The Forms of Flowers in *Valeriana dioica*, L. By R. P. GREGORY, M.A.,
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SEWARD, F.R.S., F.L.S.)

(PLATE 8.)

[Read 17th December, 1908.]

IN 1877 Hermann Müller * described four forms of *Valeriana dioica*, L., distinguished one from the other by structural peculiarities of the flowers. The descriptions which Müller gave of these forms are:—(1) male, without the rudiment of a pistil, with the largest corolla; (2) male, with the rudiment of a pistil, with a rather smaller corolla; (3) female, with distinct rudiments of anthers, with a still smaller corolla; (4) female, with scarcely visible rudiments of anthers, with the smallest corolla.

A somewhat similar case of dimorphic male and female forms, occurring in *Rhamnus catharticus*, is described by Darwin †. A comparison of Müller's figures and descriptions with those of Darwin, suggests that Müller's first form of *Valeriana dioica* corresponds with what Darwin called the "short-styled male" of *Rhamnus*; the second form with the "long-styled male"; the third with the "short-styled female," and the fourth with the "long-styled female."

Darwin's description of the various forms of *Rhamnus* indicates that we are there dealing with a dioecious heterostyled plant. To work experimentally with such a plant as *Rhamnus* is out of the question, but it seemed likely that *Valeriana dioica* offered a parallel case, in which some results might be hoped for from experimental breeding. For several reasons the Valerian has proved unsatisfactory as a subject for experimental work, but during the past six summers numerous observations have been made upon the forms of flowers which occur in the species. It is with these observations that the present paper deals.

In May 1903, forty-six plants of *Valeriana dioica* were brought in for experimental purposes from Dernford Fen, near Cambridge, where they were growing wild. These and their offspring (which numbered about four hundred), together with numerous wild plants, which were examined from time to time at Dernford and Wicken Fens, form the material upon which the observations were made. I have no exact record of the total number of plants which I have examined, but it is well over a thousand.

Four fairly definite types of flower can be recognized among the plants

* "Das Variiren der Grösse gefärbter Blütenhüllen," Kosmos, Bd. ii. 1877, p. 131.

† 'Forms of Flowers,' p. 294 (in Reprint of 1892).

which have come under my notice. If suitable examples be chosen there is no difficulty in discriminating between these four types, but each type-form is connected with the next in the series by a number of intermediate forms, which so completely fill in the gaps between the types, that the latter can only be looked upon as the central forms of the groups in which it is convenient to arrange the various forms of flower*.

For the sake of convenience I have applied Darwin's terms of "long-styled" and "short-styled" to the two type-forms in the males, since these terms fairly describe the main point of difference between them. At the same time it must be pointed out that, in *Valeriana dioica*, there is no sharp discontinuity between the two forms, such as the use of these terms might, by analogy, seem to imply.

Among the female plants, I have found large numbers of plants which agree with the description of Müller's fourth class:—"Female, with scarcely visible rudiments of anthers"; but with regard to his third group there is some doubt. Perhaps it corresponds with those plants which it has seemed to me to be best to class as hermaphrodites.

In the following descriptions, therefore, the four groups are called: (1) short-styled male; (2) long-styled male; (3) hermaphrodite; (4) female. Of these the last is much the most easily recognized, and perhaps shows fewer transitional forms, if only for the reason that, in the production of pollen, one has a definite character which marks off the hermaphrodite. For this reason the description of this form is given first, and is followed by those of the other forms, in the reverse order to that used by Müller.

Female Plants.

The great majority of the female plants which I have examined have borne flowers which correspond well with the description of Müller's fourth type—"Female, with scarcely visible rudiments of anthers, with the smallest corolla."

These plants can be recognized readily by means of the small corolla and relatively inconspicuous flowers. The fully open flower measures about 4 mm. from the base of the inferior ovary to the tips of the petals. In such a flower the ovary will be about 2.5 mm. long, the corolla about 1.5 mm. long, while the style projects beyond the corolla-lobes for at least 1 mm. (Pl. 8. fig. 1).

