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Biology of a Weird Plant: The Voodoo Lily *(Sauromatum guttatum)*

Karen M. McDougal, Judy E. Moore, and Marsha E. Fanning
Lenoir-Rhyne University, Hickory NC 28603 USA
(mcdougalk@lr.edu;judy.moore@lr.edu;fanning@lr.edu)

Sauromatum guttatum, the Voodoo Lily, is an unusual arum lily which has considerable potential for classroom and research use. Aspects of voodoo lily biology include: 1. Vegetative and reproductive phases of the life cycle, with directions for culturing corms and planting fruits; 2. Biochemical background on thermogenic reactions which volatilize compounds and attract pollinators, and 3. Information on a Seek Thermal IR camera for measuring heat generated by the inflorescence. Classroom/lab topics in which the voodoo lily has been used include vegetative structure, inflorescence structure and function, and pollination biology.

Keywords: Voodoo lily, thermogenesis, Seek Thermal camera

Introduction

Biology of the Voodoo Lily, *Sauromatum guttatum* Schott

During the early 1990's Dr. Charles Wells, who taught genetics and plant anatomy and physiology at LR, attended a botany workshop and returned with a voodoo lily corm and instructions for growing it. He tended it for a few years, and then passed it on to Dr. Karen McDougal, who joined the faculty when he passed away after a courageous battle with colon cancer. She began cultivating the lilies outside and soon had numerous large and small corms to share with students. Eventually the strange arum lily found its way into the botany class, both for its vegetative structure (the corm) and for its unusual inflorescence (a spathe and spadix, as found in the familiar peace lily). Increased interest in the biology of this plant led us to investigate the author of the growing instructions and the source of the original corm. The initials on the original handout (B.J.D.M) and some references within it led us to a wealth of literature on Prof. Bastiaan J.D. Meeuse, a faculty member at the University of Washington for five decades who published extensively on arum lilies and thermogenesis. He died at age 83 in 1999, not long after the workshop which provided us with our voodoo lily corm.

The Life Cycle of the Voodoo Lily

Corms

The voodoo lily, *Sauromatum guttatum* Schott, is a member of the arum family (Araceae), to which the skunk cabbage, Jack-in-the-pulpit, and peace lily also belong. It is usually propagated from a firm, upright underground storage stem known as a corm (Figure 1a). Unlike a bulb, a corm is solid throughout, with a single bud and small membranous leaves on top. Voodoo lily corms can sit on a shelf or windowsill inside during cold weather; it is not necessary to add any soil or water to them during this time. When the days get longer the bud on the top of the corm begins to elongate. Sometime after this, roots will emerge from the top of the corm around the bud; they look something like spider legs.

Vegetative Growth

Once the roots begin to emerge, the corms may be planted, either in a pot of potting soil (equal parts garden soil, compost and ground peat moss) or in an outdoor container if all danger of frost is past. The bud should point upward, with a bit of it exposed. Frequent watering should keep the soil moist but not soggy. In a few days to a few weeks, depending on the temperature, the bud will begin to emerge from the soil and the roots may be seen curving around the corm into the soil. The roots grow quickly, so if transplanting is anticipated it should be done fairly soon. The leaves quickly begin to expand vertically and then outwardly; the petiole is green with purple spots and the leaf blades are solid green and dissected, similar to a giant Jack-in-the-Pulpit (Figures 1b-d). Some may grow as tall as three feet, although the size of the plant is somewhat proportional to the size of the original corm. The plants do well with morning sun and a good bit of moisture; a light application of fertilizer is helpful during the growing season. Support is often needed for the large heavy leaves.

In mid to late summer the leaves begin to yellow and die (Figure 1e). Leaves should be left as long as

possible in order to maximize the carbohydrates stored in the corm, but the corms should be removed from the soil before frost. Excess soil should be brushed off, the corms brought inside and placed on a shelf or in an open container to rest till spring. Medium to large corms will produce smaller "cormlets" on the upper surface of the corm; they should also be collected; a round scar may be seen where they were attached.

