A RADIOGRAPHIC AND PHOTOGRAPHIC STUDY OF THE CRANIO-FACIAL COMPLEX OF THE RABBIT

A Thesis

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by

A. Dean Glattly

Department of Preventive Dental Science

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ABSTRACT

A longitudinal three-dimensional cephalometric radiographic study was carried out on a "large" and "small" breed of rabbit. Also included in the investigation was a three-dimensional photographic study of six groups of the skulls of wild rabbits. The rabbit was chosen primarily because of its range of size variation in the different varieties. The skull is large enough to measure accurately, small enough to handle easily, and growth is completed in six months. The object of this thesis was to examine the mode of growth of the rabbit skull and relate it to the variations seen in adult animals in an attempt to predict adult form from data obtained during growth.

A method for examining the mode of growth for the rabbit skull was developed and it was concluded that:

(1) The basic nature of variation in the adult form of the different rabbit groups can be demonstrated.

(2) Growth occurring in three dimensions can be described as a precise logarithmic process involving changes in size and shape. The process is basically a *cohesive phenomenon involving the entire head.

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* --cohering, or sticking together, as in a mass. Webster's New International Dictionary, Second Edition, (unabridged).

(3) Points on the rabbit skull can be represented as closely adhering to the allometric growth equation $Y = aX^n$, thus the direction of movement for any given point throughout growth on an individual animal is constant and is represented by the two invariates "a" and "n".

(4) A precise mode of growth, if described mathematicaly, affords a method of projecting the future shape of the skull.

(5) After examining the relationship between attained adult size and the size at specific ages during growth, it was found that a strong correlation existed between the size at seven weeks and that at maturity. The method of measurement was found to be important as measurement in a traditional linear manner yielded lower correlation values than measurements made along the growth curvatures.

(6) High correlations permitted a relatively accurate prediction of "final" adult size to be made from the seven week records.

(7) The strong size correlations in combination with the dependability of the growth predictions confirm the contention that genetics and not environmental

factors are dominant in growth under controlled environmental conditions.

(8) The similar magnitude of variation in wild and domestic groups, suggest that no substantially greater environmentally induced variation occurs in adult wild animals.

(9) The application of similar techniques to man might eventually lead to a clinically valuable method of predicting the adult dimensions of the human cranium.

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INTRODUCTION

The object of this thesis is to examine the mode of growth of the rabbit skull and relate it to the variations seen in adult animals in an attempt to predict adult form from data obtained during growth.

Most studies of skull growth have examined human material in the lateral orientation. No successful method of growth prediction has emerged from these investigations. Recent investigations by McKeown (1972) has suggested that skull growth in dogs can be represented as a precise and predictable process when viewed in three dimensions.

It was decided to carry out a longitudinal three-dimensional cephalometric radiographic study using a large and small breed of rabbit. Also included in the investigation was a three-dimensional photographic study of six groups of the skulls of wild rabbits. The rabbit was chosen primarily because of the large range of size variation in the different varieties. The skull is large enough to measure accurately, small enough to handle easily, and growth is completed in six months.

REVIEW OF THE LITERATURE

Growth is a complex phenomenon and the methods used to describe it have taken many, and often divergent, pathways. There are numerous ways to represent the changes which occur in growth. Workers interested in nutrition will often describe growth as increased changes in weight and height. Physical anthropologists often use metric linear measurements on dry material to describe changes that have taken place. Many of these methods are not designed to define precisely the changes in overall form. Only in radiographic growth studies has this been attempted and it has been mainly in two dimensions.

Numerous growth studies have and are still being done in man. Broadbent (1931), in a longitudinal study of 1700 children between the ages of 9 months and 21 years, published the first work in the United States describing a standardized cephalometric technique. Keith and Campion (1922) and Krogman (1958) utilized tracings which were obtained from craniostatic drawings of skulls. Broadbent (1937) suggested that there was a pattern of facial growth which was in a downward and forward direction and showed some consistency in change. Metallic implants have been inserted into patients to study growth. Bjork (1955) placed metallic implants in the

mandible and maxilla of young orthodontic patients, and a series of longitudinal records were obtained using a cephalometric radiographic technique. The changes noted were linear and no precise patterns were found to describe the mode of growth, hence, no accurate methods of prediction in the individual's growth has emerged.

Many methods have been pursued in an attempt to predict growth. These investigations have been made almost without exception using the 90 degree right lateral cephalogram, the records being superimposed often on the cranial base. Univariate, bivariate and multivariate statistical analysis have been used in attempts to identify certain trends. Most workers, however, have not been able as a result of these methods, to describe with a sufficient degree of accuracy the magnitude and direction of growth so that the ultimate shape and size of an individual can be predicted.

The development of microscopy as a method of describing growth has allowed researchers to get involved in the particular rather than the general. Another way of saying this is that they have become involved in reductionism, to the exclusion of the investigation of modes

of growth of the total shape and form.

Growth is not a single, but a multiple event. It is the combined expression of the development of a number of parts of an organism. To express the sum of the parts of the growing form without looking at the whole and total morphologic shape of the growing form from inception to maturity is a form of reductionism. The fact that growth and shape could be described in measurable relationships was recognized as early as the 13th century. Most of the early mathematical descriptions of shape involved symmetry in plants and animals.(Holt, 1966) With a greater knowledge of geometry and the use of logarithms, shape and growth changes were more accurately described. Logarithmic spirals occur in the curve of elephant tusks, sheep horns, the claws of a bird and in rodent incisors. Spiraled flowers and chambered shells were found to change with a certain mathematical sequence.

Descartes, (Struik, 1948) was often skeptical of men who proudly announced that they had discovered something new. He realized that what was believed up to that point in the 17th century was brought from the past and was not exactly new, and furthermore, there was very little within the sphere of

knowledge that was not still in dispute. Descartes wrote a rather philosophical book in 1637 and at the end of this book he placed a footnote which he called "The Geometry". From this footnote, which was written long before anyone had thought of such a thing as graph paper, came the basics for the techniques involved in describing growth.

In 1641, Descartes published his "Discourse on Method", (Thompson, 1971) in which the third of his four rules of logic stated that "to commence my reflections with objects which were the simplest and easiest to understand, and rise thence, little by little, knowledge of the most complex." This concept placed within his mechanistic awareness of the body the foundation for the modern "reductionist" approach (Koestler and Smythies 1968), a philosophy vigorously opposed by the concept of 'holism'. This word was used by General Smuts in 1926 to push at a very ancient doctrine that the whole is always something very different from its parts.

The work of D'Arcy Thompson, 1917, pointed out the important relationship between form and function and the biological implication of its limitations. He defined the form of objects and attempted to demonstrate the way in

Huxley (1924 and 1932) sought to clear up the diversities in terminology that were used to describe the relative growth of an organism. Many early terms were confusing. Disharmony was an early term used to denote the exaggerated proportions of some of the parts. There was a connotation associated with much of the early terms which suggested an abnormality. He suggested that the concept of allometry (Huxley, 1936) be used to describe growth of a part at a different rate than the whole. As Huxley (1932) states, "The co-ordinate method, while of ultimate importance in affording a graphic and immediate proof of the need for postulating regularities in the distribution of growth throughout the body, it is of little use for detailed analysis, because by its nature it neglects the fundamental attribute of differential growth, namely the change of relative proportions with absolute size. It is static instead of dynamic and substitutes the short-cut for a geometric solution and a more complex reality actually underlying the biological transformation."