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AGE AND GROWTH OF JUNE SUCKER (*CHASMISTES LIORUS*) FROM OTOLITHS

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Key words: June sucker, Chasmistes liorus, *age, growth, life history, otoliths, Utah Lake.*

June sucker, *Chasmistes liorus,* is endemic to Utah Lake, Utah County, Utah (Miller and Smith 1981). This species is federally listed as endangered, and the wild population may number <500 individuals (based on mark-recapture estimates, C. Keleher, Utah Division of Wildlife Resources, personal communication). The remaining *C. liorus* population appears to suffer from lack of recruitment to the adult population, apparently in part due to predation on juveniles by an abundant population of introduced white bass (*Morone chrysops*; U.S. Fish and Wildlife Service 1995). Present recovery efforts include artificial propagation. Adult *C. liorus* are captured as they proceed up the Provo River to spawn, gametes are stripped and combined, and offspring are raised in captivity until they reach a size large enough to avoid predation by white bass. These juveniles then are returned to Utah Lake, except for those retained as brood stock. To effectively evaluate survival of captive-reared individuals and to estimate age at recruitment to the breeding population, one must understand natural patterns of *C. liorus* growth in Utah Lake. Although adult size is well documented, no data are available on *C. liorus* growth patterns. In this paper I report growth pattern, size at age, and age at death of individuals estimated from presumptive annuli on otoliths (lapilli) from 10 *C. liorus* from the wild population. This study provides previously unavailable data on age and growth to serve as a baseline for comparing *C. liorus* growth patterns.

Ten *C. liorus* (7 in June 1992 and 3 in June 1994) died from unknown causes, possibly as a result of stress associated with spawning activities, and were recovered by the Utah Division of Wildlife Resources. Standard length, total length, mass, and sex were recorded for each individual. Lapilli were removed, cleaned, and embedded in epoxy resin (Serifix, Struers Corporation, Westlake, OH) for sectioning. Otoliths were sectioned in the frontal plane using a lapidary grinder (Struers Model DAP-7, Struers Corporation, Westlake, OH) and mounted on a glass slide. Thin sections were observed with a Wild dissecting microscope at 24X to determine number of annuli (age), and images were captured via a video camera mounted on the microscope and a TARGA board in the computer to measure annual increments on otoliths. Annual increments for the first 10 presumptive annuli were measured with the use of MOCHA image analysis software (Jandel Scientific Inc.). Estimated length at age was calculated using the following formula (modified Fraser-Lee method, Campana 1990):

$$L_x = L_o + (L_c - L_o)(R_x - R_o)/(R_c - R_o)$$

where L_x is estimated total length 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_o is estimated length at swim-up (11 mm; Snyder and Muth 1988), and R_o is estimated otolith radius at swim-up (0.09 mm, measured from otoliths). An age-growth curve for ages 1–10 was generated by averaging back-calculated sizes at age for each sex (Fig. 1).

Estimated ages of individuals ranged from 10 to 41 yr. Two individuals had 10 presumptive annuli at death in 1992. All others had more than 25 annuli at death (Table 1). *Chasmistes liorus* exhibited a 3-stage growth pattern. Back-calculated lengths at age indicated

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TABLE 1. Presumptive age, sex, total length, year of death, and estimated total length at presumptive ages 1–10 for 10 *Chasmistes liorus*. Total lengths at ages >10 yr were not calculated.

Presumptive age	Sex	TL	Death	Estimated total length at annulus									
				1	2	3	4	5	6	7	8	9	10
10	M	502	1992	87	256	355	421	461	477	492	498	501	502
10	F	526	1992	101	277	388	437	468	487	503	520	522	526
26	M	518	1992	91	259	343	380	393	414	430	449	469	470
31	F	580	1992	197	294	353	397	425	457	476	497	517	538
34	F	539	1992	149	273	302	332	351	366	390	421	434	457
35	F	568	1992	70	176	232	262	299	330	348	368	382	403
41	F	555	1992	141	204	264	320	365	395	420	438	451	455
30	F	558	1994	78	203	296	325	366	383	393	411	421	430
36	F	592	1994	97	205	251	291	327	348	373	394	405	424
37	M	502	1994	96	172	214	255	286	322	350	369	380	400
$\bar{x}$		544		111	232	300	342	374	398	418	437	449	460
s		31.7		39	45	59	64	63	60	57	54	53	49

