Extended Longevity in a Large-bodied Stickleback, *Gasterosteus*, Population

T. E. REIMCHEN

Department of Biology, University of Victoria, P.O. Box 1700, Victoria, British Columbia V8W 2Y2

Reimchen, T. E. 1992. Extended longevity in a large-bodied Stickleback, *Gasterosteus*, population. Canadian Field-Naturalist 106(1): 122–125.

Mark/recapture data combined with counts of pelvic spine annuli on adults of the large-bodied Threespine Stickleback (*Gasterosteus aculeatus*) at Drizzle Lake, Queen Charlotte Islands, demonstrate that adults do not die after the first breeding season (usually 2-3 y of age), as commonly assumed, but can reach 8 y of age. This is almost twice the known maximum age observed in any population within the five genera of Gasterosteidae.

Key Words: Giant stickleback, *Gasterosteus*, growth rate, life span, aging techniques.

The life history of the Threespine Stickleback (*Gasterosteus aculeatus*) is characterized by simple demographic factors including early reproduction and short life span. In most populations, adults range from 1-2 years of age and are 40 to 70 mm standard length (SL). Maximum life span in natural populations does not appear to exceed 4 y (*see* Wootton 1984 for review). On the west coast of North America, but not elsewhere in the circumboreal distribution of the species, Threespine Sticklebacks may reach exceptionally large sizes, with adults averaging 85 mm SL and occasional individuals exceeding 100 mm SL (Moodie 1972; Moodie and Reimchen 1976; Bell 1984). Proximate causes of large size could be extended longevity or possibly accelerated growth rate. In giant sticklebacks, from Mayer Lake, Queen Charlotte Islands, males and females breed during their second year (third summer) and are assumed to die at the end of the first breeding season (Moodie 1984) suggesting accelerated growth and a typical life span.

As part of the ongoing studies of the giant stickleback at Drizzle Lake, Queen Charlotte Islands (Reimchen 1988, 1991), I describe here a substantially divergent pattern of age structure to that known for any other population within the Gasterosteidae.

Methods

Young of the year fish were seined monthly (August to November, 1976; July to September 1977; May to July 1978) while sub-adults and adults were trapped (Gee minnow traps and Fyke net), measured and released bimonthly from 1980 to 1983. Growth rates of young of the year and subadults (< 70 mm) were determined from plots of length frequencies where distinct cohorts could be followed over time. In 1985, randomly sampled adult stickleback (N = 17 033) were marked (spine clip) and released as part of a study on population estimates in the lake (Reimchen 1990). Collections were continued in summers from 1985 to 1990 in which all adult fish were scored for several traits including presence of spine clips. In 1988, recaptures were kept (N = 23) for aging. Otoliths proved unsatisfactory as they were exceptionally opaque. Pelvic spines from each fish were decalcified and embedded in historesin. Thin sections (4-5 microns) were prepared from near the base of the spine and stained with Richardson's solutions (Azure Blue and Methyl Blue 1:1). Annuli were counted under a dissecting microscope. All body size measurements are given in SL.

Results

Fry first appear in the lake in June and are abundant near shore from July to October, ranging from 14 to 25 mm. Juveniles reach 40-45 mm within 12 months and 60-70 mm after 24 months. Very few fish of this size are reproductive (identified by accentuated melanism in males and egg development in females); most breeding adults range from 75 to 85 mm. This suggests that reproduction does not occur until the following spring when fish are approximately 32 months of age.

TABLE 1. Mark/release and recapture data of 17 033 adults marked in spring 1985 at Drizzle Lake, Queen Charlotte Islands, British Columbia.

