The Tiger Salamander in British Columbia: An Amphibian in an Endangered Desert Environment

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ABSTRACT

The Red-listed tiger salamander (*Ambystoma tigrinum melanostictum*) is found in a limited range in the South Okanagan, where it is subject to large-scale habitat alienation. We studied a series of 10 ponds to determine larval growth rates, juvenile recruitment, movement of adults to and from breeding ponds, and terrestrial habitat use by adults during the summer. Ponds varied in the rate of larval growth, size at metamorphosis and timing, and the number of new recruits. Two of the most productive ponds were shallow and most susceptible to drying prior to larval development, indicating that the productivity of a given pond may vary from year to year. Through the summer months adult tiger salamanders did not move >150 m from the pond where they were captured, and used open sagebrush-grassland habitats. In this arid environment they did not select dense cover or mesic sites, and likely avoided dehydration by entering small mammal burrows.

Key words: *Ambystoma tigrinum*, amphibian, grasslands, Okanagan, populations, radiotelemetry, tiger salamander, wetlands.

Amphibians are sensitive to land-use alteration and there is widespread concern that environmental contamination and land conversion are responsible for their decline. The tiger salamander (*Ambystoma tigrinum melanostictum*) is a widely distributed species in North America, but within British Columbia it is only found at a limited number of sites in the South Okanagan and Similkameen areas (Sarell 1996). The species is Red-listed by the Wildlife Branch of the British Columbia Ministry of Environment, Lands and Parks (1996). Habitat protection for this species and other organisms in grassland and sagebrush areas is urgent because of the rapid alienation of the remaining habitat. Despite its broad distribution in North America, there have been no studies on the species in the western part of the continent, and none on habitat requirements in a landscape as xeric as the bunchgrass biogeoclimatic zone in British Columbia (Lloyd et al. 1990).

Most amphibians have a complex life history with dependence upon 2 or more habitats to complete their life cycles: an aquatic breeding and larval habitat; and a terrestrial habitat, where juveniles and adults spend most of their time. In addition, amphibian adults need appropriate winter resting places to avoid freezing and predation. In setting priorities for land conservation for particular species, it is essential that the full needs of the species be evaluated. In this study we had several objectives. The first was to evaluate the productive capability of a series of ponds and wetlands by monitoring larval densities, growth, and survival to age of metamorphosis. We also estimated the numbers and directions of dispersal of newly transformed juveniles from many of our study ponds. Finally, we began an evaluation of terrestrial habitat use by adult salamanders following the spring breeding period by tracing the movements of adults with radiotelemetry implants. The results presented here are part of the ongoing study of a population of tiger salamanders in southern British Columbia.

STUDY AREA AND METHODS

We studied tiger salamanders at 10 wetlands or ponds around and including White Lake (49°18'N, 119°37'W), southwest of Penticton, B.C. The west side of White Lake has been purchased by The Nature Trust of British Columbia and the remainder of the study area is part of a Government of Canada grazing lease administered by the Dominion Observatory. The 10 ponds vary in depth and area, as well as in the vegetation of the area surrounding each, despite being in an area of only approximately 10 km^2 (Fig. 1). The ponds also vary in the permanence of standing water, and some ponds may dry out, or nearly so, during some years, depending on weather and depth. This variation between ponds provides a convenient contrast for assessing the population ecology and habitat use of tiger salamanders in relation to changing habitats in space and time.

Larvae were trapped in all 10 ponds with baited (using commercial pet food in plastic canisters) minnow traps secured near the water surface during several sampling sessions in 1997 and 1998. Larvae were measured for total length and weighed. A small notch was cut in the tail fin prior to their release at the point of capture, thereby preventing the double-counting of an individual in a sampling bout of several days. We assumed changes in mean size between dates within a pond were due only to growth and not to any size-specific mortality.

Arrays of drift fences and pitfall traps were established to capture newly transformed juveniles leaving ponds. Pond 2 was completely encircled and all metamorphosed individuals could be captured, while pond 6 was also completely encircled, but only completed after most of the larvae had transformed. At another 3 ponds (White, 3, and 4) we established 4 linear drift fences of 20 m each, and pitfall traps at each end and in the middle. We used capture rates at these linear fences to estimate the number of newly metamorphosed juveniles leaving these ponds and to record the phenology of transformation. Each newly transformed juvenile received a pond-specific toe clip for identification on future capture. Samples of these animals were measured and weighed.