These measurements are of course only roughly approximate; the more so as the relative sizes of the various parts vary very much as the age of the flower increases. In the newly opened flower, the style scarcely projects at all beyond the corolla, and the ovary is relatively short (figs. 3, 3a). As the

* Müller leaves open the question of the existence of forms intermediate between his types.

flower ages, the style undergoes marked elongation and the ovary increases rapidly in size.

The stamens of these flowers are the merest rudiments, in by far the largest number of cases, and are scarcely visible from above (figs. 3 *a*, 4). There is, however, considerable variation in this respect, not only as regards the flowers of different female plants, but also between different flowers of the same individual plant. Of course, the degree of visibility of the stamens depends to some extent upon characters, such, for instance, as the openness of the throat of the corolla, which have nothing to do with the stamens themselves. It depends, too, on the age of the flower, the stamens being somewhat more conspicuous in the young flower. But there is also a real variation not dependent on such factors as these, which is sufficiently great to render the stamens, in some cases, easily visible from above. The variation may be either in the size of the rudimentary anthers, or in the length of the filaments, or in both (see figs. 5, 6).

In the more extreme forms of this variation, the staminal rudiments are sufficiently obvious to give rise to some doubt as to whether the plants might not correctly be placed under Müller's third type—"Female, with distinct rudiments of anthers." Especially is this the case when this variation is accompanied by another, in the form of an unusually large corolla. The combined effect of masses of such flowers upon the general appearance of the flower-head is such that the plants could be picked out from the other female plants of more usual type, among which they were growing. The plants were therefore kept under observation for two or three years, when it became quite clear that no real line of separation could be drawn between them and the more usual types into which they grade.

Although such plants as these just mentioned cannot be separated from the females, on the other hand, in their more extreme forms (see figures 10, 11, 11 *a*, 11 *b*) they closely approach another type of flower which is hermaphrodite both in structure and function.

Plants with Hermaphrodite Flowers.

In making the records of the plants examined, I have included under the title "Hermaphrodite," all plants which produced pollen and indicated, by the continued growth of the ovary after the corolla had fallen and by the development of a pappus, the power to produce good seed. The possibilities of testing the seed produced by these plants were limited; the wild plants had already begun to set seed from the earlier flowers when they were transferred to the garden, but they suffered so much from the transplanting during their flowering period that only one plant ripened a few seeds, from which one seedling was obtained. Exceedingly poor harvests were obtained in all cases from plants which had been raised from seed in the garden, and

the two hermaphrodite plants were no better than the rest in this respect. In 1905 both plants were badly blighted, in 1906 one of the plants did set four seeds, in spite of the attacks of *Aphis*, but no seedlings were obtained. As, however, this result is hardly, if at all, worse than that experienced in the attempts to obtain seed from the ordinary females which were raised in captivity, it does not reflect on the power of the hermaphrodite plants to produce good seed under more favourable conditions.

There is, of course, some variation of flower-structure within the limits of this group of plants as defined above. Even so, the number of plants which fall within the group is very small. In the course of this work I have examined about a thousand plants, of which only eight belonged to the group in question. Two plants*, which I have included with the females, nearly approached this type in all characters but the production of pollen, while on the other side, the line between the hermaphrodite and the long-styled male forms is not always easy to draw, since it depends chiefly on the negative character of non-production of seed. At the most, however, this uncertainty only affects three plants which I have classed with the males. Of the eight hermaphrodite plants, five were found in the wild state at Dernford Fen, and three have appeared among the offspring obtained by breeding from them.

The flower of the most typical hermaphrodite form (figs. 14, 14*a*) has a somewhat larger corolla than that of the typical female flower. Neither the style nor the stamens project much beyond the corolla; the style bears stigmatic lobes at its apex, and the stamens contain pollen, though not always in very large quantity. Such plants as this might perhaps be considered to represent Müller's third type, although his description "with distinct rudiments of anthers" hardly seems to meet the case where good pollen is produced. On the whole, I think both his description and his figures of this type agree more closely with the more extreme forms which I have classed as females.