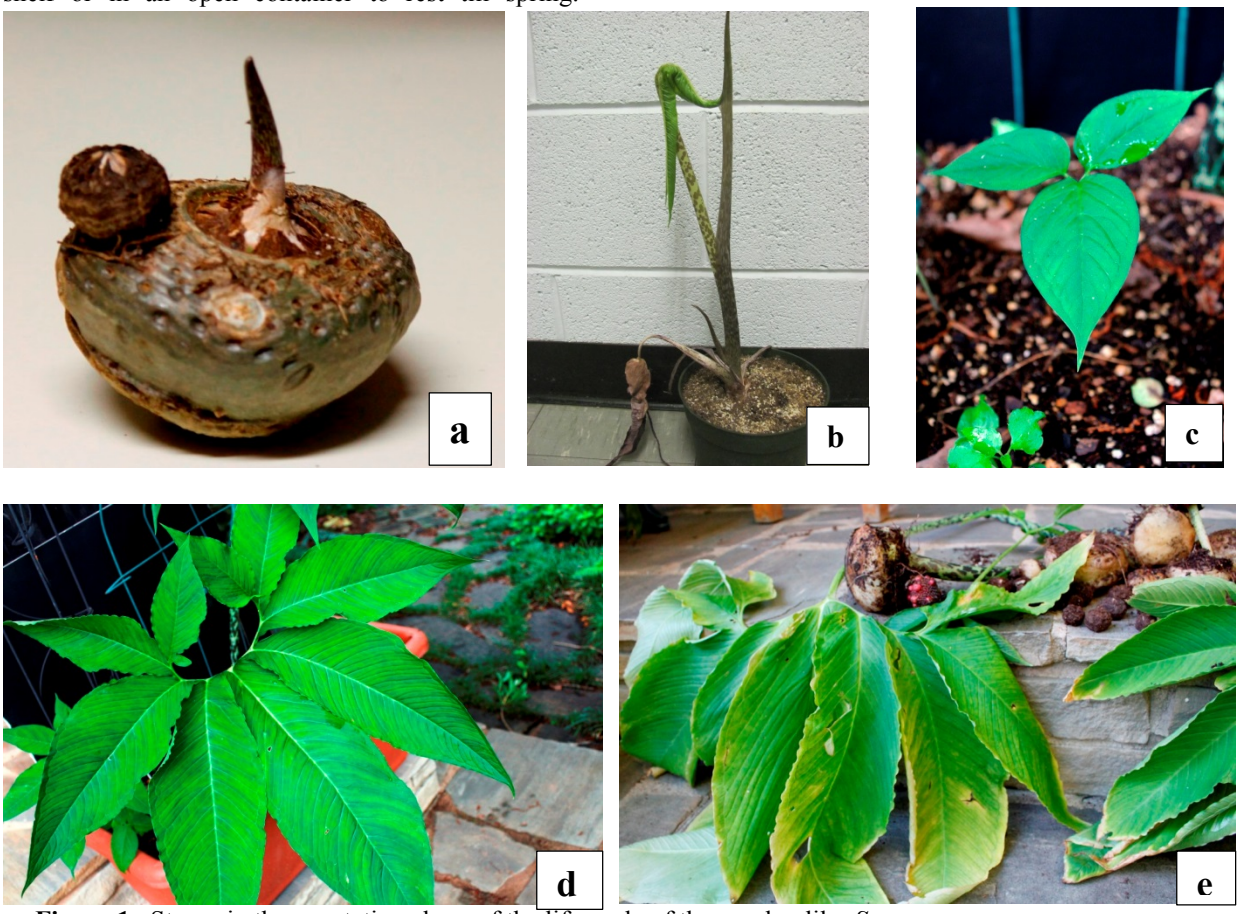

Figure 1. Stages in the vegetative phase of the life cycle of the voodoo lily, *Sauromatum guttatum*. a. Voodoo lily corm with attached cormlet; b. Petiole and expanding leaf (wilted inflorescence to left); c. expanded leaf of young plant; d. expanded leaf of mature plant; e. excavated corms and leaves at end of season.

Flowering and Fruiting

Small (quarter size) corms may continue to grow vegetatively for several years before they get large enough to produce a bloom (Figures 2a, b). Planting them outside (in North Carolina) in rich soil seems to enhance their growth. Once corms accumulate enough carbohydrates, they will bloom *before* the leaves emerge. Larger corms bloom first, usually in February to March (and often while the plants are still inside!), and then the leaves emerge after the inflorescences have faded. The flowers are "stinky" and attract pollinators. The bloom begins to open in the morning (artificial lights affect the sequence) and is usually collapsed by the second day (Figures 2c-f). The outer leafy spathe opens to reveal a fleshy spadix with a long fingerlike appendix which is called an osmophore, or smell producer, due to its ability to produce heat and volatilize ammonia-based compounds (Meeuse, pers. comm.). On the spadix below the appendix there are male flowers at the top, then club-shaped organs and female flowers at the base. Different portions of the spadix produce heat at different times, with the male and female flowers maturing separately so that out-crossing is more likely to occur (Meeuse and Hatch 1960).

