

## „Some observations on the longitudinal growth of stems and flower-stalks”.

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Superficial observation already shows that in many cases the growth of stems, leaf- and flower-stalks is greatly dependent on the organs which they bear: buds, leaf-lamina, flowers. When these latter are removed the growth of the axial parts is generally arrested and they even die after a shorter or longer time.

In literature I have found no mention made of investigations, attempting to analyse this phenomenon more closely; e.g. in the case of flower-stalks, to find out whether excision of certain parts of the flower had as much influence on the growth of the stalk as the removal of the entire flower. I have now been able to make this out for some vernal plants by measurements of growth and I shall in what follows give a short account of the results.

I chose preferably flowers for this purpose, since here at the top of the same spindle organs of different physiological functions occur together and so the experiments admitted of greater variety. In one case, that of *Eranthis hiemalis* Salisb., I shall describe the course of the investigation and its results a little more in extenso; the other examples will be more briefly dealt with.

The stem of *Eranthis*, as will be known, bears at its top a single flower and close under it, united to a sort of broad collar, a whorl of three green sitting parted leaves.

As long as the stem is still under the ground, its top is sharply bent downward and the still perfectly closed flower is protected by the three leaves, still yellow then, by which it is enveloped, and hangs down. As soon as the top of the stem has come above the ground and also the flower has come free, this latter raises and soon unfolds itself; then the basal collar spreads out and turns green. The measurements of growth were made in the stage between the period when the stem is not yet visible above the ground and that, in which, after the petals and stamens have fallen off, only the fertilised pistils remain. About this time the longitudinal growth stops. Whether afterwards, during the ripening of the fruits, a new period of growth begins, as in other plants, I have not investigated.

The plants, serving for the investigation, were placed in a hothouse of the Botanical Garden at Amsterdam, in which the mean temperature was 20° C. and in which the specimens developed very rapidly and entirely normally.

I will first show by a few examples that the presence of the organs on the top is necessary in order to cause the stem to grow normally in length.

The stem of an *Eranthis* was on February 4, 1905, 40 mm. long, measured from the base near the rhizoma to the junction of the leaf-whorl. Placed in the hothouse the plant was at first measured daily, afterwards every other day; for briefness' sake I shall here only give the length reached by the stem after every four or five days.

Date	4.2.05	8.2	13.2	17.2	22.2	26.2
Length in mm.	40	89	135	154	162	162

In the same time the development of a stem on which leaves and flower had been cut away, was:

Date	4.2	8.2	13.2	17.2
Length	49	52	54	55

Another example of growth with a normal stem

Date	5.2	9.2	13.2	17.2	22.2	26.2
Length	44	98	128	145	150	150

and of a stem, bereft of leaves and flowers:

Date	5.2	9.2	13.2	17.2
Length	97	103	104	104

Whereas with normal *Eranthis*-stems the top with the flower on it, had in the hothouse after a couple of days, entirely erected itself, on the other hand the hook-shaped curvature of the stem without flower or leaf-whorl, partially remained and it was only very slowly that its extremity raised itself to some extent. This need cause no wonder, if it is remembered that the disappearance of this curvature is caused by asymmetrical growth of the top of the stem.

Now in a series of *Eranthis*-plants the organs on the top of the stem were only partly removed; e.g. the three green leaves, the petals, the stamens, the pistils. The length of the stems was measured from day to day. The result of these experiments has been very clear. As long as the green leaves remained undamaged, the growth of the stem might be called normal. At the utmost the stem remained a little below its normal length if the whole flower or certain parts of it were cut away. On the other hand the growth was very considerably impeded by removing the whorl of green leaves. This will be seen from the following measurements.

*Eranthis*-stem, on which only the three leaves under the flower have been preserved, the flower itself having been removed:

Date	7.2	11.2	15.2	19.2	22.2	26.2
Length in mm.	51	107	134	141	141	141

Another example of the same case:

Date	6.2	10.2	13.2	17.2	22.2	26.2
Length in mm.	58	104	129	135	135	135

*Eranthis*-stem of which the basal whorl has been cut away, the flower remaining intact:

Date	6.2	10.2	13.2	17.2	19.2
Length in mm.	86	96	97	100	100

Another example of the same case:

Date	7.2	11.2	15.2	17.2
Length in mm.	59	72	74	74

Hence a stem which had been bereft of its flower grew in length in a period of twelve days 176 % in the first and 133 % in the second experiment, this increase in length being only 16 % and 25 % respectively in the same time with a stem on which the flower had been preserved but the whorl of leaves removed.

