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Kleine Mitteilung

The preferred temperatures of three *Semotilus* species

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With 1 figure and 1 table in the text

Abstract

The final preferred temperatures of *Semotilus atromaculatus, Semotilus corporalis* and *Semotilus margarita* were 26.4, 22.3 and 16.0 C, respectively. The preferred temperature/acclimation temperature response curves for each species were significantly different ($P \leq .05$) and coincided with thermal characteristics of their respective distributions.

Introduction

The genus *Semotilus* consists of four species: *Semotilus atromaculatus, Semotilus corporalis, Semotilus lumbee* and *Semotilus margarita. S. atromaculatus* occurs throughout much of the United States and Canada east of the continental divide (Lee & Platania 1980). For the most part, it is absent from the Coastal Plain of the southeastern states and from peninsular Florida (Lee & Platania 1980). *S. corporalis* is generally distributed along the Atlantic slope from the James River in Virginia north to the Miramichi drainage of Canada (Gilbert 1980). *S. lumbee* is restricted to the Carolina sandhills in southcentral North Carolina and northern South Carolina where it inhabits the Lumber (Peedee drainage), Yadkin and Cape Fear rivers (Snelson 1980). *S. margarita* occurs across the northern portion of the United States, and Canada (Lee & Gilbert 1980). The purposes of this paper are (1) to report the preferred temperature of the three most widely distributed members of the genus (i.e., *S. atromaculatus, S. corporalis, S. margarita*), and (2) to determine if there is a relationship between preferred temperature and known distributions.

Methods and materials

All specimens were collected from tributaries of Raystown Branch of the Juniata River (Susquehanna River) near Raystown, PA in July 1979. Fish were collected with a 3.2 m seine and transported directly to the Appalachian Environmental Laboratory in 75.7 l containers. Constant aeration was provided and collection temperatures were maintained within 1 C by using dechlorinated ice. At the laboratory fish were transferred to 75.7 l glass aquaria and maintained at the capture temperature (± 1 C) for five days. After the five day holding period, fish were acclimated to one of the following temperatures at a rate which did not exceed 1 °C/day: 6, 12, 18, 24, 30 and 33 C. Fish

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were fed a commercial diet except on test days and maintained on a 12 : 12 L : D photoperiod.

Temperature preference trials were conducted in an aluminum preference trough (after MELDRIM & GIFT 1971, 3.6 m × 0.203 m × 0.254 m) coated with white non-toxic epoxy paint. The trough was heated from below by a series of 250 watt heat lamps set at progressively increasing intensity. Cold water introduced at one end was heated as it flowed down the trough; thus creating a thermal gradient. Twenty-three thermistors evenly spaced within the trough and connected to a multi-channel readout were used to record the temperature gradient.

For each species and each acclimation temperature, eight fish were individually tested. After the gradient was established, a fish was placed in the trough at its acclimation temperature and allowed to orient to the test conditions for 40 minutes. Following this orientation period, the temperature at the point where the fish was located was recorded every 15 seconds for 20 minutes. The mean of these observations was deemed the acute preferred temperature for that individual.

Simple linear, quadratic, log transformation, and third and fourth degree polynomial regressions were used to determine the model which best explained the relationship between preferred temperatures and acclimation temperatures for each species (STAUFFER 1981). Once the best fit model was determined by using a stepwise regression procedure, it was solved for the point at which acclimation temperature equalled preference temperature. This point was reported as the final preferred temperature (FRY 1947).

The following analysis was performed to determine if the selected temperatures of the three different species were significantly different ($P \leq .05$). A model was fitted to all the data as though they were from one population. Residuals were then calculated for each species by subtracting the observed preference temperature from the predicted preference temperature. The calculation of the residuals removed the effect of acclimation temperature. The main effect (i.e., the effect of species) was analyzed by nesting the residuals of the observations for each fish within fish. In effect, a nested analysis of covariance was performed. This procedure used all of the data, but also tested the main effect by a mean square with the proper degrees of freedom.

Results

The relationship between acute preferred temperature and acclimation temperature for all three *Semotilus* species is depicted in Fig. 1. *S. margarita* were not acclimated to 33 C, because repeated attempts to acclimate them to this temperature resulted in death. The model which best described the relationship between acute preferred temperature (P) and acclimation temperature (A) for *S. atromaculatus* was $P = -0.00736\,A^2 + 0.7506\,A + 11.72$ ($R^2 = 0.78$), for *S. corporalis,* $P = -0.00536\,A^2 + 0.6551\,A + 10.34$ ($R^2 = 0.75$), and for *S. margarita,* $P = 0.012\,A^2 + 0.024\,A + 12.59$ ($R^2 = .64$). The calculated final preferred temperatures for *S. atromaculatus, S. corporalis,* and *S. margarita* were 26.4, 22.3, and 16.0 C, respectively. The responses among species were significantly ($P \leq .05$) different (Table 1).

