SPATHYEMA FOETIDA

J. MARION SHULL

(WITH PLATES I–IV)

The history of the "skunk cabbage" dates back to its earliest mention by JOHN JOSSELYN, in *New England's rarities discovered*, published in 1672, where he includes it among such plants as are "proper to the country, and have no name." A crudely engraved illustration enables us today to recognize the subject of his description, but if there were any question as to its identity, his statement that "the whole plant sents as strong as a fox" would tend to remove any lingering doubt. Ever since those early days the skunk cabbage has been an object of interest both to botanist and layman; to the latter mainly perhaps because of its pungent, skunklike odor, and because of its seeming extreme precocity in the matter of bloom. In many regions it has come to be looked upon as the earliest of spring flowers. Not having been seen earlier in the season, and then being found in an already spent condition has led to a popular belief that these inflorescences are of extremely rapid, almost spontaneous growth. They are compared with mushrooms for rapidity of development, but this is a mistake.

Impressed by the popular belief in this rapidity of growth, some years ago the writer began a series of observations on a station near Cleveland Park in the District of Columbia, only to find that in this latitude *Spathyema foetida* was hardly to be classed among spring blooming flowers at all. In this locality flowers might have been found in full anthesis at any time between the latter part of November, 1918, and early March of the following spring, a winter of no extreme or long continued cold. Probably few seasons pass at this station without some of the more precocious spathes reaching maturity during the fall or during somewhat protracted periods of warmth in winter. Very likely in more northern regions this fall and winter blooming would occur with less frequency, but it has occasionally been reported from places farther north, and in some cases has led to the mistaken assumption

that it may sometimes flower more than once in the same year. This is not the case, however, since the plant that blooms itself out in November or December does not bloom again the following spring, there being but one annual blooming period for each individual plant, whether it come in fall, winter, or spring. In the region under consideration fall blooming may be looked upon as habitual. It is noteworthy, however, that while these early spathes are developing, all of which are usually destined to be frozen later, others under apparently identical environment as to heat, light, and moisture make no considerable response to the unseasonable warmth, but remain almost entirely quiescent. Thus it would appear that the species is well fortified against such possible disaster as might result from freezing if all the plants pushed their spathes forward with equal promptness under the stimulus of unwonted warmth.

The growth of these earliest appearing spathes, moreover, is not by leaps and bounds, as is the case with so many other spring flowers, but is a gradual and fairly continual process, mostly at relatively low temperatures. Spathes carefully measured and marked with waterpoof India ink were observed at intervals from November 6 to December 31, 1918. Later observations were discontinued at this point, owing to accidental damage to a number of the marked plants, but up to this time each successive examination had showed greater or less increase over the next preceding record, the spathes during the whole period having made an average increase of about 4 mm. in diameter and 7 mm. in height, notwithstanding that during much of the time the ground was frozen at the surface. It is probably true that the plant maintains an internal temperature somewhat higher than that of the surrounding air and soil in winter, so that it is not uncommon to find specimens with a small circle about them freed of snow or ice somewhat in advance of its disappearance elsewhere, and under circumstances that apparently cannot be explained except on the assumption of internal warmth. While not being able to find any published data to bear out the statement, nor having had opportunity to corroborate it in any way, it is the writer's understanding that actual measurement of this internal warmth was made some years ago

which showed an internal temperature several degrees higher than that of the surrounding environment. If this is correct it would partially account for the gradual if slow development throughout the greater part of the winter season, as indicated by the measurements here reported.

That the finding of flowers in early autumn led to reports of more than one flowering season per year has already been noted, and can readily be understood, but it is rather difficult to understand how ENGLER (2) should have made the mistake of thinking that *Spathyema* bloomed only in alternate years, foliage one year and flower the next. It is true that to the layman the plant might be rather puzzling, for in the fall or in early spring he might see the spathes with practically no indication of any foliage growth (fig. 12). If in spring, a few weeks later there would be a great mass of light green leafage (fig. 13), which to the casual observer would have no obvious connection with the curious flower found upon the former visit. A few months later he might find an unusual looking object about the size of an average potato, roughened on the outside in a way somewhat suggestive of a pineapple (fig. 15), but so entirely detached from any plant growth then visible as to be beyond his powers of identification, so completely does the foliage disappear. Still later he might find a somewhat scattered handful of something suggestive of ground nuts in appearance, the seeds, now divested of the soft, spongy tissue of the fruit (fig. 14), without even associating them with the peculiar object previously found.

