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ALLOMETRY IN CHELONIANS

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SUMMARY

Measurements have been made on the relationship between body mass and carapace length in four species of chelonian. The results, in the form of allometric equations, show that in general carapace length is proportional to body mass$^{0.34}$.

INTRODUCTION

Jackson (1978, 1980) has reported on a relationship between carapace length and body mass in *Testudo graeca* and *Testudo hermanni.* His method of determining this relationship, by dividing mass by the carapace length, produced a series of ratios ranging from 0.39 to 7.90 in *T. graeca* and from 1.99 to 9.19 in *T. hermanni.* By comparing data from sick tortoises, Jackson (1980) argued that it should be possible to determine the health of each individual animal by use of these ratios. Recently Lawrence (1981) using Jackson's method, has produced ratios for several species of Chelonia from data held in the stock records of the Association for the Study of Reptilia and Amphibia. With these data, which in addition to measurements on *T. graeca* and *T. hermanni* included two freshwater species of Chelonia, Lawrence produced ratios which unfortunately appear to vary in even greater extent to those supplied in Jackson's (1980) paper.

The purpose of this paper is to produce a single mathematical formula for each species in the form of allometric equations which can be equally applied to either adults, sub-adults or juveniles. It is demonstrated that by the use of standard statistical techniques for dealing with length-body mass data, equations can be produced which in comparison to the methods used by Jackson (1978, 1980) and Lawrence (1981) give a clearer and more accurate definition of the allometric growth relationships. The principles of allometry and examples of its uses with other types of biological data have been described by Alexander (1971).

METHODS

Data from four species of Chelonia from the ASRA stock records detailed by Lawrence (1981) were used in the analysis. These species were: *Testudo graeca* (78-2381 g), *Testudo hermanni* (796-2198 g), *Emys orbicularis* (60-595 g) and *Chrysemys (=Pseudemys) scripta elegans* (25-1276 g). The standard method for measuring carapace length in chelonians is by taking a straight line from the nuchal to the supracaudal scute; it is assumed here that the measurements given by Lawrence (1981) are of this form. Allometric equations were obtained from the data by least-squares regression after transforming the data to logarithmic form (Bailey, 1959). The t distribution was used to assign 95% confidence limits to the exponents. Body mass was treated as the independent variable and carapace length as the dependent variable.

RESULTS

Figure 1 shows the data for all four species plotted on logarithmic coordinates. The allometric equations that have been derived from these data are of the form $y = ax^b$. This is where y = carapace length in mm, a = the intercept and b an exponent of the mass x in g.

This gave for *Emys orbicularis,*

$$y = 10.84 \text{ x mass}^{0.41\pm0.06} \; r = 0.99, n = 7,$$

Chrysemys scripta,

$$y = 15.25 \text{ x mass}^{0.36\pm0.01} \; r = 0.99, n = 26,$$

Testudo graeca,

$$y = 21.43 \text{ x mass}^{0.30\pm0.03} \; r = 0.97, n = 28,$$

Testudo hermanni,

$$y = 11.87 \text{ x mass}^{0.38\pm0.11} \; r = 0.94, n = 9.$$

r = correlation coefficient, n = the number of data points. A comprehensive equation obtained by combining all four data sets gives

$$y = 16.77 \text{ x mass}^{0.34\pm 0.01} \; r = 0.98, n = 70.$$

The line predicted by the constants in this equation in relation to all four data sets on logarithmic coordinates is shown in Fig. 1.

DISCUSSION

The study of allometric growth curves provides a useful basis for establishing the relationship between body mass and carapace length in chelonians. The availability of the data sets from the ASRA stock records has enabled the calculation of allometric equations which define the growth relationships of four commonly kept species of chelonian. By use of these

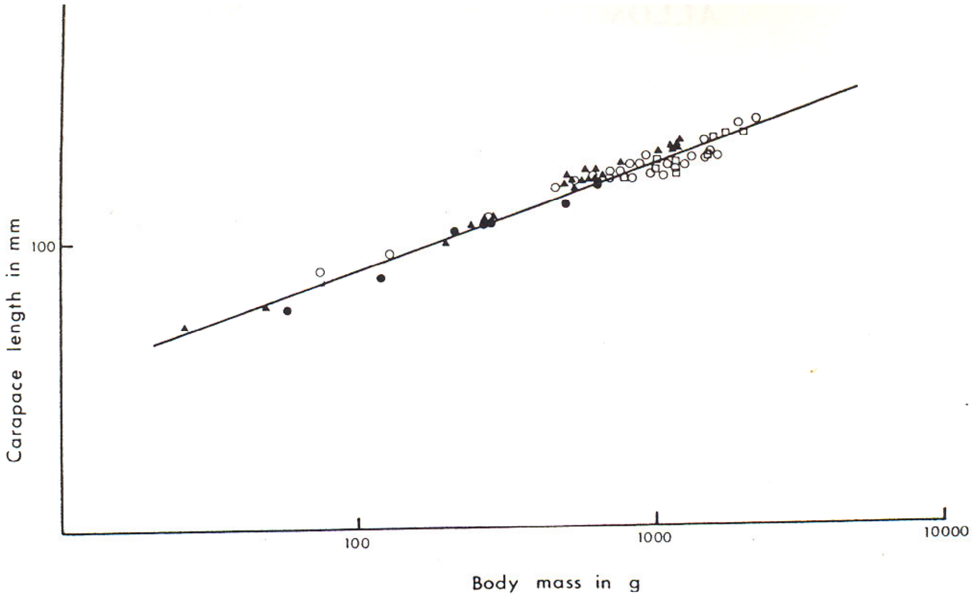

FIG. I. A graph on logarithmic coordinates showing body mass plotted against carapace length in all four species of Chelonian discussed in the text. The line taken through the data is derived from the constants in the comprehensive equation.

equations it is possible to determine whether a given individual has a typical body mass-carapace length relationship for its species. Although the equations are based on only small samples, it can be seen from the graph and the high correlation coefficients that the equations provide a reliable description of the data that has been analysed. If it can be assumed that this is typical data for the captive chelonians dealt with in this paper and that there is no radical change in growth strategy, then the equations should also be reliable for size ranges not included in the samples.

The equations can also be used to compare the growth relationships between species or populations. Here when two exponents are compared the lower value indicates a relatively greater increase in body mass in relation to increases in carapace length; an exponent of 0.33 indicates geometric similarity. In this respect it is interesting to compare the data for captive animals with those for wild tortoises, since differences in diet, food availability, and perhaps seasonal changes in climate, may produce fluctuations in body mass. Data are available for wild *T. hermanni* from Yugoslavia and Greece. Meek & Inskeep (1981) working with a Yugoslavian population found an exponent of 0.35 in their animals which when allowing for the confidence limits suggests that they do not differ too greatly from the captive tortoises. Stubbs, Hailey, Tyler & Pulford (1981) have published data for Greek populations but have not quantified the relationship. However, from their graph it is estimated that,

$$y \cong 16.00 \text{ x mass}^{0.35}$$

This equation is closer to the one for other wild *T. hermanni* than that for captive animals.

Exponents of 0.35 and 0.38 have been found for wild *Mauremys caspica* in North Africa (Meek, in preparation); these agree well with the exponent for captive *Chrysemys scripta* but are lower than that found for captive *Emys orbicularis.*

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