Among the hermaphrodite forms one meets with variations from the central type just described, approaching respectively the female and the male types. Examples of the former occurred among the offspring of a cross between a female plant and one of the wild hermaphrodite plants. From this cross, 25 offspring were obtained, of which 15 were female of the usual type, and 6 male. The remaining four were provisionally classed as hermaphrodite; two however failed to give pollen, and had to be placed among the females. It should be noted that these two plants (figs. 10-12) showed distinct structural similarities to the hermaphrodite type. The flowers were rather larger than in the typical female, the staminal rudiments were larger and easily visible, and showed a faint reddish tinge, in which they resembled the distinctly reddish young anthers of the hermaphrodite and male plants,

* See also p. 93 and Pl. 8. figs. 10, 11.

whereas the staminal rudiments of the females are colourless. Further, these two plants, together with the two hermaphrodites obtained from the same cross, were in flower on May 11, 1906, at a time when as yet the only other plants in flower were males.

Both the two hermaphrodite plants produced small quantities of pollen, which appeared to be good. The death of one of these plants, during the winter of 1905-6, prevented further observations on it. The other plant is shown in figs. 13, 13a. Although not very different from its sister plants, it had somewhat larger anthers, which showed the reddish tinge like that of the young anthers in male plants. Many of these anthers contained a small amount of pollen, but, on the other hand, those of other flowers of the same plant were devoid of pollen. These two plants therefore approach the female type very nearly.

One other hermaphrodite plant, raised by breeding from another cross, must be placed at the other end of the series of forms, approaching the type of structure shown in the long-styled males (see p. 96). In this plant (figs. 15-18), the corolla was as large as that of the ordinary male plants, the stamens were larger than in the typical hermaphrodite (and therefore very much larger than those of the plants just described), and the stigmatic lobes at the apex of the style were smaller. In 1906 this plant showed its hermaphrodite nature by producing some fruits.

One of the plants found growing wild was of a type almost exactly similar to this. It was used successfully as a male parent in some breeding experiments. These "Hermaphrodite" plants, then, constitute a series of forms, which may be grouped round such a form as that shown in fig. 14 as a central type, but on either side approach the neighbouring classes very closely.

Male Plants.

Müller divides the males into two classes: (1) those without the rudiment of a pistil, with the largest corolla; and (2) those with a rudimentary pistil, with a somewhat smaller corolla.

It may be said at once that, in all the males which have come under my notice, some rudiment of a pistil is present, though it may be scarcely half a millimetre in length, requiring careful dissection of the flower in order to expose it.

There is not, in my experience, any constant difference in the size of the corolla in the different types; and although the usually shorter ovary of the short-styled forms gives a higher value to the ratio (length of the corolla) : (length of the ovary), I have not found the size of the corolla any guide as to the nature of the flower. The point at which the stamens are inserted on the corolla-tube is so nearly the same in the different types, that I have not been able to discriminate between them in this respect. On the

other hand, in some cases the size of the ovary may be made use of. Thus in figs. 19 and 20 two sister plants are illustrated, the one long-styled, the other short-styled. In the former, the ovary of the central flower of the cyme in several cases reached, after the corolla had dropped, a length of 3 mm., and in one case was 3.6 mm. long (fig. 22) ; while the ovaries of the corresponding flowers in the latter plant were never more than 1 mm. long.

The male plants may be fairly readily divided, on inspection, into two classes, according as the style is visible from above, without dissection of the flower, or not. But this line of separation is a very rough one, since the degree of visibility of the style depends upon many other factors than its length, and is largely affected by such characters as the openness of the throat of the corolla, and the development of the hairs in the throat. Moreover, even in plants in which the style ultimately reaches some length, in the younger stages it is much shorter and often quite invisible from above. For these reasons such a line of separation would include, with the short-styled plants, many which, if the classes are to be retained at all, ought to be placed among the long-styled forms.

