

## Notes on the Irritability of the Stigma.

by

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With Plates XXVIII—XXIX.

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It is already known by the researches of Heckel\* and others that the bifid stigmas of certain plants, such as *Martynia*, *Bignonia*, and especially of some *Scrophularineæ*, e.g. *Mimulus*, *Torenia*, *Gratiola*, are irritable to touch. But as our knowledge on the subject is still scanty, it will not be superfluous here to state some of my observations on this subject. The plants I studied were *Mazus rugosus*, Lour., var. *macrantha*, Fr. et Sav., *Mimulus nepalensis*, Benth., *M. sessifolius*, Maxim., *M. moschatus*, Doug. I shall give in detail only the case of

**\*\* *Mazus rugosus*, Lour., var. *macrantha*, Fr. et Sav.  
(Pl. XXVIII, Fig. 1.)**

The plant belongs to *Scrophularineæ*, and may be briefly described as follows:—

A low annual. Branches prostrate, 5-40 cm. long, often rooted at the nodes. Leaves exstipulate, sparingly hairy, coarsely and irregularly dentate; the radical sessile, cuneate-spathulate, 1-4 cm. long, 0.5-1 cm. broad; those of the branches opposite, sometimes alternate, obovate, narrowed into the cuneate base, smaller than the radical leaves. Flowering stems, erect, more or less

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\* E. Heckel :—Du mouvement dans les stigmates bilobés des Scrophularinées, des Bignoniacées et des Sésamées. (Comptes rendus, t. LXXIX. 1874. No. 12, P. 702-704.)

\*\* The Japanese name of this plant is *Sagigoke*.

pubescent, 5-25 cm. high. Flowers distant; pedicels bracteate, minutely pubescent, 1-2.5 cm. long; bracts minute, scaly, acute. Calyx (Fig. 3) 5-lobed, campanulate, persistent, 0.7 cm. long; lobes ovate, acute, at length spreading. Corolla (Fig. 2) bilabiate, light blue or often deeper-coloured, sometimes snowy white. Upper lip erect, or curved upward, bifid at the apex. Lower lip deflexed, 3-lobed, 1-1.5 cm. broad and long; the two lateral lobes broader than the middle; its palate convex, beset with delicate hairs, whitish or yellowish, with yellowish brown or deep brown spots. Stamens (Fig. 2) 4, didynamous, inserted in the tube of the corolla, distinct at first, each pair connivent and adhering by the anthers at maturity; anthers whitish, 2-celled. Pollen-grains (Fig. 6) whitish yellow, elliptical, with 3 longitudinal grooves. Style (Fig. 3) longer than the stamens, ascending under the upper lip of the corolla. Stigma (Fig. 3) 2-lobed, lobes semicircular, 1 mm. long. Ovary superior, globose, 2-celled. Capsule compressed, loculicidal. Seeds numerous, minute, brown.

The plant is common everywhere, especially on sunny lawns, and bears flowers from early spring to mid-summer. When I happened to notice\* the irritable property of the stigma and began my observations early in April, I visited daily certain spots in the University grounds where I found the plant in profusion, some growing in positions very convenient for examination.

To observe the phenomenon, take the flower of this plant, and touch the lower lobe of the stigma with the point of a needle or the like; we shall then see the affected lobe move steadily upwards with uniform speed until it comes in close contact with the upper lobe (Pl. XXIX, Figs. 7, 8, 9). We may cause the same action with the least

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\* A few weeks after, I was informed by Mr. T. Yoshinaga of Tosa, of the same fact which he had himself observed.

possible touch as, for example, with the tip of a bristle or hair. On the other hand, placing a small drop of water on the stigmatic lobes or blowing upon them does not induce the motion. Again, mere rubbing on the style or on the outer surface of the lobes does not show even the least sign of motion, though a slight touch on the inner surface is very effective. Moreover, this curious property is not confined to the lower lobe only, as may at first sight appear, but it is possessed by the upper lobe as well. Since the lower lobe is widely reflexed, the motion there is very manifest; but the upper one being nearly in the same line with the style shows no decided motion other than a slight bending down.

