

Biometric Studies Upon Development and Growth in *Amblystoma Punctatum* and *Tigrinum*.

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Measurements of *Amblystoma punctatum* and *tigrinum* have been made in order to secure data upon the normal rate of growth and upon the modifications of this growth rate by experimental procedure. Data show that the rate of enlargement during embryonic stages is dependent upon the temperature, the size at any named stage being correlated with the size of the egg. Length increase in the embryo is made at the expense of the other dimensions. The curve of absolute increments of length when plotted against time during embryonic development is S-shaped, terminating at the end of this period.

The mean lengths of *Amblystoma punctatum*, *tigrinum*, and *Axolotls* at this point of development are 15.61 mm., 14.07 mm., and 11.96 mm., respectively. Tables for mean length, standard deviation coefficient of variation, and the probable errors of these quantities demonstrate the value of the criterion used.

Growth following the embryonic period is dependent upon food—quality, quantity, and frequency of feeding. Where feeding is alike, size relations of the embryonic period hold for larval growth. No food has been found as adaptable for early use as the natural diet which consists of small aquatic forms. Beef-liver can be used at early stages and produces a remarkable acceleration of growth. Of the tissues tried, kidney is second in value.

In the later larval development and adult life, beef muscle produces greater growth than liver; at these stages, liver feeding is attended by excessive glandular production, by lack of growth, and often with loss of appetite. Death sometimes follows. There is a weakening of normal peristaltic action, which can be compensated for, partly at least, by use of agar. Beef muscle is of poor value for early larval growth and development. Here, as later, there is a lack of pigmentation with this food. In later larval and adult life, while the growth made on muscle is large, the mineral deficiency is evident—especially the calcium lack as shown by the tetanic condition.

Feeding on earthworms, with cuticle broken and digestive contents removed, produced little growth; the animals so fed are, however, apparently normal. *Enchytraei* (white worms) as food give a good growth rate; but the animals so fed, though large and well-formed,

do not metamorphose. Animals fed on beef muscle will not metamorphose without addition of vitamins or minerals to their diet. Metamorphosis occurs successfully with liver and with earthworms, as is true with a mixed diet of the meats and worms. The latter, started in later larval life, produces the best growth of all diets. All of the reactions to foods are modified by the quality, quantity, frequency, and duration of the initial diet.

Use of synthetic diets emphasized the need for minerals and vitamins, the greater growth with vitamin A, showed greater growth with deprim present, the value of low fat content, the preference for beef muscle powder as protein basis rather than the powdered liver, egg-white, egg-yolk, casein, or klim—though growth was made with all of these. The diets were more useful with older, larger larvae. Younger larvae showed different relative reactions.

During larval life the size relations of *Amblystoma punctatum* and *tigrinum* were reversed, so that at the time for metamorphosis the ratio was approximately 1:2 in the order named. Larval life gave another S-cycle to the growth curve, this cycle terminating at the time of metamorphosis. A third life cycle, beginning at this point, is probably related to the development of sexual maturity. Plotting of the cube of length against weight, for measurements made on adults, shows the first quantity to be a linear function of the second.

Hibernation of adults was followed, on return to warm temperature and food, by a remarkable acceleration of growth until the size characteristic for the stage of development was reached or surpassed. The tail became proportionally shorter during the hibernation period, with return to normal proportion after renewal of growth. The index of build; weight/length, (Bardeen *et al*), was slowly decreased with increase of size.

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The Effect of Glucose on Ketosis.

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During a study of the influence of insulin on fat and ketone bodies in the blood of depancreatized dogs, several observations were made on the effect of glucose, without insulin, on ketosis. Since clinical