The Movements of the Stamens of *Portulaca grandiflora* (III)*

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In the previous reports (Part I¹⁾ and Part II²⁾) it has been stated that the *Portulaca* stamen was capable of making movements in any directions and that it was narcotized with the vapour of ether or chloroform. Therefore, it can be said that the movements of the stamen are biological phenomena. Hereinafter the effects of physical force applied to the stamen during its movement and the general structure of the filament will be reported.

As stated formerly the *Portulaca* stamen bends to the left (L_3 movement) and gradually restores to the 0° line (L_4 movement) after it was bent to the right²⁾. This time, experiments were made to stop the movement of the stamen with a glass rod.

Results and Discussion

1. *Experiments for stopping L_3 movements:* A stamen bending 90° to the right made a movement of about 40° to the left from the 0° line and restored gradually to the 0° line position. This is shown in the top graph of Fig. 1. Next, when a thin glass rod was placed at a point 10° to the left from the 0° line and stimulation was applied (bent to right) to the stamen, the stamen stopped at that point (10° from 0° line) and did not make any further L_3 movements. When the stimulation was repeated at 20° and 30° to the left from the 0° line, the stamen stopped at those points.

If the stamen is stopped during the L_3 movement by the method as described above, it remains there for a while. However, it begins to move gradually back to the direction of 0° line after a certain time. The time lapse between the moment of obstruction and the moment the stamen begins to move to the 0° direction is shorter if the angle between the 0° line and the filament at the point of obstruction is larger and *vice versa*. The movements of the stamen of *Portulaca grandiflora* described above are shown in Fig. 1. The graphical depiction of L_3 and L_4 movements of a stamen obstructed at 30° , 20° and 10° is given in the second, third and fourth graphs, while the top graph shows the normal L_3 and L_4 movements of a non-obstructed stamen. The curves in dash line in 3 bottom graphs indicate the normal movements of a non-obstructed stamen. Those graphs show that the artificially obstructed stamen starts to move after a certain time and that the movement thereafter follows the same curve as that of a non-obstructed stamen. This suggests that although the stamen which was stopped by a glass rod remained there for a while, the cells and tissues in the stamen were undergoing changes continuously as in the case of a non-obstructed stamen.

2. *Experiments for stopping L_4 movements:* When a stamen has completed its L_3 movement it stopped at 40° left from the 0° line. From that point began the L_4 movement to the 0° line. After a stamen completed the L_3 movement a glass rod was struttred to the filament from the right to keep the stamen in that posture (see

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Fig. 1. The movements of the *Portulaca* stamen when stopped artificially during the L_3 movement. The drawing in the upper right corner shows a glass rod stopping the L_3 movement of a filament; top graph, normal movement; 2nd graph, movement stopped at 30° ; 3rd graph, movement stopped at 20° ; bottom graph, movement stopped at 10° .

Fig. 2. The movements of the *Portulaca* stamen when stopped artificially during the L_4 movement. The drawing in the upper right corner shows the method to stop the L_4 movement; top graph, normal movement; middle graph, movement stopped for 15 sec.; bottom graph, movement stopped for 30 sec.

upper right corner of Fig. 2). Fig. 2 shows the L_4 movements of the stamen kept strutted at the end of the L_3 movement for 15 and 30 seconds according to the method described previously. The top graph and the curves in dash line in the two other graphs indicate the normal movements of a non-obstructed stamen.

From these graphs it is evident that by the artificial obstruction the stamen does not lose its motility. Further, there should be no internal changes of the filament other than normal. From these facts it is concluded that the movement is not only physical such as rebound movement, but biological.

3. *General structure of Portulaca stamen:* The filament of *Portulaca grandiflora* was observed by Haberlandt. He discovered papillae of epidermal cells and had made some sketches of them. He gave them the name "tactile papilla"³⁾ (Fühlpapille⁴⁾). But, the present author²⁾ has observed that the movement occurred even

Fig. 3. The surface of the filament of *Portulaca grandiflora*. The epidermic cell has papillate process. (magnification; a, $\times 40$; b, $\times 300$; c, $\times 800$)

Fig. 4. The papillate process at the base of *Portulaca* filament; a and b, near the base of the filament; c, the contents of a big papilla (n, nucleus; $\rightarrow$, direction of protoplasmic streaming).

when papillae were not touched at all.

Since stamens of *Portulaca* can make quite similar movements in water to those in the air and free stamens can also make movements as described before, free stamens in distilled water on a slide glass could be considered as a normal stamen. The photographs of Fig. 3 show the surface of the filament of *Portulaca grandiflora* in distilled water. Many papillae are shown in diverse magnifications. Papillae of the epidermal cells of filament are smaller near the top and bigger near the base.

