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DAILY FOOD INTAKE OF REARED LARVAE OF THE EUROPEAN SEABASS (*DICENTRARCHUS LABRAX L.*) STATISTICAL ANALYSIS AND MODELLING[1]

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The daily quantity of prey ingested by larvae of sea bass (*Dicentrarchus labrax* L.) aged from 10 to 75 days, and maintained at 19° C in 60 and 150 liter tanks varies significantly with the tank volume, the excess of prey furnished, and the larval stages (before and after metamorphosis). The differences are, however, small in number and can be overlooked at first glance. The relationship between wet weight (W_p) in mg of prey ingested by larvae and by day and the age (t) in days is

$$W_p = 0.4682 \exp(0.0948t).$$

The relationship between W_P and wet weight (W_l) of larvae fixed in formalin, are from $W_P = 0.9444\ W_l^{(1.0575)}$ and $W_P = 1.7369\ W_l^{(0.9665)}$ before and after metamorphosis.

– Modelling the relationship between daily food intake of larval fishes and age is useful for estimating the amount of prey required daily in an aquaculture project and for studying changes in the metabolism of larvae throughout their growth.

The information given on daily food intake of larval marine fishes such as *Sparus aurata* (Alessio, 1975), *Solea solea* (Flücher, 1974), *Pleuronectes platessa* (Riley, 1966; Howell, 1973), *Engraulis mordax* (Lasker, 1976; Hunter, 1976), *Archosarqus rhomboidalis* (Stepien, 1976) frequently do not match, even for similar species. This is possibly because of a wide variability in individual feeding rates and of different rearing conditions.

We analyze and model the daily amount in number and in weight of prey eaten by European seabass (*Dicentrarchus labrax* L.) larvae as a function of age, weight and length of the larvae. –

MATERIALS AND METHODS

DATA

Fifty larvae/l were introduced in seven 150 liter and two 60 liter tanks. They were reared at 19 ± 1° C as described by Barahona-Fernandes (1978). Their daily intake of *Artemia* nauplii was assessed between the ages of 10 and 75 days. The larvae appeared to be overfed in two of the 150 liter and one of the 60 liter tanks (many prey individuals always remained uneaten from one day to the next).

The method used for estimating the daily food intake was described by Barahona-Fernandes and Girin (1977). The number of uneaten prey remaining in a tank is estimated once a day at a given hour. A calculated amount of fresh prey is then added to complement the remaining stock.

A daily evaluation of the surviving larvae in a tank by a cumulative mortality curve technique cannot be performed prior to the age of 25 days because the dead larvae are then too small to be counted. According to Stepien (1976), the mortality curve is a negative exponential of the type $N_t = N_o \exp(-mt)$ where N_t is the number of individuals alive at time t, N_o is the initial number of individuals at hatching, and t is the age in days from hatching. Parameters N_o and m are fitted to observations made after 25 days and N_t is estimated by back calculation. The individual daily larval food consumption is defined as the estimated number of prey eaten over a 24 h period divided by the estimated number of surviving larvae on the same day.

For practical reasons, the length and wet weight of the larvae are measured from samples preserved in 5%

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neutralized formalin diluted in sea water. According to Barahona-Fernandes (1978) the relationship between length (L_d) of preserved larvae and length (L_l) of live larvae is $L_d = -2.2433 + 0.9696 L_l$, ($R = 0.98$ for 488 degrees of freedom); within the range of sizes studied, the correction is about 25%. Lockwood and Daly (1975) calculated that the amount Δ_w to be to the weight W of preserved *Pleuronectes platessa* and *Limanda limanda* was $\Delta_w = 32.22 + 0.20$ W.

We used average figures for larval weights and lengths at age. Standard deviation to mean ratios vary from 0.02 to 0.2 for individual lengths at age and from 0.1 to 0.5 for individual wet weights at age.

STATISTICAL ANALYSIS

The average wet weight of prey eaten per larva per day was modelled as a function of either age or average wet weight of a larva. The average number of prey eaten per larva per day was modelled as a function of length of the larvae.

Simple predictive linear regressions were used because the errors on the independent variable were assumed either null or smaller than on the dependent variable. Logarithmic (allometric model) and semi logarithmic (exponential model) were tried in order to improve the fit. The adequate transformation was selected on a criterion of lowest residual variance.

Three major factors of heterogeneity between sets of data from different tanks (tank volume, premetamorphosis and postmetamorphosis stages of larvae, amount of food provided) were tested for significance. The sets of data from the 11 tanks were pooled by groups sharing similar characteristics in order to check for significant differences.

The regression lines were not compared by usual analysis of variance techniques, because their residual variances differed. A graphical technique (Conan, 1978) was used instead. In this process elliptic joint confidence limits for paired estimates of slope and elevation of the compared regression lines are drawn in a two dimensional plot of elevations versus slopes. Differences between paired estimates for elevations and slopes are significant when the ellipses do not intersect.

RESULTS

For overall data the exponential relationship $W_p = 0.4682 \exp(0.0948\, t)$ provided the best fit between wet weight in milligrams of prey eaten per larva per day (W_p) and age (t) in days ($R = 0.95$ with 267 degrees of freedom). Lack of fit around age 30 days (Fig. 1) is attributed to changes in physiological processes during metamorphosis.

