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AGE, GROWTH, AND REPRODUCTION OF LEATHERSIDE CHUB (*GILA COPEI*)

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Key words: *Gila copei*, *leatherside chub*, *life history*, *reproduction*, *age*, *growth*.

The leatherside chub (*Gila copei*) is a small cyprinid native to eastern and southern areas of the Bonneville Basin of Utah, Idaho, and Wyoming, to Wood River, Idaho, and to regions of the Snake River, Idaho and Wyoming, above Shoshone Falls (Baxter and Simon 1970, Simpson and Wallace 1982, Sigler and Sigler 1987). *Gila copei* is currently listed as a candidate for federal protection under the Endangered Species Act.

Conservation efforts for *G. copei* would benefit from accurate life history data, yet the life history of *G. copei* is not well known. This species was thought to live less than five years (Sigler and Sigler 1987). Based on bright coloration of males and abdominal distension in females, Sigler and Miller (1963) concluded *G. copei* spawns between June and August. Using similar coloration criteria on males from Sulphur Creek, WY, Baxter and Simon (1970) suggested breeding occurred in late summer; Simon (1951) found females distended with eggs in early August. Other than these few observations, no data on age, growth, or reproduction are available.

We present data on age, growth, and reproduction of leatherside chub from central Utah; these data were generated as a first step to understanding and protecting this potentially threatened, endemic fish species.

STUDY SITE

Age and growth data were obtained from 36 *G. copei* collected from Thistle and Main creeks, both tributaries to larger rivers that flow into Utah Lake. Thistle Creek, a tributary to Spanish Fork River, was sampled in May, September, and October 1993 ($n = 25$) ($39^{\circ}52'N$, $111^{\circ}32'W$) at an elevation of approx-

imately 1700 m. Main Creek flows directly into Deer Creek Reservoir (an impoundment of Provo River) and was sampled in July 1993 ($n = 11$) 500 m upstream from the reservoir ($40^{\circ}24'N$, $111^{\circ}28'W$) at an elevation of 1650 m. Chubs used for determining reproductive patterns (below) were collected from the latter site in 1978–79. Creeks at both locations flow slowly at low gradient through meadows. The Main Creek site is downstream from beaver dams; tall grasses and small trees grow along banks. Collections for both creeks were made from vegetated pools separated by shallow riffles; stream substrate is silt, gravel, and boulders.

MATERIALS AND METHODS

Because *Gila copei* is a species of special concern, our permit was limited to 40 specimens, and care was taken to collect the entire size range. Following collection by electroshocking, fish were placed on ice and transported to Brigham Young University (BYU) where they were stored frozen. Individuals were then thawed, rinsed in water, blotted dry, and weighed (0.001 g) on a Denver Instrument XD-1200D[®] electronic balance; standard length (SL) was determined (0.01 mm) using Fowler Ultra Cal III[®] electronic calipers.

Ages were determined by grinding otoliths (lapillus) to a thin section and counting opaque bands under a Leica dissecting microscope (40X). Opaque bands were validated as annuli using a marginal increment analysis; because juvenile (ages 1–2) and adult fish (ages 3–8) demonstrated distinct growth rates, they were evaluated separately. Identification of annuli was facilitated by generating digitized images of otoliths on a video monitor using a Hitachi

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CCTV[®] camera fitted to a Heerbrugg Wild[®] dissecting microscope. Annual growth increments along the longest axis of the otolith were then measured (0.001 mm) using video image analysis software (Mocha release 1.0, Jandel Scientific; Rundel 1993), which reduces measurement errors introduced when reading otoliths directly under a microscope (McGowan et al. 1987).

Size at age was back-calculated from otolith measurements using a modified Fraser-Lee formula (Campana 1990):

$$L_x = L_0 + (L_c - L_0)(R_x - R_0)/(R_c - R_0),$$

where L_x is estimated SL at age x , L_c is length at capture, R_x is otolith radius at age x , and R_c is otolith radius at capture. L_0 is estimated length at swim-up (estimated at 4 mm from data on *Gila atraria*; Varley and Livesay 1976), and R_0 is otolith radius at swim-up (estimated from otoliths at 0.01 mm).

There was no significant difference in back-calculated lengths at age I between Main and Thistle creek chubs (Main Creek, $n = 11$; Thistle Creek, $n = 25$; $T = 1.96$, d.f. = 34, $P = .06$). Numbers of age II ($n = 2$) and age III ($n = 3$) fish from Main Creek precluded statistical comparisons; however, back-calculated lengths at age II and age III for Main Creek fish were within the range of comparably aged fish from Thistle Creek. Hence, growth data for the two populations were combined. An age-growth curve was generated for the combined samples by averaging back-calculated sizes at age.