Many features of this interesting plant are not well known, even among botanists. ENGLER pointed out that most of the Araceae are sympodial in their manner of growth, and that *Spathyema* was no exception in this respect, but as he depended on a single dried herbarium specimen for his detailed account of it, it is hardly surprising that he should have gone astray in his description of the succession shoot (1), where he indicates not only too many sheaths or reduced leaves together, but too great a number of ordinary leaves occurring between succeeding spathes. Morphologically, of course, we should make no distinction between these wintering-over sheaths and the more fully expanded leaves of the active vegetative period. Both vary somewhat in number in

different plants, or may grade one into the other to some extent; but so far as the succession shoot is concerned, it invariably consists of two of these units, following which the terminal bud is consumed, one might say, in the development of the inflorescence. Of the two buds in the axils of these two leaves, the upper must always be developed into the new terminal shoot to take the place of the former terminal now converted into a spathe and spadix. The lower of the pair of buds remains of microscopic size until such time as it approaches the outer region of the crown, when it may distinctly be seen without a lens. These may be looked upon as reserve buds and do not ordinarily develop, apparently never do so while the original crown continues to function, and perhaps this is what ROSENDAHL (6) really means when he says, "in no case . . . . do they develop into lateral shoots." That these lateral buds do have the power to develop, presumably after many years of dormancy, and do in consequence provide insurance against the destruction of the crown, is well shown in fig. 18, where a portion of an old trunk has freely given rise to lateral growths. Doubtless these lateral growths, had they remained undisturbed, would presently by their very manner of growth have broken themselves free from the parent trunk, and in a few years would have presented all the appearance of individual plants developed from the seed.

In studying the morphology of this plant, FOERSTE (3) explains at some length the deceptiveness of appearances met with when dissecting a mature crown. At first sight it would seem, from their location near the outer circle, that the spathes should have been developed from axillary buds, but on closer examination the ordinary relations of such buds do not hold. There is the added difficulty, of course, that each leaf base makes a practically complete circle, with a series of exactly similar fibrovascular bundles, or shall we say leaf traces, no one of which can be positively determined upon as representing the midvein, so that it is almost impossible to determine the true axis of the leaf. Near the outer portion the bud occurring in the axils of alternate leaves helps to locate the exact axil of the lower leaf of each shoot, but these buds soon become invisible as dissection progresses, and even under a high power lens are frequently missed.

Once it is realized, however, that each spathe in its turn represents the terminal of the whole plant at a certain period, each yielding in its turn to the bud next below with clocklike precision as long as the plant may live, it is easier to interpret what is actually happening. An attempt to diagram this condition is shown in fig. 1, where each circle represents a complete succession shoot with its two leaves, but for clearness the individual leaves are not indicated as extending entirely around the circle. A spathe stands outside the outer circle, the latter representing the axillary bud lying next below the spathe; that is, in the axil of a leaf of the preceding year, which has disappeared. The first or lower leaf is shown with a small white circle at the center, to indicate the presence and location of the lower lateral bud, destined to remain dormant until needed by reason of accident to the upper portion of the plant. The second leaf lies approximately two-fifths around the circle, and in its axil lies the bud represented by the second circle from the outside. This circle lies directly between the second or upper leaf and what is for the moment the axis of the plant here represented by the second spathe. Thus it is clear that the developing and great expansion of this upper of the pair of lateral buds will push the axis or spathe off to a considerable distance, but always directly opposite the upper leaf, the spathe appearing clasped within the margins of the leaf base as seen in figs. 8 and 10. In fig. 1 each succeeding circle, proceeding toward the center, represents the bud lying in the axil of the second leaf of the next preceding circle or shoot, but no attempt has been made to show the large number of such succession shoots that are actually present in any strong crown.

Before dealing further with minute details of dissection, however, it may be well to trace somewhat more connectedly the development of the plant from seed. First, the seed itself is quite unlike most seeds in that there are no seed coats in evidence, these having disappeared during development of the ovary through the absorption of the endosperm and integuments, as reported by ROSENDAHL (5). The mature seeds average about 1 cm. in greatest diameter, and are nearly spherical, except when distorted by pressure due to crowding. Externally they are light brown, while the dense firm

flesh, homogeneous throughout, is of a peculiar bluish white. Opposite the hilum lies the plumule, imbedded in the starchy tuber-like mass of the seed itself, a small slit on the surface adjoining the micropyle serving to show its location. A median longitudinal section of the seed is shown in fig. 6, where the vascular relationship may be noted. The plumule shown under greater magnification (fig. 5) and again in cross-section (fig. 4) is in no respect different from the lateral bud shown in fig. 3, all the same magnification, and quite a number of rudimentary leaves are already clearly in evidence. NUTTALL (4) describes the seed as not appearing to "possess anything like a proper cotyledon," declaring that "in place of a cotyledon there is a sheathing stipule similar to that which is ever after produced; in fact it is viviparous." He is mistaken, of course, in attributing this sheath to stipular origin, whether in the plumule or in the mature plant, since in either case they are merely reduced leaves. ROSENDAHL (5), on the other hand, looks upon the entire fleshy body of the seed as the "cotyledon," in which the plumule is all but completely buried. Shall we say that this seed has already germinated, and so agree with NUTTALL in describing the plant as viviparous? This must depend of course on our definition of germination. In any case this would seem to be the condition in which the seed is prepared to undergo whatever period of inactivity it is capable of sustaining. So far as the writer knows, no determinations have ever been made as to whether or to what extent the seed may undergo drying and still retain its power to develop, or how long it may remain inactive yet viable with a minimum requirement of moisture to prevent shriveling.

