

## SIAMESE TWINS OF ARISAEMA TRIPHYLLUM OF OPPOSITE SEX EXPERIMENTALLY INDUCED.\*

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In an article published several years ago, the writer† described a number of dichotomous twins of *Arisaema triphyllum* and *A. dracontium*, all of which showed a very decided similarity of vegetative and reproductive characters and were also exactly alike in sexual expression. Because the reversibility of sex in *Arisaema* had been previously definitely established, the exact correspondence of the sexual nature of these as well as of other identical twins was thus known to give no weight to the often assumed hypothesis that the similarity of sex indicates a differential hereditary basis for maleness and femaleness. The conclusion was thus drawn 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." The following statement was also made: "Although so far the writer has no evidence that *Arisaema* twins placed in different environments would develop the opposite sexual states in a 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."

In the meantime Maekawa‡ has shown that the sexual condition of *Arisaema japonica* is essentially the same as in *A. triphyllum* and can be controlled by experimental means.

A small carpellate plant, transplanted to the garden, developed a dichotomous cleavage of the bud and thus became the subject of the experiments described below. This carpellate plant, along with others, was taken from the forest in 1922 and placed in an experimental plot. In transplanting, both the roots and leaves were injured to such an extent that in 1923 it

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\*Papers from the Department of Botany, The Ohio State University. No. 166.

†SCHAFFNER, JOHN H. The Sexual Nature of Vegetative or Dichotomous Twins of *Arisaema*. Ohio Jour. Sci. 22: 149-154. 1922.

‡MAEKAWA, TOKUJIRO. On the Phenomena of Sex Transition in *Arisaema japonica* Bl. Jour. Coll. Agr. Hokkaido Imp. Univ. 13: 217-305. 1924.

produced only a vegetative shoot. But it now showed definite signs of twinning, having two similar leaves distinct from the very base. The leaf surface was somewhat reduced by cutting off the tips and the plant was kept in comparatively dry condition during the spring growing season.

In 1924, according to expectation, definite twin shoots were produced and both were pure staminate, according to the treatment given for the control of the sexual state. The two shoots were still united for the most part by the original corm. These identical twins were absolutely alike in size and vegetative and reproductive characters. The anthers were a conspicuous red. From appearances, it seemed probable that these Siamese twins would be united for another season, so a careful attempt was made so to control the food supply of the two growing buds that one would change to female while the other remained in the male state. The leaf surface of the one now staminate twin was much reduced while its brother was left intact with a normal leaf development. The twins were then treated with an abundance of water for some time, and carefully watched and cultivated so that differential physiological gradients might be established in the two forks of the corm and differential growth and food storage take place. Of course, it was not possible to apply any accurate quantitative treatment, since food could easily be transferred from one side to the other. It was merely a matter of judgment as to what should be done, gained from former experience in controlling the sex of *Arisaema*. The attempt was to develop just the proper balance that the one bud would just reach the condition to induce female determination and still keep the other one reduced sufficiently to continue it in the male state. It was, of course, recognized that too great a deprivation of food of the proper sort would cause a sterile shoot without inflorescence to develop.

In the spring of 1925, the results of the experiment were awaited with anxious anticipations of success or failure. For as intimated above, it was well known that success would depend on a very close margin in the control of the storage and transference of food in the two buds of the still united corm. But when the two "jacks" began to break out of their "pulpits," all proved to have been done properly. For the "Siamese twins" were one staminate and the other carpellate—male and female. The one treated for staminateness was staminate and the one treated for carpellateness was carpellate. The attempted

balance had been properly accomplished. The female condition was just intense enough to hold out to nearly the end of flower development on the carpellate spadix, maleness being only very slightly expressed at the very last stage. There were a small staminate flower and a vestigial flower at the top of the inflorescence. The staminate plant was pure in sexual expression and also according to expectation, was noticeably smaller in size than the carpellate twin. See the accompanying Figure 1. The staminate plant had the same characteristics as the

