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## THE SEXUAL NATURE OF VEGETATIVE OR DICHOTOMOUS TWINS OF ARISÆMA.\*

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While studying sex reversal in *Arisæma triphyllum* (L.) Torr., the writer accidentally came across some interesting examples of dichotomous twins which have a bearing on the theory of sex determination. Twin flower clusters were reported several years ago by Pickett† who discovered about a dozen of such plants. He says the two flower clusters were surrounded by two leaves, and also makes the casual remark that the two clusters "are of the same sex on each plant and are entirely independent, arising from two separate initial groups."

The twin shoots and separated twins must not be confused with the normal lateral buds, which are produced each season from the corm. The main corm often becomes smaller, not only from accidents to the aerial shoots and poor growing seasons which reduce the available food supply but also from excessive or vigorous lateral bud production. In case of dichotomy of the growing bud which results in twins, one can find all gradations from simple inflorescences with slightly flattened spadices ending in two tips and with a double-pointed spathe to individuals which have two entirely distinct aerial shoots, identical in appearance and situated closely side by side. Such pairs of twin shoots become entirely separated after a year or more because of the further development of the two buds and the dying off of the back end of the corm. The twins can often be recognized as such for several years after com-

\* Papers from the Department of Botany, The Ohio State University, No. 134.

† PICKETT, F. L. A Contribution to our Knowledge of *Arisaema triphyllum*. Mem. Torr. Bot. Club. 16:48. 1915.

plete separation, both because of their position in the ground, close together and with the buds pointing in the same direction, and because of the remarkable similarity of the vegetative characters and similarity in size. Occasionally there is a difference in size of the individuals, or in the length of the sterile tips of the spadices, or in the time of emergence from the ground. There is no reason why such differences should not be decided, since the original fission of the bud may be quite unequal. In the dichotomous branches of *Vernonia baldwinii* Torr. and *V. altissima* Nutt., for example, there is frequently a decided difference in the length and complexity of the two forks.\* There might also be a difference in the more specific vegetative characters occasionally, for the same reason that the two sides of a symmetrically bilateral body may differ in the characters expressed as, for example, the differences in the details of venation of pairs of insect wings, differences in the lobings of the two halves of a leaf, differences in the colored spots of the heads of certain turtles which are usually symmetrical, and differences in the color of the eyes of dogs and men, where one occasionally finds individuals with one eye blue and the other brown. The same differences of expression must take place occasionally after separation of two bilateral halves of an egg or vegetative bud and it is, therefore, possible that identical twins may differ decidedly in very important characters.

Not only are the *Arisæma* twins, so far discovered, all remarkably alike in vegetative characters but they are of the same sex. Some are staminate pairs, some are carpellate, and some intermediate with both staminate and carpellate flowers on the spadix, just as is the case with normal individuals. But the most remarkable characteristic exhibited by the bisporangiate twins is that so far they have been identical or nearly identical in the distribution, position, and numbers of the staminate and carpellate flowers. Since the elaboration of the hypothesis of the Mendelian nature of sex, it has been supposed by some that the fact that identical or duplicate twins are apparently always of the same sex gave a very strong presumption in favor of the correctness of the chromosome-linked or Mendelian hypothesis. This is, however, not at all the case as will appear from the evidence given below, derived from a

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\* SCHAFFNER, JOHN H. Unusual Dichotomous Branching in *Vernonia*. Ohio Jour. Sci. 19:487-490. 1919.

study of a considerable number of twins of *Arisæma*, when it is remembered that sex in *Arisæma* has nothing to do primarily with chromosome shiftings and can be controlled and reversed almost completely by environmental means.

#### CHARACTERIZATION OF TYPICAL EXAMPLES.

1. A plant with twin leaves on a common petiole and twin spadices on a common peduncle. The two leaves each had three leaflets and had short petioles coming from the common petiole. The spathe had two points and surrounded the two spadices. Both spadices were pure carpellate and the sterile tips both had the upper two-fifths colored dark purple.

2. Twin shoots coming from the same corm. They were alike in size and general appearance. Both had the sterile tip purple. Both had identical sexual expression, being monocious with a zone of carpellate flowers below, covering about three-fifths of the spadix, and with a staminate zone above. Both inflorescences had purple-red anthers and greenish white stigmas.

3. A pair of large twins with separate corms but evidently just recently divided—probably the preceding summer. Both were very late in coming out of the ground; both had green spathes and green sterile tips; and both were pure carpellate with violet stigmas.

4. A pair of small twins with distinct corms but still close together. Both had green spathes and green sterile tips. Both were pure carpellate. One plant was 8 in. tall and the other  $7\frac{1}{2}$  in.

5. Large separated twins, both 12 in. tall to the tip of the spathe. The spathes of both were a uniform dark purple at the tip on the inside, and purple and greenish-white striped below. The sterile tips of both were dark purple above, purple spotted in the middle part, and green below. The sterile narrow stalks of the sterile tips were both purple spotted. Both were pure carpellate with pale violet stigmas.