At an early stage of this investigation it became apparent that, under each of the two classes "long-styled" and "short-styled," more than one type of flower would have to be included. For convenience of recording, five forms were therefore chosen as types, and each plant was entered according to the type which it most nearly resembled. Of the five types A, B, C, D, and E (see figs. 32, 34-37 and explanation of Plate), A and B are long-styled, D and E are short-styled, and C is intermediate between the two. The lengths of the styles in the flowers referred to the different groups were approximately :—

Group A : 2 mm. and over.

Group C : 1.1-1.6 mm.

Group B : 1.4-1.9 mm.

Group D : 0.6-1.0 mm.

Group E : 0.5 mm. and under.

But a really nearer idea of the types may be given by saying that :—

In Group A, the style reaches nearly or quite to the top of the corolla-tube.

In Group B, the style is somewhat shorter, but reaches a point above the level at which the stamens are inserted on the corolla-tube.

In Group C, the style barely reaches the level of the insertion of the stamens.

In Group D, the style does not reach the level of the insertion of the stamens.

In Group E, the style is a very small rudiment.

Plants belonging to group A are easily recognizable, the style standing up prominently in the middle of the corolla-tube in the mature flowers (figs. 21, 23, 25). Plants belonging to the other groups are by no means so easily

recognized, for, since the style undergoes elongation while the flower is open, the younger flowers of each type tend to resemble the older flowers of the succeeding one. In addition, there is often considerable variation between the different flowers of the same plant *, apart from any differences due to the age of the flower. In practice, therefore, each plant was recorded as belonging to the group indicated by the structure of that flower which had the longest style, a large number of flowers from each plant being examined in each case, especially in the short-styled plants. It may be mentioned here that flowers of the type C (figs. 29, 35) were most frequently met with on plants which bore other flowers conforming to one or both of the long-styled types, although in one or two cases such flowers were found on plants which otherwise bore only flowers of the short-styled types.

While there is no doubt that the majority of the males can be separated into two groups, according to the length of the style, if care be taken to dissect several fully mature flowers, there is equally no doubt of the existence of a series of connecting forms. I do not wish to suggest that there is any true line of separation whatever between my groups A & B, and D & E, which were used merely for convenience in recording types intermediate between those described by Müller. That such types were of not infrequent occurrence is shown by the fact that of 60 † male plants recorded under this system,

21	were placed in Class A,
4	were recorded as intermediate between A & B,
8	were placed in Class B,
4	were placed in Class C,
6	were placed in Class D,
17	were placed in Class E.
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Not only are there connecting forms between the various types of male flower, but the long-styled males, in their extreme forms, approach the hermaphrodite type. Thus, one of the plants found in the wild state, which was classed as a long-styled male, had a very well developed style with distinct (stigmatic) lobes at its apex. Two other plants, offspring of a cross [Female × Long-styled male], in some of their flowers approached so nearly the hermaphrodite type, that they were distinguishable from the plant shown in figures 15-18 (which bore fruit) only in their somewhat smaller ovary and

* One very extreme case of this is referred to later (p. 98.)

† All the offspring of one cross are excluded from these figures, because continued examination of some of the plants has shown that such extreme variation occurs in the different flowers of the same plants, that the accuracy of the classes recorded for the remainder is laid open to doubt (see figures 32-37; and the description on pp. 98, 99).

in the fact that, in their young flowers, the style was not visible from above, whereas it was visible in all the open flowers of the hermaphrodite plant.