Leatherside chub collected in 1993 were sexed by dissection and examination of gonads; individuals lacking mature gonads were classified as juveniles. Immature testes were translucent and threadlike, while mature testes were opaque (white or pinkish) and firm. Reproductive states of ovaries were determined according to criteria in Holden and Berry (1983); immature ovaries were small, translucent, and lacked yolked ova; mature ovaries were larger and contained both immature ova and firm, yolked ova.

Reproductive data were obtained from a collection of 176 adult leatherside chubs archived in the Monte L. Bean Museum at BYU (#5592-5619, 5629-5686, 5688-5775). Monthly collections from Main Creek (August 1978 to September 1979) were made using

minnow traps, hand nets, and electrofishing gear, and preserved in formalin. Daily temperature was recorded from September 1978 to July 1979.

Standard length was measured (mm), and preserved wet mass (0.01 g) was recorded, for each specimen. Gonads from all ($n = 176$) individuals >50 mm SL were removed and weighed (0.001 g). No fish <50 mm SL had enlarged gonads. A gonadosomatic index (GSI) was generated for each fish using the following formula (Andreasen and Barnes 1975):

$$GSI = (\text{gonad weight} / \text{body weight}) \times 100.$$

Mean monthly GSI values were used to determine onset and duration of spawning. Ova counts were made on nine fish collected in May 1979. The relationship between number of ova present and SL was evaluated by linear regression.

RESULTS

Opaque bands on leatherside chub otoliths appear to be valid annuli as demonstrated by an increase in the marginal growth increment throughout the growing season for both adult and juvenile fish (Fig. 1).

