Temperature Selection by Flathead Catfish in a West Texas Reservoir

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Abstract: Ultrasonic telemetry was used to determine seasonal temperature selection by adult flathead catfish *(Pylodictis olivaris)* in a 93-ha reservoir in west Texas, Buffalo Springs Lake. We implanted temperature-sensing ultrasonic transmitters in 29 flathead catfish and monitored them from June 1993 through June 1995. During the summer months, flathead catfish were found in the warmest lake waters (24.5–31.5 C) even though cooler well-oxygenated water was available. As lake temperatures decreased in fall and winter, flathead catfish were located in the warmest available water. Coldwater habitats were utilized only when the reservoir was not stratified. There was no significant difference in temperature selection by flathead catfish based on size, sex, year, or month. Other habitat variables may be more important to the overall habitat selection by flathead catfish in Buffalo Springs Lake.

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Flathead catfish are primarily a riverine species. However, their numbers have increased in lentic habitats because of the impoundment of streams and rivers, as well as widespread stocking. Suitable habitat for flathead catfish is poorly defined in the literature and may be dependent on a variety of factors including the temperature regime of a given body of water. Knowledge of temperature selection by flathead catfish can assist resource managers in managing this important sport fish.

There have been few studies examining temperature selection by flathead catfish in lentic environments. Cherry et al. (1975) found that warmwater fish species had a wider range of temperature tolerance than coldwater species. Overall, ictalurids and centrarchids selected the highest temperatures, as high as 32.1 C. Gammon (1973) determined that the upper avoidance temperature for flathead catfish was 32.0 C.

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The behavior of eurythermal species is influenced by several factors including ecological and genetic factors (Cherry et al. 1975). Confounding factors that can affect thermoselection behavior in fish include food availability (Beitinger and Magnusson 1975, Magnuson and Beitinger 1979, Bevelheimer 1996), dissolved oxygen and other water quality parameters (Bryan et al. 1984), and intra- and interspecific interactions (Beitinger and Magnuson 1975, Reynolds 1977).

Temperature selection by flathead catfish was examined in a small west Texas reservoir to determine 1) seasonal changes in temperature utilization, 2) use of the littoral zone when surface temperatures in these areas reached or exceeded 30.0 C, and 3) whether temperature selection was related to the size and the sex of the individual.

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Methods

The study was conducted at Buffalo Springs Lake, a 93-ha reservoir located approximately 11 km southeast of the city of Lubbock in west Texas. Buffalo Springs Lake is an impoundment of the North Fork of the Double Mountain Fork of the Brazos River. Buffalo Springs Lake has 2 main basins, a shallow basin with a maximum depth of 5 m and a deeper basin with a maximum depth of 16 m. The water in Buffalo Springs Lake is relatively turbid (Secchi depth 0.3 to 0.6 m) and has a high conductivity (1,200 to 1,600 μ S/cm), which is typical of west Texas reservoirs.

Temperature-sensing ultrasonic transmitters (Sonotronics Inc., Tucson, Ariz.) were used to measure fish temperature selection. Internal transmitters were used because they have greater longterm retention, do not cause external sores, and will not become entangled in vegetation (Winter 1983). The 74 kHz ultrasonic transmitters were cylindrical, 70 mm long and 18 mm in diameter, and weighed 24 g in air. These transmitters had a sensitivity of 0.01 C and a battery life of 54 months. Each transmitter had a unique coded signal so individual fish could be identified. All tags were calibrated in the lab by exposing them to 8 different temperatures between 0.0 and 35.0 C.

A preliminary experiment was conducted to determine if the response time of an internal transmitter to changing temperatures was rapid enough for an environment with small temperature gradients. A flathead catfish with an internal transmitter was exposed to known temperatures and the amount of time required for the tag to equilibrate was recorded. A 2.0 C change in temperature required 20 minutes to equilibrate and a 4.0 C change required about 40 minutes. Similar equilibration times have been recorded for largemouth bass *(Micropterus salmoides)* (Weller et al. 1984). The response time was acceptable since the nearshore temperature variation was not great (<5.0 C). The tracking process was long enough to determine whether a fish was stationary, and the pulse decoder would detect unstable temperature readings.

Flathead catfish were captured with gill nets and by electrofishing. After capture, the fish were measured, weighed, and held in a tank at the lake for 24 hours prior to surgery. Winter (1983) recommended that transmitter weight not exceed 2% of the body weight. Therefore, we only implanted transmitters in fish larger than 1.1 kg. Captured fish were anesthetized with 150 mg/liter of MS-222 prior to surgery. Surgical implantation of transmitters into the peritoneal cavity was done using methods described by Hart and Summerfelt (1975). Gonads were inspected at the time of surgery to determine the sex of the fish. After implantation, the fish were held an additional 24 hours prior to release at their capture site.