Finally, mention must be made of the variation which exists between flowers of the same individual male plant, quite independently of any differences which may be referred to the age of the flower. It is of course a common occurrence that different flowers of the same plant should show slight differences. Not infrequently these differences are more pronounced: thus, the plant shown in figs. 29–31 was classed in 1905, according to the flowers showing the longest style, as type B; in 1906, in the 7 flowers examined, the style scarcely exceeded that of type C. In 1907, this plant gave 16 flowers in which the style was visible from above; from 12 of these 16 flowers the anthers had already dropped, and the style was in most cases clearly visible; in the other four flowers the anthers still remained, and the fact that, in them, the style was only visible with difficulty, serves to illustrate the elongation of the style which takes place with age. But in 8 other flowers, the style could not be seen at all from above. Among the 24 flowers the measures of the $\frac{\text{length of the style}}{\text{length of flower over all}}$ varied from $\frac{1.7}{5.2}$, in an old flower in which the style was easily visible, to $\frac{1.0}{4.7}$, in a flower of similar age in which the style was not visible. The former is of type B, approaching type A; the latter scarcely more than type D.

A quite extreme case of the same kind is illustrated in figs. 32–37, which show the different types of flower encountered on the same plant on May 27, 1907. The range of variation is so remarkable that it is worth considering in detail. In 1905, this plant was classed as a short-styled male; in 1906, twelve flowers were taken from one inflorescence of the same plant; of these, ten were of the type E, two of the type D, while flowers taken from another spike showed similar characters. In 1907, the flowers borne on nine inflorescences of this plant were examined and measured. These inflorescences were numbered respectively A I–IV, B I & II, and C I–III. The four heads A I–IV bore flowers corresponding exactly with the description of 1906; some, or all, of the flowers borne on each of the remaining heads were long-styled, while in one case (B II) every type of flower from A to E was represented.

On the inflorescence B I, the flowers ranged between types B–D; the longest style measured 2 mm.,* the shortest was only half that length.

On the inflorescence B II, the range was even greater, viz. from A–E, the majority being B; the longest style recorded was 2.6 mm. in length, the shortest (fig. 37) only 0.4 mm.

* These measurements apply to the mature state; flowers in which the stamens had withered, or actually fallen, being chosen wherever available.

On the inflorescence C I, most of the flowers were of the types A & B, the styles ranging from 3.2–2.2 mm. in length, but one flower of the type D was found, whose style measured only 1.1 mm.

On the head C II, the only four flowers in a mature condition were all within the limits of the type A, while on the inflorescence C III, four flowers were of the type A, two between A & B, and one of the type B.

Similar, though less extensive, variations having been noticed in other plants, an analysis of several inflorescences was made, in an attempt to discover whether any phyllotactic or symmetrical arrangement of the different types of flower might be found to exist. The flowers in *Valeriana dioica* are borne in a series of opposite axillary cymes; in some cases there seems to be some suggestion that the shortest-styled flowers are generally borne in the lowest pair of cymes. In the spike referred to above as B I, long-styled flowers of the type B were present in all the cymes except the lowest pair. Of the flowers borne in this pair of cymes, only one approached type B; in the four other flowers the style reached respectively 1.2, 1.3, 1.0, and 1.2 mm. in length. That these were not simply young stages is shown by the fact that the anthers had dropped in each flower.

Again, in the inflorescence C I, one flower of the upper cymes had a short style (1.1 mm.), but the average length of the style in the remaining six flowers was 2.8 mm. In the two mature flowers on the lowest cyme the length of the style was only 2.2 mm.; and young flowers, of about the same age taken from the upper and lowest cymes gave, respectively, lengths of 2.0 and 1.6 mm.

In another plant, the flowers of one inflorescence were mostly of the type A, but two flowers of type B were found on the lowest pair of cymes; while on another inflorescence of this plant, in which most of the flowers were of the type B, a few found on the uppermost cymes were type A.

On the other hand, in the inflorescence B II, no sort of arrangement could be discovered. One cyme of the uppermost pair bore five flowers (in three of which the anthers had either withered or dropped), all of type E or D, the styles measuring from 0.4–0.6 mm. The corresponding cyme on the other side of the axis bore three flowers, one near type A, with a style 2.6 mm. long, and two of type D in which the longer style only measured 0.9 mm.

