

## ON THE ABSORPTION OF NUTRIENT MATERIAL BY THE LEAVES OF SOME INSECTIVOROUS PLANTS.

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IN a report\* of Dr. Balfour's interesting and important experiments recently read before the Botanical Society of Edinburgh, occurs the following passage in reference to the absorption of insects and other nutrient material by the leaves of the *Dionæa Muscipula*. "The notion that any nourishment was obtained from insects so enclosed has been controverted; but Dr. Balfour pointed significantly to the fact that young plants of *Dionæa* under bell-glasses had not been found to thrive so well as those left free, and that while a piece of beef in another leaf became putrid, a piece enclosed by the *Dionæa* remained perfectly fresh and inodorous, but soon lost its red colour, and was gradually disintegrated more and more until it was reduced to pulp." Thus not only does the proof of absorption by the leaves of insectivorous plants rest upon indirect or unsatisfactory evidence,† but considerable diversity of opinion appears to exist upon the subject, and it was in hopes that some conclusive proof might be obtained and all doubt removed that the following experiments were made.

### SERIES I.—*Drosera rotundifolia*‡ and *D. intermedia*.

*Locality*.—An unlimited supply of these plants could be obtained from some marsh land in the New Forest, a few miles from Southampton, where the following experiments were carried on.

*Method of preparation*.—In these experiments the delicacy and certainty of the spectroscopic test for lithium was made use of,§ and the lithium applied to the plants by means of flies, which, after their wings and legs had been removed, were macerated in a strong solution of citrate of lithium, cut up into suitable sized pieces and placed upon those leaves which had been selected and prepared to receive them.

By placing the plants in the pots rather higher than the surrounding earth, the leaf-stalks could easily be brought into a horizontal position or caused to bend downwards towards the blade of the leaf, at a considerable angle from the plant, thus lessening the possibility of the lithium getting on the leaf-stalk: when necessary the leaves were retained in this position by peculiarly shaped pins.

When the plants had been thus potted and supplied with prepared flies, they were one by one put into a zinc tank about two inches deep, with half an inch of water on the bottom, and enclosed by a fine gauze cage, thus preventing insects getting in and carrying the lithium on to other parts of the plant. For further protection this was kept in an open greenhouse where the temperature was but little above that of the air outside.

\* "Pharmaceutical Journal," July 3, 1875.

† The above was written before I was aware of the publication of Mr. Darwin's work on Insectivorous Plants.

‡ *D. rotundifolia* has been mostly employed in these experiments on account of its larger and more conveniently shaped leaves.

§ Other methods have been tried, but this has proved the most successful.

Each pot was marked by a letter, and every prepared leaf had a number stuck by the side of it, corresponding with which notes were made. The time was observed at the beginning and end of the preparation of each plant.

*Method of examination.*\*—The time elapsing between the preparation of the plants and their examination was found by successive trials to be the best when between 45 and 50 hours, which was therefore adopted. At the expiration of this time they were taken, plant by plant, and leaf by leaf, in the order in which they were prepared, and the stalks of the prepared leaves were first severed at the plant-end by a fine pair of scissors; next, the blade of the leaf with the remains of the fly was cut off, and then the stalks after being washed with distilled water were dried in linen. Their length in centimetres were also found, so that the distance the lithium had travelled through the stalk from the leaf-end could be ascertained, and finally its plant-end was introduced into a gas flame burning in front of a direct-vision spectroscope, when the presence of the lithium was revealed by its characteristic spectrum.

*Explanation of the Table.*—For convenience the results thus obtained have been tabulated; on the left-hand side are the particulars of the preparation of the plant, and on the right hand those of their examination. The fourth column on the right-hand side contains a list of various parts of the plants which were examined for lithium absorbed from the flies placed on the prepared leaves of the plant. The distance in mms. from the plant-end of the prepared leaf-stalks to the point where the lithium was found, is given in the third column. The remainder appears to require no explanation.

