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Distribution and Life History of the Western Tiger Salamander (*Ambystoma mavortium*) in Southwestern Alberta, Canada

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Abstract.—**The conservation status of many species of amphibians is difficult to evaluate because data regarding fundamental demographic characteristics are often unavailable. We evaluated the relative occurrences, population densities, and life-history characteristics of larval Western Tiger Salamanders, *Ambystoma mavortium*, in 15 wetlands in southwestern Alberta using modified funnel traps. Just over half of these sites contained larval salamanders. Estimates of relative larval densities based on catch-per-unit-effort showed that densities were at least three-fold higher at Livingstone Lake than at seven other occupied sites. Livingstone Lake is a relatively large, permanent, and pristine wetland where larvae were present during each year from 2013 to 2015. Larvae in Livingstone Lake demonstrated a consistent pattern of growth and timing of metamorphosis from 2013 to 2015, with maximum size reached in late July, followed by metamorphosis in mid-August. Paedomorphic larvae were never observed. Our results indicate that larval *A. mavortium* occupy approximately 50% of wetlands in this region. Relatively low larval densities at all but one site indicate either low rates of larval survival in this region, low adult population sizes, or low rates of visitation to vernal ponds by breeding adults.**

Key Words.—amphibian population declines; amphibian conservation; wetland biodiversity

Introduction

The 32 species of ambystomatid salamanders (the mole salamanders) are, arguably, among the most recognizable amphibians in North America. Relative to other amphibian taxa, they are among the most threatened amphibians in the world, with greater than average declines in population and range sizes (review by Stuart et al. 2004). The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2014) lists 11 of the 32 species of ambystomatids as Endangered or Critically Endangered. In North America, populations of almost one half of the species of *Ambystoma* are in decline (Adams et al. 2013), including catastrophic declines of the Sonoran Tiger Salamander (*Ambystoma tigrinum stebbinsi*) in Arizona (U.S. Fish and Wildlife Service 2002), the California Tiger Salamander (*Ambystoma californiense*) in California (Fisher and Shaffer 1996), and the Mexican Axolotl (*A. mexicanum*) in northern Mexico (Contreras et al. 2009). Appropriate data are lacking to accurately assess population status of an additional 19% of the Ambystomatidae (IUCN 2014). Although it is difficult to distinguish real declines in population sizes from inherent annual variation in recruitment and reproduction (Pechmann et al. 1991), current evidence is consistent with the general observation that the ranges and population sizes of many species of ambystomatids are declining.

The population status of the Western Tiger Salamander, *Ambystoma mavortium* (Fig. 1), is poorly known throughout its range in western North America. Published range maps indicate that the species occurs throughout much of the western part of the continent, but at unknown densities (Keinath et al. 2010). Direct assessments involving long-term monitoring are absent. The formal population status of *A. mavortium* within the northwest of its range varies: Secure in Idaho, USA, Special Concern in Alberta, Canada, Vulnerable in Washington, USA, and Endangered in British Columbia, USA (Committee on the Status of Endangered Wildlife in Canada [COSEWIC]. 2012. COSEWIC assessment and status report on the Western Tiger Salamander *Ambystoma mavortium* in Canada. Available from http://www.registrelep-sararegistry.gc.ca/default_e.cfm. [Accessed 15 September 2014]; NatureServe. 2014. NatureServe explorer: an online encyclopedia of life. NatureServe, Arlington, Virginia. Available from http://www.natureserve.org/explorer [Accessed 15 November 2014]). In Alberta, Canada, data on the distribution and population status of *A. mavortium* is limited (COSEWIC op. cit.). Anecdotal evidence suggests that widely scattered and high-density populations of *A. mavortium* existed across the prairies and into the foothill regions prior to land clearing and to extensive fish stocking.

Here, we use standard survey methods to assess the occurrence and relative population densities of larval

Figure 1. Adult *Ambystoma mavortium* (Western Tiger Salamander) at a study site in Southwestern Alberta. (Photographed by Stephanie Reimer).

