NOTES ON THE ABSORPTION OF WATER BY AERIAL ORGANS OF PLANTS.

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(With Plate XXVIII.)

At the last meeting of this Society a paper was presented by Dr. Schönland "On the Absorption of Water by the Aerial Organs of some Succulents." From the results of certain experiments which the author had made with several species of plants, particularly with *Mesembrianthemum barbatum*, *Anacampseros filamentosa*, and *Crassula cymosa*, he came to the conclusion that "*Mesembrianthemum barbatum* and *Anacampseros filamentosa* cannot absorb any appreciable quantity of water through their aerial organs."

It appears to me, however, that the experiments described by the author do not justify such a conclusion, especially as the conditions under which some of them were carried out are very different from those existing in nature. A twig of *Anacampseros filamentosa*, weighing 9·277 grammes, was kept in the laboratory for 7 days, when it weighed 8·672, having lost 0·605 grammes of water—that means 0·086 per day. It was then immersed in water on 5 consecutive days for 15 minutes each time, and on the sixth day for 5 hours, and then found to weigh 9·011, having gained since the last weighing 0·339 grammes.

The author considers that "the gain is evidently due to the absorption of water by the long dead hairs and not by the leaves themselves. This gain is readily acquired, but also readily parted with." The author, however, takes no notice of the loss, which the twig must have experienced during the time it was not immersed. As this time amounts to $5\frac{3}{4}$ days, and as the transpiration of the twig caused a daily loss of 0·086, the total loss during the period of the experiment from this source would have been 0·494, giving a total absorption of 0·833, acquired during $6\frac{1}{4}$ hours of immersion, while in nature the plant would have been able to continue the absorption, at certain times of the year when dew is a regular occurrence every night, for at least 60 hours during that period. As the quantity of water absorbed amounts to 0·833 grammes, or, roughly speaking, 16 drops,

while the twig weighed only 9·011 originally, it does not appear possible that this amount, which is equal to 9·2 per cent. of the weight of the twig, could have been contained in the hairs only, and that nothing of it should have passed into the tissue of the leaves.

In the case of *Mesembrianthemum barbatum* a drop of water was placed daily on the stellate hairs, and yet a twig, weighing originally 0·391, lost 0·109 in 7 days, or 27·9 per cent. of its weight. Here again the experimental conditions differ widely from those existing in nature, where the hairs would have, during 4 or 5 months of the year, at least 10 hours every night for carrying on the absorption of dew. Further, the specimens experimented with must have been in a very luxuriant condition, being probably from garden plants, for a twig of *Mesembrianthemum barbatum* taken by me from a wild plant gathered a few days before in the Karroo and kept in the laboratory for 7 days, during which the midday temperature was about 25° C., lost only 9·7 per cent. of its weight. Cultivated plants of *Mesembrianthemum barbatum* are, however, less suitable for such experiments than wild plants, for they wither much quicker, and their stellate hairs have lost much of their power of absorption. The hairs are mostly smaller, often less in number or quite absent.

Having carried out numerous experiments * with several species of plants some time ago, but with specimens brought directly from the Karroo, I had come to the conclusion that these plants are able to absorb appreciable amounts of water by means of specially constructed organs, viz., hairs, stipules, or aerial roots. I shall quote only one of these experiments here. A leaf of *Crassula tomentosa*, weighing 28·67, was kept in the laboratory for 3 days, when it had lost 0·7 grammes. By placing the leaf every night into the open, thus exposing it to the dew, while during the day it was kept in a cardboard box, it regained its original weight in 12 days, although it must have lost some more water by transpiration during that time.

A few additional experiments were made by me recently, selecting *Mesembrianthemum densum* for the purpose, as the structure of the stellate hairs of this species is quite similar to that of *M. barbatum*, of which I had no suitable specimens at my disposal. The leaves lend themselves well to such experiments, for they may be suspended in such a way that the apical hairs only touch the water, while the remainder of the leaf remains quite dry. In each case some young pairs of leaves were chosen, and having been kept in the laboratory for a few days to allow them to lose a little water by transpiration, two of them were suspended in a beaker side by side, in order to make sure that both were surrounded by air of equal relative humidity. One was a little above the water, the

* A full account of these experiments is given in Marloth, "Das Kapland," Jena, 1908, pp. 303–309.

other one just touched the surface with the tips of the stellate hairs. The results of two experiments made in June on twigs from cultivated plants, no wild plants being available, are as follows:—

I.	Initial weight of A (touching the water)	0·036
	After 3 days	0·036
	Initial weight of B (just above the water).....	0·051
	After 3 days	0·041
	Loss 0·010, equal to 20 per cent.	
II	Initial weight of A	0·137
	After 3 days	0·132
	Loss 0·005, equal to 4 per cent.	
	Initial weight of B	0·172
	After 3 days	0·139
	Loss 0·033, equal to 19 per cent.	