Series I.—All *D. rotundifolia* except P and U, *D. intermedia*.

*Preparation.*

*Examination.*

| Time.      | Plant. | Distinguishing number of prepared leaves. | Citrate of Lithium how applied to the leaves. | Time.      | Length of prepared leaf-stalk in cms. | Distance from the plant at which Lithium was found, in millimetres. | Other parts of the plants examined for absorbed Lithium. | Where absorbed Lithium was found. |
|------------|--------|---|---|------------|---------------------------------------|---|--|-----------------------------------|
| July 13th. |        |   |   | July 15th. |                                       |   |  |                                   |
| 7.58 p.m.  | A      | 1   | fly   | 2.25 p.m.  | 2 cms.                                | 5 mm.   | One old & Young leaf.<br>1 young leaf.                   |                                   |
|            |        | 2   | ...   |            | 2 cms.                                | 3.5 mm.   |  |                                   |
|            |        | 3   | ...   |            | 2.1 cms.                              | † 0 mm.   |  |                                   |
| 8.2 p.m.   |        | 4   | ...   | 2.45 p.m.  | 2.3 cms.                              | 5 mm.   |  |                                   |

\* There were two series of experiments commenced early in June on the *Droseras* before that which is here given as Series I., in order that the best conditions of success might be ascertained. I hope that at some future time I shall be able to arrive at some accurate results as to the rate at which absorption takes place.

† 0 mm. signifies that it had reached the extremity of the plant-end of the stalk.

‡ The parts of the plants here mentioned were all washed in distilled water and dried in linen previous to examination.

