

plant (888) greater than corresponding values for plants clipped every 10 days (16.8 cm, 28.9 cm, and 760). Values for plants clipped at 20- and 30-day intervals are averaged to give results comparable to medium-grazed fields. These means are slightly exceeded by plant spread and total seed output in plants clipped every 10 days and presumably comparable to over-grazed fields. It thus appears that the clipping effect of grazing, rather than trampling or soil compaction, is the chief cause of the difference in form and seed production of *E. tenella*.

Moisture experiments were designed to approximate rainy season conditions (daily watering) and winter conditions (2-8 days between watering). Vegetative spread of plants was inhibited, while number of spikelets and total seed output per plant showed a fourfold increase in drier conditions.

In an experiment to determine the optimum level of exchangeable calcium for this species, five sets of six pots were planted with seed of *E. tenella*. One set contained washed sand to which no lime was added, the second contained garden soil to which no lime was added, the third, fourth, and fifth contained garden soil to which 43, 86, and 172 g of lime, respectively, were added. The amount of exchangeable calcium was determined, 2 months after the addition of lime, in an unplanted control pot for each soil group. The percentage of exchangeable calcium (meq%) was: set 1, 0.0; set 2, 12.7; set 3, 14.5; set 4, 27.9; and set 5, 34.4.

The growth of the plants was somewhat irregular, but the average fresh weight of the plants, the number of seed spikes, and the seed output was greatest in the soil containing 14.5 meq% exchangeable calcium. The seed output, height, weight, and number of seed spikes decreased with further increase in exchangeable calcium. Plant spread, on the other hand, was slightly greater at 27.9 meq% exchangeable calcium.

### Acknowledgments

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## A MODIFIED PICHE EVAPORIMETER

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*Abstract.* A Piche evaporimeter is described that has only one evaporative surface, is constructed from inexpensive plastic tubing, and from which water loss is measured gravimetrically. Such instruments were calibrated in the laboratory by controlling vapor pressure deficits, and their precision was found adequate for many laboratory experiments. Field use for 30 days or longer is possible with the large reservoir capacity.

Our demand for a Piche evaporimeter of high precision, that was inexpensive, did not require individual calibration, and would operate satisfactorily over long intervals without service, led to the development of the instrument discussed here. In the modified evaporimeter, plastic tubing is substituted for glass, measuring is gravimetric, and water loss is restricted to only one surface.

### Description of the Instrument

The reservoir of the evaporimeter (Fig. 1) is made from plastic tubes with an inside diameter of 1¼ inches to a length that will provide the desired capacity. We use tubes about 16 inches long, with capacity of about 250 cc. The plastic cone and head[1] (Kudrjavcev 1960) are bonded with a styrene plexiglas cement. The assembly is designed to make a tight friction seal with the plastic tube. The other end of the tube is sealed with a no. 7 rubber stopper. A screw-eye permits the evaporimeter to be suspended on a hook beneath the weighing pan of a triple-beam balance. Water is added with a funnel through the center hole in the head of the evaporimeter. Filter paper of 3-cm diameter will form an immediate seal with the head of the evaporimeter if the instrument is moved quickly downward and then abruptly stopped. The instruments are placed in slotted wooden stands where the elevation of the evaporative surface is controlled by adjusting a rubber slip-joint washer on the plastic tube.

[1] The evaporimeter cone and head are available, unassembled, for $0.75 from the Forest Research Laboratory.

### Calibration and Precision

Over 100 instruments have been tested at controlled vapor pressures in rooms 8 ft by 15 ft by 8 ft. To more successfully reduce the effect of ventilation evaporimeters were suspended inside a plastic shelter 4 ft long by 2.5 ft high and open at the top. A representative calibration run at three different vapor pressure deficits is shown, wherein each point represents the average of 10 measurements each of a different instrument (Fig. 2). Although reduced, air movement still caused a measurable effect. Water loss rates were consistently higher at some positions, independent of which instrument occupied a given position. Time limitations and our inability to control vapor pressure exactly, week after week, did not permit tests of precision under these experimental conditions.