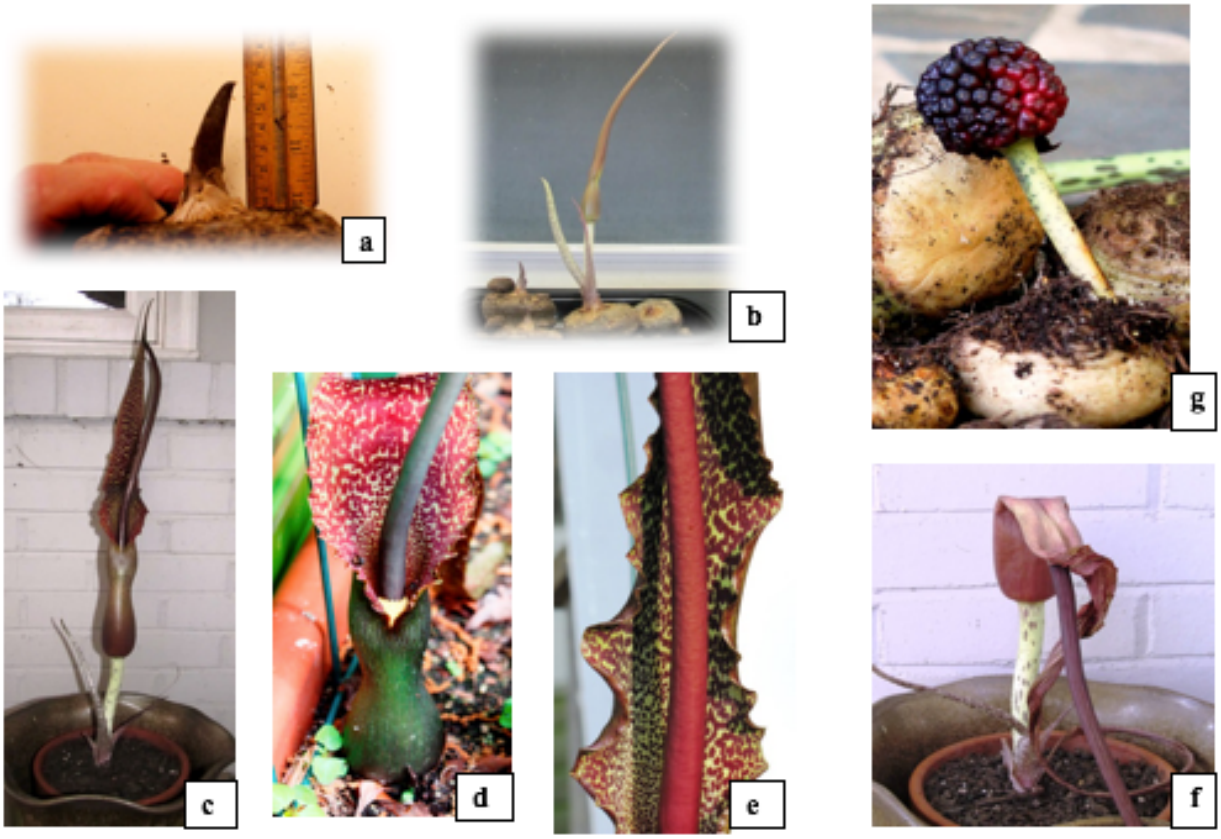

Figure 2. Reproductive phase of the voodoo lily life cycle. a. Large corm with elongating floral bud. a. Elongating inflorescence with spathe still closed; c. Open inflorescence, day 1, with mottled inner surface of spathe and purple appendix; d. base of inflorescence, with male flowers at base of appendix and swollen floral chamber, day 1; e. Colorful spathe and purple appendix, day 1; f. Collapsed spadix and appendix, shriveled spathe, day 2; g. corm with cluster of fruits (berries).

If the plants bloom outdoors, the female flowers are likely to be pollinated by the numerous flies that are attracted to the "stinky flower", resulting in round clusters of red fruits (Figure 2g). Red fruit coats should be removed before seeds are planted as they have been shown in our studies to inhibit germination. Soaking overnight may also improve germination. Seedlings, which consist of a single, entire leaf, are tender and require care in transplanting.

Thermogenesis and Pollination in the Voodoo Lily

Heat is produced in the appendix early in the day of blooming; this heat serves to volatilize various amines, ammonia and indoles which vary with the species of arum lily (Skubatz et al. 1996). This particular voodoo lily flower smells like rat urine, though others smell like rotting meat. This odor attracts flies and other pollinators to the "flower" early on the first day of bloom, when they enter the floral chamber and may pollinate the female flowers (Figure 3). They are trapped there by the arms of the club-shaped organs which protrude horizontally from the spadix above the female flowers. Later the region of the spadix containing the female flowers begins to produce heat, which subsequently causes the club-shaped organs to wilt, and release insects from the floral chamber. As they leave, they may pick up pollen from the male flowers and transport it to other (Skubatz et al., 1991) inflorescences.

