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A TWO YEAR POPULATION ECOLOGY STUDY OF PUTTYROOT ORCHID (*APLECTRUM HYEMALE* (MUHL. EX WILLD.) TORR.) IN CENTRAL INDIANA

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ABSTRACT. *Aplectrum hyemale*, puttyroot orchid, is a terrestrial, winter perennial found in rich, mesic forests throughout the Midwest as well as in Hougham Woods Biological Field Station (HWBFS) near Franklin in Johnson County, Indiana. This orchid overwinters as a single basal leaf that may produce a flowering shoot in spring. The size of the *Aplectrum* population at HWBFS remained relatively stable with 305 to 311 individuals during this 2012-2013 study. Only 2.9% of the plants flowered and only one plant produced fruits in 2012. No flowering or fruiting occurred in 2013. Plants that produced flowering shoots had basal leaves that were larger than the vegetative plants. However, basal leaf size was not correlated with the number of flowers per plant. It appears that weather, including the unusually warm spring and summer drought in 2012 and the dry spring in 2013, affected phenology and reproduction of *Aplectrum*.

Keywords: *Aplectrum hyemale*, puttyroot, Adam-and-Eve orchid, mesic woods, phenology

INTRODUCTION

Puttyroot orchid, *Aplectrum hyemale*, is a winter perennial that is found throughout the eastern deciduous forest in mesic woods in much humus (Homoya 2012). The plant has a coefficient of conservatism of 7, indicating that it tolerates little disturbance (Rothrock 2004). The vegetative plant, a single basal leaf, emerges in fall, overwinters, and withers in May or June (Homoya 1993).

In contrast to many orchids, *Aplectrum* has relatively non-showy flowers that are somewhat camouflaged due to their dull coloration. In addition, the inflorescences emerge in May to June (Homoya 1993; Yatskievych 2000) as the basal leaves wither, making the plants somewhat inconspicuous to the casual observer. Similar to many orchids, *Aplectrum* plants often do not flower or fruit every year (Homoya 1993).

Aplectrum, which is found throughout Indiana especially in southern counties (Fig. 1), is reported for the first time in Johnson County. The plant received the common name of puttyroot from the mucilaginous substances in the corms that Native Americans and pioneers used as a paste to mend broken pottery (Correll 1950; Whiting & Catling 1986). It is also known as the Adam-and-Eve orchid because of the paired corms (Porcher & Rayner 2001).

In contrast to some of the large, showy orchids that have been extensively studied, there is a lack of information on *Aplectrum*, including fruiting phenology, frequency of flowering, and number and viability of seeds. The objectives of this research are: 1) to establish baseline information on the population size and location of individual *Aplectrum* plants at Hougham Woods Biological Field Station (HWBFS) in Johnson County, Indiana; 2) to determine the stability of population size and reproductive effort of *Aplectrum* at HWBFS by comparing the 2012 and 2013 data; 3) to assess whether leaf size is predictive of flowering; and 4) to explore possible impacts of weather variation on *Aplectrum* reproduction.

METHODS

Study site.—HWBFS is a 12 ha relatively flat, mesic forest (dominant canopy species include *Acer saccharum*, *Fagus grandifolia*, and *Quercus* spp.) that was donated to Franklin College in 2006. The forest is located in Johnson County west of Franklin, Indiana in the Tipton Till Plain Section of the Central Till Plain Natural Region (Homoya et al. 1985). Soils are often neutral silt and silty clay loams

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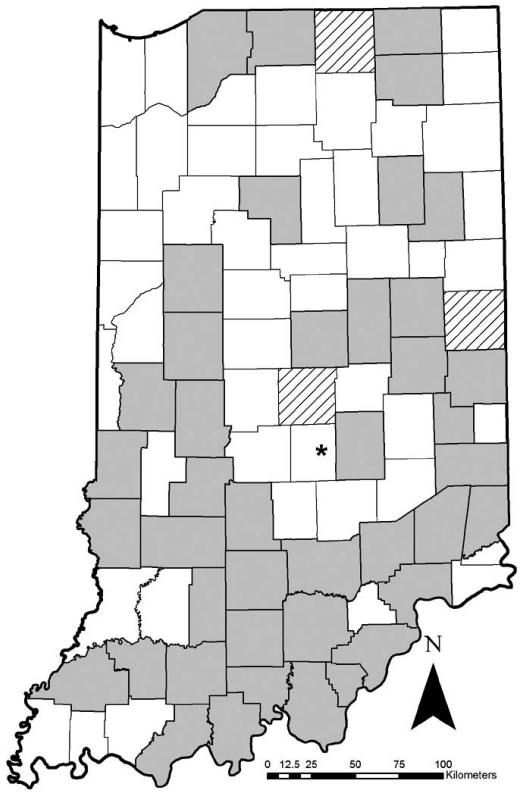

Figure 1.—Distribution of *Aplectrum hyemale* in Indiana. Shading indicates distribution from Homoya (1993), hashing indicates new records in Elkhart County (K. Yatskievych Pers. Comm.), Marion County (Homoya Pers. Comm.), and Randolph County (Ruch Pers. Comm.), and the star indicates the county record for Johnson County.