One other type of variation may be mentioned. In one plant all the flowers examined in 1905 had an unusually long corolla-tube below the spur (fig. 28). In these flowers the style measured from 1.8–2 mm. in length, and yet scarcely reached the level at which the stamens were inserted (fig. 28a). In later years this elongation of the tube was less marked and the plant bore several flowers of the type A.

Conclusion.

It appears that the individuals of *Valeriana dioica* may, for convenience, be arranged in classes, distinguished from one another by the relative development of the male and female reproductive organs, and to some extent by the size of the corolla. Each class consists of a number of plants which differ slightly from one another, but may be arranged around a central form, which may be taken as the type for the group. In each group the extreme forms approach very nearly the extreme forms of the neighbouring group or groups; and, while the central forms of each type are easily distinguishable from one another, there is absolutely no sharp line of separation between successive groups, although the intermediate forms occur in relatively small numbers. The wide range of variation shown by flowers of one individual, in certain cases, tends to emphasise this continuity of the series from type to type.

Whether the hermaphrodite plants described above may properly be regarded as a group, or whether they ought to be regarded simply as a series of transitional forms, is a debateable matter. It would be natural to suppose that in a species where the males are separable into two groups, according to the degree of development of the rudiments of the female organs, a corresponding line of division might be found in the sex in which these organs are functional. Müller's class of "Females with distinct rudiments of anthers" corresponds much more closely, I think, with certain forms which I have classed with the females, than it does with the hermaphrodite group; yet I think a separation of these forms from the commoner type of female would be extremely difficult to effect, and the boundaries of the two resulting classes would be even more ill-defined and artificial than they are in the males. On the other hand, the eight hermaphrodite plants would form a group most disproportionately small in comparison with the size of the other groups.

As regards the relative numbers in which the various forms occur, in the wild state at Dernford Fen the males appeared greatly to outnumber the females. On the other hand, of the plants obtained by breeding under cultivation, 298 were females, 3 hermaphrodite, and 65 males. Of the 298 females, 132 were obtained from crosses of which *all* the offspring were female. With regard to the apparent preponderance of males at Dernford Fen, two circumstances, both of which introduce a source of error into any counts which may be made, must be taken into consideration: first, that the flowering period of the males tends to be slightly earlier than that of the females (at any rate when the plants are cultivated in a garden), so that the counts might vary substantially, according to the season at which they were made; second, that, owing to the stoloniferous habit of the plant, the

more profusely branched male plant would tend to give rise, vegetatively, to a larger number of apparently separate plants than would the more compact female.

From what has been said above, it will be clear that *Valeriana dioica* is not a favourable subject for experimental work which requires the rapid and accurate determination of the characters of large numbers of offspring. Other sources of difficulty lie in the fact that the plant is a perennial, and frequently does not flower until the third year, and also in that plants raised from seed in the garden have, in my experience, generally proved weakly and very liable to the attacks of Aphis, rarely ripening any useful quantity of good seed. It has therefore been decided to abandon the experimental work begun in 1903. Below I give a summary of such results as have been obtained.

So far as they go, they indicate that:—

(1) The cross ($\text{♀} \times \text{♂}$ Long) may give, according to the individual plant used, either

(a) Both of the parental types, and no others. The total numbers obtained here were 62 ♀ , 23 ♂ L., or 2.52 : 1.

(b) Female only, no male offspring. Three crosses gave 116 ♀ , 0 ♂ .

(c) Two crosses of this type are recorded as giving three types of offspring, viz. 22 ♀ , 4 ♂ L., 5 ♂ Sh. But as these records were made before the great variation, which may occur in the flowers of the male plant, was fully realized, I do not wish to lay stress on them.

(d) Male offspring only, occurred in one cross, viz. 0 ♀ , 4 ♂ Long.

