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Growth Rates of Juvenile Red Drum *Sciaenops ocellatus* Reared on Commercial Salmon Feed in Fresh and Salt Water

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The red drum *Sciaenops ocellatus* meets the criteria for an excellent aquaculture species. Under ideal conditions, red drum have attained sizes from 0.45 kg to 1.36 kg in one year (Luebke and Strawn 1973; Robert L. Colura, personal communication). Red drum typically reach 450 g in one year on their natural feeding grounds (Simmons and Breuer 1962; Harrington et al. 1979). The purpose of this research was to evaluate growth equations and to calculate growth rates for red drum reared in fresh and salt water. The experiments were conducted at the Aquaculture Research Center of Texas A&M University.

Red drum were cultured in three different environments: salt water containing 35 g/L total dissolved solids (TDS), dilute sea water (5 g/L TDS), and fresh water (0.9–1.9 g/L TDS) with different hardness concentrations. Experimental units (114 L tanks each maintained by an under-gravel airlift biofilter), replicated three times for each level of total dissolved solids and hardness, were stocked with 15 red drum weighing between 1–3 g each. Fish were fed daily at a rate of 5.0–6.0% of tank biomass with commercial salmon feed (48% protein). Feeding rates were adjusted biweekly after fish weights were obtained. Details of water treatment preparation and fish performance were presented by Wurts and Stickney (1989).

Feasibility studies were conducted with larger fish (18–700 g). One of these experiments took place in a recirculating, dilute seawater system (5 g/L TDS) and the other in a freshwater pond (1.1 g/L TDS with 123 mg/L calcium) as described by Wurts (1987).

Weight data were transformed using the natural logarithm (ln weight). Linear regression analyses were performed on transformed, biweekly weight data from each experimental group of fish, weighing 1–3 g initially. This analysis was applied to determine if red drum growth was adequately described by the exponential growth function (Everhart et al. 1953):

$$W_t = W_o e^{kt}, \qquad (1)$$

where W_t is the weight at time t; W_o is the initial weight; e is the natural logarithm; k is a rate constant; and t is time in days. Transformation with the natural logarithm generates an equation with linear form:

$$\ln(W_t) = \ln(W_o) + kt;$$

$\ln(W_o)$ at $t = 0$ is the y axis intercept and k is the slope. The y intercept and slope were considered significantly different from zero at $P \leq 0.05$. Coefficients of determination (R^2) were calculated for each experimental group to evaluate how accurately the equation predicted observed growth (Ott 1977).

Values for the rate constant, k, were calculated using the algebraically rearranged transformation of equation 1:

$$k = [\ln(W_t) - \ln(W_o)]/t; \text{ and}$$

weight data collected (initially and after each of the three biweekly growth intervals) from all replicates within each experimental water treatment. One-way analysis of variance

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TABLE 1. *Coefficients of determination (R^2) of red drum growth (1–17 g fish) in fresh and salt water for the exponential function, $W_t = W_o e^{kt}$,* mean values of the rate constant, k, and mean initial (W_o) *and day 42 (W_t) weights.*

Total dissolved solids (g/L)	Calcium (mg/L)	Coefficient of determination	Mean value of k	W_o (g)	W_t (g)
35	465	0.999	0.043	2.7	16.5
5	61	0.997	0.043	2.9	17.4
1.9	403	0.991	0.034	1.2	5.1
1.3	204	0.984	0.034	1.2	4.9
1.1	124	0.988	0.036	1.3	5.7
1.0	71	0.988	0.035	1.3	5.6
0.9	47	0.994	0.037	1.3	6.0

(Ott 1977) was performed to determine if significant differences existed, with respect to k, among groups of fish subjected to different environmental conditions. Significance was tested at the 0.05 level. Temperatures for all studies were between 24–32 C with temperature means between 27–31 C.

Regression analyses revealed a good fit, $R^2 = 0.99$, for weight data and the growth equation $W_t = W_o e^{kt}$ (Table 1). Calculated mean values of the rate constant, k, ranged from 0.034 to 0.043 (Table 1). The overall mean value of k was 0.0374 with a standard error of ±0.0027. Analysis of variance indicated no significant differences ($F_{6,56} = 2.19$) among values of k for 1–17 g fish reared in fresh water containing 0.9–1.9 g/L TDS or salt water containing 5 and 35 g/L TDS.

In the feasibility studies with larger fish, 89 fish at 0.05 fish/L raised in dilute seawater grew from an 18 g initial mean weight to a 50 g final mean weight in 28 d. Growth on 44% protein salmon feed was rapid with k = 0.035–0.04 and a food conversion ratio (FCR) of 0.8, over the 28 d period. Red drum reared in a freshwater pond at 494 fish/ha and with an initial average weight of 35 g attained a weight of 258 g after 61 d (k = 0.033). In addition to 32% protein catfish feeds, red drum in freshwater ponds consumed crayfish *Procambarus* sp. and tilapia fry *Tilapia aurea.*

All of the observations made suggest that the equation and rate constants employed are sufficiently reliable to predict the growth of 1–50 g red drum fed 44–48% protein salmon feeds under typical production conditions (temperature, 24–31 C). In fresh and salt water, growth rates were comparatively constant for fish ranging from 1–258 g.

The exponential function describes a growth pattern with an initial lag phase followed by a rapid growth phase. Either phase, if analyzed separately, would reveal linear equations (growth). However, each would have dramatically different slopes (rates). The exponential function effectively encompasses both phases. The present data suggest that juvenile red drum are in the lag phase between 0–6 g and begin rapid growth between 6–15 g. When data from the feasibility studies are included, it becomes evident that growth of juvenile red drum follows an exponential pattern with the rapid growth phase occurring when fish are between 18 and 258 g.

The rate constant, k, can be estimated from the following equation (Swingle 1967):

$$k = \%\ \text{feeding rate/FCR}. \quad (2)$$

Using equation 2, k values of 0.034–0.043 and FCR values (Wurts and Stickney 1989) of 0.8–1.2; one can calculate the predicted range of daily adjusted feeding rates for red drum fed 44–48% protein salmon diets as lying between 2.7–5.2% of total biomass daily. Based on the present research, the use of a high protein feed is warranted in conjunction with a daily adjusted feeding rate of 3% of fish biomass for 15–50 g fish. Smaller fish may perform better if fed a 48% protein feed at the rate of 4 or 5% of body weight (adjusted daily).

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