(Homoya et al. 1985). The forest is surrounded by agricultural fields and an industrial park, and has experienced past disturbances including selective cutting and wind throw. However, a few species with high coefficients of conservatism, such as *Fagus grandifolia* and *Epifagus virginiana* (Rothrock 2004), are found in the forest as well as one of Indiana's largest bur oaks.

Aplectrum plants in HWBFS were marked using GPS in February, 2012 and March, 2013. Basal leaves were measured for length and width at the largest dimensions. To determine flowering and fruiting data, the plants were monitored once per week in spring of 2012, every other week in summer of 2012, and every other week in spring and summer of 2013. Length and weight of capsules and seeds on the one fruiting plant were obtained in 2012. Number of seeds/capsule was determined by weighing a measurable amount (0.3–1.2 mg) of seeds then counting them using a compound microscope. The total number of seeds/capsule was calculated using a proportion (number of counted seeds/weight of counted seeds = x number of seeds/total weight of seeds). Photo documentation (Friesner Herbarium at Butler University) was used to report *Aplectrum hyemale* as a county record for Johnson County because removing a specimen would alter the population size and prevent that specimen from possibly producing fruits.

Minitab 16 Statistical Software was used to perform two-sample t-tests or Mann-Whitney test when sample sizes were low. Pearson correlation was used to determine if the following correlations were significant: leaf size and the number of flowers/plant and capsule length and the number of seeds/capsule. Weather data were obtained from the National Weather Service station in Franklin, Indiana.

Plant description.—*Aplectrum hyemale* produces green, overwintering basal leaves with white parallel veins that extend from the base to the tip of the leaves (Homoya 1993). The lower surface is often light green but may have a purple tint (Homoya 1993). *Aplectrum* typically produces two corms but may occasionally have three or four interconnected corms (Fernald 1950). Each year, the younger of the two corms increases in size while the older corm gradually shrinks and sends its nutrients to the younger corm. The basal leaf emerges from the younger corm (Stevens & Dill 1942). The corms produce a sticky paste that contain 13.43% water, 29.65% mucilage, 55.92% starch, and traces of albumin (Stevens & Dill 1942).

Flowering stalks typically have 8-15 relatively non-showy greenish flowers with white to purple-brown tips (Fig. 2) (Homoya 1993; Yatskievych 1999). The three-lobed flowers are small, averaging 1.5 cm in length (Homoya 1993). Fruiting capsules (Fig. 3), which range from 1.5 to 3.0 cm long (Yatskievych 1999; Weakley et al. 2012), contain thousands of dust-like seeds (Fig. 4) that are easily wind dispersed (Stevens & Dill 1942; Case 1964).

The crane-fly orchid, *Tipularia discolor* (Pursh) Nutt., is similar to *Aplectrum* in that it is also a winter perennial with a single basal

Figures 2–5.—*Aplectrum hyemale*. 2. Flowering stalk. 3. Fruit. 4. Seeds (10 μm long). 5. Two basal leaves emerging from one corm. (Photos 2, 3, 5 by Renee Knight; photo 4 by Sarah Mordan-McCombs.)

leaf. However, *Tipularia* leaves lack white veins and have a dark purple undersurface (Homoya 1993). Because *Tipularia* may be found in second growth forests and areas that have been cultivated, it is more common than *Aplectrum* where their ranges overlap (Homoya 1993). In addition, *Tipularia* flowers later than *Aplectrum*, July to August verses May to June, and often occupies drier sites (Homoya 1993). By growing in winter when tree leaves are absent, these orchids do not compete with most plants for light. *Aplectrum*, which is capable of photosynthesizing under light snow cover and can photosynthesize at temperatures as low as

Table 1.—*Aplectrum hyemale* size and reproduction in 2012 and 2013 in Hougham Woods Biological Field Station in Johnson County, Indiana. Standard deviations are in parentheses. Length and width measurements are in cm. NA = no data due to no flowering. *Not all plants that produced flowering stalks flowered.