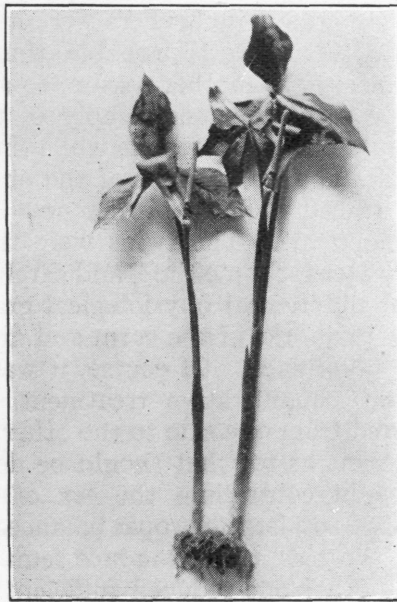


FIGURE 1.

Siamese twins of *Arisema triphyllum*, one male, the other female. Note the difference in size between the staminate and carpellate plants. The spathes have been folded back so as to expose the spadixes.

staminate shoots of the previous season, with bright red anthers. The stigmas of the carpellate flowers were green, while the anthers of the small staminate flower, according to genetic expectation were typically red. Outside of the difference in size of the two plants there was also some difference in the robustness of the peduncles, that of the carpellate plant being the larger. The vegetative hereditary characters were exactly alike and the "jacks" or sterile tips of the spadixes were both

green as they had uniformly been at all previous developments. The sexual dimorphism of the two spadixes, however, appeared quite prominent because of the decided difference in color between the anthers and stigmas.

The twins were now dug up and examined carefully and were found still to have a considerable connecting bridge of living tissue between the two forks of the corm. Here then we have a case of plant Siamese twins, originally of the same sex, in which opposite sexual states were induced by a carefully estimated control of the food supply produced in the leaves together with a proper water and nutrient supply from the roots.

As stated in the previous paper and confirmed by further observations, the dichotomous twins of *Arisaema* are normally of the same type of sexual expression, whether staminate, carpellate, or some degree of monociousness. It is only rarely that one finds twins, both those still united and those already separated but still growing side by side in the same intimate environment, that show some very slight difference in sexual development. Occasionally one can find carpellate twins for example in which one individual is pure carpellate and the other carpellate with one or two imperfect or perfect staminate flowers at the tip of the spadix.

It is established then, that sameness of sex in identical twins cannot be used as evidence for the hypothesis that sex is determined by heredity, nor for the supposition that identical twins have the same sex because they have the same heredity. Such a conclusion is unwarranted in any event, without additional support, because correspondence of phenomena does not establish a causal relation.

As is well known, in the nine-banded armadillo\* nearly every female gives birth to quadruplets and all in a given set of quadruplets are of the same sex, either four females or four males. This indicates as in the case with identical twins of other higher animals that sex is determined in the egg before any cleavage takes place. Differentiation processes are set up which establish the given sexual state so that no reversal under ordinary conditions takes place. And this may be further intensified by the differential presence of allosomes having a pronounced effect on the established physiological

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\*See "The Physiology of Twinning," p. 100. H. H. NEWMAN. The University of Chicago Press. 1923.

gradients. The continuity of the sexual states in the twinning process is, however, not different than its continuity in plants derived from cuttings in numerous higher species. Sexual conditions can become highly fixed through differentiation as well as can vegetative conditions. The primary cause of sex determination which starts a definite course of differentiation in the normal environment is undoubtedly the same in animals and plants, whether they have allosomes or not, since it is now known that both plants and animals with allosomes show sex reversal the same as those without such specialized chromosomes. There can be no question but that the sex of incipient twins, which have not passed through a differentiation cycle, is subject to reversal even more readily than that of mature or differentiated individuals. In the latter, dedifferentiation has been accomplished and the sex reversed in both plants and animals, by a proper manipulation of either the external or internal environment.

In conclusion, then, it can be stated that the sex of identical *Arisaema triphyllum* twins is normally the same, but that this does not at all imply that the sameness is due to a differential hereditary cause; since it is demonstrated that by a suitable manipulation of the environment, these identical twins, even after they have been developed as blooming plants and even while they are still connected by a considerable band of living tissue, can nevertheless be developed so as to be, simultaneously, the one a male and the other a female.