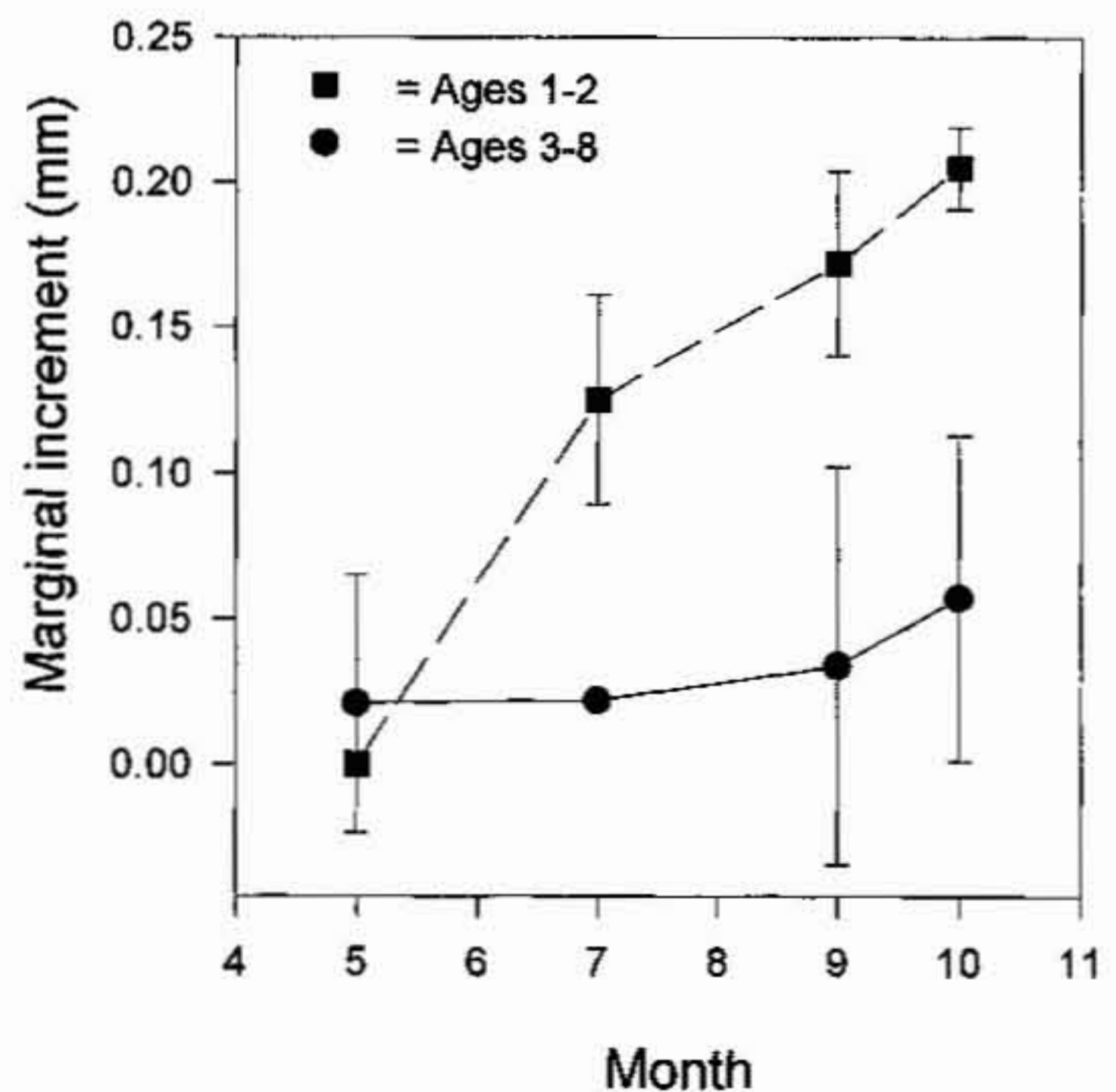


Fig. 1. Mean marginal increment widths (± 2 S.E.) measured from otoliths in *Gila copei* ($n = 36$). Immature age classes (1-2) and mature age classes (3-8) plotted separately.

Ages of 36 *G. copei* collected in 1993 ranged from one to eight years, with SL of 38–110 mm (Table 1). Chubs grew rapidly to ~58 mm SL at about age II (Fig. 2, Table 1). From age II on, annual growth was slower and fairly uniform. Mean GSI values for males and females (Fig. 3a) were highest for both sexes in spring with maxima in May (female GSI = 12.3, male GSI = 2.7). Increasing water temperatures from January through May (Fig. 3b) were associated with increased GSI values for both sexes. Average water temperature in May, corresponding to GSI maxima, was 9.4° C.

Fecundity (as measured by ovum counts) increased with SL for females collected in May

1979 and ranged from 938 in a 67-mm-SL, 5.9-g female to 2573 in a 92-mm-SL, 14.6-g female. Average count for leatherside chubs collected in May 1979 was 1813. Significant correlations existed between SL and fecundity ($R^2 = .82, P < .05, n = 9$) and weight and fecundity ($R^2 = .72, P < 0.05, n = 9$).

DISCUSSION

A maximal age of eight years in our sample of *G. copei* indicates a life span much longer than previously thought (Sigler and Sigler 1987). Longevity in *G. copei* may be a life history trait that has evolved in response to living

TABLE 1. Capture and back-calculated standard lengths (SL) of *Gila copei* from Thistle and Main creeks, central Utah.

Age	N	SL at capture		Mean back-calculated SL at annulus									
		Mean	Range	1	2	3	4	5	6	7	8		
1	8	44	38–49	32									
2	9	76	65–85	41	65								
3	2	87	71–104	42	68	82							
4	1	85	—	51	65	77	83						
5	1	97	—	38	53	70	87	96					
6	7	92	83–110	35	52	63	73	82	89				
7	7	94	88–105	36	54	66	73	80	86	91			
8	1	96	—	31	46	54	62	67	76	86	93		
Overall means					37	58	67	74	81	87	90	93	