The young plant shown still attached to the seed in fig. 2 is thought to be a one-year old plant. At this stage of development, and apparently for a number of years to follow, the growth is monopodial and relatively slow. No one seems to have determined how long the monopodial stage continues, but it is evident that some of these young plants, making often only several leaves in a season, must continue many years before they outgrow this period of infancy. During this time the life of *Spathyema* constitutes one monotonous unfolding of leaf after leaf in exactly the same manner in slow succession, broken only by such periods of rest as the

changing seasons impose, each leaf rolled round and round on itself and completely inclosing the next succeeding leaf, and all rolled in the same direction on the same plant. Only in a single instance among the number of young plants examined was a change in the direction of rolling of the leaf found, and then it manifested itself in serious deformity of the plant. Probably there is considerable variation in the time required to outgrow the monopodial stage, but the crown must have attained a diameter of 20–25 mm. before the change takes place. This is an important period in the life of the young plant, for at this point the younger stage disappears with the converting of the terminal bud for the first time into an inflorescence. After this it will with absolute precision produce two leaves and then an inflorescence, unless through some mishap the growing point should be destroyed, a contingency not often to be reckoned with, since this same point is usually maintained several inches below the surface of the ground and well beyond the reach of animals that sometimes feed upon the leafage; and while damage might be caused by trampling of heavy animals, the mere fact of its swamp habitat would insure against this happening with any frequency.

A young plant having cut off its terminal bud for the first time to form an inflorescence would still be flowerless for a considerable period, possibly for a couple of years; but it will be better at this point to start with a large crown and follow step by step the dissection in detail. The results are shown in condensed form in table I. A large number of crowns of varying sizes were dissected and recorded, and the figures here given are the direct record of a very strong plant with a crown 41 mm. in diameter and as found in November 1918. First there is a large wintering over sheath without leaf expansion, rolled on itself as indicated in the table when looking down on the plant. In the clasp of the leaf base margins there is a wasted spathe. In most plants of this size this spathe would have been sound and there would be no remnants of last year's inflorescence in evidence. In other words, most strong plants at this station produce two mature spathes each season, but there are weaker plants with only one, and yet others that produce three, while an extreme of four has been reported. Next there is

another sheath with slight expansion of leaf at the apex, but the edges overlap in the opposite direction and there is no spathe present. The third sheath, again with slight leaf expansion and

TABLE I

RELATIONSHIPS IN LARGE CROWN OF *Spathyema*, 41 MM. DIAMETER, DISSECTED IN NOVEMBER

No.	Condition	Direction of roll	Spathe	Season
1	Large sheath, no leaf expansion	↻	+aborted	
2	" " slight expansion	↺	o	
3	" " slight expansion	↻	+live 28×92 mm.	Spring
4	" " considerable expansion	↺	o	1919
5	Leaf fully formed	↻	+aborted	
6	" " "	↺	o	
7	" " "	↻	+aborted	
8	" " "	↺	o	
9	" " "	↻	+aborted	
10	" " "	↺	o	
11	" " "	↻	+aborted	
12	" " "	↺	o	
13	" " "	↻	+live 4×10 mm.	Spring
14	Rudimentary leaf	↺	o	1920
15	" "	↻	+live 3×6 mm.	
16	" "	↺	o	
17	" "	↻	+live 2×4 mm.	
18	" "	↺	o	
19	" "	↻	+live	
20	" "	↺	o	
21	" "	.....	+live	
22	" "	.....	o	
23	" "	.....	+live	
24	" "	.....	o	
25	" "	.....	+live	Spring
26	" "	.....	o	1921
27	" "	.....	+live	
28	" "	.....	o	
29	" "	.....	+live	
30	" "	.....	o	
31	" "	.....	+live	

again reversing the direction of its rolling, clasps a live spathe 28 mm. wide and 92 mm. in height, not yet in anthesis but practically fully grown, and apparently destined to bloom in the spring of 1919. This is followed by a fourth sheath which now shows considerable leaf expansion and is again minus the spathe. Very careful inspection at its axil would probably reveal a minute vegeta-