A. mavortium within selected water bodies in southwestern Alberta. We also evaluate larval life-history characteristics (growth rate and size, timing, and age at metamorphosis) of individuals captured, and released, at a targeted mid-elevation site where *A. mavortium* was known to occur at relatively stable, high population densities. Although 3–4 mo larval periods are characteristic in populations located within prairie wetlands (Deutschman and Peterka 1988), and 1–2 y larval periods are common in high elevation sites in the Rocky Mountains (Bizer 1978; Sexton and Bizer 1978), little is known about life-history variation of *A. mavortium* at mid-elevation sites that are characteristic of the eastern slopes of the Canadian Rocky Mountains.

Materials and Methods

Site selection.—Our survey focused on the southwestern corner of Alberta (Fig. 2), an area located within the Subalpine, Montane, and Foothills Fescue natural sub-regions (Downing and Pettapiece 2006). Grasses, particularly *Festuca campestris*, Mountain Rough Fescue, dominated the vegetation in this region, which is characterized by forbs (e.g., *Potentilla frutilla*, Shrubby Cinquefoil) and interspersed with stands of Aspen (*Populus tremuloides*), Cottonwood (*Populus balsamifera*), and Lodgepole Pine (*Pinus contorta*) (Downing and Pettapiece 2006). The sites within the survey area ranged between UTM zone 11U (695693E) and zone 12U (299120E) and between 5439194 and 5512211N. Elevation within the sampling area ranged from 1,250 to 1,550 m.a.s.l.

We selected wetlands for sampling using ArcGIS™ software (Environmental Systems Research Inc., Redlands, California, USA). We obtained shapefiles of all water bodies within the study area, more than 3,000, from GeoGratis (Natural Resources Canada. 2013. Geogratis Download Directory: National Topographic Data Base. Available from http://geogratis.cgdi.gc.ca/geogratis/DownloadDirectory?lang=en. [Accessed 15 October 2014]). Using the program ArcMap™ (Environmental Systems Research Inc., Redlands, California, USA), we selected an initial group of 100 water bodies, consisting of 28 wetlands (0.5–1.0 ha), 60 ponds/small lakes (0.5–20 ha), and 12 artificial dugouts (0.3–0.5 ha). We assessed each site for accessibility and landowner permission. Acceptable sites were required to be < 1 km from an access road and > 1 km from an adjacent site. We selected 25 water bodies for our surveys; however, following initial visits, we excluded 12 of these sites because cattle density or inaccessibility precluded trapping. Thus, we surveyed 13 sites. Prior surveys completed by our laboratory since 2005 indicated that *A. mavortium* was consistently present at two additional sites. We targeted these two sites, Waterton Pond and Livingston Lake (Fig. 2), for more intensive sampling.

Sampling procedures.—We used four modified funnel traps (Mushet et al. 1997) to assess the presence and density of larval *A. mavortium* at each site. Mushet et al. (1997) showed that these traps (45 × 50 × 100 cm steel frame covered with 32 mm galvanized steel mesh) were more effective at trapping larval salamanders than minnow traps, dip nets, or seine nets, particularly during mid to late summer when there was excessive macrophyte growth. The design of this trap allows for the live-capture of larval and adult salamanders by sampling a known region of the water column throughout a defined period of time. Benoy (2005) and Balas et al. (2012) used this trapping method to survey populations of *A. tigrinum* in prairie wetlands.