| Time.<br>July 13th. | Plant. | Distinguishing number<br>of prepared leaves. | Citrate of Lithium how<br>applied to the leaves. | Time.<br>July 15th. | Length of prepared<br>leaf stalk in cms. | Distance from the<br>plant at which Lithium<br>was found, in millimetres. | Other parts of the<br>plants examined for<br>absorbed Lithium. | Where absorbed Li-<br>thium was found. |
|---------------------|--------|--|--|---------------------|--|---|--|--|
| 8.3 p.m.            | B      | 5  | fly  | 2.45 p.m.           | 1.5 cms.                                 | 0 mm.   | Young leaf   | Young leaf                             |
|                     |        | 6  | ...  |                     | 1.4 cms.                                 | 0 mm.   | stalk.   | stalk.                                 |
| 8.6 p.m.            |        | 7  | ...  | 2.51 p.m.           | 1.3 cms.                                 | 0 mm.   |  |  |
| 8.7. p.m.           | C      | 8  | fly  | 2.51 p.m.           | 1.3 cms.                                 | 0 mm.   | Flower   | In both.                               |
|                     |        | 9  | ...  |                     | 1.5 cms.                                 | 0 mm.   | stalk and  |  |
|                     |        | 10   | ...  |                     | 2.3 cms.                                 | 0 mm.   | leaf bud.  |  |
| 8.11 p.m.           |        | 11   | ...  | 3.0 p.m.            | 1.8 cms.                                 | 0 mm.   |  |  |
| 8.12 p.m.           | D      | 12   | fly  | 3.0 p.m.            | 2.15 cms.                                | 0 mm.   | Leaf stalk   | In both.                               |
|                     |        | 13   | ...  |                     | 1.5 cms.                                 | 0 mm.   | and flower   |  |
|                     |        | 14   | ...  |                     | not<br>measured                          | about $\frac{1}{2}$<br>down the   | stalk.   |  |
| 8.16 p.m.           |        | 15   | ...  | 3.11 p.m.           | 1.6 cms.                                 | 0 mm.   |  |  |
| 8.15 p.m.           | E      | 16   | fly  | 3.11 p.m.           | 2.4 cms.                                 | 0 mm.   | 2 very small   | Flower                                 |
|                     |        | 17   | ...  |                     | 2.5 cms.                                 | 0 mm.   | leaf buds,   | stalk and 2                            |
|                     |        | 18   | ...  |                     | 2.5 cms.                                 | 0 mm.   | flower stalk,  | leaf stalks.                           |
| 8.23 p.m.           |        | 19   | ...  | 3.30 p.m.           | 2.7 cms.                                 | 0 mm.   | and 2 leaf<br>stalks.  |  |
| 8.22 p.m.           | F      | 20   | fly  | 3.30 p.m.           | 3.0 cms.                                 | 0 mm.   | Young leaf   | Young leaf                             |
|                     |        | 21   | ...  |                     | 2.3 cms.                                 | 0 mm.   | and stalk.   | and stalk.                             |
|                     |        | 22   | ...  |                     | 2.5 cms.                                 | 0 mm.   |  |  |
| 8.28 p.m.           |        | 23   | ...  |                     | not measured                             | 0 mm.   |  |  |
|                     |        | 24   | ...  | 3.48 p.m.           | 2.5 cms.                                 | 0 mm.   |  |  |
| 8.30 p.m.           | G      | 25   | fly  | 3.48 p.m.           | 1.7 cms.                                 | 0 mm.   | A large  | Leaf stalk.                            |
|                     |        | 26   | ...  |                     | 1.5 cms.                                 | 0 mm.   | sized leaf   |  |
| 8.32 p.m.           |        | 27   | ...  | 3.51 p.m.           | 1.5 cms.                                 | 0 mm.   | stalk.   |  |
| 8.35 p.m.           | H      | 28   | fly  | 3.51 p.m.           | 2.5 cms.                                 | 0 mm.   | A large leaf   | Leaf stalk.                            |
|                     |        | 29   | * Solu-  |                     | not measured                             | 0 mm.   | stalk.   |  |
| 8.39 p.m.           |        | 30   | tion fly,  | 4.5 p.m.            | 2.2 cms.                                 | 0 mm.   |  |  |
| 8.43 p.m.           | I      | 31   | Spider   | 4.5 p.m.            | 2.1 cms.                                 | 0 mm.   | Very young   | Both.                                  |
|                     |        | 32   | fly  |                     | 2.3 cms.                                 | 0 mm.   | leaf bud   |  |
|                     |        | 33   | ...  |                     | 2.0 cms.                                 | 0 mm.   | and full-  |  |
|                     |        | 34   | ...  |                     | 2.1 cms.                                 | 0 mm.   | grown leaf.  |  |
| 8.46 p.m.           |        | 35   | ...  | 4.17 p.m.           | 2.4 cms.                                 | 0 mm.   |  |  |
| 8.49 p.m.           | J      | 36   | fly  | 4.17 p.m.           | 2.0 cms.                                 | 0 mm.   | Flower, stalk,   | All,                                   |
| 8.50 p.m.           |        | 37   | ...  | 4.24 p.m.           | 2.0 cms.                                 | 0 mm.   | leaf and stalk.  |  |
| 8.52 p.m.           | K      | 38   | fly  | 4.24 p.m.           | 2.5 cms.                                 | 0 mm.   | Leaf stalk, bloss-   | Stalk blossom                          |
| 8.54 p.m.           |        | 39   | ...  | 4.31 p.m.           | 2.5 cms.                                 | 0 mm.   | om and stalk<br>and bud.                                       | and bud.                               |
| 8.58 p.m.           | L      | 40   | fly  | 4.31 p.m.           | 2.1 cms.                                 | 0 mm.   | Leaf stalk.  | Leaf stalk.                            |
|                     |        | 41   | ...  |                     | 2.5 cms.                                 | 0 mm.   |  |  |
| 9.0 p.m.            |        | 42   | ...  | 4.38 p.m.           | 2.3 cms.                                 | 0 mm.   |  |  |

\* In a former series a fragment of citrate of lithia placed on a leaf was also absorbed.