Papillae of cells near the base are so big that sometimes it looks as if the entire cells were inflated (Fig. 4). The epidermal cell consists mostly of cell sap and protoplasmic streamings are evident. The speed of the streaming is about 3.4μ per second and the type of the streaming resembles that of the hair of *Tradescantia* stamen. Small grains scattered within the protoplasm were not found moving together with those streamings.

The inner tissue of the filament possessing cells arranged lengthwise in the form of a tube, is surrounded by about 20 of those papillae. There within is parenchyma consisting of small cells. In the center there are phloem and xylem. Details about the structure of the filament will be described in the later report.

Fig. 5. Existence of gaseous substance within the filament; a, picture of the normal filament in distilled water; b and c, big bubbles made by pressing with the finger; d, bubbles pressed out of the filament at the cut end.

It is very interesting that there is a gaseous substance within the *Portulaca* filament. When a filament imbedded in water is observed through the microscope the central part has a black luster. So, the structure of the inner part of the filament is hard to be seen. When such filament is pressed with the right pressure on the cover glass there appear big bubbles here and there within the filament. Picture a of Fig. 5 shows a filament imbedded in distilled water. Pictures b and c show big bubbles made by pressing with finger. These bubbles could be pressed out of the filament into the water (Fig. 5d). If these bubbles are thus pressed out, the filament becomes almost transparent and the cells and tissues can be clearly seen. There is a considerable amount of gaseous substance confined within the filament. It is thought that this gaseous substance is normally scattered among the cells of the parenchyma such as in the *Mimosa* leaf⁵⁾ and that it has some relation to the movements of the stamen of *Portulaca grandiflora*.

Summary

After the *Portulaca* stamen is stopped artificially during its movements, it keeps ability making its original movement in its original pace (Figs. 1 and 2). This shows that during the obstruction the internal changes of the cells and tissues of the fila-

ment take place just as in a normal movement.

The epidermal cells of the filament have papillae. The papillae of the cells at the base of the filament are very big and in this big papilla the protoplasm makes streaming movement. The speed of it is about 3.4μ per second (Figs. 3 and 4).

There is a gaseous substance within the filament. The author thinks that the gaseous substance is scattered in the intercellular space of the parenchyma and that it has some kind of relations to the movements of the *Portulaca* stamen (Fig. 5).

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References

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摘 要

岩 波 洋 造: マツバボタンの雄ずいの運動 (III)

マツバボタンの雄ずいは、刺激と反対の方に曲がる運動を行なう (L_3) が、この曲がった雄ずいは、やがて静かにもとの位置にもどりはじめる (L_4)。これらの運動の途中に細いガラス棒をおいて雄ずいの動きを妨げ、それぞれの場合の運動のしかたの変化について調査した。

L_3 の運動の途中にガラス棒をおいて雄ずいの動きを妨げると、雄ずいはそのまましばらく止まっていたが、一定時間が過ぎるとガラス棒から離れて、もとの位置にもどりはじめた。このばあい、運動が早い時期に止められるほど、ふたたび動きはじめるまでの時間は長く、おそくになって止められるほど、早く動きはじめた。

L_4 の運動が始まろうとするとき、ガラス棒でそれを妨げ、しばらくしてこのガラス棒を離すと、雄ずいは急に一定距離の間を動き、やがて静かに本来の L_4 の運動に移った。これらのことは、雄ずいは運動の途中で、物理的にその動きが妨げられても、運動の原因となる花糸の内部の変化は、運動を行なっているときと同じように進行していることを示している。

花糸の表皮細胞には小さな突起がある。ただし、花糸の基部の細胞の突起はたいへん大きく、ときには細胞全体がふくれたような形態をとっていて、このような大きな突起の内部には原形質流動がみられた。流速は約 3.4μ /秒であった。

花糸のなかには、ある種の気体が含まれている。この気体は正常のときには花糸全体に散在しているらしく、そのために花糸を水で封じてみると、表皮細胞以外の部分は全体が黒ずんでいて細胞や組織の形がみえないが、花糸を軽く押えたと内部に大きな気泡ができてきて、気泡以外の部分は透明になってくる。この気泡は、花糸の切り口から外にとりだすことも可能である。この種の気体の存在は、オジギソウの葉においても知られているので、運動の機構とある種の関係をもっているのではないかと考えられる。(横浜市立大学生物学教室)