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Temperature Preference of the Crayfish *Orconectes obscurus*

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Abstract. Acclimation temperature influenced the acute preferred temperature of the crayfish *Orconectes obscurus*. This species preferred a higher temperature than its acclimation temperature for those acclimation temperatures ranging from 6° to 26°C. When acclimated to 30° and 33°C, the crayfish preferred a lower temperature than its acclimation temperature. The final temperature preferendum is estimated to be approximately 30°C.

Discharges associated with waste heat and power production technology cause significant behavioral modification for ectothermic invertebrate organisms in aquatic systems. Regulatory authorities have the task of establishing temperature standards for various aquatic systems and a fundamental requirement for establishing these standards is the thermal preference of aquatic organisms inhabiting each body of water (Stauffer *et al.* 1976, Richards, *et al.* 1977). Since temperature is a major factor affecting the life processes of organisms, it is not surprising that mobile organisms, including crayfish, exhibit locomotor responses to thermal stimuli. Mobile organisms typically express active temperature preference or avoidance responses that enhance or optimize its chances of survival and reproduction (Reynolds 1977).

The importance of behavioral studies in thermal discharge impact evaluations can be seen in the review of successive drafts of the United States Environmental Protection Agency's 316(a) Technical Guidance Manual (Stauffer *et al.* 1975, Gift 1977). The temperature preference data on fish exceeds 100 species (Coutant 1977), but data on freshwater decapods are limited (Mihursky and Kennedy 1967). Heat resistance (Becker, *et al.* 1975 and Spoor 1955) and thermal shock studies (Becker and Genoway 1974) have been reported on invertebrates, and Crawshaw (1974) and Fast and Momot (1973) conducted temperature preference studies on *Orconectes immunis* and *O. virilis*, respectively. The objective of this research was to determine the temperature preference of a common Maryland

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crayfish *Orconectes obscurus,* a large crayfish species that prefers clear gravel bottom streams of the Piedmont and mountain regions of the eastern United States, (Meredith and Schwartz 1962).

Materials and Methods

Crayfish were collected during the spring of 1976 in the Savage River, Maryland with seines (1.5 – 3.8 m, .635 cm mesh size), D-frame dip net and A-frame benthic samplers (Cincotta *et al.* 1976). The collection temperatures ranged from 6.5° to 20°C and the crayfish were initially held in 38 or 76 L aquaria at capture temperatures, controlled with aquarium heaters. Crayfish were acclimated to the following temperatures at the rate of 1°C per day: 6°, 10°, 14°, 18°, 22°, 26°, 30°, 33°C. A 5-day holding period at each acclimation temperature preceded the temperature preference tests. Crayfish were fed approximately .01 g of Rise® trout chow per animal every two days, but they were not fed on testing days. Constant aeration in the holding aquaria supplied oxygen levels between 90 to 100% saturation. Photoperiod was maintained according to natural spring conditions (11L:13D) via Vitalites. Light intensities at the surface of the aquaria ranged from 1.4 to 2.3 lux (32.2 lux represents a sunny day). All tests were conducted during the day between 0700 – 1800 hr.

The trough used in the preference trials was patterned after Meldrim and Gift (1971) and made of aluminum (3.6 x .203 x .254 m) coated with a non-toxic epoxy paint. Twelve heat lamps were secured beneath the trough at increasing levels of intensity with dimmer controls for each pair of lights. Twenty-two thermistors were equally distributed along the trough to record the temperature gradient. Cold water from a circulating water bath was introduced at one end of the preference trough to intensify the temperature gradient and therefore increase the temperature range of the horizontal gradient. This technique allowed crayfish broader selection temperatures. Water depth in the trough was approximately 2 cm. Lights supplied constant illumination equal to approximately 2 lux during the test.

Crayfish were introduced into the trough at their acclimation temperatures and a thermal gradient of approximately 9°C above and below this temperature was established. A 45-minute orientation period preceded the test, which allowed for position effects that could interfere with the actual temperature preferred. After the orientation period, the temperature preferred by each crayfish was based on their proximity to one or more of the 22 thermistors. Eight crayfish were individually tested at each acclimation temperature, and the temperature selection relative to each thermistor was recorded each minute for 20 min by overhead mirrors. The mean of the 20 observations was deemed the preferred temperature for that particular test. Carapace length, weight, and sex were recorded for each crayfish. Linear regression quadratic equation, log transformation, and "eyeball" plots (Coutant 1977) were used in an attempt to determine the relationship between preferred temperature and acclimation temperature. The point at which each of the above curves intersected a theoretical line with a slope of 1 was deemed the final temperature preferenda (Fry 1947).

Results and Discussion

The mean acute preferred temperature was higher than the acclimation temperatures when the latter ranged from 6° to 26°C (Figure 1). The most significant gap of preferred temperatures occurred between acclimation temperatures of 14° and 18°C (Figure 1). For acclimation temperatures higher than 26°C, the preferred temperature was lower than the acclimation temperature.

Fry (1947) defined the final temperature preferendum as that point where the preferred temperature equals the acclimation temperature, and where an animal will finally select regardless of its acclimation temperature. Theoretically, the final temperature preferendum is the temperature which an organism will prefer, given sufficient time and expanded temperature gradient.

