Ecology of Moorland Plants.

OTTO STOCKER, of Bremerhaven, has a very interesting review of the recent work by Montfort and himself upon this problem in *Die Naturwissenschaften* for August 8. The problem is an old one. Plants of the heath and of moorland, such as Calluna and Erica, have a form and structure that suggested to some of the earlier workers, and notably to Schimper, that they must be adapted to reduce water-loss arising from transpiration. Schimper advocated this view in his classical book upon "Plant Geography," and, faced with the problem that moors are by no means dry places, influenced probably also by his earlier studies of the mangrove swamps bordering salt water lagoons, he escaped from the difficulty by the assumption that these moorland soils must be "physiologically dry." This view of the xerophytic character of moor vegetation has been handed on from text-book to text-book, although it is based almost entirely upon the appearance of the vegetation and is unsupported by experimental evidence, apart from certain American experiments which showed that extracts of bog soils were toxic to certain non-ericoid mesophytes under certain experimental conditions.

Now Montfort has shown by direct experiment that the water of moorland soils is not toxic to moorland plants, and he also concludes by the way in which these plants still release water from cut stems, or exude it in drops from the leaves (guttation), that the moorland water in no way diminishes the absorption of water by the root system or its active pumping upwards into the shoot. Furthermore, by measurements of transpiration as well as of water absorption, Montfort showed that these processes went on freely in all plants grown in normal moorland water, though some extracts of soils in which secondary decompositions were proceeding might prove toxic to plants and reduce water absorption and transpiration as well as every other normal activity of the plant.

"Physiological dryness" seems, then, to be a myth; under the examination of Stocker there is not much left of the case for the xerophytic character of Calluna and the ericoid shoot. It is true that the single leaf of the ericoid plant may be interpreted as xeromorphic in structure, but a calculation of the total leaf surface per unit of root system puts Calluna ahead of many mesophytes in its proportion of transpiration surface, and an examination of the amount of transpiration of the plant as compared with its root absorbing system shows Calluna to be better classed as a "xeromorphic mesophyte," able to lose water like a mesophyte because in its natural habitat plenty of water is practically always available. Stocker has his own teleological explanation to replace the one he has so decisively disposed of. He suggests that the special ericoid type of leaf has its advantage on the wind-swept moor as a type that prevents the marginal withering effect produced by drying winds.

It may be pointed out, however, that exactly the same criticism can be brought against this view of Stocker's that he levels against the view of Schimper, namely, that it lacks experimental basis. His next suggestion, that this type of vegetation dominates the moors because its high rate of transpiration enables it to accumulate large quantities of salts from the relatively dilute salt solution of the moor, certainly seems to rest upon a fundamental fallacy, which again has often crept into the text-books. The salts in the soil are not drawn in with a current of water rushing into open pipes and then concentrated by the evaporation of this solution at the leaf surface. The water itself enters, diffusing across a protoplasmic membrane in accordance with the osmotic gradient, and this condition determines the entry of water alone and not of the salts with it. If the salts enter, they in their turn will diffuse inwards according to their relative concentration within and without the plant, and therefore their rate of entry will only be indirectly affected by the rate of transpiration, and this process is not likely to influence greatly the amount of salt collected in the plant.

This conclusion, the only one possible from a physico-chemical point of view, has now an experimental basis in the work of Muenscher (*American Journal of Botany*, vol. 9, pp. 311-329, 1922). Whilst, then, Stocker disposes effectually of the present teleological explanation of the characteristic ericoid type of leaf, he is not very happy in the similar type of explanation that he puts forward himself. But it may be asked —is it necessary to put forward any theory of this type to account for the characteristic heath and moorland vegetation? The writer has recently approached the subject from another point of view in two brief papers with Miss Hinchliff, published in the *Naturalist* (1922, pp. 263-268, and 1924, pp. 201-209).

Dr. F. E. Clements, Associate in Ecology of the Carnegie Institution, has recently shown in his monograph upon "Aeration and Air Content," published by the Carnegie Institution, that one of the governing factors in the peaty soil of the moorland and the heath is the lack of proper aeration in this soil, which renders it unsuitable for the growth of the root system of a normal plant. The present writer has pointed out that the metabolism of the root system of different plants may be expected to differ, and that some plants may require less oxygen for their growth; that the plants on peat are perhaps such plants, and that associated with this peculiarity they have another, namely, that they form unusually large quantities of fat in the roots as they grow. These fatty substances are then sent up into the shoot and accumulate first at the surface of the shoot as an early and abnormally thick cuticle, and then within the shoot again in early deposits of secondary endodermis and then of cork layers within that endodermis. It is pointed out that these fatty deposits are responsible for certain structural changes, and a later paper (Beatrice Lee and J. H. Priestley, "The Structure, Occurrence and Distribution of the Cuticle," *Annals of Botany*, July 1924) has strengthened the conviction that a thick cuticle deposited at an early stage will profoundly modify the structure of the young shoot and of the leaves upon which it is deposited.

This developmental factor may in the end prove to have a great deal of influence upon the characteristic form and structure of the plants growing on the peat. In this case their characteristic habit is not traced to an adaptation to control water loss, but is found to be a natural developmental consequence of the characteristic metabolism of a root system growing in a soil that lacks sufficient aeration. Wherever the peat plants grow, whether in peat or in other soils, they will retain this characteristic metabolism, accumulate fats, and show the same characteristic structure. But in peat soils they reign supreme because other plants which do not have this metabolism fail to grow there. One further interesting point about this view is the light it throws upon the unsuitability of many of these peat plants to soils that are rich in calcium, calcium salts producing very insoluble soaps with fatty acids, so that in a soil rich in calcium the fatty acids, instead of passing upwards to the shoot, accumulate in the root system and plug it up until its normal functions are carried out with difficulty.

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