We estimated the perimeter of each site by pacing the shoreline. We placed four traps at randomized positions along the perimeter. Randomization was assigned with the use of random numbers tables. At Livingstone Lake, the largest of the sites, we placed four traps at randomized positions along a 500 m section of the western shoreline. The maximum depth that we placed the bottom of a trap was 1.5 m. We oriented the funnel part

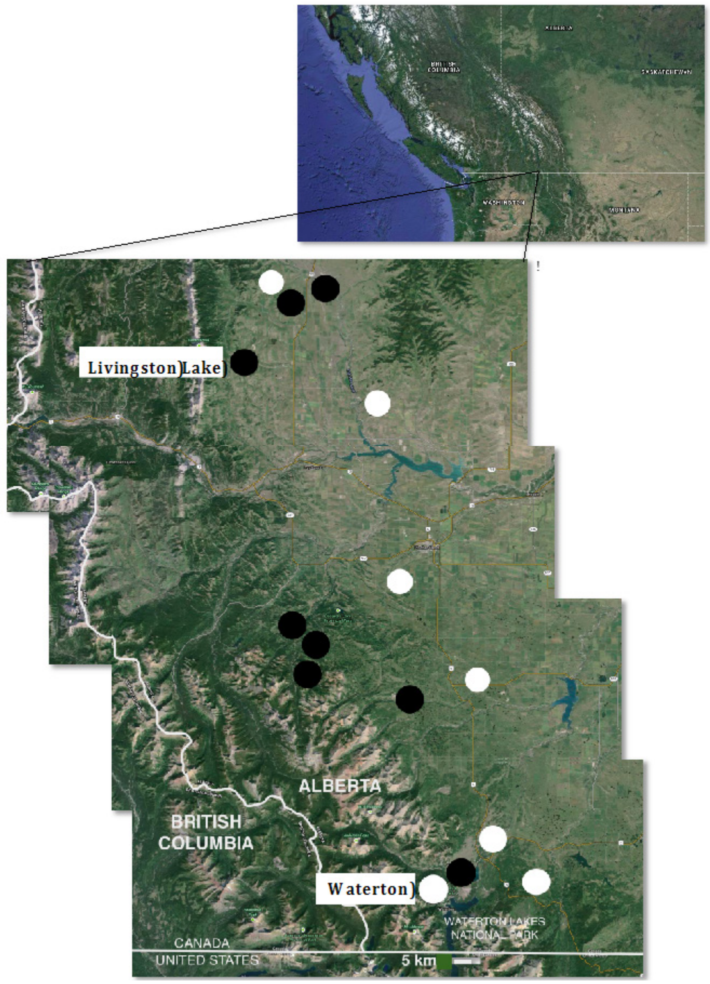

Figure 2. Occurrence of *Ambystoma mavortium* (Western Tiger Salamanders) in 15 selected wetlands in Southwestern Alberta. Black points indicate sites where *A. mavortium* was present; white points indicate sites where *A. mavortium* was absent.

of the trap perpendicular to the shore to target foraging larvae that tend to move into the water column at night. We sampled each site at least once during June, July, or August of 2012, 2013, 2014, or 2015. We sampled several sites more than once/season or during more than one year. We sampled Waterton Pond and Livingstone Lake two to five times each year from 2012–2015.

Following the 48-h trapping period, we removed larval salamanders and placed them into 2 L plastic containers. We photographed, weighed, and released each salamander at the site of capture. We removed a small piece of tissue from the tip of the tail to evaluate infection status with *Ambystoma tigrinum* virus (ATV; Reimer 2015). We measured the total length of each larvae from the tip of the snout to the tip of the tail from the digital image with ImageJ software (Abràmoff et al. 2004). We cleaned and sterilized traps and handling equipment with a 3% sodium hypochlorite solution following each trapping session. We assessed selected habitat characteristics at each site when the traps were placed. Collected data included location, elevation, type of water body (pond, lake, wetland, or dugout), surface area, distance to nearest water body (< 1 km or > 1 km), fish presence/absence, cattle access, permanency (temporary or year-round), and presence of other species of amphibians.