For this reason, precision tests were conducted with

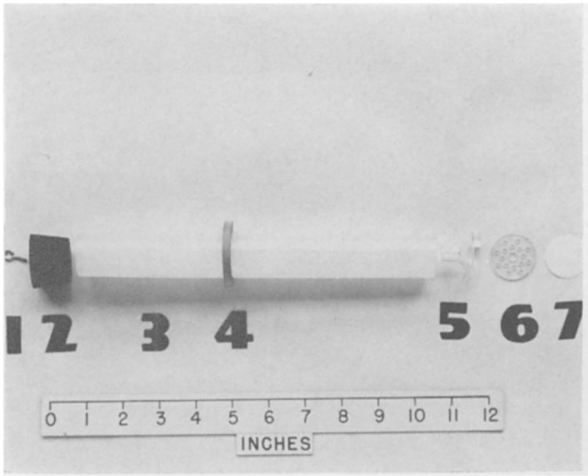


FIG. 1. Component parts of evaporimeter: 1, screw-eye; 2, no. 7 rubber stopper; 3, plastic tube, 1¼ inches inside diameter; 4, slip-joint washer; 5, cone of evaporimeter; 6, head of evaporimeter; 7, filter paper, 3 cm diameter.

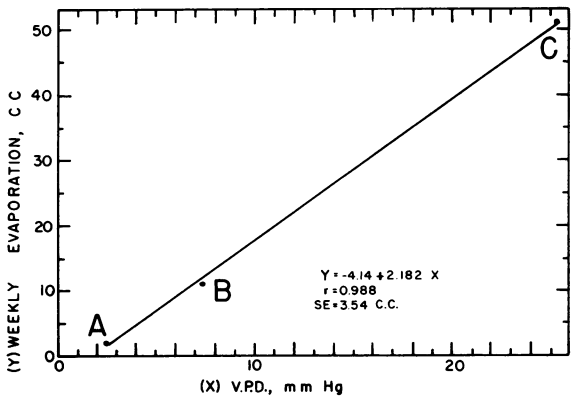


FIG. 2. Relationship between evaporation and vapor pressure deficit (V.P.D.) Temperatures of wet and dry bulbs were: A, 89°F and 87°F; B, 70°F and 61.5°F; C, 90°F and 67.5°F.

the plastic shelter covered and air exchange restricted to a ½-inch opening around the bottom. Psychrometer measurements, with the instruments available, could not be obtained inside the shelter without disturbing the system. Despite the increased closure, the mean of weekly evaporation was 10.83 cc. With 12 evaporimeters the standard deviation was 0.14 cc and the coefficient of variation was 1.3%. Most of the variation can be ascribed to the weighing error on a triple-beam balance, which is ±0.1 g.

## FIELD USE

For carrying the balance, a box, open on the front and with a hole 1 inch in diameter drilled under the weighing pan, is suggested. A sheet of clear plastic, dropped over the front of the box, is useful when measurements are taken under windy conditions.

A weighing platform consisting of a board, spiked to a post, is worth constructing if repeating measurements are taken. A hole is drilled in the platform to permit suspending the evaporimeter on a hook attached to the balance (Fig. 3). Usually, a simple wooden rack consisting of two stakes and a slotted cross member is adequate for support. If strong winds are common, a more rigid support should be built. Screening from animals may be necessary under some conditions.

FIG. 3. Balance on weighing platform (right) and rack for holding instruments (left) shown in place in the woods.

## INTERPRETATION OF DATA

Evaporation from wetted filter paper does not simulate moisture loss from a leaf. Transpiration responds not only to the diffusive and turbulent vapor flux of the external air, but is a function of stomatal and cuticular resistance to vapor diffusion. The internal diffusive resistance, as well as transpiration, can be measured directly using a fused-salt electric hygrometer (Wallihan 1964, Van Bavel, Nakayama, and Ehrler 1965). However, the Piche evaporimeter data can be used as a precise measure of mean daily wet-bulb saturation deficit according to Prescott and Stirk (1951). Through use of the general psychrometric equation the mean wet-bulb temperature can be calculated, which, in conjunction with a mean daily temperature, permits determination of the mean daily vapor pressure or humidity. These authors also present a quantitative evaluation of air movement upon Piche evaporation rates.

Development of this instrument was prompted by our needs for an index of evaporative stress, as measured by water loss, at hundreds of points over long intervals. Calibration and tests of precision were required to demonstrate that one instrument could be exchanged for another without recalibration, and that most of the variation recorded in the field results from sampling variation, not instrument error.