6. A pair of twins just separated and situated close together. Both were  $6\frac{1}{2}$  in. tall to the top of the sterile tip; both had one larger and one smaller leaf; both had the spathes striped above, broad purple stripes alternating with narrow greenish-white stripes, and uniform greenish-white below. Both had the

sterile parts of the spadices purple mottled at the tip, with a solid band of purple just above the middle, and with a slight purple spotting below, extending from the purple band to the base of the sterile stalks. Both inflorescences were carpellate on the main part of the spadix with purple stigmas; and on the stalks of the sterile tips, a little way above the carpellate inflorescence, both had four purple-anthered staminate flowers! There was a slight difference between the two inflorescences in that one had a small, additional staminate flower in the top of the carpellate part, in addition to the four staminate flowers further up.

7. A pair of separated twins with green sterile tips but with their short stalks above the flower-bearing part slightly purple mottled. The spathes had green tips with purple stripes on their sheaths below. Both plants were robust. One was 12 in. tall to the top of the sterile spadix and the other was 11 in. Both were pure carpellate.

8. A pair of twins still united on the same corm. They were remarkably alike but one was slightly taller than the other, measuring  $7\frac{1}{2}$  in. while the other measured  $7\frac{1}{4}$  in. Both had the sterile spadices or tips expanding decidedly toward the base. The tips were purple mottled while the bases were pure green. The spathes were greenish on the outside; but each had a broad band of purple on the inner side, one on the right side and the other on the left. The opposite sides of the spathes had a narrower purple mottled band, while the center of each was green slightly mottled with purple. The spathes, therefore, showed a decided right and left symmetry. The sheaths of the spathes were both folded clockwise, but this is a fluctuating character. Both inflorescences were pure staminate.

9. A pair of twins which developed in the writers experimental plots. The original plant was a pure carpellate individual brought in from the woods with others for experiments on sex reversal. This individual was treated for reversal to the male state by having its root system and leaves greatly reduced and being kept in a comparatively dry condition. The following year the growing bud showed that dichotomy had taken place, as the corm developed twin shoots. Both branches were pure staminate, being completely reversed in sex, along with a similar change in most of the other individuals in the plot that had been treated in the same way. The twins were of equal size and

character and developed at the same time. The plot containing the twins was then treated for reversal to the female state by an application of rich cow manure and abundant water supply during the entire spring and summer. The following spring (1921) the twins had both reversed their sex completely and were now pure carpellate again. Examination of the underground parts showed that the corms had separated, although with the dead part still united. The twins were now of unequal size and one was nearly a week earlier in coming out of the ground than the other.

*Arisæma dracontium* (L.) Schott.

Some observations and experiments were also made on the green-dragon. This species consists of normal monocious and staminate individuals with occasional abnormal intermediates.

10. A plant with dichotomous inflorescens. The spathe ended in two separate points, the free points being one inch long. The spadix was double but united except near the tips of the sterile part. The entire double spadix was staminate. One of the free sterile tips was five-eighths inch long and the other seven-eighths inch. There was also some difference in thickness.

11. A simple staminate plant was transplanted from the woods with others in 1920 and treated for continuation of the staminate condition. In 1921 it gave rise by dichotomy to identical staminate twins.

12. A pair of tall, robust twins that looked like monocious individuals, but both stalks were completely sterile, each having a small, abortive structure where the inflorescens should have developed. They were still united on a single very large corm. This corm was transferred to the experimental plots in 1920 and treated for reversal to the staminate condition by reducing the root system and leaf surface decidedly. In the spring of 1921 both came up as pure staminate shoots. One came out of the ground a week earlier than the other.

CONCLUSIONS.

All of the twin Arisæmas described above showed a remarkable similarity in vegetative characters and were exactly alike in sexual expression. Since it has been established that the sexual state of Arisæma can be changed at will by proper

treatment,\* it becomes evident that *identity of sex in duplicate twins can not be regarded as giving any conclusive evidence in support of the hypothesis that sex is determined by Mendelian factors*. As shown in the examples of twins described above in Numbers 9 and 12, the sex of twins has been completely reversed and the reversal was identical for each twin of a pair. The intermediate examples are even more striking than those with pure sexual expression. Cases like the one described under Number 6 must certainly be regarded as most remarkable in view of the fact that the sex of the individual is so easily changed. All these cases show that the nutritive balance or whatever it is that determines the sexual state must act with decided precision when individuals of like heredity develop under like conditions. Although so far the writer has no evidence that Arisaema twins placed in different environments would develop the opposite sexual states in any given season, yet, in view of the fact that any ordinary individual can be changed from season to season and that the pairs of twins have actually reversed their sex to the opposite state in agreement with a change in nutritive environment, it appears that such must be the case.

As shown by the examples listed above, certain pairs of dichotomous twins show fluctuation of a considerable degree, but so far this has been found mainly for size, folding of the spathe, emergence from the ground, and the like. The varietal characters, like coloring of the spadix and spathe, shape of the sterile spadix and length of its stalk, shape of leaflets, color of anthers and stigmas, etc., are remarkably alike in each pair and deviate only in minute detail.

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\* SCHAFFNER, JOHN H. Control of the Sexual State in *Arisaema triphyllum* and *Arisaema dracontium*. *Am. Jour. Bot.* 9: 72-78. 1922.