In spring of 1998 we used pitfall arrays to capture adults returning to ponds to breed. Adults were measured and weighed, and 14 animals were captured for surgical implantation of radio-transmitters (Holohil BD-2GH, 1.6 g) as they left the ponds. After surgery, these individuals were allowed to heal for about a week (until the incision had healed). The animals were released at the point of capture and tracked by radiotelemetry for up to 4 months.

RESULTS

Of the 10 ponds studied, tiger salamander larvae were found in 8: White Lake, 2, 3, 4, 5, 6, 7, and 10. Larvae were never found in ponds 8 and 9. We captured larvae at pond 4 in 1997, but not in 1998. Ponds 2 and 5 both dried early in 1998 (by 31 July) and apparently no larvae survived. The trapping success in ponds 4 and 7 (ponds that had resident turtles) was variable, and very low in comparison with the other ponds.

Larval growth rates varied considerably among ponds, as did the apparent timing of hatching and completion of growth. In both years the total growth of larvae was highest in White Lake. Larvae in White Lake reached the size for metamorphosis earlier on average than populations in the other ponds. Larval size in White Lake was significantly higher than in other ponds by mid-summer in each year

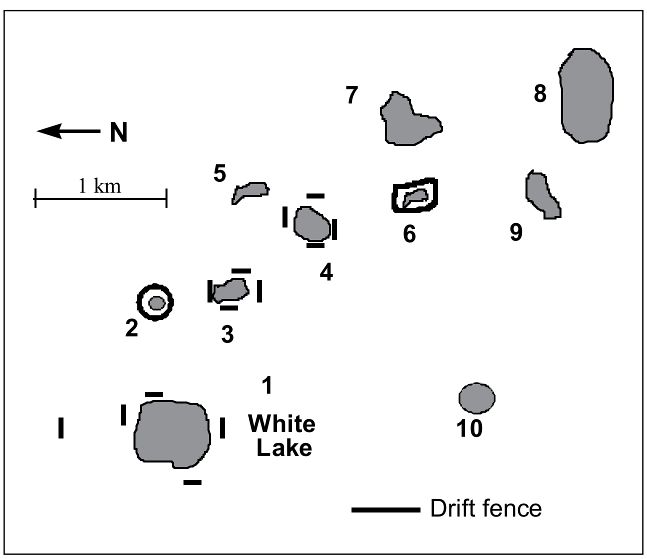

Figure 1. Map of the study area indicating the relative size and position of the 10 ponds studied in the White Lake area.

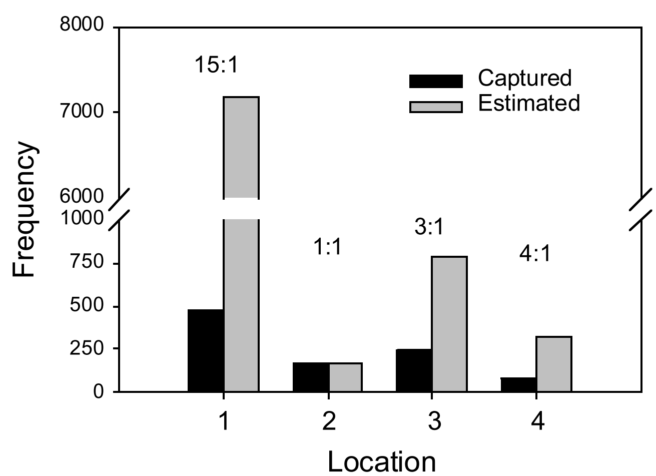

Figure 2. Actual and estimated numbers of newly recruited juveniles from 4 of the ponds, based on pitfall trap counts between mid-August and early October. Extrapolations to total numbers were based on the simple ratio of drift fence length to pond perimeter.