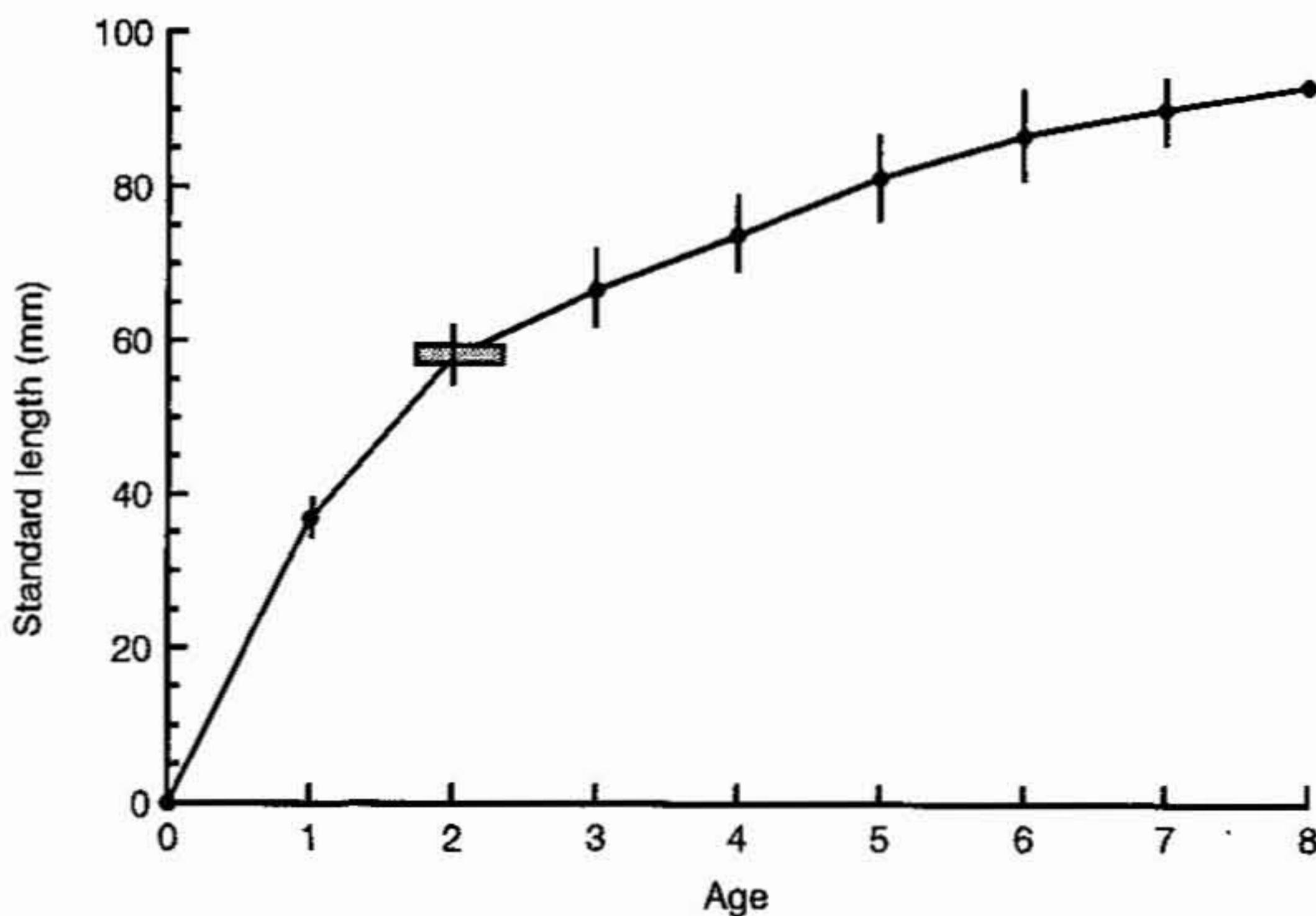


Fig. 2. Mean back-calculated standard lengths at age (±2 S.E.) for *Gila copei* (n = 36) in central Utah. Shaded block indicates estimated age at first reproduction.