| Time.<br>July 13th. | Plant. | Distinguishing number<br>of prepared leaves. | Mode of Lithium how<br>applied to the leaves. | Time.<br>July 15th. | Length of prepared<br>leaf stalks in cms. | Distance from the<br>plant at which Lithium<br>was found in millimetres. | Other parts of the<br>plants examined for<br>absorbed Lithium. | Where absorbed Li-<br>thium was found. |
|---------------------|--------|--|---|---------------------|---|--|--|--|
| 9.2 p.m.            | M      | 43   | fly   | 4.38 p.m.           | not measured                              | 0 mm   | 3 leaves<br>and stalks.  | One leaf<br>stalk.                     |
|                     |        | 44   | ...   |                     | 2.0 cms.                                  | 0 mm.  |  |  |
|                     |        | 45   | ...   |                     | 2.5 cms.                                  | 0 mm.  |  |  |
| 9.4 p.m.            |        | 46   | ...   | 4.54 p.m.           | 2.3 cms.                                  | 0 mm.  |  |  |
| 9.11 p.m.           | N      | 47   | fly   | 4.54 p.m.           | 1.5 cms.                                  | 0 mm.  | 9 leaves and<br>stalks 1 bud & 1<br>flower stalk.              | In all.                                |
| 9.12 p.m.           |        | ...  | ...   | 5.4 p.m.            |   | 0 mm.  |  |  |
| 9.12 p.m.           | O      | 48   | fly   | 5.43 p.m.           | 3.0 cms.                                  | 0 mm.  | Young<br>leaf and<br>stalk.                                    | In both.                               |
|                     |        | 49   | ...   |                     | 3.0 cms.                                  | 0 mm.  |  |  |
|                     |        | 50   | ...   |                     | 3.1 cms.                                  | 0 mm.  |  |  |
| 9.14 p.m.           |        | 51   | ...   | 5.52 p.m.           | 2.5 cms.                                  | 0 mm.  |  |  |
| 9.21 p.m.           | P      | 52   | fly   | 5.25 p.m.           | 2.5 cms.                                  | 0 mm.  | Young leaf<br>and stalk.                                       | All.                                   |
| 9.23 p.m.           |        | 53   | ...   |                     | 3.0 cms.                                  | 0 mm.  |  |  |
|                     |        | 54   | ...   | 5.30 p.m.           | 2.1 cms.                                  | 0 mm.  |  |  |
| 9.26 p.m.           | U      | 55   | fly   | 6.0 p.m.            | 3.0 cms.                                  | 0 mm.  | Flower<br>stalk, bud<br>and stalk.                             | All.                                   |
|                     |        | 56   | ...   |                     | 3.0 cms.                                  | 0 mm.  |  |  |
|                     |        | 57   | ...   |                     | 3.5 cms.                                  | 0 mm.  |  |  |
|                     |        | 58   | ...   |                     | 2.5 cms.                                  | 0 mm.  |  |  |
|                     |        | 59   | ...   |                     | not measured                              |  |  |  |
| 9.32 p.m.           |        | 60   | ...   |                     | lost                                      |  |  |  |
| 9.38 p.m.           | V      | 61   | fly   | 6.12 p.m.           | 3.8 cms.                                  | 0 mm.  | Flower<br>stalk.<br>(8 cms<br>high)                            | Flowers<br>and stalk.                  |
|                     |        | 62   | ...   |                     | 3.4 cms.                                  | 0 mm.  |  |  |
|                     |        | 63   | ...   |                     | 3.9 cms.                                  | 0 mm.  |  |  |
|                     |        | 64   | ...   |                     | 3.4 cms.                                  | 0 mm.  |  |  |
| 9.41 p.m.           |        | 65   | ...   |                     | 6.21 p.m.                                 | 3.5 cms.   |  |  |
| 9.45 p.m.           | W      | 66   | fly   | 6.21 p.m.           | 3.5 cms.                                  | 0 mm.  | 3 leaves and<br>stalks.<br>Flower<br>stalk.<br>and 2 buds.     | All.                                   |
| 9.46 p.m.           |        |  |   |                     |   |  |  |  |