A total of 29 flathead catfish were implanted with ultrasonic transmitters between 25 June 1993 and 29 April 1995. Ten flathead catfish were implanted with ultrasonic transmitters during summer 1993, 14 during summer and fall 1994, and 5 during spring 1995. These fish ranged in length from 470 to 992 mm and weighed between 1.12 and 17.92 kg. Sixteen of these fish were males, 10 were females, and the sex of 3 fish was indeterminate.

During 1993, spring 1994, and winter 1994–95, tagged fish were located at least once a week. During summer and fall 1994, and spring and summer 1995, tagged fish were located from 2 to 8 times a week. Fish were located with a submersible directional hydrophone mounted on the end of a 150-cm PVC pipe. Once a fish was located, air temperature, and surface and bottom water temperatures were measured with a YSI model 57 oxygen meter. Fish body temperature was recorded from the ultrasonic tag. Transmitter temperature readings were not taken in the field until the pulse readings stabilized and data for highly active fish where the transmitter may not have equilibrated were excluded. To determine the available thermal habitat, vertical temperature and dissolved oxygen profiles were taken from a standard site during most sampling trips. In addition, water temperature data were collected from the littoral zone with three permanently deployed miniature temperature data loggers (Onset Instruments, Pocasset, Mass.).

Means, ranges, and standard deviations were calculated bimonthly for fish body temperature, littoral zone temperature, and bottom temperature. In addition, mean lake littoral zone temperature and the mean depth where flathead catfish were located was calculated monthly. The frequency of temperature selection by flathead catfish was calculated during periods of pronounced thermal stratification, June, July, and August. Frequency histograms were not calculated during other months because of a lack of variation in temperatures occupied by the fish during times of weak or no stratification.

A 4-way ANOVA was used to determine if there were statistical differences in temperature selection by flathead catfish based on size, sex, month, and year during periods of stratification. In addition, the software program MIX which was developed by Ichthus Data Systems was used to determine the statistical distribution (X^2) of the temperature frequency histograms. This program was originally designed to fit curves to fisheries length frequency data to determine age classes and similar data. Using this program we were able to determine whether 1 (unimodal) or 2 (bimodal) curves better represented the temperature data.

Results

Flathead catfish moved into deeper water during the autumn months when the lake destratified and temperatures throughout the lake were uniform (14.0–22.0 C) (Fig. 1). When mean water temperatures were the lowest in January and February (5.0–8.0 C) (Table 1), flathead catfish could be found at the greatest depths (2.7–12.5 m) (Fig. 1). Flathead catfish did not begin to migrate back into shallower water immediately after initial littoral zone warning. During early March 1994, the mean temperature occupied by flathead catfish was 9.0 C while mean littoral zone temperature was 11.8 C and mean bottom temperature was 8.0 C.

Flathead catfish migrated into shallower water in late March and April when mean littoral zone temperatures reached 17.0 to 19.0 C. As littoral zone temperatures approached 24.0 C in late June or July, tagged catfish moved into the rocky rip-rap of the dam and began spawning. Flathead catfish continued to use the littoral zone even when temperatures in this region exceeded 30.0 C. When mean littoral zone temperatures were the highest (26.0–31.0 C), flathead catfish were found at the shallowest depths (0.9 to 5 m) (Fig. 1). During this same time, dissolved oxygen levels in the epilimnetic zone ranged from 7.5 to 12.0 ppm, whereas dissolved oxygen levels below the thermocline ranged from 2.0 to 6.2 ppm.

Flathed catfish selected temperatures similar to surface (0 to 0.5 m depth) and littoral zone (0.5 to 2.0 m depth) lake temperatures during periods of stratification, even though cooler oxygenated water was available. During all seasons, mean daily fish temperatures ranged within ± 4.0 C of the mean daily littoral zone temperature. The standard deviation of mean daily temperatures of fish during all seasons was

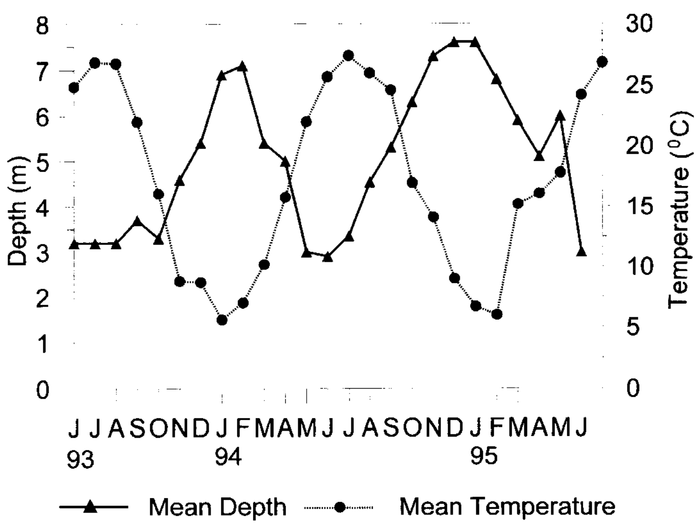

Figure 1. Mean temperature of lake littoral zone in degrees Celsius and mean depth utilization in meters, by flathead catfish from June 1993 through June 1995 in Buffalo Springs Lake, Texas.

