Eye Lens Weight as an Age Indicator of White-tailed Deer in Central Kentucky

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ABSTRACT

Although a wildlife population is a dynamic entity, knowledge of age and sex structure provides an indicator to population composition in a particular locality. This report presents a study of age determination of the white-tailed deer population at the Blue Grass Army Depot in central Kentucky. The aging method used incorporated the dry eye lens weight technique and the principal objective was to determine a regression formula for the relationship of eye lens weight to age. The best formula found from available data was $A = (1.7357 \times 10^{-7}) \times W^{3.0544}$, where A is the age of deer and W is the eye lens weight. This model explained 91 percent variability and visually appears to present a good overall fit.

INTRODUCTION

Perhaps the most powerful tool of the wildlife investigator is understanding the age and sex structure of a population. This permits determination of breeding males and females, the number of young of the year, the number of yearlings, and possibly post reproductive adults. Thus, the reproduction and survival of a wildlife population lends information of fundamental importance to population dynamics.

One recommended method of aging white-tailed deer is by means of tooth eruption and tooth wear which gives reasonably accurate results. However, that technique lacks the accuracy favored for aging purposes (Downing and Whittington 1966). In his pioneer study of eye lens weights in the cottontail rabbit, Lord (1959) effectively introduced an improved aging technique, and subsequent investigators have employed that method for a variety of wildlife species (Beale 1962, Campbell and Tomlinson 1962, Payne 1961, and Sanderson 1961).

The first qualitative observations on the measurements of the eye were by the French ophthalmologist du Petit who reported on lens weights in the second decade of the eighteenth century (Friend 1967). Detailed reports on the topic were first documented by Smith (1883) who reviewed the information on lens growth to that time. In one of his reports, Smith elaborated upon the physical–biological properties of human eye lenses and concluded that the growth of the lens does not cease with the rest of the body, but is continuous throughout life. Researchers that followed made efforts to support Smith's conclusions, and the concept is currently being applied to birds and mammals. The significance of this technique is that it determines age more accurately than other methods; hence, it is highly regarded among wildlife population analysts. The present study reports the relationship of the dry lens weight to age among white-tailed deer *Odocoileus virginianus* in central Kentucky by use of regression analysis, and also attempts to further strengthen this technique as a means of population analysis.

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METHODS AND MATERIALS

The present aging study basically follows that described by Kolenosky and Miller (1962), Longhurst (1964), and Lord (1959). A total of 326 white-tailed deer eyes were collected on 9, 10, 23, and 24 November 1974 during a split hunting season at the Blue Grass Army Depot in central Kentucky. Care was exercised in removal of the eyes so as not to traumatize the lenses. Small curved scissors and a short hemostat clamp were used to sever extraocular muscles, the optic nerve, and posterior fascia in removal of the eyeballs.

Each deer was assigned to an estimated age group by methods of tooth eruption and wear (Severinghaus 1949), and pertinent data were assigned to each collected eye before fixing in 10 percent formaldehyde solution. Friend (1968) suggested that the fixative solution be used to eliminate autolysis, to prevent necrosis from bacterial action, and to harden the lens in order to reduce damage in further handling. Friend also pointed out that formaldehyde acts as a protein fixative which proves most appropriate in this case, since approximately 95 percent of the dry weight of the lens is protein. Some experimenters (Connolly 1969, Downing and Whittington 1966) allowed the eyes they studied to remain in solution for as long as 6 months, perhaps so that the hardened lens would allow easier handling and fewer sources of error. Before fixing, each eyeball was tagged with appropriate data tied to the optic nerve, although Downing and Whittington (1966) suggested the use of clip-on alteration tags to save time.

Eyes were allowed to remain in formaldehyde for 9 weeks before removal of the lenses. First, the limbus area was punctured with a pointed scalpel and an incision was made approximately three-fourths around the corneal periphery. After lifting the corneal flap, the iris was carefully slit transversely and the lens extracted.

Small Coors crucibles were used to retain individual lenses while drying in a precision oven at 80 C for 2 weeks. Lenses were allowed to cool at room temperature 3 to 5 min before weighing, because this cooling permitted reduction of convection currents as indicated by Longhurst (1964). Lenses were weighed and recorded to the nearest 0.1 mg on an analytical balance. After weighing the lenses, the lens weights and the ages of the deer as ascertained by the dentition method were recorded. The regression equation for the relationship of the population ages to eye lens weights was obtained.

