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Effect of temperature on growth of juvenile *Oreochromis mossambicus* and *Sarotherodon melanotheron*[1]

Edmund E. Price, Jay R. Stauffer, Jr.* & Michael C. Swift
University of Maryland, Center for Environmental and Estuarine Studies, Appalachian Environmental Laboratory, Frostburg State College Campus – Gunter Hall, Frostburg, MD 21532, U.S.A.

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Synopsis

Survival and competitive ability of juvenile fish is often dependent on their growth rate. Temperature is the physical component of their environment which most affects growth rate. To determine the effect of temperature on the growth rate of two exotic warm water species we measured growth of *Oreochromis mossambicus* and *Sarotherodon melanotheron* at 25, 30 and 35° C. There was a significant interaction of species and temperature on growth. The growth rate of *O. mossambicus* was faster than that of *S. melanotheron* at 25 and 30° C but slower at 35° C. Weight gain of *S. melanotheron* was significantly greater at 30° C than at 25° C. Weight gain of *O. mossambicus* at 25 and 30° C was significantly greater than at 35° C. Temperature had no effect on the weight-length relationship of either species.

Introduction

The first few months of life are perhaps the most critical for the survival of juvenile fish. Exogenous feeding, development of sensory and motor capabilities and development of physiological characteristics occur during this period and affect survival and competitive ability. Growth is particularly important during this period because of the relationship between fish size and food size (Hyatt 1979). Growth is an index of the integration of the structural, physiological and behavioral characteristics of an organism with its environment. The 'scope for growth' (Warren & Davis 1967) is a function of environmental conditions, primarily temperature, which has been defined as a controlling factor for growth in fish (Fry 1947). Bioenergetics studies on the relationship between temperature and growth have shown that food consumption and scope for growth are greatest at the middle of the temperature range which the fish can tolerate and least at the extremes (Warren & Davis 1967). The mechanism by which temperature affects growth at the extremes of the tolerance range of an individual is complex but includes effects on food consumption, assimilation, specific dynamic action and metabolic rates (Warren & Davis 1967).

The effect of temperature on growth of juvenile *Oreochromis mossambicus* and *Sarotherodon melanotheron* is of particular interest because these species are exotics which are established in Florida. They are potential competitors of native species and it is thought that temperature limits their distribution. This study was designed to measure the

[1] Scientific Series No. 1546-AEL from UM-CEES, Appalachian Environmental Laboratory.
* Current address: School of Forestry, The Pennsylvania State University, University Park, PA 16802, U.S.A.

effect of temperature on growth of juvenile *O. mossambicus* and *S. melanotheron.* The genera *Oreochromis* and *Sarotherodon* historically have been included in the genus *Tilapia.* We are following the notation of Trewavas (1984).

Materials and methods

Duplicate 381 aquaria, each containing 10 fish, were maintained at 25, 30, and 35° C (± 1° C) for each species. Juveniles were obtained from brooding parents at 30° C. The day each brood was released, they were randomly sorted, acclimated to experimental temperatures for one hour, weighed and placed into the experimental aquaria. During the experiment, fish were fed commercial food (Rise Floating Fish Diet, ProPet) ad libitum; the photoperiod was 12 L:12 D.

Measurements were taken at the beginning of the experiment and approximately once per week thereafter. Fish were individually weighed in a dish of water and all the fish in each aquarium were subsequently photographed in a shallow pan containing a ruler. Length measurements were made with calipers and actual size was read from the ruler in each print.

Since the fish were not individually marked, it was not possible to identify individual fish within each aquarium, thus, average weights and lengths were used for the weight-length relationship. Two aquaria contained aberrant fish. In 10 weeks, one *S. melanotheron* at 30° C and one *O. mossambicus* at 25° C weighed 3.6 times more and 7.6 times less, respectively, than the mean weight of the other fish in their respective aquaria. To exclude these two fish from the analyses, we deleted the largest weight and length from the 30° C replicate and the smallest weight and length from the 25° C replicate on each date. Weight gain of individual fish was calculated by subtracting the mean initial weight within each replicate aquarium from the final weight of each fish in that replicate.

ANOVA was used to determine the effect of temperature and species on weight gain. A model of the form $W = aL^b$ was used to determine the relationship between weight (W) and length (L) for each species. Data from all temperatures were fitted to the model for both species. Subsequently, the residuals were calculated at each temperature for each species and a one-way ANOVA on the residuals was used to determine the effect of temperature on the weight-length relationship for each species. The significance level for all analyses was $p \leq 0.05$.

Results

There was a significant effect of temperature and species on growth and a significant interaction of temperature with species. There was no effect of replicate on weight gain so the two replicates of each treatment were pooled for further analyses. Temperature significantly affected growth of both *O. mossambicus* and *S. melanotheron. O. mossambicus* gained more weight at 25 and 30° C than at 35° C. Mean weight at 35° C was significantly less than at 25 and 30° C by day 61 of the experiment and thereafter (Fig. 1). Weight gain of *S. melanotheron* at the end of the experiment was significantly greater at 30° C than at 25° C. Once growth in the three temperature treatments began to diverge at about day 35, growth at both 30 and 35° C was usually significantly greater than at 25° C except on days 88 and 108 (Fig. 2). The average growth rate of *O. mossambicus* was higher than that of *S. melanotheron* at 25 and 30° C but lower at 35° C (Table 1).

Table 1. Average growth rates (g day^{-1}) of *O. mossambicus* and *S. melanotheron* as a function of temperature.