I made these experiments on the natural position of the flowers, and measured the time required for the closing and reopening of the lobes. The results varied not only in the flowers of different stocks, but in different flowers of the same stock, even in the same flower in different stages of development, in different hours of the day, and also in different states of temperature and weather. Generally speaking, the closing and reopening in a given flower are more rapid at the middle of a clear warm day than at other times and in other states of weather. Complete closing is performed usually in 3-6 seconds, but may sometimes take 7, even 10, seconds. Complete reopening takes place usually after 7-12 minutes, but sometimes sooner, sometimes later. Some flowers which I examined on a very warm day, reopened only after 5 minutes. I also found that in young flowers, the closing is more rapid, while the reopening is much slower, requiring about 13-15 minutes. But in mature flowers, closing takes place in the usual interval of time, while reopening is quicker (7-10 minutes). In all cases the movement of closing may easily be observed, but that of reopening is so gradual that we cannot recognise it without careful observation. The experiments may be

repeated several times in a given flower apparently without any sign of decrease in irritability. The experiments may also be made on the plants kept in the house with just as good results as on those in their natural habitats. Of the flowers detached from the shoot, the same holds good as long as they are prevented from withering.

\*The stigmatic lobes, when magnified are seen to be made up of bundles of filaments (Pl. XXIX, Fig. 10, 11, loos. tiss.) composed of cells full of granular protoplasm. The filaments are very loosely aggregated, passing below to the closer conducting tissue (cond. tiss.) of the style. The inner surface (Fig. 10) of the lobe is quite naked but studded with many papillæ (pap.) or the clavate apices (clav. ap.) of the above-mentioned filaments, among which the pollen-grains (pol. gr.) take lodgement. The outer surface (Fig. 11), on the contrary, is loosely covered with a very thin layer of epidermis (directly continuous with that of the style), the cell-walls of which are more or less cuticularized and marked with minute longitudinal wrinkles (Fig. 11). Besides, there may be seen differences in the outlines of the component cells of the epidermis, as we pass from the lobes of the stigma (stig.) to the stylar portion (styl.) below—those of the former being irregular and sinuate, while those of the latter are almost rectangular.

As has been pointed out by Pfeffer, Sachs, and others, cells forming irritable parts of plants, when acted on by external stimulus, allow water to pass out of their protoplasm, thereby suffering diminution of volume; and this contraction affecting the extensive and elastic cell-walls makes the motion visible to the naked eye. This, I believe, may also explain the irritability in the present case,

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\* The structures of the style and stigma have been studied by J. Behrens. (*Untersuchungen über den anatomischen Bau des Griffels und der Narben.* Göttingen, 1875.)

although I am as yet unable to detect any decided structural peculiarity.

The following observations were made to ascertain the significance of the movement and to know in what relations, if any, it stands with respect to the visits of insects.

April 16, 17. Rainy. I visited certain spots where the plants were abundant. Many flowers were open. I saw no single insect near, and the stigmatic lobes of almost all the flowers were deflexed.

April 18. Clear warm day; 22°C. at noon. At one o'clock P. M. I went to the same places and found that many of the flowers had their stigmas closed. Soon I saw two or three bees come with a buzzing note. They alighted on some of the flowers, thrust their mouth-parts deep into the throat of the corolla which had honey stored in the basal part of the lower lip. In so doing the heads of the insects unavoidably struck against the open lobes of the stigma which at once closed. The heads were then thrust in deeper and came in contact with the anthers. In a few minutes they visited no less than a hundred flowers and then flew away.

At 3 P. M. On the same day I revisited the same places and found a similar occurrence.

At 6 P. M. Comparatively small number of flowers (about one-third) had their stigmas closed; no insects were flying about.

At 9 P. M. Dark night. The flowers did not close, and the stigmas were wide open.

April 19. Foggy morning. At 7 A. M. I saw the stigmatic lobes quite reflexed.

At 9 A. M. A few insects were found entering the flowers.

April 20. Clear but very windy day. At noon I visited

the same place without noticing a single insect, and most stigmas were open.

During these days I likewise examined the same species in the Botanic Garden of the University at Koishikawa, and found almost the same state of things.

In all cases I observed that those growing in shady places and those kept in the house had their stigmas always open, while those on open sunny lawns had the parts mostly closed,—the differences seeming to be due to the relative frequency or total absence of the insect-visitors.

These insect-visitors belong almost exclusively to the Hymenoptera, a species of *Eucera* (Pl. XXVIII. Figs. 4, 5) of Apidæ, identified for me by Dr. C. Ishikawa, being the chief visitor. The visit of this bee, however, is not confined to the flower of *Mazus*, for I often noticed that the insect burdened with yellow pollen dusts of other flowers, probably of *Taraxacum*, thrust its body into the lips of the flower smearing the stigma as well as the corolla with the golden yellow powder.