Table 1. Mean combined bimonthly fish and lake temperatures in Buffalo Springs Lake, Texas, during 1993 through 1995.

Months	*N*	Mean fish temp. (C)	SD	Range	Mean littoral temp. (C)	Mean bottom temp. (C)
Jan – Feb	68	6.1	1.8	3.0 – 9.8	7.8	5.3
Mar – Apr	53	12.5	3.5	6.1 – 16.6	13.9	11.9
May – Jun	238	23.6	4.5	9.9 – 31.5	26.0	16.2
Jul – Aug	272	28.0	2.8	26.5 – 32.0	27.4	16.3
Sep – Oct	46	24.1	3.3	15.3 – 31.0	24.4	18.1
Nov – Dec	33	9.2	2.4	4.0 – 12.7	9.5	8.2

relatively small (SD=± 3.0 to 3.9 C). In late winter and spring (January–April), mean temperatures of flathead catfish were typically 1.0 to 2.0 C less than mean littoral zone temperatures and within 1.0 C of bottom temperatures (Table 1). During the prespawning, summer, and fall seasons (May–October) mean fish temperatures were very similar to mean littoral zone temperatures.

There was no significant difference in the temperatures selected by flathead catfish during June, July, and August based on size, sex, month, and year (4-way ANOVA, $P>0.05$). However, the 4-way interaction term was significant ($P=0.0001$).

During July 1993, the mean temperature occupied by flathead catfish was 27.8 C. These fish were found at water temperatures between 24.1 and 30.9 C (Fig. 2). The software program MIX determined that temperature orientation by flathead catfish during August 1993 and July and August 1994 was best represented by a bimodal curve (X^2, $P<0.05$). This bimodal distribution was the result of six fish which consistently chose warmer temperatures (>30 C). The mean temperature occupied by flathead catfish during these months was 28.0 C. The 2 ranges of temperature where flathead catfish were found were 25.5 to 28.5 C and 30.0 to 31.5 C (Fig. 2). A bimodal distribution did not occur during June of 1994 and 1995 or during July 1993 (X^2, $P>0.05$).

Discussion

Flathead catfish did not immediately move into the littoral zone from their deep water winter habitats as temperatures increased in the spring. The delay in migration is probably because the development of gonads and spawning migrations are primarily timed to photoperiod, which insures that fish do not migrate prematurely and expose vulnerable eggs and young to weather reversals (Diana 1995). This is of particular importance to fish in west Texas where daytime and nighttime air temperatures during spring can vary by as much as 20.0 C and surface water temperatures can change as much as 5.0 C.

The temperatures where we found flathead catfish may have been the preferred temperature of their prey species. Clupeids, ictalurids, and centrarchids are the dominant prey items of adult flathead catfish in several southern rivers (Guier et al. 1981, Ashley and Buff 1987, Quinn 1987). Sunfish and gizzard shad *(Dorosoma*