(ANOVA, p < 0.0001 for both years). In 1997, pond 10 larvae were intermediate in size between White Lake individuals and those from other ponds (p < 0.05, Tukey's test). Although we began larval trapping later in 1997 than in 1998, it was apparent that there were higher densities and that they stayed in the ponds longer in 1997 than in 1998. In 1997 the larval density was sufficiently high along the margins of White Lake that the water would "boil" when disturbed by our activities as we walked along the perimeter, but this was never observed in 1998. In 1998 larval densities were much lower than in the previous year, and the density of larvae appeared to decline as early as mid-July.

Newly transformed individuals were trapped in 1997 at our arrays of pitfall traps and drift fences. White Lake was by far the biggest contributor of new recruits to the population, with an estimate of almost 7,200 new juveniles in 1997 based on our array of drift fences (Fig. 2). The other 3 ponds where emigrating juveniles were censused (pond 6 drift fences were not in place for the whole period) contributed modest numbers to the overall population, but in combination only about 18% of the numbers from White Lake (Fig. 2). Juveniles from White Lake were about 15% heavier on average than those from pond 6, which had the next largest metamorphs (Fig. 3A). There were significant differences in size at transformation among the 5 ponds where we operated pitfall traps (ANOVA, p < 0.0001). The coefficients of variation were between 18.6 and 31.9% across the 5 ponds and, in part, reflect the inclusion of both sexes and individuals across the period of transformation (it is a well-known phenomenon that size at metamorphosis declines as the season proceeds). Ponds 2 and 3 had significantly smaller metamorphs (Tukey's test, p < 0.05), despite having high numbers of recruits relative to ponds 4 and 6.

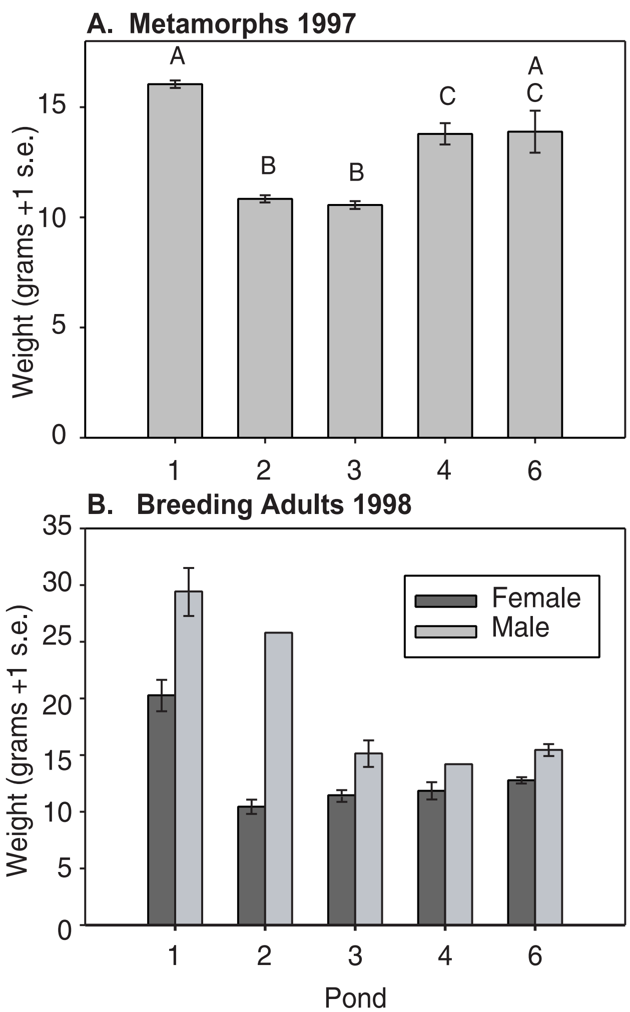

Figure 3. Weights of (A) newly transformed juveniles from late summer 1997, and (B) adults returning to ponds to breed in spring 1998. Bars with different letters are significantly different (p < 0.05). Bars lacking standard errors (males, ponds 2 and 4) are for single individuals only.