Year	Month	Collected	Recaptured	
		N	N	freq
1985	August	2423	635	0.262
1986	May	2065	512	0.199
	August	307	81	0.209
1987	July	1275	160	0.111
1988	June	898	28	0.030
	August	481	12	0.024
1989	June	538	2	0.004
	August	321	2	0.006
1990	July	766	0	0.000

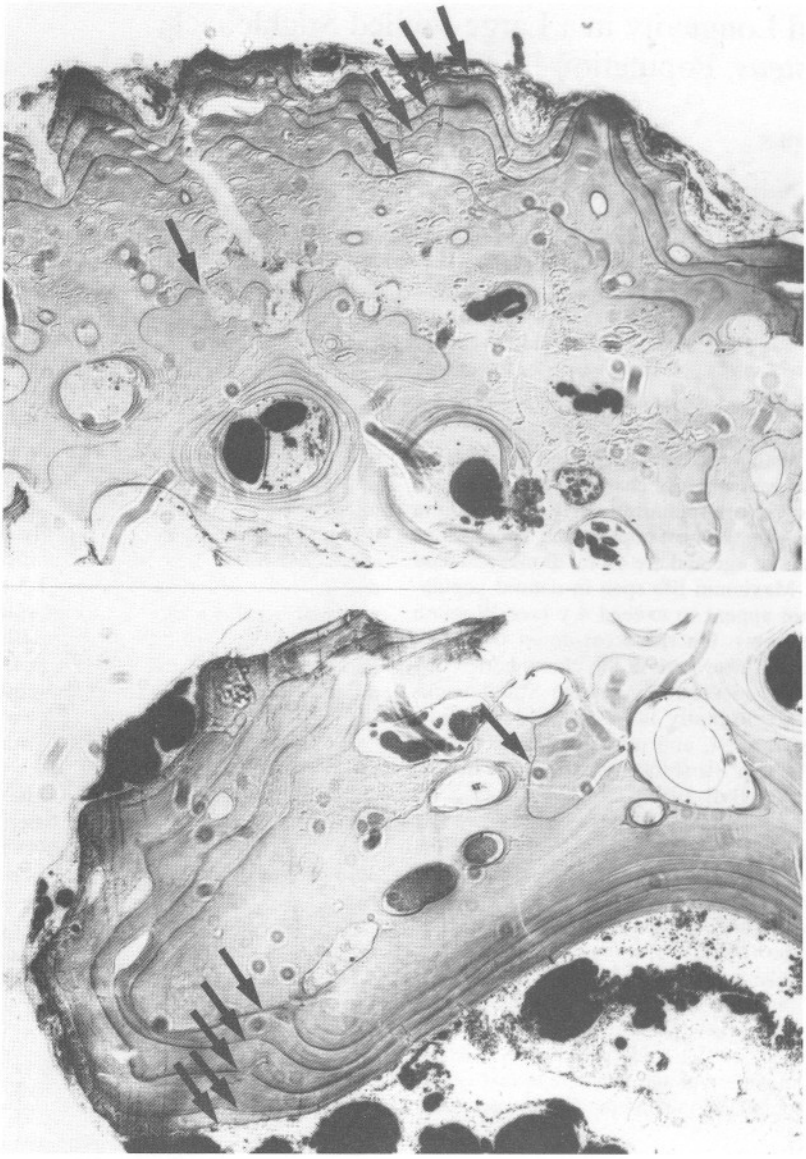

FIGURE 1. Thin-sections of pelvic spines obtained from two sticklebacks marked as adults in spring 1985 and recaptured in June 1988. Each shows six distinct annuli (arrows) and one possible outer annuli. Assuming adults were marked at minimum age (32 months), individuals should have six annuli and be at least 68 months of age.

Sticklebacks do not succumb to mass mortality after their first breeding season. Adult sticklebacks, marked during the breeding season in spring 1985 were recaptured during four successive years (Table 1) indicating a potential life span of 7 y assuming a minimum age of 32 months at the time of marking. High recapture frequencies in spring and summer 1986 demonstrate that the longevity is common. Gradual reduction in recaptures from 1986 to 1990 presumably indicates a loss of the oldest cohorts and continued recruitment of younger fish into the breeding population.