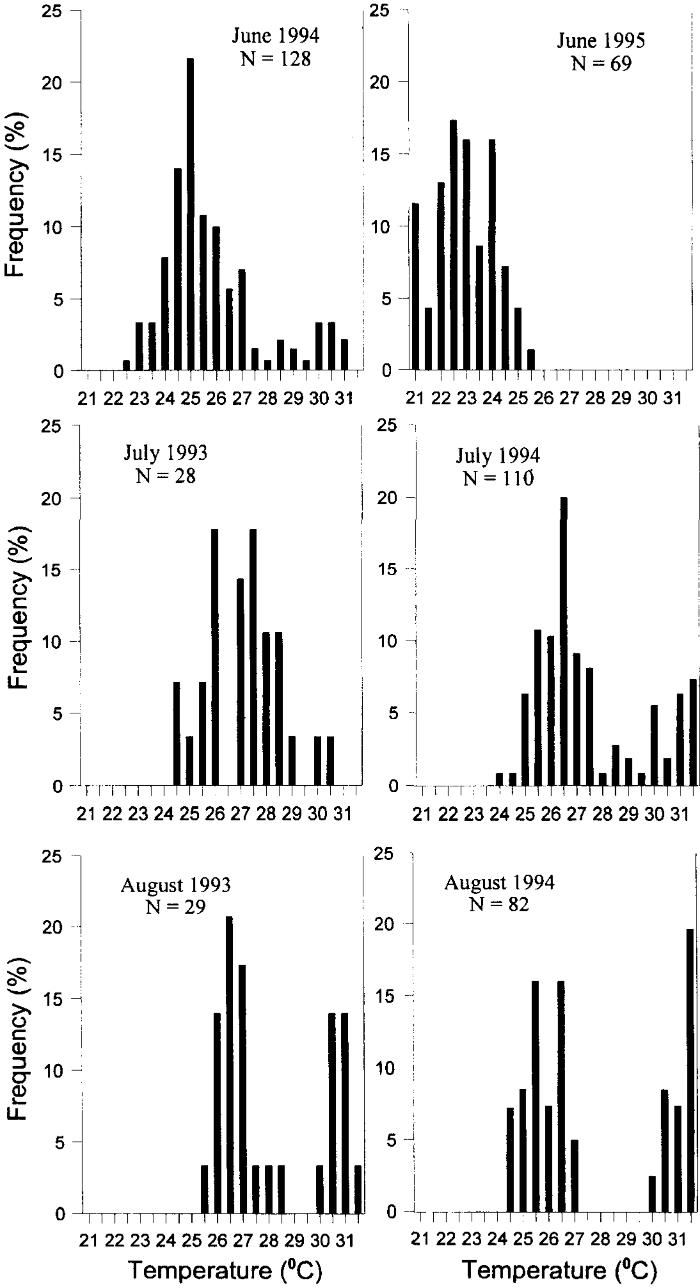

Figure 2. Frequency (%) of temperatures occupied by flathead catfish during June, July, and August 1993–1995 in Buffalo Springs Lake, Texas.

cepedianum) have been shown to be the primary prey items of flathead catfish in large reservoirs (Edmundson 1974, Layher and Boles 1980), Buffalo Springs Lake contains abundant populations of clupeids, ictalurids, and centrarchids. Gizzard shad and sunfishes (*Lepomis* spp.) have high temperature preferenda. Gizzard shad prefer temperatures from 20.5 to 23.0 C, but only avoid water warmer than 30.0 C (Coutant 1977). Temperature preferences of several sunfish species range from 21.5 to 32.3 C depending on the age and size of the individual. During June, July, and August, flathead catfish were found at temperatures between 21.0 and 31.0 C, which is the temperature range of their preferred prey.

The bimodal temperature distribution that occurred during August of both years was not due to the size or sex of the fish. There was not a significant difference in temperature selection based on fish size or sex. Different life stages of a species can have different temperature preferences (Reynolds and Casterlin 1978, Brandt et al. 1980, Coutant 1980). The flathead catfish we monitored were all adults and although there was a large variation in size among individuals, they were apparently beyond the size for ontogenetic shifts. The bimodal distribution that occurred during August was due to 6 fish which consistently chose warmer temperatures (>30.0 C). Three of these fish were males, 2 were females, and the sex of the other was indeterminate. All 6 of these fish were located at or very near the spillway the majority of the time. This area is relatively shallow and was often warmer than the remainder of the lake. Temperatures in this area did not go above 32.0 C, which is the reported upper avoidance temperature for flathead catfish (Gammon 1973). The increased flow and perhaps increased prey availability may be why these fish were consistently found near the spillway.

Temperature selection by flathead catfish follows a yearly pattern, but indication of the most important variable responsible for this pattern was not clear. There was not a significant difference in temperature selection based on size, sex, month and year. Uneven seasonal warming by month and temperature variation among years could make clear significant differences difficult to ascertain. The highly significant 4-way interaction term indicates that several factors are responsible for temperature selection by flathead catfish. Other habitat variables such as cover and prey availability have been shown to influence temperature selection of predatory fish (Bevelhimer 1995, 1996). Habitat variables such as these may be more important than temperature in the overall habitat selection of flathead catfish in Buffalo Springs Lake.

In summary, flathead catfish were found in the warmest thermal habitats during most of the year. Only during the initial warming period of early spring did flathead catfish not use the warmest available temperatures. Flathead catfish exhibited a bimodal distribution in temperature orientation during late summer. Some individuals were located in temperatures from 26.0 to 27.9 C, while others were found in temperatures from 30.0 to 31.9 C. Based on the results of this study we conclude: (1) flathead catfish do not avoid the littoral zone even when temperatures in this region exceeded 30.0 C, and (2) the presence of relatively deep water (3 to 12 m) may be preferred by flathead catfish for overwintering.

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