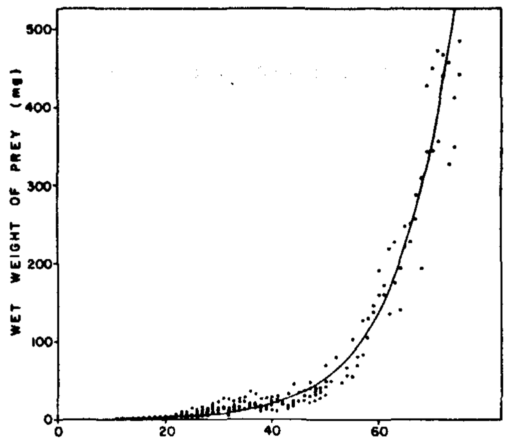

Figure 1. Exponential relationship between average wet weight W_p of prey eaten per larva per day and age (t) in days of a larvae.

For overall data the allometric relationships $W_p = 0.9444\, L^{1.075}$ and $W_p = 1.7369\, L^{0.9665}$ provided the best fits between wet weight in milligrams of prey eaten per larva per day (W_p) and wet weight of a larva W_l, respectively for larva before metamorphosis ($R = 0.927$ with 191 degrees of freedom) and after metamorphosis ($R = 0.931$ with 48 degrees of freedom). The discontinuity observed in Figure 2, around $L_n(W_l) = 3$ and $l_n(W_l) = 4.2$ is attributed to metamorphosis.

Figure 3 shows ellipses of confidence limits for the regressions of sets of data pooled in five groups sharing common characteristics. Differences tend to

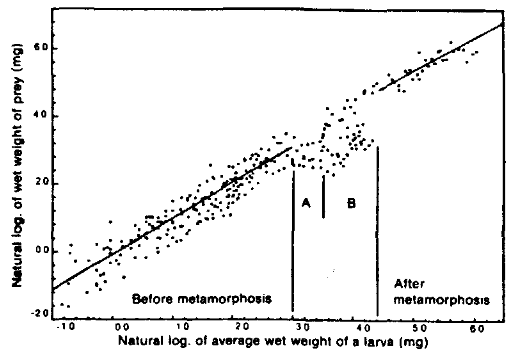

Figure 2. Allometric relationship between average wet weight of prey W_p eaten per larva per day and average wet weight W_l of a larva. The units are milligrams. During metamorphosis larvae first have a decreased feeding phase (A) following by a compensatory feeding phase (B).

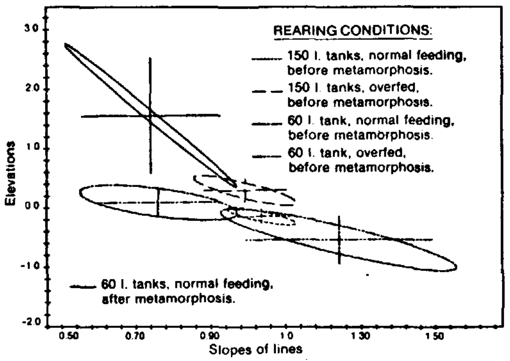

Figure 3. Comparison of the regressions fitted to data on average wet weight of prey eaten per larva per day versus average wet weight of a larva. Significant differences between regressions are shown graphically when the ellipses of joint confidence limits for slope and elevation of the lines do not intersect.

appear between data from overfed and normally fed tanks of same volume prior to metamorphosis and between data from tanks of different volumes but with the same type of feeding prior to metamorphosis. Large tank volumes and over-feeding seem to have similar effects, i.e., enhanced feeding rates; no difference is found between 150 liter tanks with normal feeding and overfed 60 liter tanks. Post-metamorphosis and pre-metamorphosis rates of feeding widely differ. Differences tend to exist between overfed and normally fed tanks of same volume prior to metamorphosis and between tanks of different volumes but with the same type of feeding prior to metamorphosis.

Allometric relationships provided the best fits between average number of prey (N_p) eaten per larva per day and length (L_l) of larvae in mm. These relationships are $N_p = -2.6126\ L_l^{3.5315}$ ($R = 0.9351$; 115 degrees of freedom), $N_p = -2.6665\ L_l^{3.7457}$ ($R = 0.9443$; 35 degrees of freedom), and $N_p = -0.2060\ L_l^{2.3920}$ ($R = 0.7696$; 30 degrees of freedom) respectively for, larvae before metamorphosis (1) fed on *A. salina* nauplii; (2) overfed on *A. salina* nauplii; and (3) larvae after metamorphosis fed with 4 days old *A. salina*.

DISCUSSION

Feeding rates of larvae reared in tanks of different volumes and either overfed or regularly fed tend to statistically differ. These differences are slight however. Thus the data for average wet weight of prey eaten per larva per day versus wet weight of a larva may be modelled by two allometric relationships one for premetamorphosis stages, the other for postmetamorphosis stages (Fig. 2). An exponential relationship fits the data of average wet weight of prey eaten per larva per day versus age of the larva (Fig. 1). We suggest however that over a wider age range the relationship would rather be of the logistic type.

Allometric relationships are convenient for modelling number of prey eaten per larva per day versus length of a larva. This could be expected since the relationship between weight and length is also allometric.

The daily requirements of an individual for food in weight are frequently expressed as a percentage of the weight of the individual. Because the relationship is allometric this would be inaccurate over wide weight ranges.

For purposes of comparison, however, within the range of observations, one *Dicentrarchus labrax* larva eats 75 to 102% of its own wet weight per day when normally fed and 105 to 200% when overfed. Gunkel (in press) mentions 91% for white fish, Stepien (1976) 80 to 151% for sea bream, and Fujita (in press) indicates 80% as an ideal percentage. Fish larvae contain about 75% of water and *Artemia* about 90%; thus in dry weight, *D. labrax* larvae would eat 40 to 64% of their own weight per day.

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