Cross-sections of pelvic spines taken from recaptured fish in 1988 show exceptionally clear annuli (Figure 1). Ages of the recaptures are 5 y (N = 5), 6 y (N = 11), 7 y (N = 5) and 8 y (N = 2) demonstrat-

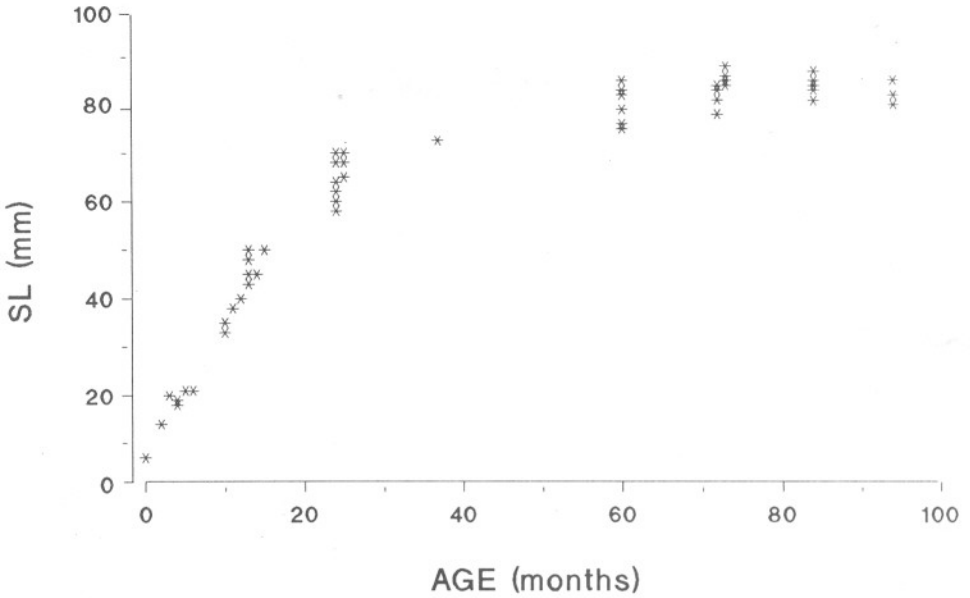

FIGURE 2. Growth rate of Drizzle Lake sticklebacks obtained from length frequency cohorts (<70 mm) and from pelvic spine annuli (> 70 mm).

ing that the original cohort marked in 1985 comprised multiple year classes, possibly with a mode at 3 + y.

Addition of the age/length data from these recaptured fish to length-frequency cohorts of juvenile and sub-adults demonstrates a characteristic asymptotic growth curve with most growth occurring during the first two years (Figure 2). The two oldest fish (8 y) in these samples were 80 mm SL, comparable in size to fast-growing 3 y fish.

Discussion

European and North American studies of body growth in Threespine Sticklebacks show that individuals usually reach 40 mm during the first 12 months with extremes ranging from 30 to 60 mm (Greenbank and Nelson 1959; Wootton 1984). By 24 months, sizes range from a low of 45 mm to a high of 78 mm. In the Drizzle Lake stickleback, mean sizes during the first and second year (42 mm and 65 mm respectively) fall near the average for the species and there is no evidence for accelerated growth. Therefore, the large size at first reproduction (approximately 75 mm) results from prolonged subadult growth. In sticklebacks, this trait has high heritability (McPhail 1977).

Available data from diverse studies indicate that most sticklebacks die after their first breeding season (Wootton 1984). This also appears to apply to the giant stickleback at Mayer Lake (Moodie 1984). Although I am not able to ascertain that the adults in the Drizzle Lake population are breeding each year, the high frequencies of recaptures on successive years clearly indicates that many adults do not die following the first breeding season and have the potential of multiple breeding years (see Reznick and Endler 1982 for discussion of adult size and life history strategy).

Age determination in sticklebacks can be usually made from length frequency distributions and counts of otolith annuli. However, in the Drizzle Lake population, the extended longevity, the small increments of yearly growth and large variability in growth among adults greatly limit the use of length as an estimate of age. Pelvic spine cross-sections had excellent resolving success relative to otoliths and this method may allow for more detailed evaluation of age structure in populations where length frequencies and otoliths are of limited use.