From the above figures the offspring of one cross are omitted, owing to the widely different types of flower borne on the same male plant (see pp. 98, 99, and figs. 32–37). This cross gave 7 ♀ , 9 ♂ .

Taking into consideration only the sex of the offspring, we find that the above crosses give, in the cases where both sexes appeared among the offspring, 84 ♀ , 32 ♂ , or 2.62 : 1.

(2) The cross ($\text{♀} \times \text{♂}$ Short) may give, according to the individual plant used, either

(a) Three types, viz. ♀ , ♂ L., and ♂ Sh. This occurred in one cross only, the numbers obtained being 30 ♀ , 10 ♂ L., 7 ♂ Sh.

(b) Both parental types, and no others. These occurred in the proportions of 37 ♀ , 10 ♂ Sh. (In one of the male plants the style was somewhat longer than usual, reaching type C.)

(c) Female only, no male offspring. One cross gave 16 ♀ , 0 ♂ .

Taking into consideration only the sex of the offspring, the above crosses give, in the cases where both sexes occur among the offspring, 67 ♀, 27 ♂, or 2.48 : 1.

Combining the results of all the above crosses in which both sexes occur among the offspring, the numbers obtained were 151 ♀, 59 ♂ (including both long- and short-styled), or 2.56 : 1.

(3) Hermaphrodite plants were only obtained in those crosses in which one of the parents was of that character. In one case the hermaphrodite plant was used as the female parent; one seedling only, an hermaphrodite, was raised. In the other case the hermaphrodite plant was the male parent; the offspring were 15 ♀, 2 ♀ approaching the hermaphrodite form (see p. 93, and figs. 10, 11), 2 ♂, 5 ♂ L., 1 ♂ doubtful (died without producing a sufficient number of flowers; those examined were short).

The most interesting fact shown by the above results is the large preponderance of females which occurs in the offspring. In each type of cross where the two sexes appear among the offspring, this preponderance is in the proportion of, roughly, 2.5 : 1. This ratio may, however, be affected by the power which this species appears to possess of producing seed in the absence of pollination. In the course of these experiments 30 inflorescences, borne upon 20 plants, were covered to prevent accidental pollination, and were left without artificial pollination. The majority of these spikes produced nothing, but from 5 of them 62 fruits were obtained, many of which indeed appeared empty, but others appeared good, and 11 seedlings have been raised from this harvest.

EXPLANATION OF PLATE 8.

The figures are from free-hand sketches drawn to scale from measurements of the flowers represented. The scale is the same for all the figures except Nos. 5, 6, 19, & 20. In figs. 5 and 6 the scale is twice, and in figs. 19 and 20 it is one half, that employed for the other figures. For the sake of clearness no attempt is made, in the figures showing flowers which have been dissected, to represent the hairs which occur in the corolla-tube.

Figs. 1 & 2. Female flowers in side view.

Fig. 3. Young female flower in side view; the style is not yet elongated. Fig. 3 a. The same flower seen after the corolla has been split up from the side.

Fig. 4. Diagram of a typical female flower as seen directly from above.

Figs. 5 & 6. Female flowers displayed by splitting up the corolla from the side, to show the variation in the form of the anther rudiments. (The magnification is twice that used for the other figures of female flowers.)

Figs. 7-9. Flowers of an abnormal female plant. The corolla is relatively very large, and, except in one flower, always divided into more than 5 lobes.

- Fig. 7. Side view of a flower showing supernumerary corolla-lobes. Fig. 7 *a*. The same flower after splitting the corolla. Fig. 7 *b*. View from above.
 Fig. 8. Flower with two separate styles, displayed by splitting the corolla. Fig. 8 *a*. View from above.
 Fig. 9. View from above of a flower with supernumerary corolla-lobes.

Figs. 10-12. Flowers of a female plant which approached the hermaphrodite type in the large corolla and the large staminal rudiments (see p. 93).