The primary goal of regression analysis is to obtain predictions of one variable using the known values of another. In the case of simple linear regression, these predictions are made by means of an equation of the form $Y = a + bX$ where a is the intercept and b is the slope of a straight line. This line used to describe the relationship between X and Y is generally obtained from sample data. Utilizing the theory of least squares, a is found to be $\bar{Y} - b\bar{X}$ and

$$b = \frac{\sum_{1}^{n} (X - \bar{X})(Y - \bar{Y})}{\sum_{1}^{n} (X - \bar{X})^2}$$

for the regression of Y on X, where n is the number of observations, $\bar{Y}$ and $\bar{X}$ are the arithmetic averages of the dependent and independent variables, respectively. The intercept a, as given, can be interpreted as the point where the estimated regression line crosses the Y axis in the usual cartesian coordinate plane. It is

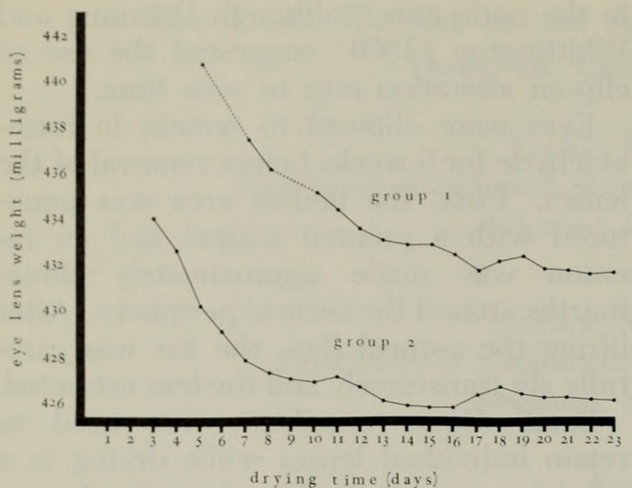

FIG. 1. Rates of oven drying of eye lenses of white-tailed deer at 80 C. Each group indicates average values of 10 randomly chosen lenses.

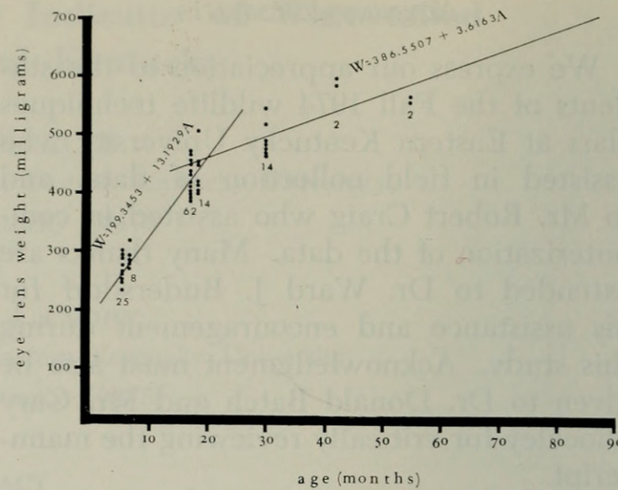

FIG. 2. Regression lines for 2 categories of data on male white-tailed deer. Numbers assigned to respective age groups indicate actual sample sizes.

noted that this value is obtained by adjusting the average of the dependent variable values (Y's) for the slope and the average of the known values. The slope is obtained from the sample data by summing the products of the deviations from the means of the paired observations relative to the sum of squared deviations from the mean of the known values (X's).

However, it is emphasized here that a straight line is not always an appropriate function for relating Y to X. Polynomial functions, exponential functions, and logarithmic functions are usual examples of nonlinear relationships between variables. A quadratic equation of the form $y = a + bx + cx^2$, an exponential function of the form $y = ae^{-bx}$, and a logarithmic function of the form $y = a + b \log X$ are illustrations of the examples mentioned above. The method of least squares is extended in the case of the quadratic to obtain the formulas from which a, b, and c may be obtained using the data points. A function of the form $Z = kw^b$ upon taking logarithms is $\log Z = \log k + b \log X$ or $y = a + b \log X$ where $a = \log k$, $y = \log Z$, and $X = W$. This logarithmic transformation allows the use of simple linear regression techniques for these data. Conversion back to its original form becomes, $A = kw^b$, where A represents age, w represents weight of eye lens, and k and b are regression constants.

The transformation of the data to logarithms, the determination of the "best-fitting" regression equation, and the transformation back to original form were all done with computers.

RESULTS

Friend (1968) indicated that eye lenses were considered dry when an additional drying period produced no significant reduction in weight. Various workers have employed different drying temperatures and drying periods depending on the size of the lens (Kolenosky and Miller 1962, Longhurst 1964). During the present study an attempt was made to determine the rate of desiccation and the time of adequate stabilization of white-tailed deer eye lenses. Average values of 2 groups of deer lenses with each group having 10 randomly chosen samples are shown in Fig. 1. Periodically, each group was weighed, usually midday, and a progressive decline in weight loss was recorded throughout the drying period. Satisfactory weight stabilization in Group 1 was established by the fourteenth day followed by less than 0.4 percent reduction in weight throughout the remainder of that drying period. Group