Adult sticklebacks in this locality have a yearly probability near 0.1 of being attacked and escaping from a vertebrate predator (Reimchen 1988). Therefore, the long potential life span greatly extends the period over which predator-prey interactions occur. Any persistent difference in relative fitness among phenotypes could produce a large change in frequency between 3 y old and 8 y old sticklebacks. This may provide an explanation for the striking associations between average vertebral number and adult body size observed in these sticklebacks (Reimchen and Nelson 1987).

Maximum life span of the Threespine Stickleback is geographically variable. In small-bodied populations (30-50 mm), individuals generally die prior to their second winter while in larger-bodied populations (50-90 mm), sticklebacks may survive for 3 y

and occasionally 4 y (Greenbank and Nelson 1957; Aneer 1973). The oldest age recorded for any of the other four genera in Gasterosteidae is 5 y, found in *Pungitius pungitius* (Wootton 1984). Clearly, the Threespine Sticklebacks in Drizzle Lake which reach at least 8 y of age are exceptional in the taxon. However, since this is the first study involving long term collections of a marked population of sticklebacks, it is plausable that extended longevity will be found elsewhere if increased attention is given to multiple year sampling.

Acknowledgments

I thank S. D. Douglas for field assistance, T. Jacobsen, P.O'Reilly, and J. Westley for technical assistance and the Ecological Reserves Branch, Ministry of Parks, Government of British Columbia for permission to work on the Drizzle Lake Reserve. This work was supported by an NSERC grant (A2354) to the author.

Literature Cited

Aneer, G. 1973. Biometric characteristics of the three-spined stickleback (*Gasterosteus aculeatus* L.) from the Northern Baltic proper. Zoologica Scripta 2: 157–162.

Bell, M. A. 1984. Gigantism in threespine stickleback: implications for causation of body size evolution. Copeia 1984: 530–534.

Greenbank, J., and **P. R. Nelson.** 1959. Life-history of the three-spine stickleback *Gasterosteus aculeatus* Linnaeus in Karluk Lake and Bare Lake, Kodiak Island, Alaska. United States Fish and Wildlife Service Bulletin No. 153.

McPhail, J. D. 1977. Inherited interpopulation difference in size at first reproduction in threespine stickleback, *Gasterosteus aculeatus* L. Heredity 38: 53–60.

Moodie, G. E. E. 1972. Morphology, life history and ecology of an unusual stickleback (*Gasterosteus aculeatus*) in the Queen Charlotte Islands, Canada. Canadian Journal of Zoology 50: 721–732.

Moodie, G. E. E. 1984. Status of the Giant (Mayer Lake) Stickleback, *Gasterosteus* sp., on the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 98: 115–119.

Moodie, G. E. E., and **T. E. Reimchen.** 1976. Phenetic variation and habitat differences in *Gasterosteus* populations of the Queen Charlotte Islands. Systematic Zoology 25: 49–61.

Reimchen, T. E. 1988. Inefficient predators and prey injuries in a population of giant stickleback. Canadian Journal of Zoology 66: 2036–2044.

Reimchen, T. E. 1990. Size-structured mortality in a threespine stickleback (*Gasterosteus aculeatus*) - cutthroat trout (*Oncorhynchus kisutch*) community. Canadian Journal of Fisheries and Aquatic Sciences 47: 1194–1205.

Reimchen, T. E. 1991. Trout foraging failures and the evolution of body size in stickleback. Copeia 1991: 1098–1104.

Reimchen, T. E., and **J. S. Nelson.** 1987. Habitat and morphological correlates to vertebral number as shown in a teleost, *Gasterosteus aculeatus*. Copeia 1987: 868–874.

Reznick, D. and **J. A. Endler.** 1982. The impact of predation on life history evolution in Trinidadian guppies (*Poecilia reticulata*). Evolution 36: 160–177.

Wootton, R. J. 1984. A functional biology of sticklebacks. University of California Press, Berkeley and Los Angeles. 265 pages.

Received 18 March 1991
Accepted 20 February 1992