SELECTION TO ALTER THE SHAPE OF GROWTH CURVES

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Selection to increase weight gain over a particular time interval and/or increase weights at specific ages results in positive correlated responses in weights at other ages (Eisen, 1974; McCarthy, 1977) and in voluntary food intake (Hayes and McCarthy, 1976). Undesirable changes in weight and body composition at different ages have generated considerable interest in investigating the possibility of altering shape of the weight/age growth curve, in conjunction with changes in gross efficiency and body composition. The desired changes in the growth curve would be:

a) Moving the sigmoid curve to the left on the time axis

b) Either decreasing or at least not increasing mature weight

c) Not increasing birth weight.

Selection experiments with mice, chickens and turkeys have resulted in changes in the shape of the weight/growth curve. These experiments have been based on selection for a combination of weights separated considerably on the time axis, with response each generation being low.

Consideration of the genetic flexibility in the shape of the growth curve has been largely overlooked. Although considerable empirical and stochastic effort has been directed toward describing the sigmoid shape of growth curves, little attention has been focused on the utilization of growth function parameters as selection criteria.

Models which are non-linear in their parameters have been used extensively to fit weight, time (W, t) data points. Four parameter functions (Fitzhugh, 1976) have been especially popular, although not necessarily testifying to their suitability for biological interpretation.

Fitzhugh (1976) utilized the general indeterminate form of the Richards function:

$$Y = A(1 \pm be^{-kt})^{m}$$

A, b, k and m are the fitted non-linear parameters, where

A = mature weight (kg)
b = scaling parameter of the initial conditions
k = maturing index
m = inflection parameter

and suggested various selection criteria based on derivatives of the function and combinations of the parameters, which could alter the shape of the growth curve.

However, functions and the derived selection criteria utilizing only (W, t) data points are restricted in their approach as the animal is treated as an output system only, and they ignore the considerable role of the inputs into the system.

Parks (1970, and unpublished) has suggested a series of functions utilizing weight, food, time (W, F, t) data points simultaneously. Although Parks (unpublished) has extended his model of growth to include situations involving controlled feeding, only the *ad libitum* situation is considered here. The model suggested for describing growth in the W, F versus time domain may be summarized as:

1. *Ad libitum* feed rate

$$dF/dt = (C - D)(1 - \exp(-t/t^*)) + D$$

2. Cumulative food consumed (integral of equation 1)

$$F = C(t - t^*(1 - D/C)(1 - \exp(-t/t^*)))$$

3. Live weight vs cumulative food consumed

$$W = (A - w)(1 - \exp(-(AB)F/A)) + w_o$$

with the important relations

$$dW/dt = f(W, dF, dF/dt) = (dW/dF)(dF/dt)$$

and $$dW/dF = (AB) \times (1 - W/A)$$

The fitted non-linear parameters are A, (AB), C, t*, D, where:

w_o = initial weight (kg)

A = mature weight (kg)

(AB) = growth efficiency factor

C = mature food intake (kg/wk)

t* = Brody's time constant (wks)

D = initial food intake (kg/wk)

Selection criteria can be deduced by utilizing combinations of the parameters or individual parameters themselves.

A theoretical situation is considered in which selection criteria suggested by Fitzhugh (1976) and modifications to Parks parameters are used to illustrate changes possible in the shape of the growth curve.

Until estimates of the genetic variability in growth parameters are obtained, responses indicated by the theoretical manipulation of growth curve parameters are obviously questionable. To this end a selection experiment is suggested in which the extent of the genetic variation and independence among derived parameters and/or selection criteria will be investigated. Using a mouse population, genetic coefficients will be determined for a number of different growth functions using both (W, t) and (W, F, t) data points. Both mathematical and biological fit of the various functions will be considered in the determination of selection criteria to be used to select over a number of generations to alter the shape of growth curve.

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