The influence which the presence of the leaf-whorl has on growth follows clearly enough from this. Also in the other cases which I investigated, the growth of stems that bore flowers only, may have been a little greater than of stems from which the leaf-whorl as well as the flower had been removed, it is certain, however, that the longitudinal growth is chiefly regulated by the presence of the green leaves.

A related fact is that after removal of the leaf-whorl the flower raises itself only very slowly and often only partly.

Although the supposition is not very probable, it might be presumed that the observed effect of the three leaves is caused by the circumstance that they have to provide the stem with food. That this is not the case follows from the fact that the same results are obtained in the dark and that consequently the presence also of the non-

assimilating leaves renders a strong longitudinal growth of the stem possible, which does not occur if only the flower is preserved on the top. It will be superfluous to mention figures in this respect.

No more does it appear necessary to give in extenso the measurements proving that removal of the pistils, the stamens or the petals has with *Eranthis* little or no influence on the longitudinal growth of the stem. On the other hand it is not superfluous to remark that the leaf-whorl must be pretty completely cut away if we want soon to arrest growth. The three green leaves namely show basal growth themselves and if their foot is not damaged, this latter may appreciably grow in size in the course of a few days; at the same time the stem continues growing in length.

Example: foot of the three green leaves kept; also the flower intact.

Date	8.2	11.2	15.2	20.2	26.2
Length in mm.	54	81	113	145	145

Already on the 13<sup>th</sup> the leaf-whorl had considerably grown out; at the edge nothing of the nature of a wound could still be seen. In the same time a stem of 102 mm. length on which the leaf-whorl had been completely cut away, the flower remaining intact, had only reached a length of 117 mm.

If one should be inclined to think that not the presence of the whorl of green leaves but the intact condition of the junction of the leaves on the stalk is the principal point here, I must remark that of this junction-zone a layer of tissue may be removed all round without the longitudinal growth being materially affected. Also from the somewhat vaulted receptacle a part may be removed or the middle part may be hollowed without any other consequences than would ensue on the plucking off of the floral parts situated on it.

Finally we remark that *Eranthis*-stems, cut off near the junction on the rhizoma can continue growing for days when they are put with their feet in water and then show the same behaviour as whole plantlets. Besides, the presence of one out of the three green leaves is sufficient to render a considerable growth in length of the stem possible; e.g. lengthening from 53 to 89 mm. in two weeks. That also with *Eranthis*-leaves the growth of the leaf-stalk depends on the presence of the leaf-disk will now be obvious; I have ascertained myself of it by measurements, however.

*Galanthus nivalis* L. enables us to observe phenomena of a different kind in this same respect. With this plant also, the stem terminates in a single flower which, however, when it is fully developed and unfolded, hangs on a thin, limp, flower-stalk. This is implanted on the top of the stem, where also the coalescent bracts are found which enveloped the flower-bud before its unfolding. Hence we must here investigate the influence of the terminal organs on the growth of the stem as well as on that of the flower-stalk.

Concerning the longitudinal growth of the stem, we find that it is completely independent of the presence of the flower. A single example will suffice to show this. The stem was measured from the point where it appears from the bulb to the implantation of the bracts; these latter still surrounded the flower-bud; in *a* the plant remained undamaged; in *b* bracts and flower were cut away to the foot.