tive bud, but even at this early point in the dissection they begin to be difficult to find. Fifth in order is found a fully formed leaf, lacking only expansion to make the very large leaf common to the plant as seen in early summer. Beginning at one edge it is tightly rolled many times around itself with much crumpling. Entirely within it lies the next leaf, and within the clasp of the basal margins of the petiole is found a spathe that is no longer alive, as is shown by the discoloration and the membranaceous character of the tissues. The succeeding leaves are much the same, except that they grow smaller and smaller, the sixth, eighth, tenth, and twelfth without accompanying spathes, the seventh, ninth, and eleventh clasping aborted spathes. The thirteenth leaf (fig. 8), however, while still a fully formed leaf like its predecessors, clasps at its base a live spathe 4 mm. wide and 10 mm. high, obviously destined to come into flower one year later than the large spathe associated with the third leaf, or sheath, already mentioned, or in the spring of 1920. Now there is found an abrupt change in character from 13 to 14, the latter (fig. 9) being very definitely rudimentary and destined more than a year in advance to become the wintering-over sheath to protect the bud through that period of cold. Figs. 8 and 9 show both leaves to the same scale. From this point on all the spathes are alive, despite the fact that only 13, 15, and 17, in that immediate region, have the slightest possibility of coming to maturity, and probably not more than two of these will escape. Up to the twentieth leaf dissected off, it has still been possible to determine which way the leaf rolls, and, as shown in the table, there is no break in the rule of constant reversal of direction. The seventeenth leaf with its clasped spathe is shown in fig. 10, and beyond this the height of the leaf is reduced more and more. They become mammiform, occupying a pronounced depression at the center of the crown, whence they were dissected to the final number of 31 (fig. 11), the spathe accompanying this last leaf being shown in fig. 7, and photomicrographs of another at about the same stage in figs. 16 and 17. Since the scheme of annual development is so clearly indicated, just as the number of leaves in the bud of many oaks and other trees is definitely fixed long before growth begins in the spring, it is allowable to set aside a

second series of equal number, and assume that this will represent the following year's quota of leaves. Thus it will appear from table I, that 25 and 27 of this crown, had they been permitted to grow, would have provided the bloom in the spring of 1921, some twenty-seven months after the date of this dissection. The remaining spathes there indicated would fall into the third series of aborted spathes, abortion due to occur two years later.

One is tempted to speculate concerning this suppression of more than fifty per cent of the spathes. This behavior is noted by ROSENDAHL (6), who attempts to explain it on the basis of habit, a habit acquired during an earlier assumed tropical existence, and which it has been unable to leave behind when forced to live under the adverse conditions of alternating winter and summer. In the opinion of the writer this explanation is untenable. In any case such an assumption seems quite unnecessary. The plant is only functioning in a way that is common throughout the plant world. The very manner of its growth, that of converting its terminal bud into an inflorescence at every second turn, leaves no possibility of reducing their number. Consider that the individual fruit is of large size (figs. 14, 15), containing many large seeds consisting of dense albumen. Also, notwithstanding the supposed tropical origin of the species, the plant confines its vegetative growth to a brief two months of the spring, after which the foliage dies off. Obviously it would be impossible for each pair of leaves, large as they are, to provide sufficient photosynthetic action to meet all the needs of the plant otherwise, and also mature a fruit of such size and character. An apple tree, even with the most perfect pollination, drops most of its fruit in order that it may properly mature the remainder. So with *Spathyema*, it is necessary to secure a proper balance between photosynthesis and seed production, which is brought about by the abortion of approximately two-thirds of the spathes inescapably laid down. As to just how this abortion of these particular spathes, attributed by ROSENDAHL (6) to the rigors of winter, is brought about, whether by pressure, by diversion of growth materials, or otherwise, would be a problem for the physiologist. The writer is inclined to think, however, that growth pressure is the means of accomplishing the desirable reduction in number.

To revert to the matter of leaf disposition in the bud and the change that takes place on the transition from monopodial to sympodial manner of growth, it would be interesting to know whether or not the constant alternation of direction is a natural consequence of the latter manner, in a succession shoot of but two leaves. At any rate it is plainly a great advantage in a large, compact, rapidly growing bud, to secure easy and unrestricted expansion, free from all friction of adjacent unrolling leaf surfaces. This may be well illustrated by taking half a dozen strips of paper, rolling the first very closely on itself and the second outside of this but in the opposite direction, and so continuing until all are rolled together. On releasing them note how they all expand at once and throughout the entire roll without the slightest obstruction. This is just what happens with *Spathyema* buds during the extremely rapid vegetative growth of early spring.