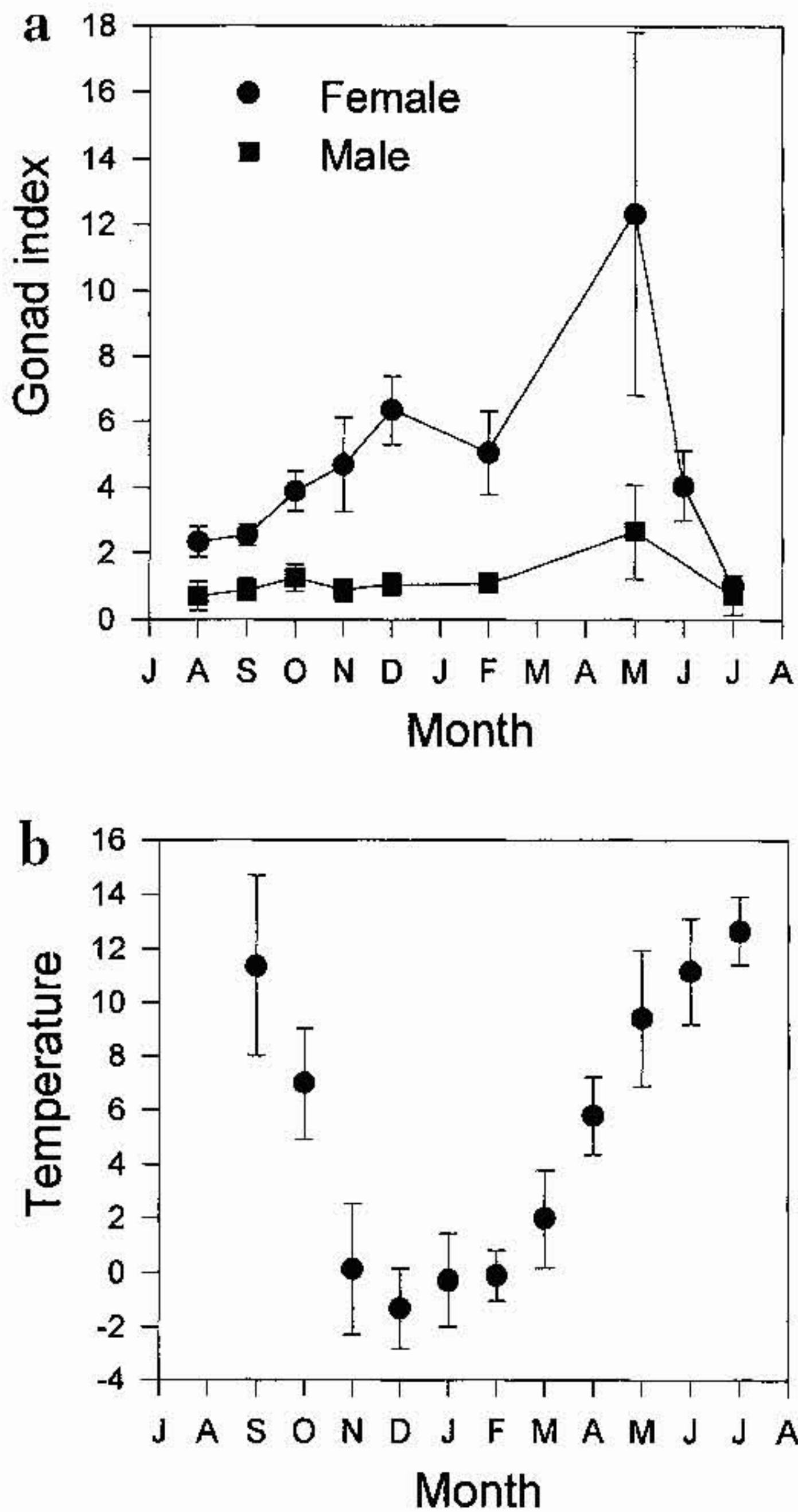


Fig. 3a. Mean gonadosomatic indices (± 2 S.E.) for male and female *Gila copei* ($n = 176$); b, mean monthly temperatures (± 2 S.E.) from August 1978 to July 1979 in Main Creek, Wasatch County, UT.

in an environment where annual precipitation and stream flow vary considerably. Successful chub reproduction and recruitment may be uncertain in any given year. An extended life span would increase the likelihood that appropriate environmental conditions for reproductive success would be met at some time in an individual's life; thus, longevity may be a "bet-hedging" strategy (Stearns 1976) for living in unpredictable conditions.

The growth pattern of *G. copei* is typical of other fishes in which rapid juvenile growth decreases at the onset of sexual maturity as finite energy resources are allocated to both growth and reproduction (Roff 1984). The inflection point in the growth curve (Fig. 1),

coupled with the facts that the smallest fish with developed gonads collected in 1993 was 65.2 mm SL and no fish in the museum collection <50 mm SL had enlarged gonads, suggests that first reproduction in *G. copei* occurs at age II.

High GSI in May followed by decreased GSI in June and minimal values in July and August (Fig. 3a) indicates that peak spawning occurred in May, with some activity possibly extending into early June. *Gila copei* apparently follows a pattern of reproduction common to various cyprinids living in temperate climates (Munro et al. 1990). This pattern is characterized by the onset of spawning in late spring followed by a period of gonadal recrudescence and inactivity; size of gonads begins to increase in autumn and continues through winter, with final maturation occurring in early spring.

If temperature influences the onset of spawning, differences in temperature (as a function of latitude) between Main Creek (this study) and southwestern Wyoming (Simon 1951) could explain the discrepancy between onset of chub spawning at these locations (May vs. August). A more detailed investigation of *G. copei* will be required to resolve questions of differences in reproductive and life history characteristics among populations.

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