Pond 2 was completely encircled by a drift fence, so we were able to plot the direction of emergence of newly transformed juveniles in 1997. There was a clear pattern of tiger salamanders emerging from the southwest side of the pond (Fig. 4). The direction was towards the sagebrush grasslands and away from any wooded areas. Long-toed salamanders (*A. macrodactylum*), which were also common in the pond, showed a clear direction to their emergence as well: to the northeast, i.e., upslope towards a wooded area.

In spring 1998 adults were captured using pitfall traps and drift fences that had been established for juveniles the previous summer. Our sampling began on 31 March, after the start of the breeding migration, and adults were last trapped on 22 May. Most adult males had entered the ponds before we started trapping. We found significant differences in the mean size of males and females overall (17.4 vs. 14.7 g for males and females respectively, 2-way ANOVA, p < 0.0001). There were significant differences in the mean sizes of adults returning to each pond (2-way ANOVA, p < 0.0001), with White Lake adults being largest (Fig. 3B, p < 0.05, Tukey's Test).

Of the 14 adults that were implanted with radio-transmitters, 9 were tracked between 57 and 93 days. One animal did not survive the implant procedure; 1 was killed by a raptor within 2 weeks of release; and 3 others could not be located despite extensive searching. The 9 transmitter-equipped animals were located 146 times, with observations distributed across the 2- to 3-month monitoring period. None of the animals being monitored travelled >150 m from the pond where they had been captured. Upon release, all animals moved away from the pond within a week and, with the exception of one animal, inhabited dry sagebrush-grassland habitat, often in areas with >30% mineral soil exposure. Movement patterns varied between animals, but in general were characterized by extended periods (e.g., 2–3 weeks) of restricted movement, where activities were constrained to a 5-m radius area, punctuated by abrupt movements of 10–100 m to a new location. Salamanders were always in subterranean burrows during the day, and used the loose soil and tunnels excavated by Great Basin pocket mice (*Perognathus parvus*). One salamander was repeatedly found at the same location in an area of mesic soil within 10 m of the release site. When excavated, this animal was alive and <30 cm below the surface.

DISCUSSION

Larval habitats vary in productivity, growth rates of larvae, and size/timing of transformation. White Lake was the most productive of the set of 10 ponds, on the basis of growth rate, densities, and numbers of juveniles produced. Pond 10 was also quite productive, but as with White Lake, very shallow and prone to drying during summer prior to tiger salamander metamorphosis. Other ponds were less productive by most measures, but still contributed recruits to the population.

Juveniles leave ponds at a time of year when they are potentially vulnerable to desiccation, and vegetative cover may be critical. Most of the captures of juveniles in our pitfall trap arrays coincided with precipitation, suggesting the juveniles have some capacity to remain in refugia until weather becomes suitable. Cover provided by large pieces of wood or small mammal burrows may be critical to survival of juveniles at this stage of their lives. The observation that juveniles from pond 2 dispersed primarily in 1 direction is intriguing, suggesting there may be some cues for habitat selection. We assumed *a priori* that any directionality would be towards forest cover, which was clearly rejected by the observation of almost all juveniles moving in a direction away from any trees.

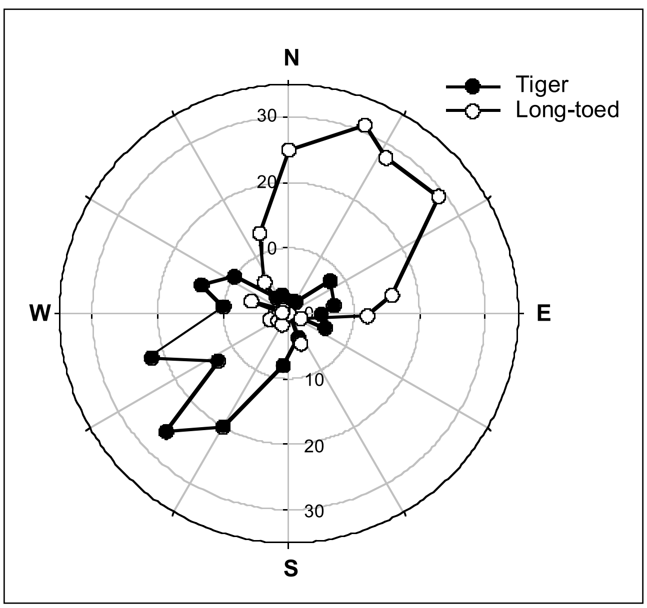

Figure 4. Frequency of juvenile tiger salamanders and long-toed salamanders (*Ambystoma macrodactylum*) captured in pitfall traps as they dispersed from pond 2 in 1997.