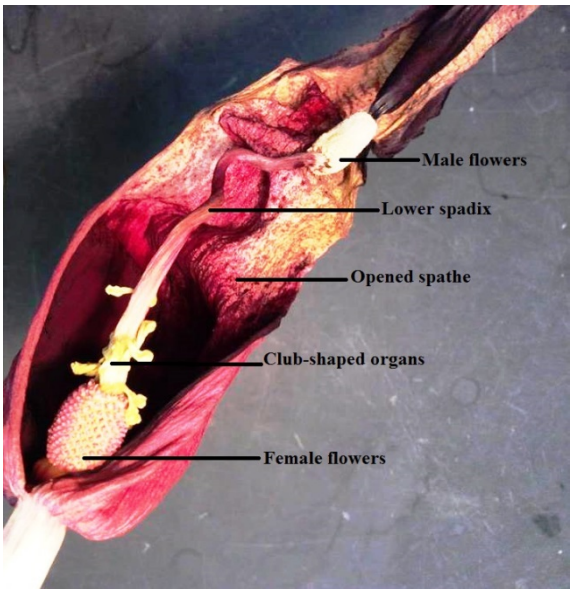

Figure 3. Dissected inflorescence of a voodoo lily, showing male and female flower clusters and yellow club-shaped organs. Erect club-shaped organs spread out horizontally from the spadix, and cover the top of the floral chamber early in the flowering process.

Voodoo lilies, skunk cabbages and quite a few other plants have an unusual mechanism for regulating their own temperature … homeothermy. They use metabolic energy from the mitochondrial respiratory chain to produce heat instead of ATP. In addition to the normal electron carrier complexes for aerobic respiration in these plants' mitochondria, they have an alternative oxidase that can act as a bypass part way through the process of electron transport. By directly transferring electrons to oxygen without pumping protons, it does not contribute to ATP synthesis but instead converts the released energy to heat (Seymour and Blaylock. 1999, Onda et al. 2008, Rhoades and McIntosh 1991.) Further bypassing ATP synthesis, these plants also have alternative NADH dehydrogenases that route electrons directly to the alternative oxidase without contributing to the proton gradient, thus adding to the amount of heat than can be generated (Elthon et al. 1986).

This is an intriguing topic than can be used to enrich student understanding of both biochemistry and plant biology as students consider the process from two different angles. Further, it nicely exemplifies interrelationships among various cellular processes and /or signaling pathways. The short lived but dramatic shifts to and from heat generation in voodoo lilies and skunk cabbage demonstrate alternative metabolic/biochemical pathways that could potentially be observed and quantified as lab exercises in a partnership between plant biology and biochemistry/cell biology labs.

Temperature Recording and Thermal Imaging

An attempt was made to monitor the temperature increase in the voodoo lily inflorescence with a handheld IR thermometer, and as blooming approached we were able to discern a slight difference in temperature at the base and apex of the inflorescence. However, it was difficult to maintain consistent positioning of the instrument (Figure 4a). There are reports in the literature of thermal imaging of this plant and others, but the equipment used was quite expensive (Skubatz et al. 1991). We were able to obtain a Seek brand thermal camera (Figure 4b), an inexpensive and versatile tool. This camera is small and attaches to mobile devices (iPhone, iPad or Android compatible).

Figure 4. Methods of recording temperature changes in voodoo lily. a. Radio shack IR thermometer with voodoo lily bloom at Day 1. b. Seek Thermal camera and website.

The various settings on the camera allow for the determination of maximum and minimum temperature areas as well as spot monitoring (Figures 5a,b). We were able to get reasonably good thermal images of the voodoo lily in bloom as long as photos were taken in a cool environment. Timing of photography relative to heat production of the voodoo lily will require a larger sample of inflorescences.