Thus in the one case the control specimen lost 20 per cent. of its weight by transpiration, and in the other case 19 per cent., while the leaves which were able to absorb water kept up their weight in the first experiment, and lost only 4 per cent. in the second one.

This fully confirms my previous results, viz., that the stellate hairs of *Mesembrianthemum densum* are able to absorb water from the air, and that this amount is, under certain conditions, sufficient to replace the loss suffered by transpiration.

The anatomical structure of these apical hairs is quite different from that of the ordinary water-storing epidermis-cells of the leaf. Each hair has an inflated basal part, which is inserted in a specially constructed cup. The walls of the hair itself are thick, but consist of cellulose with a very thin cuticula; those of the cup-cells, especially on adult leaves, are highly culticularised. In the young leaf the sides of the cup only possess cells with thickened walls, while the bottom part of the hair is in immediate contact with a very delicate meristematic tissue. Below this are, at the circumference of the leaf, the assimilating cells, and in the centre the colourless water-storing mesophyll of the leaf. Later the tissue immediately below the base of the hair thickens and lignifies its walls, thus forming a barrier between the base of the hair and the water-tissue of the leaf, by which further communication between the two is rendered difficult and loss of water from the interior of the leaf prevented. It is obvious that the structure of these hairs is very elaborate and highly specialised, consequently they must possess some important function in the life of the plant. Their structure during the younger stages of the leaf is well adapted to the absorption of water, and as the experiments have shown that the leaves do absorb water, it seems clear that this was obtained through the hairs, and that the hairs are specially constructed

organs of absorption. The amount absorbed may not be large, but if a leaf is able to supply itself, at least during some stages of its life, such a gain must be of importance to plants living under such extreme conditions.

The negative results obtained by Dr. Schönland with solutions of eosin, when the hairs only were stained but not the tissue of the leaf, do not disprove the diffusion of water into the tissues. Water passes through cell walls much more readily than anilin-dyes. Seedlings of wheat or maize kept in water-cultures to which eosin has been added will, even after several days, show the staining only in the root-hairs and the epidermis-cells, but not in the central parenchyma nor in the vessels, although the shoot may have grown several inches during that time, and the roots had obviously absorbed a corresponding amount of the solution. The same phenomenon is also easily observed by suspending a strip of filter-paper in such a solution, when the water invariably rises much higher than the dye.

In addition to the experiment with *Crassula tomentosa* referred to above, I have recently made the following one: A young leaf, weighing 1·76 grammes, was kept in the laboratory during the month of June (temperature low, humidity of air high) for 10 days, when it weighed 1·41, having lost during that time 0·35, or 0·035 grammes per day. It was then immersed in water with the fringe of the apex for 12 hours, and found to weigh 1·69, having gained 0·28, which means that the leaf had, during one night, made good the loss experienced during 8 days by transpiration and evaporation at the cut end.

There is consequently no doubt that this plant, and, I conclude, various other succulents of our arid regions, are able to utilise the dew deposited on their leaves. I agree with Dr. Schönland that the marginal papillæ of *Crassula cymosa* and allied species are not capable of absorbing moisture. Some species may not be able to do so at all, but in others the leaves can do it, whether by means of specially constructed hairs or through the water-stomata would not matter. It is quite possible that in some species the latter mode prevails, and that the hairs and papillæ assist merely mechanically by retaining the drops of dew, which otherwise would run off too quickly. In either case the gain is so considerable that it cannot be without advantage to plants living in regions with a very scanty rainfall.

Summary.

The anatomical structure of the apical hairs of the leaves of *Mesembrianthemum densum*, Haw., and *M. barbatum*, L., show them to be well adapted to the absorption of water, at least in the younger state of the leaf.