- Fig. 10. A young flower, in which the style had not yet elongated, displayed by splitting the corolla.
 Fig. 11. Side view; fig. 11 *a*, view from above, of a mature flower of the same plant. Fig. 11 *b*. The same flower after splitting the corolla.
 Fig. 12. Style from another flower of same plant, to show the splitting of the stigmatic lobes which occurred in many flowers.
 Fig. 13. Flower of a sister plant to the foregoing. The anthers were reddish in colour and produced a small quantity of pollen. Fig. 13, the same flower displayed by splitting the corolla; fig. 13 *a*, view from above.
 Fig. 14. Flowers of the typical "hermaphrodite" type. It may be noticed that the style does not much exceed the corolla-tube in length. The anthers produced good pollen in fair quantity. Fig. 14, side view; fig. 14 *a*, the same flower displayed by splitting the corolla.

Figs. 15-18. Flowers of an hermaphrodite plant which approached the form of the long-styled male flower.

- Fig. 15. A flower in which the anthers had not dehisced, displayed by splitting the corolla, to show the short style of the young flower.
 Fig. 16. Side view of a mature flower whose anthers had dehisced. Fig. 16 *a*. The same displayed by splitting the corolla.
 Fig. 17. Similar flower seen from above.
 Fig. 18. Ovary of a flower from which the corolla dropped.

Figs. 19 & 20. Cymes from two male plants, offspring of the same cross, one long-styled (type A), the other short-styled (type E), showing the marked difference in the size of the ovary of the central (oldest) flower of the cyme. In the left-hand flower of fig. 19, the long style is visible, standing up in the corolla-tube. (The magnification is half that used for the other figures of male flowers.)

- Fig. 21. A flower of the plant represented in fig. 19, displayed by splitting the corolla.
 Fig. 22. Ovary of central flower of cyme, the corolla having fallen, of the same plant.
 Fig. 23. Flower from another plant, displayed by splitting the corolla. The flower is of type A, but the style is rather shorter than in the plant represented in fig. 21.
 Fig. 24. Ovary of central flower of cyme of the same plant, for comparison with fig. 22.
 Fig. 25. Flower of the type A, from another plant, seen obliquely from above.
 Fig. 26. Ovary of a flower, the corolla having fallen, from the same plant. A comparison of figs. 22, 24 & 26 will show the variation in the size of the ovary which exists in different long-styled plants.

Fig. 27. Longitudinal section of the young bud of a flower of the type A. In the young bud the style only reaches to the level at which the stamens are inserted (*cf.* the preceding figures in which the style has reached to the top of the corolla-tube).

Fig. 28. Flowers from one plant showing unusual elongation of the corolla-tube *below* the spur. In these flowers, although the style reached a length of from 1.7 to nearly 2 mm., it was quite invisible from above, and, as shown in the long. sect. (fig. 28 *a*), it did not reach above the level at which the stamens were inserted. Subsequently this plant bore numerous flowers of the type A, and a few of the type B, in which the variation shown in these figures was not present.

Figs. 29-31. Flowers from a plant varying between types B & C.

Fig. 29. A flower of type C, displayed by splitting the corolla. This flower was well open and apparently about the same age as that shown in fig. 30, but not as old as that shown in fig. 31.

Fig. 30. A flower of type B, displayed by splitting the corolla.

Fig. 31. An old flower whose anthers had fallen, displayed by splitting the corolla; from the same plant as the two preceding.

Figs. 32-37 represent the various types of flower which were all borne on one male plant. All the flowers represented were fully mature, while the anthers had withered in that represented in fig. 33, and had fallen in that represented in fig. 37, which had the shortest style of all. (For full description see pp. 98, 99.)

Fig. 32. Type A.

Fig. 33. Type A, but with rather shorter style than the preceding.

Fig. 34. Type B.

Fig. 35. Type C.

Fig. 36. Type D.

Fig. 37. Type E.