Apparently all who have undertaken a detailed account of this species have hesitated over the question of its phyllotaxy, indicating that the leaf arrangement of the mature plants was of a rather high ratio, ROSENDAHL (6) stating it positively as 5–13, but all seem agreed that in the young plant the leaf arrangement is of a lower order, although not risking to say with any assurance just what. ENGLER thought it probably 1–2 in the young plant, changing later to a higher ratio. FOERSTE, while noting the approximate 1–2 appearance of the first pair of leaves, and mentioning the probability of a more complicated arrangement, finally decides that it "seemed reasonable to consider this a case of 1–3 phyllotaxy," crediting such divergence as was more or less apparent to displacements necessarily taking place in so complicated and crowded a structure. There is no denying the difficulty involved in trying to determine the leaf arrangement from flowering crowns with no guiding landmarks during dissection except the recurring more or less developed spathes. Many such dissections were made, inserting pins as each spathe was dissected out, so that the record so obtained could be preserved for comparison with others. These were then compared with idealized diagrams of the various natural arrangements, without obtaining absolute agreement in any case. Various fluctuations occur, probably due to torsion caused either by the

pressure of growth at the crown or by the subsequent great contraction of the tissues as they pass on into the less active portion of the trunk. This same contraction brings the fibrovascular system into such a compact and complicated tangle that any attempt to trace leaf arrangement through that channel is hopeless. We have in fig. 19, however, strong evidence in favor of the common 2–5 arrangement, at least during the monopodial stage. This specimen is apparently the result of a lateral bud coming into activity at considerable depth, and making greatly elongated growth quite unusual for the species in its effort to reach a suitable relationship to the surface. In the old trunk, after its normal contraction, it is impossible even to count leaf scars with any certainty, but here they are far apart, and very distinct until near the crown. A very small bud is to be seen in the lowest axil shown, then at intervals of five scars in each case are three more buds in succession, the compression of the crown making it impossible to follow the series any farther. These four buds, however, are so definitely superimposed in a vertical line on the trunk as to leave no doubt of the arrangement. Even in the crowded crowns, the 2–5 arrangement is approximated, the divergence being irregular, and, on studying cross-sections of lateral buds and embryos (figs. 3, 4), the leaf traces, although in such thick sections as to make actual measurement difficult, are very suggestive of the same arrangement. In view of this evidence, the conclusion is reached that *Spathyema* maintains the 2–5 phyllotaxy through its career from embryo to mature sympodial crowns.

There remains to consider one very interesting speculation concerning this plant. No one seems to know to what age it may attain, but like most slow growing plants it is evidently of very long life. Estimates of as much as seventy-five years have been made, presumably based on the length of trunk present, but in order to understand the uncertainty of any method of estimate we must consider the manner in which the plant counteracts the tendency of all vertical trunks to elongate into the air. This is partly taken care of by the contraction of the trunk itself, as already mentioned, but even so, with an addition of but a millimeter or two each year, and with only terminal growth like a palm, there must eventually be a mounting trunk, with its ultimate risk of being

blown over by wind, or as in the case of trees reaching a maximum height to which the vitalizing forces of the plant may be sent. This possible condition is avoided by *Spathyema* by sending from the crown each season a new circle of strong roots diagonally down to considerable depths, which when well anchored contract their length and drag the whole plant downward with such force that eventually the lower end of an old plant is worn round and smooth like a potato by the thrust into the deeper soil. Thus year by year the crown is maintained at a level somewhat below the surface of the ground, the trunk, with its complement of lateral buds and marked by the scars of leaves that flourished scores of years ago, descends deeper and deeper into the mucky soil. While we may dig it up and determine by its length or by counting as nearly as possible the leaf scars the approximate number of years represented, it is obvious that what has been worn away at the bottom may have been many times greater than that which remains, and it then becomes apparent that *Spathyema* is of indefinite age.

Summary

1. In the District of Columbia *Spathyema foetida* may be found in bloom during moderately warm weather at any time from November to March or April. Each plant has but one blooming period per year, but while some bloom early and usually are frozen later, others under the same conditions of warmth remain unaffected and do not bloom until spring.

2. Growth of spathes is not by leaps and bounds, but is rather slow and continuous, apparently aided by the plant's own internal warmth.

3. Flower, foliage, fruit, and seeds may be seen in such a broken sequence that their relationship may not be very apparent.

4. *Spathyema* pursues a monopodial existence for an indefinite number of years until the first spathe appears, after which it is sympodial with a succession shoot bearing two leaves. The upper axillary bud always becomes the new terminal, while the lower one passes into reserve, developing only in case the terminal crown is destroyed.

5. During the monopodial stage the leaves are all rolled in the

same direction, each entirely outside the next succeeding leaf. On reaching the sympodial stage growth expansion is facilitated by the constant reversal of direction in which the leaves are rolled.

6. Seeds are without seed coats, and the almost buried plumule is indistinguishable from the axillary buds held in reserve.

7. From a large crown as many as 31 leaf units have been dissected. These would provide the full complement of leaves for nearly three years, since it is rare to find a plant with more than 11 leaves expanded in one season. For each second leaf there is a spathe, but more than half of these are ultimately suppressed, probably through the mechanics of growth pressure, with the result of lessening the number of fruits and so securing a proper balance with photosynthesis.