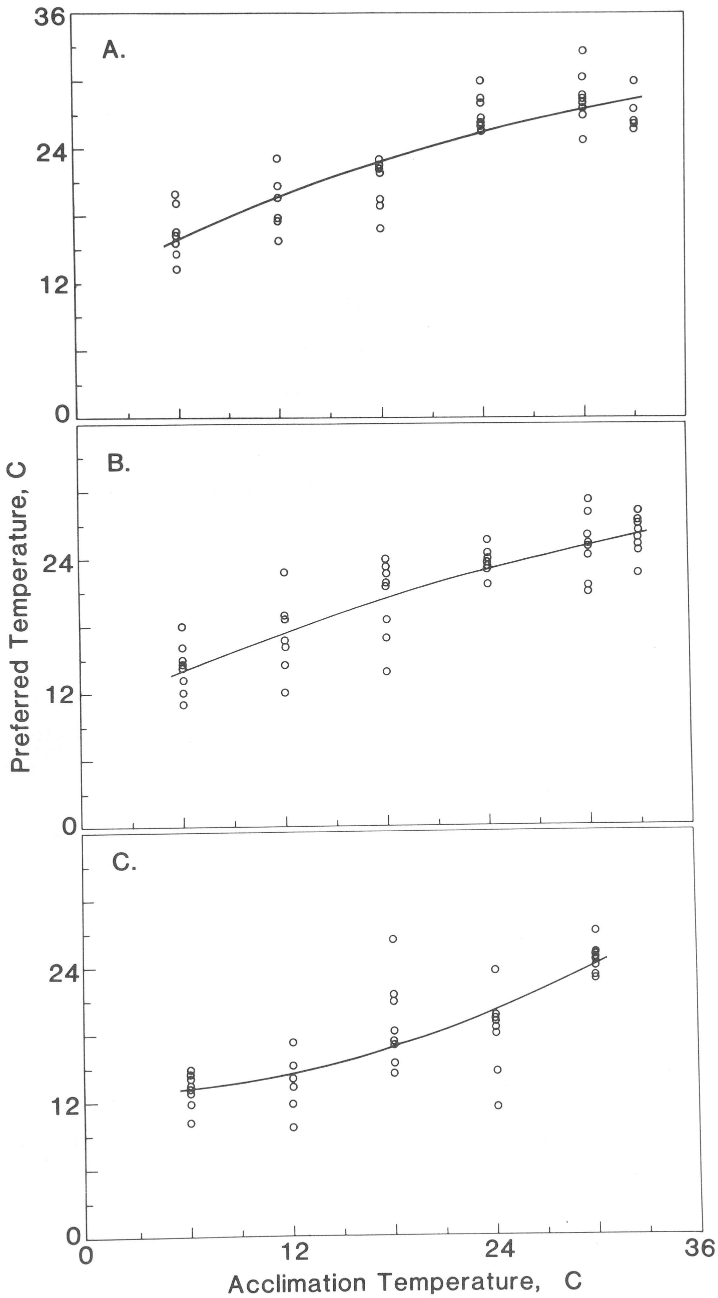

Fig. 1. Preferred temperature of *Semotilus atromaculatus* (A), *Semotilus corporalis* (B), and *Semotilus margarita* (C).

Table 1. Nested ANOVA on the residuals of preferred temperature for three *Semotilus* species.

Source of variation	Sum of squares	Degrees of freedom	Mean square	F	Probability
Among groups	27,683.5	2	13,841.7	25.8	<.05
Among subgroups within groups	71,269.8	133	535.8	49.2	<.05
Within subgroups	117,416.5	10,744	10.9		

Discussion

Numerous studies have been conducted on the effect of temperature on the physiology, biology and behavior of freshwater fishes (e.g., Raney & Menzel 1967, 1969; Raney et al. 1973; Beltz et al. 1974; Stauffer 1980, among others). Investigators have correlated the lethal responses of various fish species with their distribution (Huntsman & Sparks 1924; Battle 1926; Storey 1937 cited in Hart 1952). However, comparisons of behavior data with observed distributions of closely related species using identical laboratory procedures are lacking.

The preferred temperature responses of the three *Semotilus* species coincided with the southern limits of their respective ranges in North America. *S. atromaculatus,* which selected the highest temperature, is found from southern Canada south to Alabama (Lee & Platania 1980). *S. corporalis* selected intermediate temperatures and is restricted to Atlantic slope drainages where it is found as far south as the James River, Virginia (Gilbert 1980). *S. margarita* selected the lowest temperatures of the fishes tested. While this species extends as far south as northern Virginia, it is generally restricted to cold spring-fed headwater streams and northern lakes (Lee & Gilbert 1980). In Canada, investigators linked its distribution to the 12.98—15.6 C July iso-therm (Ryder et al. 1964 and Loch 1969 in Scott & Crossman 1973). These data agree well with the final preferred temperature of 16 C for this species.

The syntopic occurrence of these three species in the Raystown Branch of the Juniata River in southern Pennsylvania provided a unique opportunity to compare the thermal behavioral responses of three closely related species. Because populations were syntopic confounding effects of geographic location and associated climatic regions were eliminated.

Matthews et al. (1978) and Barila et al. (1981) reported on stream systems where all three *Semotilus* species occurred sympatrically. An examination of their data suggested that *S. margarita* preferred small spring-fed head water areas; *S. corporalis* preferred the larger warmer stream reaches; and *S. atromaculatus* was ubiquitous. It should be noted, however, that these distributions may be related to stream gradient, width or depth rather than temperature. It is conceivable, however, that these species minimize interspecific competition by selecting different temperatures where they are sympatric. Stauffer et al. (1983) postulated that temperature preference was a proximate factor for niche segregation in sympatric salamander larvae (*Ambystoma* sp.). Both field and laboratory studies of responses of fish to preferred temperature are needed in order to determine the effect of selected temperatures on fish distribution.

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