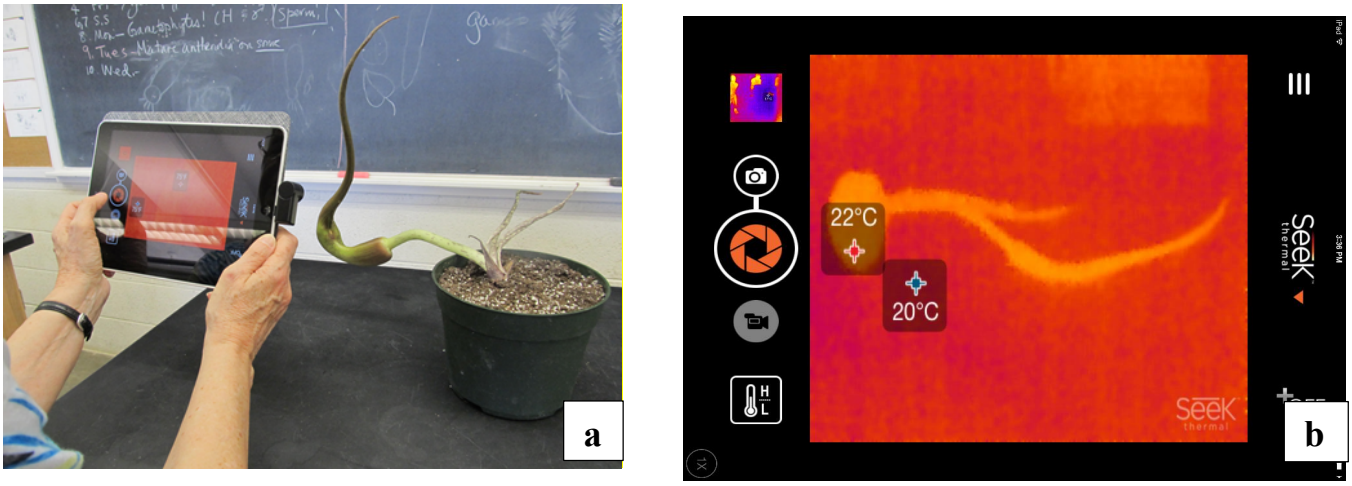

Figure 5. a. Use of the Seek camera to capture an image of a voodoo lily in early stages of bloom; b. Screen shot of iPad when using the Seek camera to capture maximum and minimum temperatures.

Ideas for Uses of the Voodoo Lily and the IR Camera in Plant, Biochemistry, Ecology/Field Biology and Cell Labs and in Research Projects

We have used the voodoo lily in our sophomore level Plant Anatomy and Physiology class to demonstrate corm structure, inflorescence structure, and to investigate the effect of fruit coat removal on germination rate. We have also used it as an example of the role of secondary compounds in pollination. It has potential for use in pollinator/pollination experiments as well. Cool storage of the corms (refrigeration) allowed us to delay sprouting in advance of ABLE 2015 and may allow us to delay flowering in order to have more inflorescences available synchronously. In biochemistry or cell biology there are possibilities for using the voodoo lily to relate oxygen consumption to temperature in active thermogenic tissues as compared to non-thermogenic tissues.

The Seek camera allows for a way to monitor the heat generation process in the whole plant as well as presents opportunities for use in many other lab settings, from wildlife monitoring to measuring exothermic chemical reactions. In addition, some of our ideas for using the Seek thermal camera include monitoring: skunk cabbage thermogenesis, microhabitat temperature differences, animal temperatures, for example of homeotherms versus

poikilotherms, field observations of mammals at night, and chemical or physical experiments.

About the Authors

Karen McDougal earned her doctorate in Botany from the University of North Carolina. She is a Professor of Biology emerita in the Biology program at Lenoir-Rhyne, where she taught introductory biology courses as well as plant anatomy and physiology, systematic botany and environmental science.

Marsha Fanning earned her doctorate in Zoology from the University of Georgia. She has been a Professor of Biology in the Biology program at Lenoir-Rhyne University for 42 years, where she teaches introductory biology courses as well as ecology, biodiversity and field biology. She also serves as chair of the School of Natural Sciences at Lenoir-Rhyne.

Judy Moore earned her doctorate in Cell and Molecular Biology from the University of North Carolina at Charlotte. She is an Assistant Professor of Biology in the Biology program at Lenoir-Rhyne, where she teaches cell biology, biochemistry and human anatomy and physiology.

Fanning and McDougal have team taught courses/labs numerous times, and have collaborated in the supervision of numerous student research projects. Moore has recently added her cell biology/biochemistry expertise to the mix, and is now team-teaching with Fanning.

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http://www.thermal.com

http://allthingsplants.com/plants/view/87607/Voodoo-Lily-Sauromatum-venosum/ is a good one!
(p.s.: *Sauromatum guttatum* and *S. venosum* are synonyms for the voodoo lily)

http://pacificbulbsociety.org/pbswiki/index.php/Sauromatum excellent photos at all stages

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