Metrics	2012	2013
Number of basal leaves	305	311
Basal leaf length × width	11.55 (2.51) × 5.33 (1.85)	12.69 (3.23) × 4.42 (1.76)
Number of flowering shoots	27	0
Basal leaf length × width of plants with shoots	13.76 (2.61) × 7.05 (2.36)	NA
Number of flowering plants*	17 in May, 1 in August	0
Number of flowers/plant	7.2 (4.0)	NA
Basal leaf length × width of plants with flowers	14.21 (2.16) × 7.43 (1.99)	NA
Vegetative basal leaf length × width	11.33 (2.40) × 5.16 (1.71)	NA
Basal leaf length × width of plants with shoots without flowers	13.04 (3.43) × 6.29 (2.88)	NA
Number of capsules/plant	13	NA
Length of capsules	2.85 (0.40)	NA
Number of seeds/capsule	26,100 (6134)	NA
Length of seeds (μm)	10	NA
Seed weight (μg)	2.05 (0.55)	NA

4.5° C, reaches its maximum photosynthetic rate at 20-25° C (Adams 1970).

RESULTS

In 2012, 305 basal leaves in three subpopulations were found at HWBFS (Table 1). In 2013, 311 leaves were found in approximately the same locations except for a new group of 10 plants that was found in the northeastern portion of the forest. In 2013, the basal leaves were significantly longer ($p < 0.001$) and more narrow ($p < 0.001$) than in 2012.

In 2012, 27 flowering shoots emerged in April with 17 of these shoots attaining floral anthesis in early May (Table 1). For unknown reasons, the other flowering stalks withered without flowering. *Aplectrum* had an average of 7.2 flowers per plant and a range of 1-14 flowers per inflorescence.

None of the spring flowering plants produced fruits. However, one orchid that flowered on May 9 with 12 flowers, bloomed a second time on August 21 with 13 flowers, and had mature capsules by early November. This lone orchid, which was located approximately 20 m from other *Aplectrum* plants, was the only plant to produce fruits in 2012. The 13 capsules produced by this plant averaged 2.85 cm in length and contained an average of 26,100 seeds per capsule (Table 1). The dust-like seeds were 10 μm long and weighed 2.1μg. In 2013, no flowering or fruiting occurred in the *Aplectrum* population at HWBFS.

There was a significant increase ($p < 0.001$ for length, $p < 0.001$ for width) in the size of basal leaves between flowering and non-flowering plants; however, there was no statistical increase in leaf size between plants that produced flowering stalks but did not flower and those that flowered ($p = 0.18$ for length, $p = 0.16$ for width). Also, there was no correlation between basal leaf length or width and the number of flowers per plant ($R^2 = 0.03$ and 0.02, respectively), or between capsule length and number of seeds per capsule ($R^2 = 0.25$).

In 2012, spring temperatures in central Indiana were much higher than average (Table 2). This was followed by an extreme summer drought (Table 3) in which only 8.9 cm of precipitation was received from May 1 to August 1 in comparison to the typical 37.1 cm (NWS 2014). However, August and September were much wetter than usual with central Indiana receiving almost twice the average rainfall for those months (NWS 2014). Spring 2013 was drier than normal with precipitation approximately 25% lower than average from March through June (Table 3).

DISCUSSION

The *Aplectrum* population size remained relatively stable during this study although

Table 2.—Monthly average high temperatures in °C from 2011 to 2013 for Franklin, Indiana (NWS 2014). AVG = average.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AVG	2.2	4.4	10.6	17.2	22.8	27.8	29.4	28.9	25.6	18.9	11.7	3.9
2011	−0.6	6.1	11.7	19.4	22.8	28.3	32.8	30.0	22.8	19.4	13.9	7.2
2012	5.6	7.8	19.4	18.9	27.2	30.0	35.0	30.6	24.4	17.2	11.7	7.8
2013	4.4	5.0	7.2	18.3	25.0	28.9	28.9	29.4	27.2	19.4	10.0	4.4

there was a slight increase in 2013. It appears that many of the 2012 plants survived the drought and emerged in 2013. These leaves, which were significantly longer but more narrow than the 2012 leaves, were comparable to sizes often reported (13.2 × 4.4 cm) (Gleason & Cronquist 1991; Homoya 1993; Yatskievych 1999).

In 2012, inflorescences emerged in late April, which is slightly earlier than Homoya (1993) reports of early to mid-May. The HWBFS plants bloomed the first week of May with most of the plants flowering by May 2, which is consistent with Homoya (1993) of early May to mid-June. In HWBFS, the *Aplectrum* basal leaves had withered by early May. The record-setting warm temperatures in March, 2012 (NWS 2014) may have contributed to *Aplectrum* developing flowering shoots slightly early and becoming dormant earlier than normal, as well as negatively impacting fruiting.