So far as my observation extends, I may conclude that the irritability of the stigma of this plant is not for the purpose of protection against wind and rain, of which the stigma may be tolerably well kept out by the overhanging upper lip of the corolla, but—as has been suggested by Hermann Müller\* in the case of *Mimulus luteus*—for a more important purpose, i.e. for cross-fertilization, which no doubt takes place in the following manner.

A bee laden with the pollen of one flower enters another flower of the same species for honey, and thus comes with its head in contact with the lower lobe of the stigma which just overhangs the

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\* Die Befruchtung der Blumen durch Insecten und die gegenseitigen Anpassungen beider. Leipzig, 1873.

stamens. Soon after the contact (by which the stigma receives the pollen), the lower lobe folds up, opening the way for the bee which then enters deeper and becomes dusted with a new supply of pollen. That reopening of the lobe takes place in about 10 minutes after the closing seems to be well adapted to the requirement of the case, when we consider the interval of time which usually elapses before the bee revisits the same flower. The usual deep bluish purple, or rarer snowy white, colour of the corolla serves no doubt to attract the insects, while the hairs on the floor of the lower lip seem to assist the visiting insects in alighting.

In *Mimulus nepalensis*, Benth., *M. sessifolius* Maxim., and *M. moschatus*, Dougl., all of which I have observed, the mechanism is precisely similar and adapted for the same purpose as *Mazus*, so that it is hardly necessary to enter into details.



## Explanations of Plates XXVIII and XXIX.

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### Indications of Reference Letters.

*u. l.*, upper lobe of the stigma ; *l. l.*, lower lobe of the stigma ;  
*sty.*, style ; *stig.*, stigma ; *loos. tis.*, loose tissue of the stigma ;  
*cond. tis.*, conducting tissue of the style ; *pap.*, papillæ ;  
*pol. gr.*, pollen-grains.

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### Plate XXVIII.

- Fig. 1.* *Mazus rugosus*, Lour., var. *macranthus*, Fr. et Sav. (natural size).
- Fig. 2.* Corolla cut open along the middle line of the central lobe of the lower lip, showing 4 didynamous stamens (magnified 3 times).
- Fig. 3.* Calyx cut open showing the pistil and its bilobed stigma (magnified 3 times).
- Fig. 4.* *Eucera sp.* which visits the flower of *Mazus*. (magnified 1.5 times).
- Fig. 5.* Upper and lower wings of the same, showing the veins (magnified 3 times).

### Plate XXIX.

- Fig. 6.* Pollen-grains in different positions (magnified 540 times).
- Fig. 7, 8, 9.* Stigmatic lobes in the successive stages of closing (magnified 22 times). *Fig. 7*, at the moment of a shock given. *Fig. 8*, after 3 seconds. *Fig. 9*, after 5 seconds.

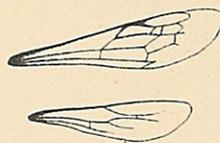
- Fig. 10.* Portion of the inner surface of the stigmatic lobe showing the papillæ or clavate apices of the loose filaments together with some pollen-grains developing pollen-tubes. The minute globules in the cells represent the granular aspect of the protoplasm (magnified 540 times).
- Fig. 11.* Outer surface of the stigmatic lobe together with a portion of the style; the epidermis is shown as broken along the middle line so as to show the loose tissue inside. The cells of the epidermis on the stigmatic portion are sinuous, those on the stylar portion nearly rectangular (magnified 230 times).



