captured per inflorescence. The most abundant visitors captured were Collembola (springtails) and Diptera (flies) with mean capture rates of 1.76 and 0.33 captures/week/inflorescence. Other taxa (beetles, spiders, mites, and small unidentified immature insects) were trapped in very low numbers.

Experimental treatment had a significant effect on visitor capture, but that effect varied according to visitor taxon (Figure 2; two-way ANOVA, interaction of treatment and taxon after square root transformation: $F_{10,480} = 2.761$, $P = 0.003$). Despite the treatment applied, the number of Diptera captured was not affected. In contrast, ablation reduced the capture of springtails to just 29 % of that of the other two treatments.

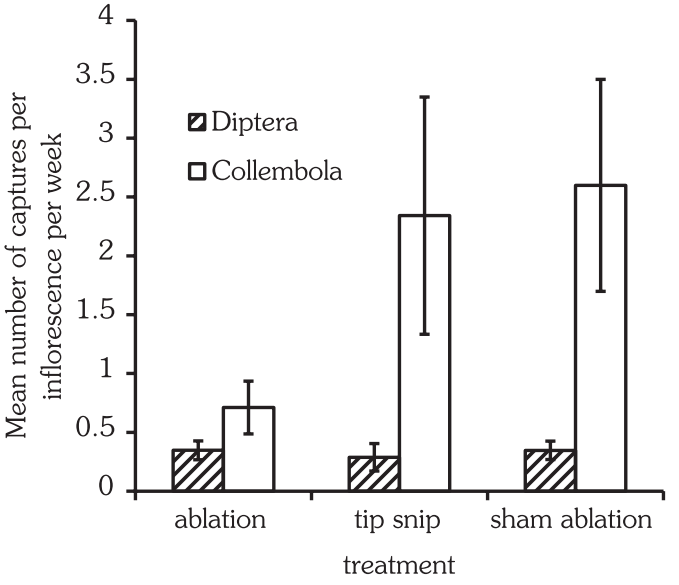

Figure 2. The effect of treatment on capture of the two most abundant visitors. Mean capture rate of Diptera was not affected by treatment. Collembola visitor activity was reduced in ablated plants (two-way ANOVA, interaction of treatment and taxon after square root transformation: $F_{10,480} = 2.761$, $P = 0.003$). Data are shown prior to square root transformation.

DISCUSSION

We found that spadix removal reduced Collembola visitation in *A. triphyllum*. Because the spadix is a key site of odor production in many aroids (1,2), and as its removal reduces vistation in a number of species (7,8,9), its importance in attracting visitors in *A. triphyllum* is not surprising. What was unexpected is that ablation reduced visitation of Collembola but not Diptera. Flies, bees, and beetles are the major pollinators of aroid species worldwide (10). Springtails, on the other hand, have been documented as visitors to *A. triphyllum* (5,11), but have not been considered likely pollinators as they cannot fly. Our findings indicate that springtails nevertheless warrant investigation as pollinators for Jack-in-the-pulpits. Although their limited mobility would make it hard for them to locate a distant odor source, springtails near an inflorescence might be encouraged by the odor to enter the spathe. Alternatively, if springtails enter the spathe simply by chance, the odor could encourage them to stay. If plants are tightly clustered, such undirected visitation could lead to successful pollen transfer. Rust (11) showed that pollination in *A. triphyllum* is enhanced when inflorescences are within 1 m of each other. Perhaps this short distance allows Collembola to serve as pollinators.

Another possibility is that springtails visit Jack-in-the-pulpits but play no role in pollination. The major pollinator of *A. triphyllum* has been proposed

to be the thrips *Heterothrips arisaemae* Hood (11). We trapped no thrips in our investigation. They may be absent in our study areas. Similarly, Pettit (12) found so few *H. arisaemae* visiting Jack-in-the-pulpits in Indiana that he concluded that *Heterothrips* plays only a minor role in pollination. However, working in Delaware, Rust (11) trapped so many *Heterothrips* he reached the opposite conclusion. If *Heterothrips* occurs sporadically in localized populations, and if Collembola do not pollinate Jack-in-the-pulpits, then dipterans may serve as pollinators where *Heterothrips* is absent. Diptera are common visitors of Jack-in-the-pulpit inflorescences (5,11,12,13). We found them to be reliable visitors even in absence of the distal spadix. Regardless of the role that dipterans might play, our findings suggest that Collembola warrant further study as potential pollinators of *A. triphyllum*.

ACKNOWLEDGEMENTS

We thank Cynthia Horne and the University of North Georgia Foundation - Dahlonega Inc. for the use of their property. We thank Alan Galloway for the use of his photograph in Figure 1.

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