Temperature Measurements of the Spadix of Symplocarpus foetidus (L.) Nutt.

ABSTRACT: *Temperatures of* Symplocarpus foetidus *spadices measured during March 1971 in a population of approximately 50 plants in northeast Iowa were as much as 25 C above ambient air temperature. A prolonged period of elevated respiration makes possible flower development and pollination at air temperatures below 0 C even though the spathe and spadix are not inherently frost-resistant.*

INTRODUCTION

An unusually high rate of respiration is characteristic of many aroid spadices at or near anthesis. James and Beevers (1950) list five species in different genera, all of which demonstrate a typical, cyanide-resistant, rapid respiration in developing spadices or flowers. Hatch and Millerd (1957), however, report that the spadix of *Zantedeschia aethiopica* Spreng. exhibits respiration which is less elevated and not cyanide-resistant, so the property is probably not universal in the Araceae. The flowering spadix of eastern skunk cabbage *(Symplocarpus foetidus)*, which does exhibit elevated and cyanide-resistant respiration, has provided experimental material for detailed investigation of respiratory pathways *(see,* for example, Storey and Bahr, 1969, and Erecinska and Storey, 1970). The possible ecological significance of the elevated respiration of skunk cabbage has received less attention. Shull (1925) mentions heat production and growth of inflorescences in frozen ground during winters in the District of Columbia, but he made no measurements of temperature or heat production. This paper reports temperature measurements of skunk cabbage spadices made in early spring on a small population of plants in northeast Iowa.

MATERIALS AND METHODS

All temperature measurements were made with a Yellow Springs Instruments model 42SC thermistor thermometer, using a small insertion probe which was introduced through the wall of the spathe and either placed in contact with the surface of the spadix or inserted into its tissues. No large or consistent differences were observed relative to these alternative placements of the probe. Measurements were made on the spadices of approximately 50 plants over a period of 10 days.

RESULTS

Measurements over an air temperature range of 8 C (from —3 to +5 C) indicated some dependency of spadix temperature on air temperature as shown in Figure 1. Each point represents the average temperature for 25-35 spadices. Maximum temperatures would be less dependent on air temperature than the averages since, in any nonselected sample, some spadices are at or near air temperature. Temperature distributions of spadices in closed spathes, corrected for air temperature, are recorded in Figure 2. The temperatures are slightly skewed toward the upper end of the distribution for the latter 3 of the 4 days on which measurements were made, indicating that peak respiration for this population occurred in mid to late March.

The immediate and continuous drop in temperature of spadices when the spathe and spadix unit was cut from the rhizome and left in place for measurement (Fig. 3) indicated that the respiratory activity of the spadix was largely supported by substrate imported continuously from the rhizome, rather than by stored material in the aboveground portions of the plant. The abrupt reduction in measured temperature could only occur if excess respiration effectively ceased at the time the spathe and spadix were cut from the rhizome. Hackett (1957) reported respiratory rates varying from 1390 to 4500 μ liter of oxygen per hr

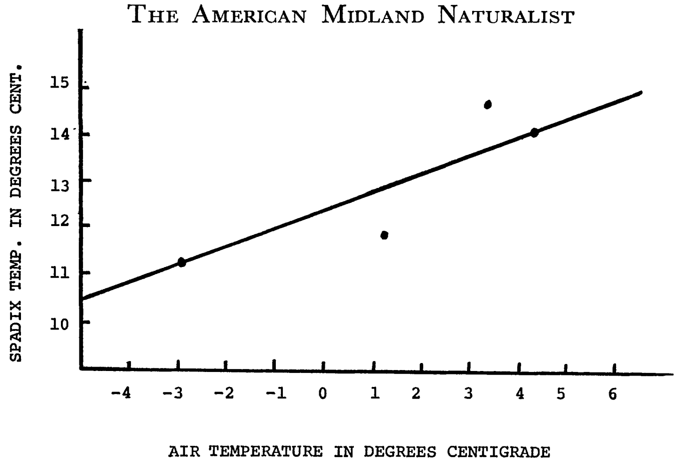

Fig. 1.—Relation of skunk cabbage spadix temperatures to air temperature

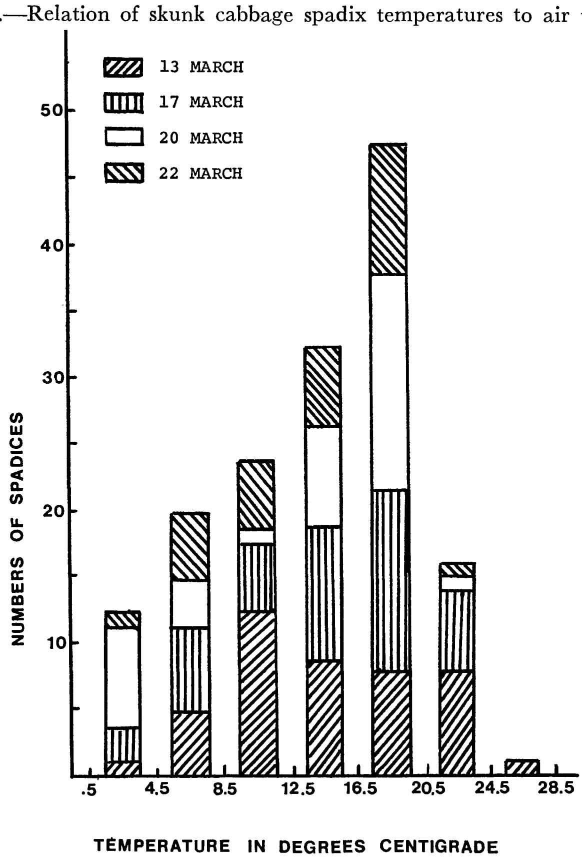

Fig. 2.—Surface temperatures of skunk cabbage spadices from 13 March through 22 March 1971