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## DETERMINATION OF ABSOLUTE POLLEN FREQUENCY[1]

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*Abstract.* Changes in technique have simplified and made more reliable a method for determining the absolute numbers of pollen grains in sediment samples. The prepared sample is suspended in its entirety in the volume of fluid from which measured portions are taken for counting; tertiary butyl alcohol, instead of benzene with dissolved silicone fluid, is used as the suspending fluid.

The absolute numbers of pollen grains in sediment samples may yield valuable information about the environment at the time the sediments were deposited. Traditionally pollen analyses have involved only the proportions of different pollen types within the total counted, but recently absolute numbers as well have been included. The increased interest stems from the availability of sediment age determinations by the radiocarbon method. A number of age determinations from different levels within a core permits estimation of the time interval represented by the thickness of a single sample. Correction by this means for the variable lengths of time represented by different types of sediment allows meaningful comparison of the absolute pollen content of samples of different ages (Davis and Deevey 1964, Whitehead 1966). Assays of absolute numbers of pollen grains are also essential to the use of sediment traps, which measure modern rates of pollen deposition in lakes (Davis 1965*b*). A simple and accurate means for determining numbers of pollen grains presents new possibilities for laboratory experimentation on problems that have long concerned palynologists, such as the effects of preparation procedures on the pollen content of samples. The assay method can also be used for direct measurement of pollen productivity through measurement of the numbers of pollen grains per flower. It may be supposed, too, that a method perfected for pollen may also be useful for assaying other kinds of particles that are similar in size and weight to pollen grains.

In a recent paper (Davis 1965*a*) I described a method for determining the absolute numbers of pollen grains in sediment samples. Subsequently I simplified this method and improved its reliability. The modifications, reported here for those who wish to study absolute as well as relative pollen frequencies, are two: the entire sample, rather than a subsample, is now suspended in the volume of fluid from which measured portions are taken; and tertiary butyl alcohol, rather than benzene with dissolved silicone fluid, is used as the suspending fluid.

After quantitative sediment samples have been prepared in the laboratory, the pollen-containing residue is dehydrated by successive washes in absolute ethanol. The residue is washed once with tertiary butyl alcohol and is then transferred, with additional tertiary butyl alcohol, to a graduate. The residue and its suspending alcohol, now of known volume, are poured into an Erlenmeyer flask, to which are added additional measured rinses of the graduate until the desired total volume (from 200 to 1,000 ml, depending on pollen frequency) has been attained. The alcohol is viscous, so care must be taken that the graduate drains well each time it is emptied. The temperature of the alcohol should also be kept constant.

A stirring bar is then placed in the flask, which is corked and placed on a magnetic stirrer. The sample must be stirred at high speed for at least 5 min to obtain even suspension of pollen; in the case of large volumes, 10 or 15 min is recommended. Stirring continues while measured portions of the suspension are removed by pipette. Pipetting is done with short-style pipettes with orifice diameter greater than 1.5 mm (Bellco 12-318 spl). The volume within the pipette is controlled with a syringe attachment; this can be made easily from a sawed-off tuberculin syringe with stopcock grease on the plunger, using a short length of rubber tubing as an adapter.

A drop of silicone fluid sufficient to spread out under a coverglass of the desired size is placed on a microscope slide and warmed on a hotplate or warming table at 170°C. Measured portions (usually 0.2 ml) of the pollen-tertiary butyl alcohol suspension are then drawn up into the pipette. The outside of the pipette is wiped off, and the pipette is emptied slowly, drop by drop, onto the silicone fluid on the slide. The silicone fluid dissolves in the alcohol, which continually evaporates during this process, so that only a small volume of fluid is on the glass slide at a time. Consequently after all the alcohol in the measured portion has evaporated the pollen that was contained therein remains in the central area of the slide, dispersed in the drop of silicone fluid. Fresh tertiary butyl alcohol is then drawn up into the pipette as a rinse; the rinse is added in the same manner, one drop at a time, to the pollen and silicone fluid on the slide. Two rinses are recommended. The pipette should then be inspected for remaining pollen under a stereomicroscope; no more than 1% of the total should remain within the pipette. A coverglass is placed over the silicone fluid and its contained pollen; the completed slide is left on the warming table until the mixture spreads to the edges of the coverglass.

The entire area under the coverglass is scanned under

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