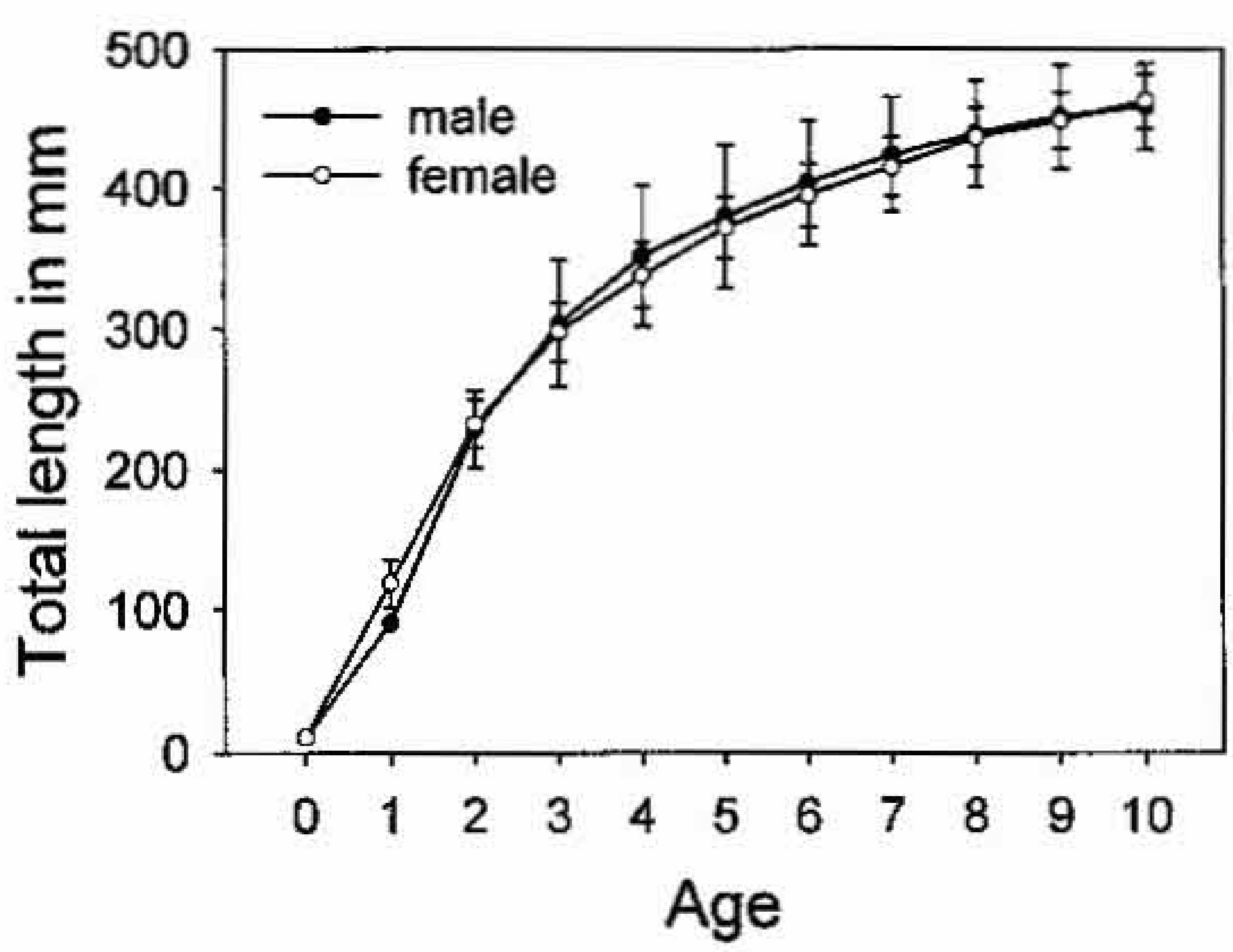

FIG. 1. Mean ($\pm 1 s_{\bar{x}}$) total length at age 1–10 for male ($n = 3$) and female ($n = 7$) *C. liorus* in Utah Lake, Utah Co., Utah, USA. Length at age calculated from presumed annual increments on otoliths. Length at ages >10 was not calculated.

rapid growth for the first 3–5 yr, and individuals averaged 69% of mean total length at death by the 5th presumptive annulus. Following this rapid growth, individuals exhibited intermediate growth rates until about age 8–10. Eighty-five percent of mean total length at death was achieved by the 10th annulus (Table 1). Growth after age 10 was further reduced. Growth trajectories did not appear to differ between sexes within the first 10 yr, and estimated length at age 10 did not differ between sexes ($P > 0.1$, Wilcoxon rank sum test, SAS 1990; Fig. 1). Based on condition of gonads and presence in the spawning aggregation in Provo River, all individuals were reproductively mature at time of death.

Although 10 is a relatively small sample size, this sample may represent 2% of the remaining population, well above the proportion sampled in most studies on age and growth of fish. Because *C. liorus* is endangered and individuals cannot be obtained easily, validation of ages derived from otoliths has not been done. Validation of age estimates using otolith annuli has been done for other cyprinids (leatherside chub [*Gila copei*], Johnson et al. 1995; Utah chub [*Gila atraria*], unpublished data), and *C. liorus* appears to exhibit similar patterns of annulus formation. Ages derived from sectioned otoliths of *Xyrauchen texanus* have been validated for younger age classes, and ages appeared reliable for older age classes (McCarthy and Minckley 1987). However, until a validation study of ages derived from sectioned otoliths of *C. liorus* is possible, ages in this study should be considered preliminary (Beamish and McFarlane 1983).

In most fishes growth rate decreases after sexual maturity (Alm 1959). *Chasmistes liorus* examined in this study show a decreased rate of growth after about 5 annuli, and all individuals in this study were reproductively mature. Assuming that decreased growth rate indicates probable maturation, *C. liorus* may mature as early as age 5, but at least by age 10. In 1980 the smallest reproductive individuals were 440 and 490 mm total length for males and females, respectively (Shirley 1983). If growth patterns of these fish are similar to that documented in this study, then the smallest individuals likely would have been 6–10 yr old.

U.S. Fish and Wildlife Service (1995) reported total length of reproducing females was larger than males in both 1980 and 1991. Until age 10 growth patterns do not differ between sexes in this study. However, all females were larger than males, suggesting that differences in total length between sexes result from increased growth of females relative to males after sexual maturation.

C. liorus age and growth patterns appear similar to those of other large-bodied western suckers (e.g., *Chasmistes cujus*, Scoppettone 1988, Scoppettone and Vinyard 1991; *Xyrauchen texanus*, McCarthy and Minckley 1987). Delayed maturity and long adult life may be adaptations to uncertain recruitment caused by environmental fluctuations (Scoppettone and Vinyard 1991). These characteristics have allowed populations of *C. liorus* and other similar species to persist, even though recruitment has been extremely limited because of recent human disturbance. It is my hope that recovery efforts can improve recruitment before the aging adult population becomes extinct.

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