J. Aquat. Plant Manage. 18: 40-41

An Empirical Equation for the Determination of Dry Weights of Water Hyacinth

JOHN VANDERMEER
and
ROBERT RICE

Division of Biological Sciences
University of Michigan
Ann Arbor, Mich 48109

INTRODUCTION

The noxious properties of the water hyacinth (*Eichhornia crassipes*, (Mart.) Solms) are well known, and have led to a variety of investigations which frequently require a knowledge of dry weights of individual plants. Often such determinations are impossible (as when an experiment needs to be set up with a living plant of a particular dry weight), and almost always are inconvenient. At times the accuracy obtained by the actual determination of dry weight is unnecessary for a study and a more practical technique would be useful, even if it were less accurate.

For the above reasons a study was undertaken to derive empirically an estimating formula which will enable the determination of approximate dry weights for individual plants of water hyacinths. The methodology is based on the assumption that a group of morphological characters, measured on a living plant, can be combined linearly to predict the dry weight of the plant. Although the limitations to the methodology is discussed, its potential utility is great if cautiously applied.

METHODS

A large population of water hyacinth growing at a variety of densities in an artificial canal was the object of the present study. The canal varied in depth from a few centimeters to two meters, and is three meters wide. It is located on the property of the Colegio Superior de Agricultura Tropical (CSAT), about 23 Km west of Cardenas in Tabasco, Mexico. The canals were constructed as part of an ongoing study of tropical chinampas which water-hyacinths is being utilized as organic matter mulch for terrestrial agricultural production.

A haphazard sample of 50 individual plants from a variety of population densities was utilized. Thirteen measurements were made on each of the 50 individuals. The characters and their definitions follow terminology as in Penfound and Earle (1):

1. Wet weight—Weight in grams of entire plant, after a few minutes of air drying.
2. Young leaf width—(here and elsewhere in this paper "young leaf" refers to that mature leaf that is closest to the center of the rosette)—The largest width (cm) from lateral to lateral extension of the pseudolamina of the young leaf.
3. Young leaf length—The distance (cm) from the juncture of the isthmus and pseudolamina to the distal end of the pseudolamina of the young leaf.
4. Young float length—Distance in cm from the proximal (juncture of the subfloat tissue and the float tissue) to the distal (juncture of the float tissue and the isthmus tissue) end of the float of the young leaf. In large leaves the float is frequently absent, but the slight difference in tissue appearance between float and nonfloat is still noticeable and was measured. Where no float was discernable, a value of 5 cm was given to the float length.
5. Young float width—Maximum width in cm of the float of the young leaf. In large leaves the float is frequently absent, but the slight difference in tissue appearance between "float" and non-float is still noticeable and the width could be measured. Where absolutely no float was discernable, a value of 1 cm was given to the float width.
6. Young petiole length—The distance from the juncture of the subfloat and rhizome (or stolon) to the juncture of the isthmus and pseudolamina of the young leaf.
7. Old leaf length—(Here and elsewhere in this paper "old leaf" refers to that mature living leaf that is furthest from the center of the rosette)—Same as 2 but measurement taken on oldest leaf.
8. Old leaf length—Same as 3 but measurement taken on old leaf.
9. Old float length—Same as 4 but measurement taken on old leaf.
10. Old float width—Same as 5 but measurement taken on old leaf.
11. Old petiole length—Same as 6 but measurement taken on oldest leaf.
12. Root length—Distance in cm from the base of the leaf insertions to the longest extension of the root filaments.

After making the 12 measurements, each plant was placed in a drying oven for 3 days at 60 C and dry weights determined for each individual.

All data were subjected to a stepwise linear regression with dry weight as the dependent variable and the above 12 characters as independent variables. This procedure systematically incorporates independent variables into the regression, one at a time, according to the goodness of their correlation with the dependent variable. It continues until those variables not yet incorporated into the model would not be significantly related to the dependent variable if they were added. It is thus a technique that determines which subset of a set of independent variables will produce the best prediction of the values of the dependent variable.

The stepwise linear regression was performed twice, once with all 12 independent variables, once with all but wet weight. Both procedures were done so as to provide for a practical situation in which the determination of wet weight may or may not be possible.

RESULTS AND DISCUSSION

In table 1 are presented the results of the stepwise linear regression with all independent variables included. When the analysis includes wet weight there are three significant independent variables that emerge from the analysis, wet weight (variable 1), petiole length of old leaf (variable 11), and float length of old leaf (variable 9). With these three variables, the variance in dry weight is 90% accounted for ($R^2 = .896$). The equation for the dry weight estimation is:

$$y = 1.219 + .074 X_1 - 1.147 X_9 + .317 X_{11} \quad (1)$$

where y refers to the predicted value of the dry weight, X_1 is variable 1, X_9 is variable 9, and X_{11} is variable 11.

TABLE 1. STEPWISE LINEAR REGRESSION WITH ALL 12 INDEPENDENT VARIABLES INCLUDED.

Step	Variables	R^2	Partial at Third Step	Significance
1	1	.799	.85	.0000
2	11	.875	.69	.0000
3	9	.896	—.41	.0000

Variables remaining at 3rd step and their partials—2 = .22, 3 = .08, 4 = .00, 5 = .12, 6 = .25, 7 = .17, 8 = .12, 10 = .20, 12 = —.12.

In table 2 are presented the results of the stepwise linear regression with all independent variables except wet weight included. When the analysis does not include wet weight, there are four significant independent variables that emerge from the analysis: young leaf width (variable 2), old leaf length (variable 8), young leaf petiole length (variable 6), and old leaf float length (variable 9). With these four variables, the variance in dry weights is 83% accounted for.

The regression equation is:

$$y = -9.364 + 2.233 X_2 - .421 X_6 + 3.770 X_8 - 1.808 X_9 \quad (2)$$

where the variables are indexed as in equation 1.

TABLE 2. STEPWISE LINEAR REGRESSION WITH 11 INDEPENDENT VARIABLES (WET WEIGHT EXCLUDED).

Step	Variables	R^2	Partial at 4th Step	Significance
1	2	.713	.50	.0000
2	8	.751	.64	.0102
3	6	.796	—.48	.0025
4	9	.830	—.41	.0043

Variables remaining at 4th step and their partials—3 = .10, 4 = .00, 5 = .02, 7 = .05, 10 = .14, 11 = .22, 12 = .15.

The methods presented herein may find use in applications in which no more than 90% (or 83%, depending on method) accuracy is desired in determining dry weights of individual water hyacinth plants. The methods obviate the need to actually dry the plant and therefore may be employed where non-distructive sampling is desired.

It should be cautioned that the method presented in this paper is based on data gathered from one specific locality. Although it should to be generally applicable in other areas, the study should eventually be repeated at other localities to insure accurate results.

LITERATURE CITED

1. Penfound, W. T., and T. T. Earle. 1948. The biology of water-hyacinth. Ecol. Monog. 18(4) :447-472.