8. Leaf arrangement in this species has been a moot question up to the present time. It is here shown to be definitely 2–5 during the monopodial stage, and this ratio is probably maintained throughout.

9. *Spathyema*, possessing contractile roots that year by year drag it downward into the soil, thereby wearing away by friction the lower end of the trunk, leaves no possible means of even estimating its age, which must be looked upon as indefinite.

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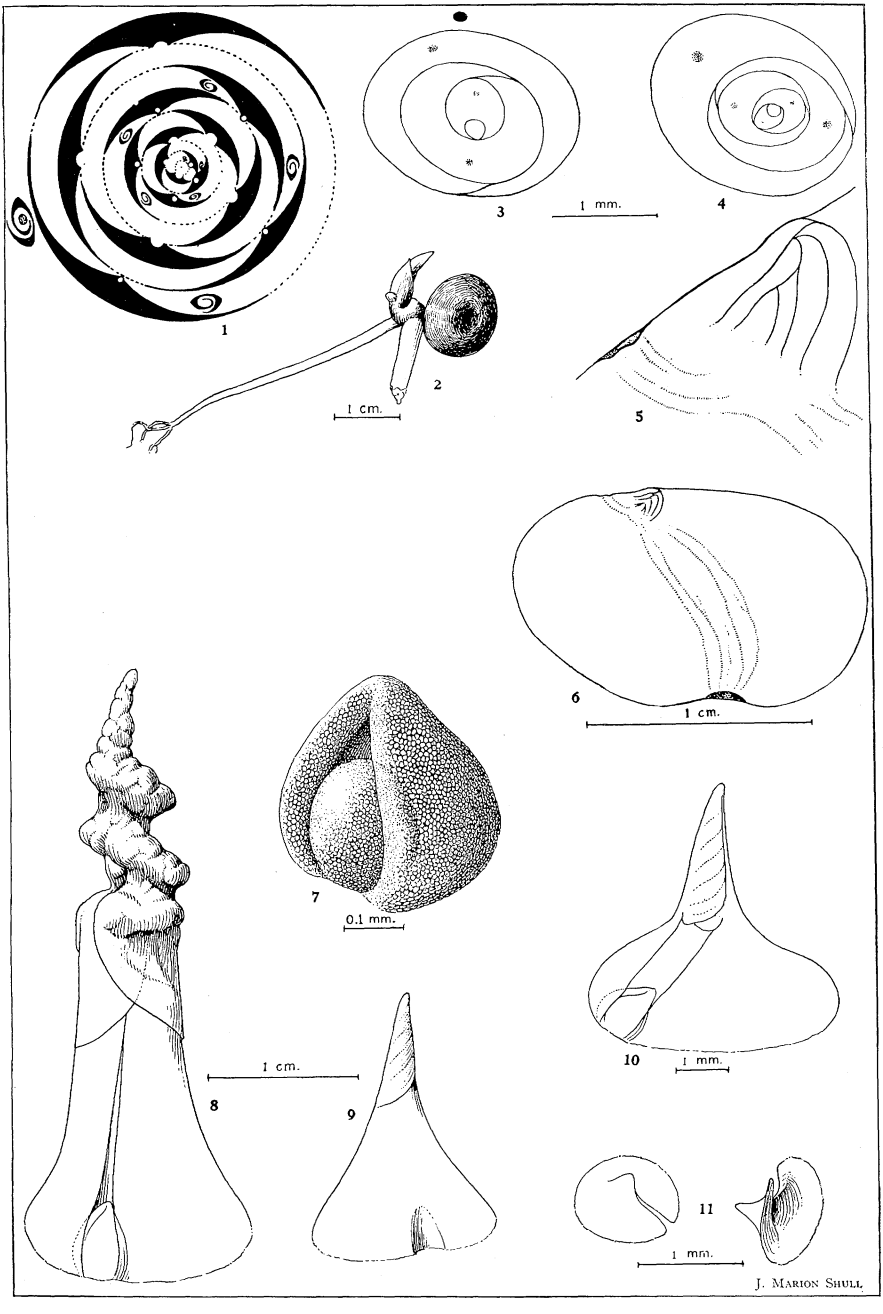
EXPLANATION OF PLATES I–IV

PLATE I

FIG. 1.—Diagram of leaf arrangement and spathe relationship in *Spathyema;* spathe being terminal bud, each successive circle represents