	Date	13.2	16.2	20.2	23.2	26.2
Length in mm.	<i>a.</i>	90	133	157	161	162
	<i>b.</i>	46	60	90	105	108

On the other hand, the growth of the flower-stalk stops as soon as the flower is removed. The influence of the flower on this organ is even so great that already after a

couple of days the stalk of cut flowers turns yellow at the top and soon dies from above downward. The measurements show that the ovary plays if not a preponderant, yet a considerable part here. So the flowers-stalks of flowers which already opened, grew from 28.2.05 to 6.3.05, in two cases from 16 and 14 mm. to 23 and 24 mm.; a flower of which the perianth was removed, in the same time from 17 to 21 mm., while two flower-stalks without their flowers measuring 20 and 14 mm. had reached 22 and 16 mm. the next day, but after that died off. Cutting the stamens has no great influence on growth; yet growth remains very small if stamens as well as perianth are removed, so that with *Galanthus* the ovary regulates the growth of the flowerstalk to a great extent but not exclusively. On the other hand the flower-stalk remains alive as long as the ovary is still present on its top.

Exactly the same behaviour is shown by *Narcissus Pseudo-Narcissus* L., where the stem continues growing when the flower is cut, but the flower-stalk stops growing and dies, if the ovary is wanting. I may add here that for the growth of the stem it makes no difference whether its top is cut above or below the swelling occurring at the point where the bracts and flower-stalk are implanted, so that this zone also has no importance for the growth of the parts under it. Also stems of *Galanthus* and *Narcissus*, cut in the basal part and hence separated from the bulb, or even parts of them, if they were taken from plants with their flower-buds still closed, continue to grow vigorously whether the flower-bud be present or not.

*Tulipa Gesneriana* L. shows something different again. Here the flower is born by a leafed stem; the internodes which are placed near the base stop growing sensibly towards the time that the flower becomes visible from the outside and is about to open. At this stage, however, the

upper internode with the flower at the top, still grows considerably in length. For this the presence of the flower is absolutely necessary. The upper portion of the stem is arrested in growth and gradually dies off as soon as the flower is cut off.

Example: *a.* flower present; *b.* flower removed. Only the upper internode measured.

	Date	6.3	8.3	13.3
Length in mm. <i>a.</i>	42	53	83	
<i>b.</i>	41	42	44	

From the following measurements the significance of the various floral parts may be seen:

- a.* perianth removed.
- b.* stamens removed.
- c.* pistil removed.

	Date	6.3	8.3	13.3
Length in mm. <i>a.</i>	36	41	45	
<i>b.</i>	46	63	70	
<i>c.</i>	41	51	68	

Although removal of each of the individual whorls of organs partly suppresses the growth of the upper internode, yet it is seen that the petals have the greatest influence here. The above is only an example chosen from several concordant measurements.

Finally some observations were made with *Crocus vernus* All. Since the ovary lies fairly deep here, hidden in the tube formed by the green leaves and the bracts round them, plants that had been cut open had to be used for the measurements, in which the flower was laid bare over its full length. For this purpose flowers were chosen

which were still surrounded by bracts and entirely closed and the top of which became just visible above the ground. It appeared, however, that at this stage the stem on which the flower is situated, had reached about its full length and only grew a few millimetres more. The further longitudinal growth, which is very considerable and brings the flower above the ground, is nearly wholly caused by the corolline tube between the ovary and the loose slips of the perianth. Only to this stage I paid attention. Some measurements of the corolline tube may follow:

- a. flower undamaged.
- b. corolline lobes removed.
- c. corolline lobes, stamens and pistil cut away at the upper end of the coalescent corolline tube.

	Datum.	8.3	9.3	11.3
Length in mm.	a.	46	101	108
	b.	55	84	84
	c.	31	72	72

So removal of the terminal organs has not remained without influence on the growth of the corolline tube, but has not been able to check it to the same extent as in the preceding cases.

It deserves notice that removing the anthers and stigmas did not prevent the stamens and styles to reach about their normal length.

Summarising the investigation has shown that the normal longitudinal growth of the stem with *Eranthis hiemalis* is only possible when the whorl of leaves at the top is present, while the flower exercises no influence on it. This latter is also the case with the stem of *Galanthus nivalis* and *Narcissus Pseudo-Narcissus*; the flower-stalk however, in these two plants, is checked in growth as soon as the

flower is cut, the ovary proving to be of especial importance. With *Tulipa Gesneriana* it is chiefly the perianth that rules the longitudinal growth of the upper internode; with *Crocus vernus*, finally, the growth of corolline tube, stamens and style is in a high degree independent of the presence of petal lobes as well as of anthers and stigmas.