	Temperature °C 25	30	35
O. mossambicus	0.076	0.077	0.048
S. melanotheron	0.045	0.058	0.054

Temperature did not significantly affect the weight-length relationship for either species so all temperature treatments for each species were pooled and regression analysis used to determine the weight-length relationship for each species. This analysis resulted in the following relationships:

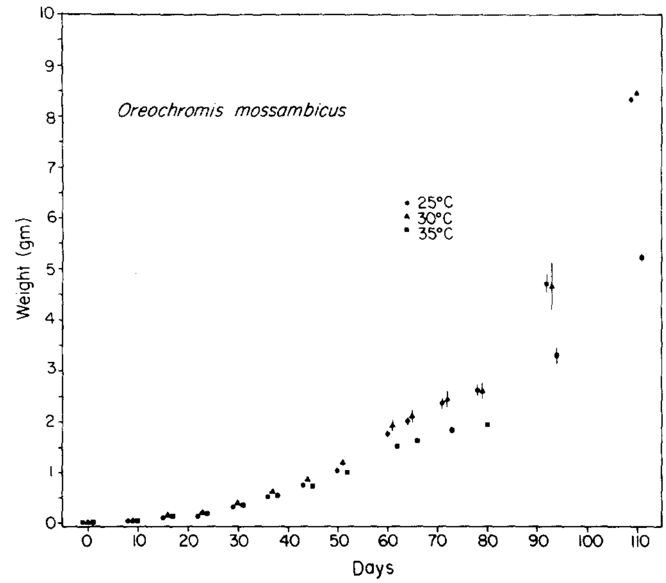

Fig. 1. Growth of *O. mossambicus* at 25 (●), 30 (▲) and 35° C (■). Measurements were made at all temperatures on the date marked by the 30° C data points; the 25° C and 35° C data points have been offset to avoid confusion. Data points are means ±95% CL.

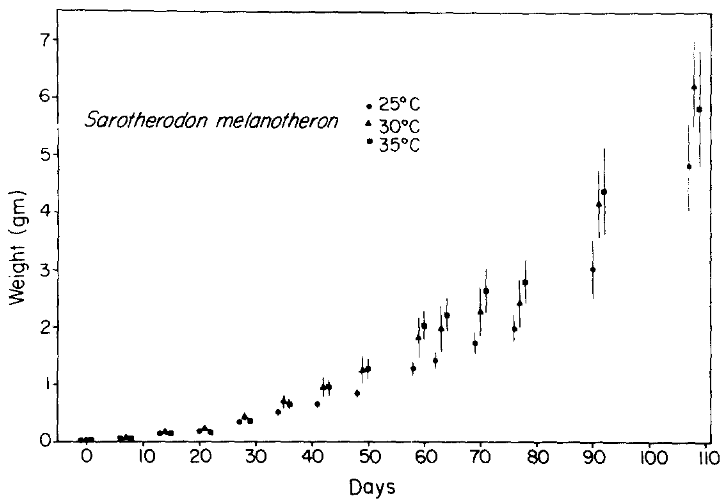

Fig. 2. Growth of *S. melanotheron* at 25 (●), 30 (▲) and 35° C (■). Measurements were made at all temperatures on the date marked by the 30° C data points; the 25° C and 35° C data points have been offset to avoid confusion. Data points are means ±95% CL.

O. mossambicus: $W = 0.0066\,L^{3.20}$ $R^2 = 0.998$
S. melanotheron: $W = 0.0100\,L^{3.18}$ $R^2 = 0.992$

Discussion

Growth studies on a range of sizes of juvenile tilapine fishes suggest that they have an optimal temperature for growth around 30° C. Mironova (1976), using three to four month old *O. mossambicus* maintained on a maximum ration, found the greatest growth at 31° C. Platt (1978) showed that 50 mm *Tilapia zilli* grew fastest at 31.4° C. Caulton (1978), studying caloric content as an index of growth in *Tilapia rendalli* of various sizes (50–160 g), observed the greatest increment in caloric content (growth) at 30° C. Our results on very small fish (<10 g) showed that *S. melanotheron* and *O.*

mossambicus grew best at 30–35° C and 25–30° C, respectively. Our data suggest that there is a range of temperatures at which growth is optimal in these two species.

The occurrence of optimal growth at the same temperature in two species does not imply similar growth rates. Although *O. mossambicus* and *S. melanotheron* grew optimally at 30° C in our experiments, *O. mossambicus* grew much faster at that temperature than *S. melanotheron*. Juvenile *O. mossambicus* were much smaller than *S. melanotheron* at the beginning of the experiment (0.006 g versus 0.016 g), but by day 55 they were about the same size and were 17% larger by the end of the experiment.

Both *O. mossambicus* and *S. melanotheron* have been introduced and become established in North America. Their temperature tolerances and growth rates may influence their ability to colonize new habitats and compete with native species. Our results suggest that *O. mossambicus* might be able to expand its range further north than *S. melanotheron* because its optimum growth rate occurs at a cooler temperature. Lower lethal temperature data support this suggestion. Shafland & Pestrak (1982) measured a lower lethal temperature of 10.3° C for *Tilapia* [= *Sarotherodon*] *melanotheron* and 9.5° C for *Tilapia* [= *Oreochromis*] *mossambica*. *S. melanotheron* has only colonized estuaries on the eastern side of Tampa Bay and the Alafia River as far as Lithia Spring, Hillsborough County, Florida, while established populations of *O. mossambicus* have been reported from California, Arizona, Texas, Florida, North Carolina, Montana and New York (Hensley & Courtenay 1980a, b). Further studies are needed to quantify the role of growth rate – temperature interactions in interspecific competition.

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