Consistent with Homoya (1993), few *Aplectrum* plants flowered in this study. However, *Aplectrum* usually has 8-15 flowers/stalk (Homoya 1993; Yatskievych 2000) but peduncles with only one flower were found in this study and the average number of flowers/inflorescence was lower than the typical range. Also, plants that produced flowering shoots had larger basal leaves than plants without shoots, but there was no significant difference in basal leaf size between plants that flowered and those that produced a flowering stalk that withered before flowering. Therefore, it appears that plant vigor, as indicated by leaf size, is correlated with peduncle production, regardless if flowers are produced. Apparently, a number of factors influence flowering because no flowering occurred in 2013 when the leaves were longer than in 2012. Perhaps the dry spring in 2013 negatively impacted flowering because inflorescences typically are produced in May (Homoya 1993). This coupled with the drought in 2012, may have resulted in the absence of flowering in 2013.

In this study, there was no correlation between leaf size and the number of flowers/plant. Because of the small sample size due to limited flowering in 2012 and the lack of flowering in 2013, additional research is needed to confirm that the number of flowers/inflorescence is not correlated with leaf size.

In 2012, one orchid flowered in May and again in August. The second flowering occurred after the first rains following the summer drought. According to herbarium records and published literature, there are no accounts of *Aplectrum* flowering twice in one year or of flowering occurring late in summer. Interestingly, this is the only plant to produce capsules in 2012. Although capsule length has not been reported for Indiana, the capsules found in HWBFS were longer than the range lengths of 1.5-2.5 cm reported for several other states (Radford et al. 1968; Yatskievych 1999; Smith 2012). However, Weakley et al. (2012) does report a capsule range (1-3 cm) that reaches the length of fruits in this study. The

Table 3.—Cumulative monthly precipitation (cm) from 2011 to 2013 for Franklin, Indiana (NWS 2014). AVG = average.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AVG	6.6	12.6	21.4	32.4	46.7	58.5	69.6	78.5	86.5	94.8	104.5	113.9
2011	3.5	15.4	25.7	54.0	68.9	86.2	86.4	89.2	104.8	112.0	127.2	138.8
2012	9.1	11.8	19.8	26.1	33.2	33.3	35.0	42.5	57.6	63.7	65.3	70.1
2013	9.9	13.2	16.4	24.7	31.3	42.6	46.0	54.3	60.3	71.2	75.1	90.0

seeds, described as dust-like and numerous (Stevens & Dill 1942; Homoya 1993), were linear (Fig. 4), adhered to many surfaces, and clumped in water. Although the correlation between capsule size and number of seeds/capsule was not significant, there was a small sample size due to the low fruiting rate in 2012 and absence of fruiting in 2013.

Lauzer et al. (2007) determined that the seed coat in *Aplectrum* is resistant to water, but that water imbibition is needed for germination. They also determined that external mechanisms, including such factors as frost and soil microorganisms, are needed to scarify the seed coat (Lauzer et al. 2007). The new subpopulation discovered in 2013 may have been a result of sexual reproduction. However, it is unknown if these plants had been dormant for a year or more or had been overlooked previously.

In 2013, several plants with two distinct leaves and petioles were observed emerging from a single corm (Fig. 5). Although most botanists describe *Aplectrum* as having one basal leaf (Gleason & Cronquist 1991; Homoya 1993; Yatskievych 2000), in the Great Plains, *Aplectrum* occasionally has been observed with two leaves (McGregor et al. 1986). In addition, in this study, several plants with three corms were observed. This does not appear to be common because few floras indicate that more than two corms may form (Fernald 1950; Radford et al. 1968). Interestingly, the orchid that bloomed twice in 2012 had three corms. The mucilaginous substances in the corms absorb and store water, which is especially important in winter when water is often limited by the cold conditions (Stevens & Dill 1942) as well as during droughts.

In conclusion, the *Aplectrum* population at HWBFS was relatively stable for the two years of this study even with the abnormal weather in 2012 that impacted the phenology of the species. Only 2.9% of plants flowered in this study and the only plant that produced fruit did so at an unusual time in autumn. Flowering plants were found to have larger leaves than vegetative plants, but leaf size was not correlated with the number of flowers per plant. Also, plants that flowered did not have significantly larger leaves than plants that produced a flowering stalk that withered before flowering. The presence of more than 300 individuals of a relatively conservative species is one indication that HWBSF is a moderately high-quality forest. Because *Aplectrum* is a conserved species, it may be possible to help determine the quality of HWBFS by monitoring the *Aplectrum* population.

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