Adults can survive in dry sagebrush-bunchgrass habitats, even during periods of high summer temperatures (>35ºC) and extended periods without precipitation. Fine-scale habitat selection, for example, for areas with dense vegetation or low mineral soil exposure, or for mesic microsites as indicated by shrubs (e.g., *Amelanchier alnifolia*), was not observed. These observations are very preliminary, but may indicate a broad habitat tolerance by terrestrial adults in summer.

Studies of movement patterns of other *Ambystoma* salamanders showed that adults rarely moved far from ponds, although individuals varied by using either forested or open sections with little overlap in habitat use between individuals (Madison and Farrand 1998). Small mammal burrows were used by *A. maculatum* both during the summer (mostly shrew [*Sorex* spp.] burrows) and winter (primarily deer mouse [*Peromyscus maniculatus*] burrows) and served as terrestrial refuges (Madison 1997). In our study area, adult and juvenile tiger salamanders used Great Basin pocket mouse burrows. We do not know where the adults and juveniles overwinter, but winter habitat is probably a critical resource for these populations.

The capriciousness of weather between years means that permanence of water bodies may vary and create high between-year variability in larval survival rates. Data for water levels and duration in White Lake do not exist, but nearby Mahoney Lake (about 10 km ESE from White Lake) had declining water levels during 1985–1995 (Northcote and Hall submitted). White Lake and many of the surrounding ponds are quite shallow, and even in the relatively wet years of 1997 and 1998, some of the ponds dried completely before tiger salamander larvae could transform. White Lake frequently dries out completely by late July (R. [Dick] Cannings, Honorary Curator, Vertebrate Museum, University of British Columbia Zoology Department, pers. comm.), and even in a wetter year may diminish in size prior to larval metamorphosis, potentially limiting the production of new recruits. Prolonged periods when the shallow ponds contribute no recruits to the adult population may lead to large declines in numbers depending upon success rates in the deeper ponds. Based on our results White Lake is clearly the biggest contributor to this metapopulation; however, we do not know the degree of fidelity individuals show to their natal pond. The similar rankings of sizes of adults returning to ponds with the size of metamorphs leaving suggests that there may be a high degree of philopatry. The potential for periodic increases in populations based on recruitment from White Lake may be short-lived, depending on longevity of adults. In a year, or many years in sequence, when White Lake produces no recruits, the deeper ponds in the area may be the only source of new recruits. This reinforces the importance of alternate habitats for population or metapopulation conservation.

There are still many critical questions about the population ecology of this species for which we have no answers. Amphibians are dependent upon suitable wintering habitats where they can escape the lethal freezing conditions. We do not know where tiger salamanders in the population we studied find such hibernacula. Predators in the more permanent ponds may make these less suitable habitat for tiger salamander larvae, but the role of predators is still unknown. These ponds may act as individual populations with high degrees of philopatry or, conversely, interannual dispersal between ponds may mean this is a large population with multiple breeding sites. The degree to which each pond is independent of the others will affect how critical each is as a habitat to be conserved. The potential for long-distance dispersal depends upon corridors of suitable and continuous habitat. We do not know the capacity for dispersal, nor the effect of barriers (partial or complete) such as roads and agricultural developments for tiger salamanders in this arid region of North America.

MANAGEMENT IMPLICATIONS

The series of ponds we studied near White Lake provide habitats of variable value for the tiger salamander. A series of larval habitats (shallow and deep ponds) seems critical to the maintenance of this population. Terrestrial adults and juveniles can manage to survive in relatively open habitat and our preliminary findings suggest terrestrial adults have broad habitat tolerance. Reproduction and productivity in drought years, the role of introduced species (e.g., rainbow trout), and the importance of overwintering habitat need to be addressed before informed management plans are developed for this species.

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