ON THE DIFFERENTIATION OF THE LEAF TISSUE FLUIDS OF LIGNEOUS AND HERBACEOUS PLANTS WITH RESPECT TO OSMOTIC CONCENTRATION AND ELECTRICAL CONDUCTIVITY.*

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The existence of a differentiation of ligneous and herbaceous plants with respect to the magnitude of the osmotic concentration of the tissue fluids was first demonstrated in a strictly quantitative manner by work on the sap of the plants of the spring flora of the Arizona deserts[1] in the neighborhood of the Desert Botanical Laboratory, and on the terrestrial vegetation of the Jamaican montane rain forest.[2] These studies, in two geographically widely separated and climatically dissimilar regions, and an extensive series of unpublished observations demonstrate that the leaf tissue fluids of ligneous plants are characterized by an osmotic concentration materially higher than that of herbaceous forms.

The magnitude of the specific electrical conductivity, K, of the fluids must now be considered in comparison with osmotic concentration as measured by the freezing point lowering, Δ, for a series of plant species on which both of these constants were determined.

The determinations here considered were made on the north shore of Long Island during the spring and summer of 1914 and 1915. Leaf

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[1] Harris, J. A., Lawrence, J. V., and Gortner, R. A., *Phys. Researches*, 1916, ii, 1.

[2] Harris, J. A., and Lawrence, J. V., *Am. J. Bot.*, 1917, iv, 268.

tissue was collected in large test-tubes and squeezed as completely as possible after freezing to render the tissue permeable as has been shown to be necessary by Dixon and Atkins and by ourselves. The freezing point lowering, Δ, was determined in the usual manner. Correction was made for the ice separating on undercooling. The specific electrical conductivity, K, of the centrifuged sap was measured at 30°C. in a Freas conductivity cell, standardized by considering the conductivity of 0.1 N KCl to be 0.01412 reciprocal ohms, by means of the ordinary meter bridge wire.

The determinations for each species were then averaged and the deviation of each determination from the average for the species was calculated. All numbers which showed a deviation of more than ±20 per cent for either Δ, K, or $\frac{K}{\Delta}$ were discarded, and a new average with

TABLE I.

Growth form.	Average. Δ	Average. $K \times 10^6$	Average. $\frac{K}{\Delta} \times 10^6$
Trees	1.292±0.043	11,213±494	9,092±462
Shrubs	1.177±0.024	10,770±339	9,529±372
Trees and shrubs	1.217±0.022	10,922±281	9,378±292
Herbs	0.846±0.011	14,308±192	17,674±282

deviations $< \pm 20$ per cent was determined. The statistical constants are, therefore, based on carefully selected averages whenever more than a single determination was available for a species. Determining the averages from the protocols of measurements we have the results for the three growth forms, and for a combination of the two groups of ligneous plants set forth in Table I.

The constants show that the tissue fluids of both trees and shrubs are characterized by a far greater freezing point lowering than are those of herbaceous plants. The mean freezing point lowering of the leaf tissue fluids is greater, although perhaps not significantly greater in comparison with its probable error, in arborescent than in shrubby species. The differences between trees and herbs, shrubs and herbs, and all ligneous plants and herbs are several times as large as the probable error of the difference and so unquestionably significant.

Expressing the differences in per cents of the values for ligneous forms, we note that the value for trees and shrubs is 30.46 per cent higher than that of herbaceous plants. These results are, therefore, in excellent agreement with those found in the Arizona deserts and in the Jamaican rain forest.

The constants for specific electrical conductivity show that the conductivity for shrubs is slightly lower than that for trees. The difference is, however, smaller than its probable error. The differences between the conductivities of the fluids of trees and herbs, shrubs and herbs, and both ligneous forms and herbs are several times as large as their probable errors and show that the conductivity is distinctly higher in herbaceous than in ligneous species.

The ratio of conductivity to freezing point depression is much smaller in both trees and shrubs than it is in herbs. The mean value of $\frac{K}{\Delta}$ is lower in trees than in shrubs, although the difference cannot be considered significant in comparison with its probable error. The ratios ($\times 10^6$) are 9,092:17,674 in the case of trees and herbs and 9,529:17,674 in the case of shrubs and herbs. Since the ratio does not differ significantly in trees and shrubs it is quite proper to combine them, and we obtain an average of $\frac{K}{\Delta}$ in all ligneous plants of 9,378 $\pm$ 292 as compared with 17,674 $\pm$ 282 in herbs. Thus the ratio $\frac{K}{\Delta}$ is about 90 per cent higher in herbaceous than in ligneous plants.

The foregoing results show clearly that the osmotic concentration is higher while the electrical conductivity is lower in the tissue fluids of ligneous than in those of herbaceous species. Because of the wide geographic range and the great diversity of conditions (xerophytic, mesophytic, and hygrophytic) under which the investigations on osmotic concentration were carried out there can be no reasonable doubt that the differentiation of ligneous and herbaceous plants with respect to the magnitude of their osmotic concentration is a general biological law. Until confirmed by investigations in other regions presenting different conditions for plant growth—investigations which are now in progress—the results for conductivity cannot be asserted to be of universal validity.