*Remarks on the experiments of Series I.*—The possibility of the lithium getting on to the earth from the leaves and thence to the roots of the plants in the experiments already described appears to be very small, and, moreover, in an experiment in Series I, a portion of earth taken from the roots of the plant showed no lithium when examined with the spectroscope. In another experiment (of a former series) two *Droseras* were growing so close together that it was diffi-

cult to assure one's-self that they were two distinct plants; on some leaves of one were placed prepared flies, but *none* on the other. When examined the one plant contained lithium, but the other did not contain a trace; if the lithium had been absorbed by the roots and not by the leaves, could this have occurred? It was to remove this possible doubt that the experiments of Series II. were instituted.\*

SERIES II.—*Drosera rotundifolia* and *D. intermedia*.

*Locality.*—The same as before.

*Method of preparation.*—The plants experimented upon in this Series were mostly those which were obtained growing in *Sphagnum*, so that it was easily removed and the roots of the *Droseras* were left uninjured.

Six half-ounce wide-mouthed bottles were procured, and a corresponding number of wooden stands constructed with holes in the centres, and of such a height as to allow the necks of the bottles underneath them to stand about 1.5 cms. above the surrounding surface. Over the necks were placed blotting-paper cones made from discs six cms. in diameter, secured in this position by pins; the roots of the plant then dipped into the water in the bottles through holes at the summits of the cones. The water lost by absorption and evaporation was replaced when necessary with a dropping-tube ending in a long and fine point.

*Method of examination.*—When the plants were examined the prepared leaves were cut off, and then the cones and the plants were placed in saucers, whilst the water from the bottles was poured into evaporating dishes and reduced to a few drops. The cones were examined with the spectroscope, as also were the various parts of the *Droseras*, after being washed in distilled water and dried in linen.

The cones were employed, firstly, to prevent the lithium running from the leaves (which were horizontal) up on to the stalks; and secondly, its getting to the roots: had this taken place the examination of the evaporated water, of the cones, and of the roots themselves could not have failed to reveal its presence.

*Results of Series II.*—The results thus obtained confirm those of Series I.; they are given in the following Table:—

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\* The effect of the lithium on the *Droseras* may be described as causing (when the flies were soaked in a strong solution, excessive withering and shrinking of the leaves and stalks to which it was applied, and occasionally the whole plant was similarly affected. This could scarcely have occurred if absorption had not taken place; it produced the same effect when absorbed through the roots.

Series II.—All *D. rotundifolia* except B, *D. intermedia*.

Preparation.

Examination.

| Time,<br>July 26th. | Plant. | Number of prepared<br>leaves on the plant. | Citrate of Lithium<br>how applied. | Time.<br>July 28th. | Whether Lithium was<br>found in the roots. | Whether Lithium<br>was found in the cone. | Whether Lithium<br>was found in the<br>evaporated water. | Parts of the plant<br>examined for absorbed<br>Lithium.†           | Where absorbed<br>Lithium was found.        |
|---------------------|--------|--|------------------------------------|---------------------|--|---|--|--|---|
| 6.37 p.m. †         | A      | 2  | fly                                | 11.50 a.m.          | No   | Trace*                                    | No   | Flower<br>stalk, 2<br>leaf stalks,<br>bud and<br>young<br>blossom. | Flower<br>stalk and 2<br>leaf<br>stalks (?) |
|                     | B      | 2  | fly                                | 12.20 p.m.          | No   | No  | No   | 3 flowers<br>and stalks,<br>5 leaves and<br>stalks.                | In all.                                     |
|                     | C      | 2  | fly                                | 12.45 p.m.          | No   | No  | No   | 3 leaves, 1<br>bud and 1<br>flower stalk                           | In all.                                     |
|                     | D      | 3  | fly                                | 1.0 p.m.            | No   | No  | No   | 1 flower<br>stalk and 2<br>leaves and<br>stalks.                   | Flower<br>stalk and<br>one leaf<br>stalk.   |
|                     | E      | 3  | fly                                | 2.0 p.m.            | No   | No  | No   | 5 leaf stalks<br>1 bud.  | 1 leaf stalk.                               |
| 7.30 p.m.           | F      | 2  | fly                                | 2.25 p.m.           | No   | Trace*                                    | No   | 1 flower<br>stalk,<br>flower bud<br>and 2 leaf<br>stalks.          | Flower<br>stalk and 2<br>leaf<br>stalks (?) |