*Fig. 4*



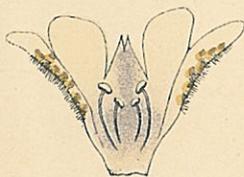
*Fig. 5*



*Fig. 1*



*Fig. 2*



*Fig. 3*



Fig. 10

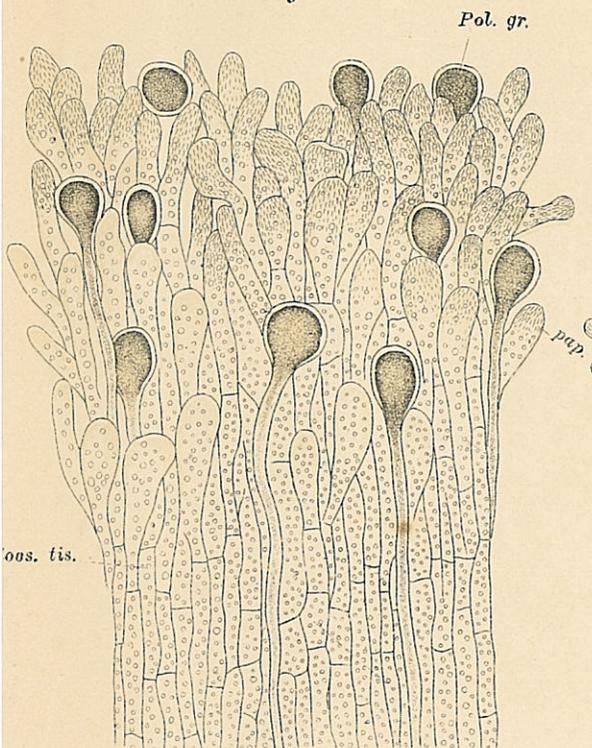


Fig. 11

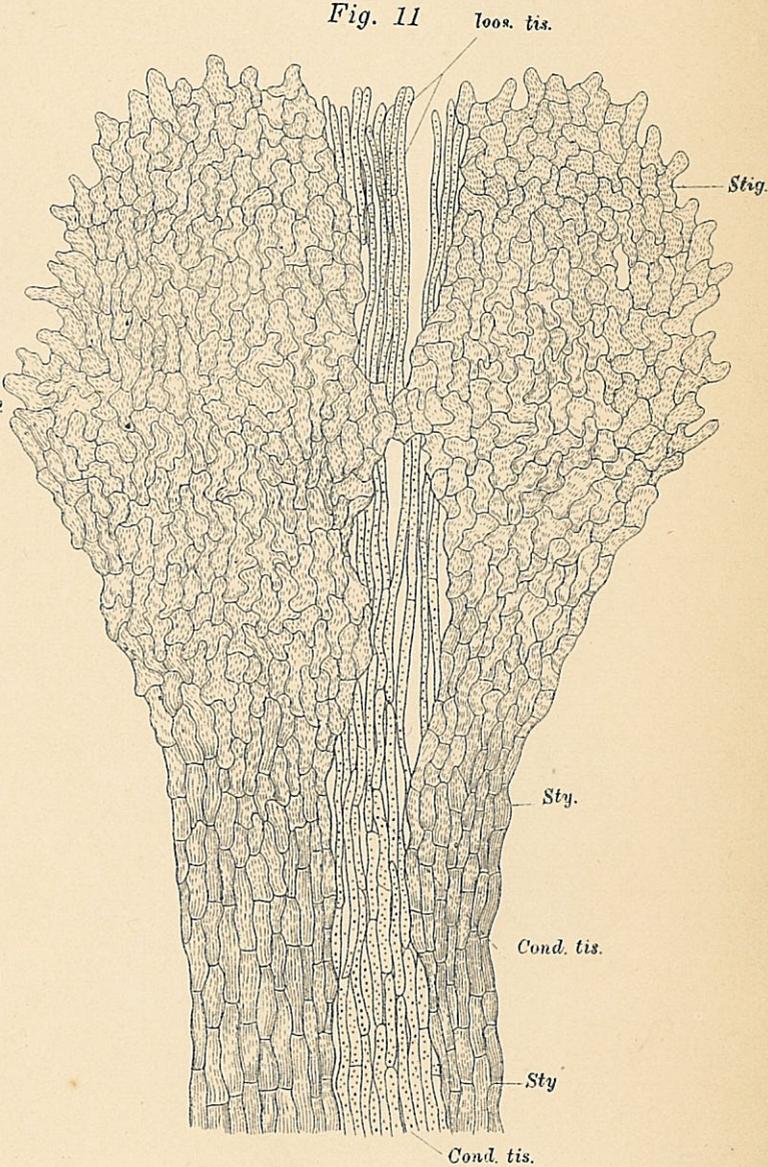


Fig. 9

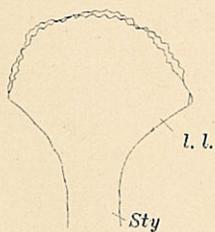


Fig. 7

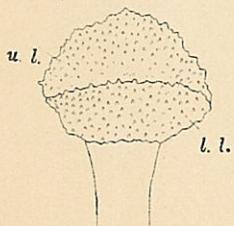


Fig. 8

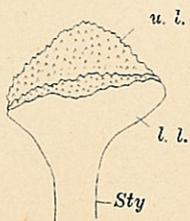


Fig. 6