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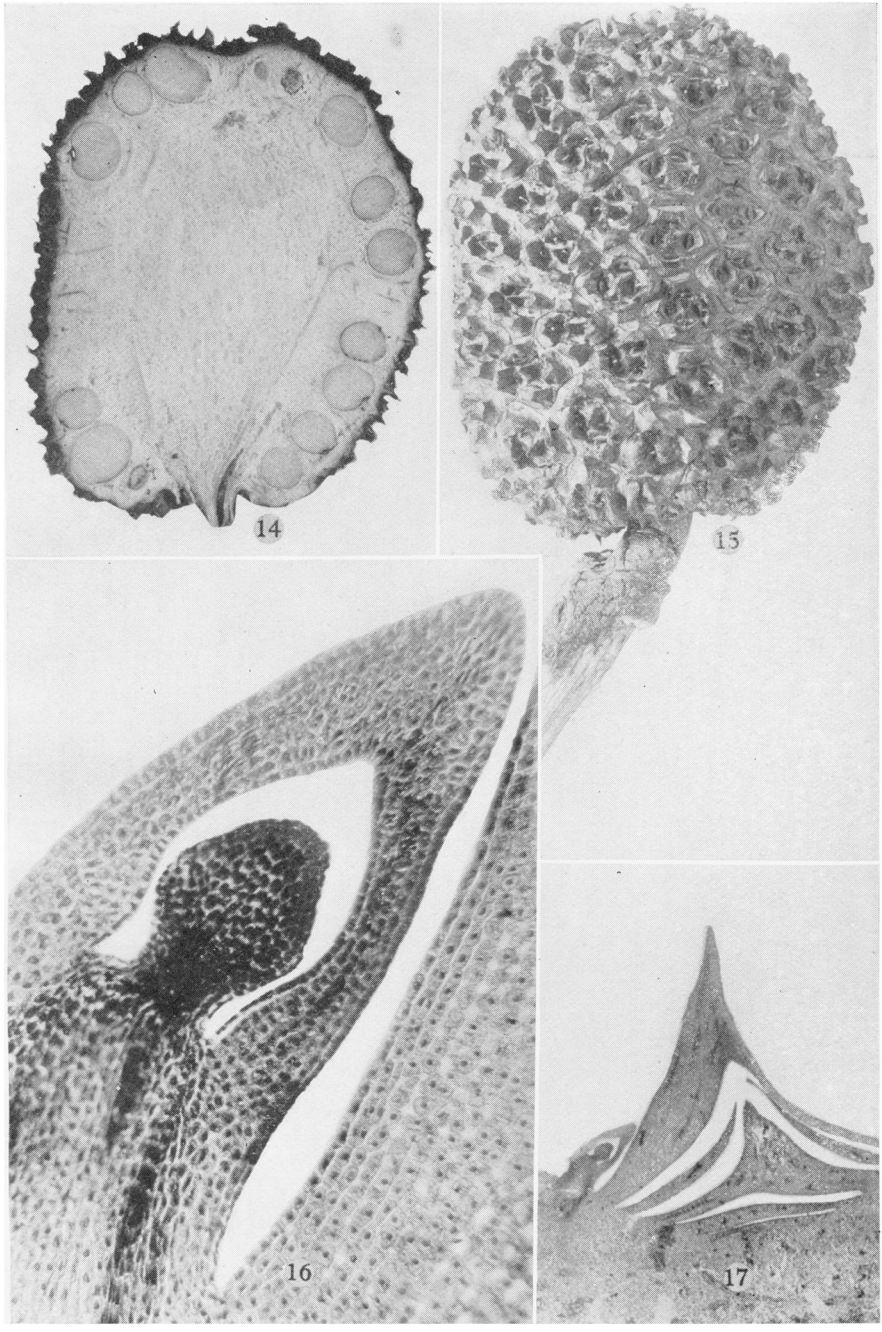
SHULL on SPATHYEMA