per g fresh weight for flowers cut from the spadix of skunk cabbage. If we assume 5 to 10 g of flower tissue per spadix and a glucose substrate, heat outputs of 100-200 cal per hr can be calculated, based on the caloric equivalent of glucose. If the spadix is maintaining a constant temperature, that same amount of heat must be lost to the environment. On this basis the temperature change illustrated in Figure 3 is not unreasonable. In addition, since Hackett used flowers of spadices cut from the plants some time before respiration measurements were made, his values may actually be low compared to the potential respiratory rate in flowers on intact plants.

Examination of freshly cut sections of spadix stalk showed 80-90 vascular bundles making up 42% of the total 50 mm² cross section. Approximately 15% of the total cross-sectional area was phloem tissue. This is an extraordinarily high value for the amount of nonfiber phloem tissue and might be related to the presumptive continuous and long-term need for large amounts of respiratory substrate during flowering.

Frost sensitivity of the spathe and spadix tissues was observed by placing spadices and attached spathes at —4 C and —20 C. At both temperatures the tissues froze to complete hardness and, when thawed, exhibited the soft, flabby texture characteristic of plant tissues that have lost cellular integrity through freezing.

DISCUSSION

The elevated respiration and accompanying heat production of many aroid spadices associated with anthesis, lasts only a few hours, and may serve to evaporate insect attractants to aid pollination (Meeuse, 1966). In the skunk cabbage the high respiration and heat output is continuous for many days and serves to protect the frost-sensitive spathe and spadix from freezing at a season of the year when both night and day air temperatures are likely to be below 0 C. A constant or near-constant temperature is provided for critical reproductive processes regardless of season: populations of skunk cabbage in New Jersey (Small, 1959) and Washington, D.C. (Shull, 1925) are reported to bloom any time from September through the following March. The thick, open, spongy, schizogenous parenchyma of the spathe is superbly adapted to insulate the heat-producing spadix, and the inflorescence produces and radiates enough heat to

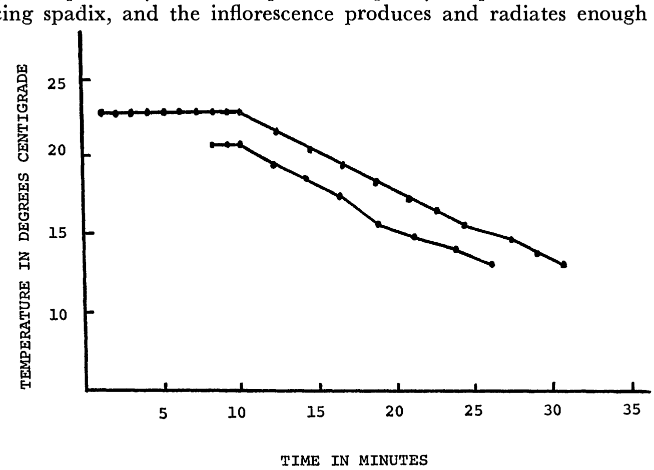

Fig. 3.—Temperature change in skunk cabbage spadices after severing floral stalk. Stalks severed at 10 min. Air temperature 0 C, no wind

melt several inches of overlying snow and ice in northeast Iowa during early March. Skunk cabbage floral structures, without physiological frost hardiness, manage to create their own near-tropical microclimate in a north temperate spring.

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Flight Speed of the Gray Bat, Myotis grisescens

ABSTRACT: *The flight speed of the gray bat,* Myotis grisescens, *was calculated at 11.14 mph when measured under natural conditions in a cave in Perry Co., Tennessee.*

Flight speeds are of increasing importance in interpreting information on feeding habits, homing ability, home range and seasonal movements of bats. Hayward and Davis (1964) recorded the flight speeds of 17 species of bats from Arizona and summarized the earlier literature. Patterson and Hardin (1969) timed the flight speeds of five species from Kentucky, and Mueller (1966) clocked *Myotis lucifugus* flights in Wisconsin. However, no data are available on the flight speed of the gray bat, *M. grisescens.*

On 2 June 1971, several individuals of *M. grisescens* were collected in a mist net, shortly after dark, as they left a cave passage 18 miles NE of Linden, Perry Co., Tenn. The bats were placed in a large container, the net was removed, and the bats were taken into the cave to be released. A gas lantern was placed approximately 20 m inside the cave; this light made the bats clearly visible during flight. The bats were released in a straight but irregularly shaped passage measuring approximately 20 m long, 5 m wide, and 3 m high. They were timed at distances of 30 (9.15 m) and 40 (12.2 m) ft as they flew toward the dark exit of the cave. All times were measured with a stop watch and only information from the most direct flights is presented.

The average flight speed of six males and 31 females, with an average forearm length of 42.6 mm, was 8.61 mph for 30 ft (SD, 1.28; Range, 6.60-10.23 mph) and 9.23 mph for 40 ft (SD, 0.06; Range, 7.80-10.97 mph). The average speed between 30 and 40 ft was 11.14 mph. This latter speed is probably the most accurate since bats reaching this distance were probably flying at their top speed and the acceleration time would be at least partially compensated for. This speed corresponds closely to the average speed of *M. sodalis* (10.8 mph), a similar species also measured in a cave passage (Patterson and