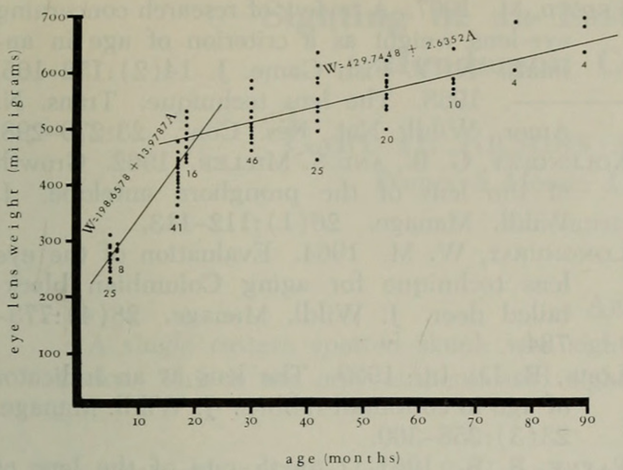

FIG. 3. Regression lines for 2 categories of data on female white-tailed deer. Numbers assigned to respective age groups indicate actual sample sizes.

2 also illustrated weight stabilization around the fourteenth day with only slight weight reduction thereafter. Therefore, a 2-week drying period was considered adequate for lenses of white-tailed deer. Shorter drying periods at 80 C have been successfully employed (Longhurst 1964); however, the main concern with any dry lens study is treating all sample lenses in the same manner.

Even though the final form of the model does a reasonable job in depicting the variability of the data, it is tempting to break up the age groups into 2 categories before applying the regression analysis. One category suggested by the observed data is 2 years and younger, and the other is 2.5–7.5 years of age. A straight line was fit to both categories for both male and female data (Figs. 2, 3). An attempt was then made to discern differences between males and females, but inadequate sample sizes for older age groups, particularly males, made it difficult to apply a reliable statistical test. The probable reason for lack of data among older males is that most hunters did not wish to relinquish antlered bucks. In the younger age category, the regression lines for bucks and does differed insignificantly.

It would be difficult to assign specific gender to random eye lenses up to 2 years

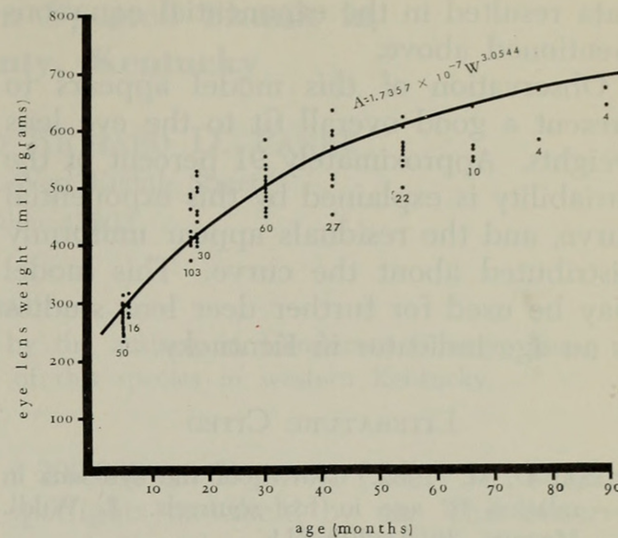

FIG. 4. Mathematical model for predicting age from lens weight in white-tailed deer. A = age, W = dry weight of lens. Numbers assigned to respective age groups indicate actual sample sizes.

of age. Assuming this is also true in the upper age category (Figs. 2, 3), the data for males and females were combined. Applying simple linear regression to the categories of male and female data, the results are: the regression line for white-tailed deer 2 years and under is $W = c + bA = 199.2482 + 13.5299\ A$, and for deer 2.5–7.5 years is $W' = 428.2967 + 2.6289\ A'$. Eighty-eight percent of the variability in the data was explained by the second line. Therefore, a straightforward linear regression was fit to all data. This model proved to be ineffective since the residuals showed a pattern of minuses, followed by pluses, followed again by minuses. Furthermore, only 72 percent of the total variability was due to the regression.

Hence, this leads one to a regression curve of the type $A = KW^b$ for predicting age from eye lens weight in white-tailed deer. Using the accumulated data, the regression equation is $A = (1.7357 \times 10^{-7})\ W^{3.0544}$ or in terms of the regression of weight on available ages, $W = 163.4557\ A^{.3274}$. It is noted here that the logarithmic transformation yielded the equations, $\log A = -5.7606 + 3.0544 \log W$ and $\log W = 2.2134 + .3274 \log A$ which when transformed back to the original form for the data resulted in the exponential equations mentioned above.

Observation of this model appears to present a good overall fit to the eye lens weights. Approximately 91 percent of the variability is explained by this exponential curve, and the residuals appear uniformly distributed about the curve. This model may be used for further deer lens studies as an age indicator in Kentucky.

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