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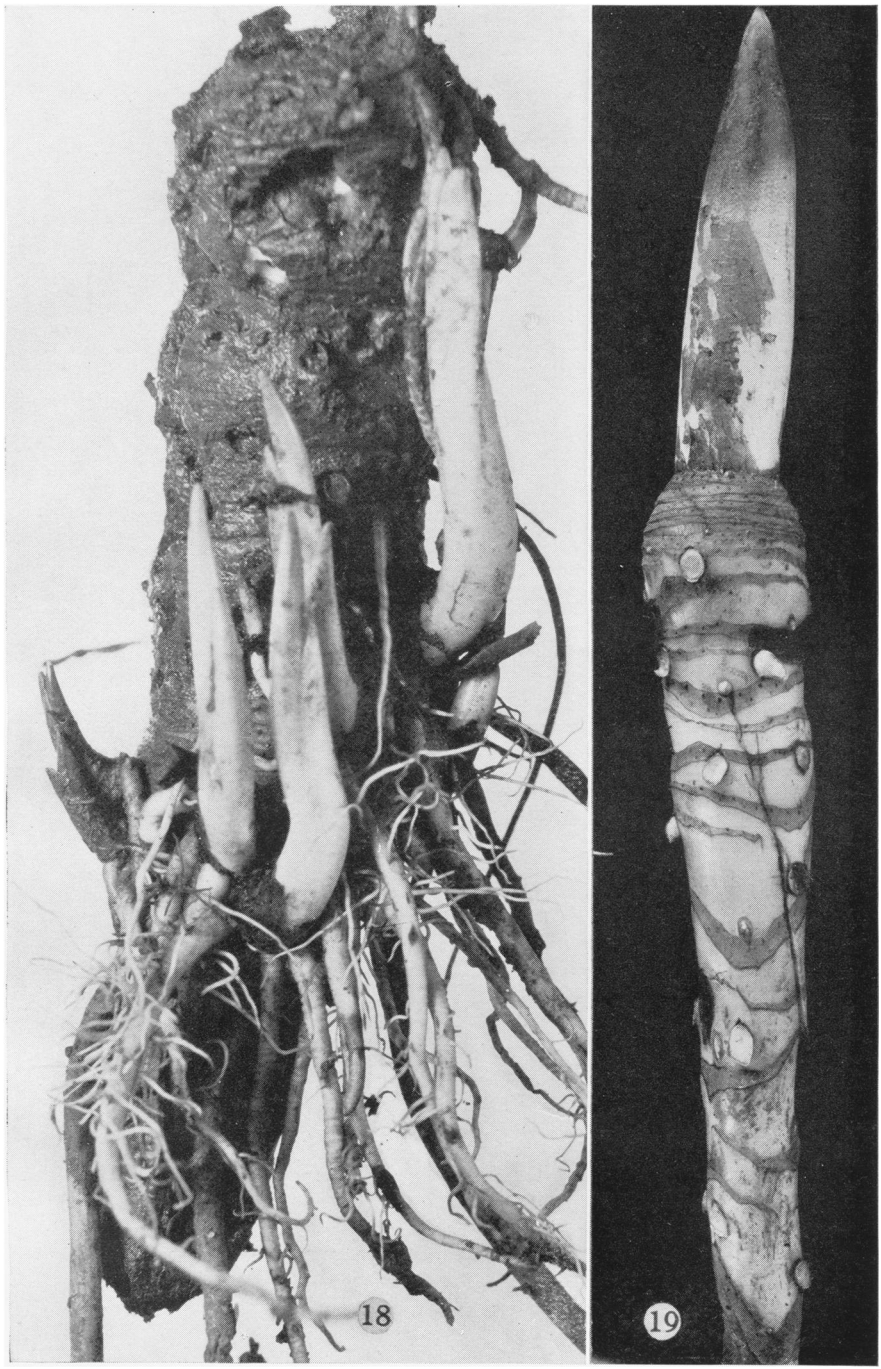

SHULL on SPATHYEMA

axillary bud lying between this and subtending leaf, missing in case of first spathe shown; each circle may also represent succession shoot of two leaves, lower one subtending a microscopic axillary bud that normally remains dormant, while axillary bud of upper leaf becomes, each in turn, new terminal destined to give rise to two leaves and then become a spathe.

FIG. 2.—One-year-old plant with seed still attached.

FIG. 3.—Axillary bud shown in cross-section.

FIG. 4.—Plumule as found in seed, shown in cross-section.

FIG. 5.—Plumule shown in longitudinal section.

FIG. 6.—Seed in longitudinal section, showing vascular relationship.

FIG. 7.—Last spathe dissected out, apparently not due to bloom until 27 months later (camera lucida).

FIG. 8.—Twelfth leaf unit dissected from vegetative bud in November, last destined to full development during succeeding spring season; probably spathe at base of leaf would have bloomed 15 months later, all those immediately preceding it being aborted.

FIG. 9.—Thirteenth leaf unit is rudimentary leaf which would close season's growth by developing into wintering-over sheath.

FIG. 10.—Seventeenth leaf unit from same bud.

FIG. 11.—Twenty-eighth leaf unit, now reduced to mere mammillary scale (camera lucida).

PLATE II

FIG. 12.—*Spathyema* plant March 6; about $\frac{1}{6}$ natural size.

FIG. 13.—Same plant, taken from same point but with different lens combination, May 21; about $\frac{1}{12}$ natural size.

PLATE III

FIGS. 14, 15.—Fruit in September; slightly reduced.

FIG. 16.—Spathe 27 months in advance of anthesis; ×120.

FIG. 17.—Center of crown with same spathe shown in fig. 16; ×14.

PLATE IV

FIG. 18.—Portion of old trunk freely giving rise to lateral growths from axillary buds held in reserve; natural size.

FIG. 19.—Elongated trunk of young plant, or rather lateral shoot, showing three distinct cycles of leaf scars and axillary buds that indicate 2–5 leaf arrangement; slightly reduced.