*Remarks on Series II.*—The presence of absorbed lithium in various parts of the plants (as shown by column 6, Table 2), is not quite so constant and invariable as in Series I., but this may be satisfactorily explained when the unnatural and disturbed state of the plant is considered. The value of the result is unaffected, as experiments B and C, Series II., conclusively show that the plants possess the power of absorption through their leaves; for the examination of the

\* In each case a faint trace of lithium was found near the bottom of the cone; it vanished almost directly, and did not reappear.

† Time of commencement and end of the preparations of the plants in Series II.

‡ Lithium was in all cases found in the stalks of the prepared leaves; they are therefore not included in the above Table.

|| The blotting-paper cone was in this experiment inverted, the apex being downwards, and thus both the leaves and stalks were inclined towards the plant.

cones and evaporated water failed to reveal the slightest trace of lithium.

SERIES III.—*Pinguicula lusitanica*.

*Locality*.—The same as before.

*Method of experiment*.—In the first series of experiments upon this plant the method adopted was that of Series II. already described; but finding lithium in the roots, and also in the earth near them, the results thus obtained seemed untrustworthy, and they were therefore subjected to the same process as that employed in Series II.

*Results*.—The results of the experiments confirm those obtained by the first method, and are given in the Table:—

Series III.—*P. lusitanica*.

| <i>Preparation.</i> |        |                                 |                            | <i>Examination.</i> |   |  |  |   |                                       |
|---------------------|--------|---------------------------------|----------------------------|---------------------|---|--|--|---|---------------------------------------|
| Time.               | Plant. | Citrate of Lithium how applied. | Number of prepared leaves. | Time.               | Whether Lithium was found in the roots. | Whether Lithium was found in the cone. | Whether Lithium was found in the evaporated water. | Parts of the plant examined for absorbed Lithium. | Where the absorbed Lithium was found. |
| July 27th.          |        |                                 |                            | July 28th.          |   |  |  |   |                                       |
| 7.30                | A      | fly                             | 1                          | 11.20a.m            | No                                      | Trace*                                 | No   | Flower stalk and 3 leaves.                        | In all.                               |
| 7.40                | B      | fly                             | 1                          | 11.35a.m            | No                                      | Trace*                                 | No   | Seed and stalk flower and stalk and 3 leaves.     | In all.                               |

*Remarks*.—Comparatively few experiments have been made upon these plants, as I have previously been unable to obtain them in sufficient numbers: the above results are reliable.

*Conclusion*.—In his work on Insectivorous Plants, Mr. Darwin has proved the absorption by the tentacles on the leaves of the Droseras and the hairs on the leaves of the Pinguiculas by observing the aggregation of the protoplasm in the cells composing them, and by the demonstration of the microscopical structure of the stems and leaves. It is hoped, however, that the experiments already described (which were mostly completed before I was aware of the publication of this work) may still be not without value, as proving conclusively that the products of digestion after absorption by the leaves do enter the leaf-stalk, and are thence distributed to other parts of the plants.

\* In both cases it was faint and at a considerable distance from the apices of the cones apparently where the ends of the prepared leaves had rested upon them.