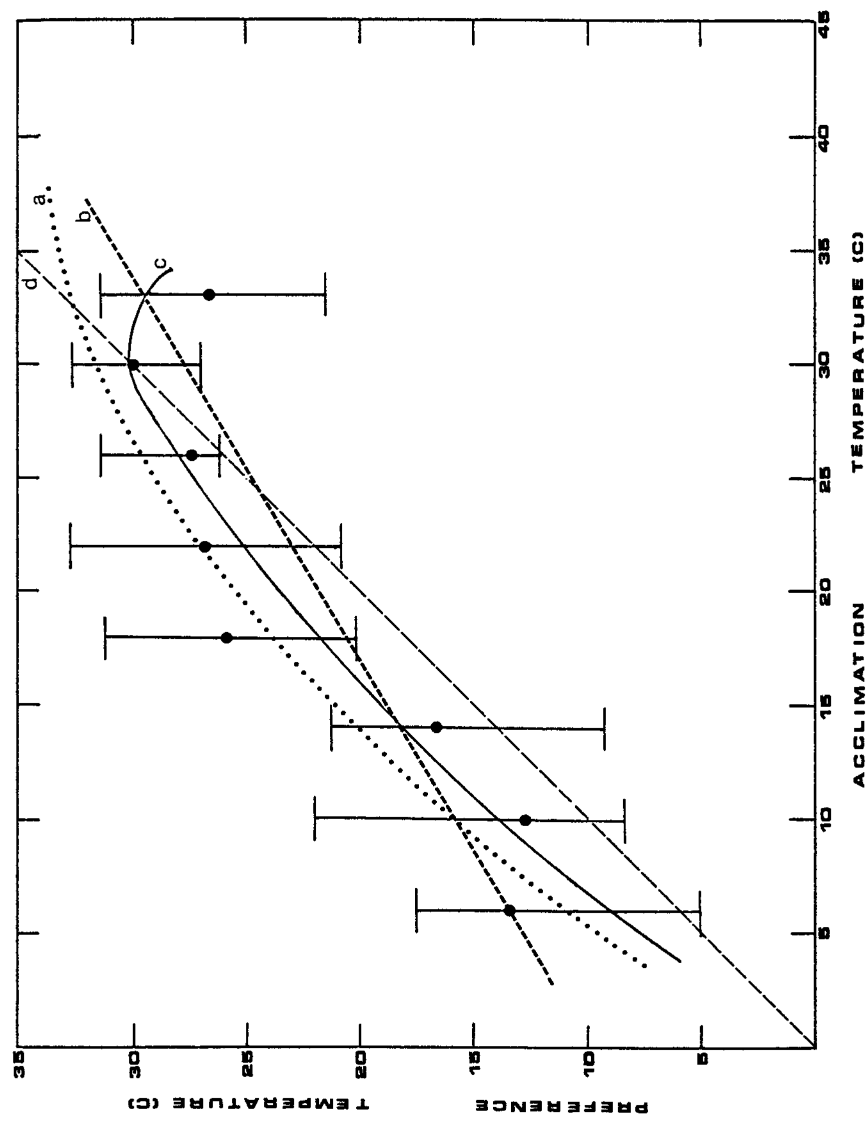

Figure 1. Graphic relationship of preferred and acclimation temperatures. a. Calculated quadratic equation b. linear regression line c. Eyeball plot (The dots represent the means, and the range extremes are also indicated) d. 45° Construction Line (Represents the point where preferred and acclimation temperatures are equal)

Richards *et al.* 1977 have discussed the validity of the various methods used to calculate the final preferendum from acute preferred temperature vs. acclimation temperature curves. The linear least-squares regression equation, $P = .65\ A + 9.3$, where P is the preferred temperature and A is the acclimation temperature, explained 48% of the data. The data were subjected to various transformations to find a better fit. The quadratic equation, $P = 1.6\ A - .02\ A^2 + 1.66$, explained 52% of the data. None of the other transformations or higher order terms of polynomials could be found which would significantly explain more of the data. "Eyeball" plots, as recommended by Coutant, were also used in an attempt to determine the final preferendum (Richards *et al.* 1977). The calculated final temperature preferenda, using the linear equation, the quadratic, and the "eyeball" technique, were 26.6°, 32.6° and 30°C, respectively. Crawshaw (1974) recorded temperature preference values of 22°C at night and 18°C during the day for a similar crayfish species *Orconectes immunis*.

For these data, the linear equation probably underestimates the final temperature preferendum while the quadratic overestimates it. The mean preferred temperature of 26.6°C, which occurred when crayfish were acclimated to 33°C, was substantially lower than the estimated final temperature preferendum of 30°C. This phenomenon has also been observed for several fish species when the acclimation temperature was higher than the final temperature preferendum (Stauffer *et al.* 1976). The mean preference values of the data indicate two distinct effective levels (Figure 1). Acclimation temperatures less than 14°C resulted in mean selected temperatures between 13° and 17°C while acclimation temperatures greater than 18°C produced selected temperatures from 26° to 30°C.

Individual command fibers have been described which control various movement patterns in crayfish (Atwood and Wiersma 1967; Kennedy *et al.* 1966; Wiersma and Ikeda 1964). Krasne and Wine (1975) observed that extrinsic systems controlled the excitability of the neurons which mediate tail flip escape. Temperature sensitive neurons isolated in the abdominal ganglia of crayfish were found by Prosser (1936) and Kerkut and Taylor (1958). In a temperature range of 10° to 30°C, the firing rates of these neurons were directly proportional to the temperature of the surrounding water. Kerkut and Taylor (1958) observed that the firing rate of these neurons was inhibited by an increase in temperature, whereas a decrease resulted in the opposite effect.

Crayfish are usually more active in unfavorable temperatures and less active in a thermoneutral environment, which would cause these animals to be found within a certain band of temperatures (Crawshaw 1974). Fraenkel and Gunn (1961) have designated this type of orientation orthothermokinesis, but it is probably more important in temperature preference orientation for certain insects (Fraenkel and Gunn 1961) than crayfish. Based on data from all these techniques, it was estimated that the final diurnal temperature preferendum for *O. obscurus* was 30°C.

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