***Analyses*.**—The small number of sites inhabited by larval salamanders placed constraints on our analyses. We used Fisher's exact tests, which produces an exact probability that two variables are statistically independent when one or more frequencies are less than five (Sokal and Rohlf 1995), to assess associations between selected habitat characteristics and the occurrence of *A. mavortium*. We estimated larval salamander density in each pond as catch per unit effort (CPUE), with one unit

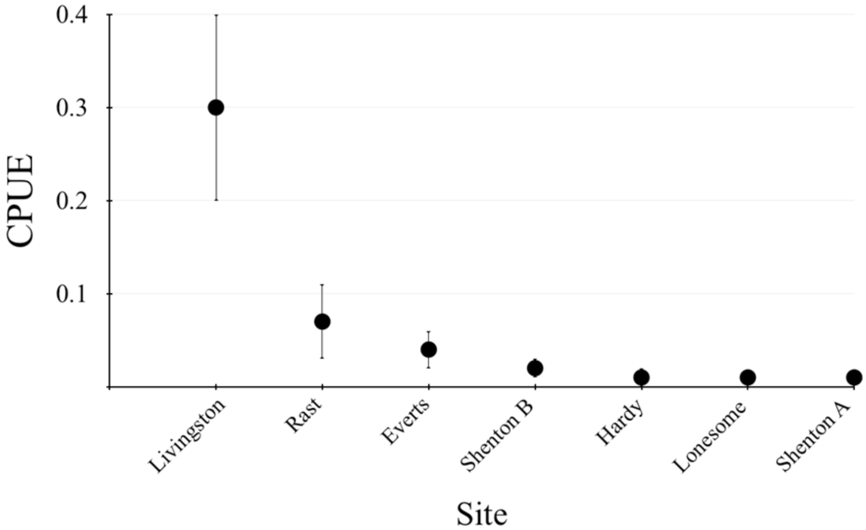

Figure 3. Catch per unit effort (CPUE) of *Ambystoma mavortium* (Western Tiger Salamanders) at seven sites in southwestern Alberta. Catch per unit effort at eight other sites in southwestern Alberta was zero. Error bars indicate 95% confidence intervals, based on sample size, for sites that were visited more than once.

equaling the effort of one trap for one hour. Therefore, CPUE can also be quantified as larvae caught per trap per hour. Statistical analyses for differences in CPUE between sites were not possible because of the small number of sites that contained salamanders and unequal sampling effort between sites. These semi-quantitative data are presented as relative differences in CPUE between sites that contained salamanders.

We determined the growth rates (± 95% confidence intervals) of larval salamanders at Livingston Lake by the following formula:

$$\text{growth rate} = (V_{present}-V_{past}) / N$$

where $V_{present}$ = weight or length at time t, V_{past} = weight or length at time t-1, and N = number of days between sampling events (Cook et al. 2000). Mean size at metamorphosis was determined as the average weight at the last trapping event in mid-August each year when all individuals were in early to mid stages of metamorphosis. We used One-way ANOVA ($\alpha = 0.05$) to examine annual differences in growth rates and size at metamorphosis at Livingston Lake.

Results

We found larval *Ambystoma mavortium* inhabiting eight of the 15 sites surveyed during 2012 and 2013 (Fig. 2). At seven of these sites, we caught larvae in funnel traps; at an eighth site we found dead larvae adjacent to the traps. Sites inhabited by salamanders were between 1,309 and 1,457 m a.s.l. There were no significant associations between the presence of salamanders and permanency of the water body (Fisher's Exact Test, $P = 0.22$), distance to nearest water body ($P = 0.22$), presence of fish (rainbow trout or fathead minnows; $P = 0.22$), livestock access ($P = 1.00$), or other amphibians present ($P = 0.15$). Other amphibian species present at the sites included Columbia Spotted Frogs (*Rana luteiventris*), Long-toed Salamanders (*Ambystoma macrodactylum*), Boreal Chorus Frogs (*Pseudacris maculata*), and Western Toads (*Bufo boreas*) (Reimer 2015).

The density of larvae at Livingstone Lake was at least three times higher than at any other site (Fig. 3). Overall, 53% of the 133 traps set over the 4 y contained no larvae. At Livingston Lake, we caught one to 62 larvae in a trap. At this site, the highest capture rates occurred during July (0.10–0.48 CPUE between 2012-2015), followed by diminishing rates during August (0.00–0.18 CPUE) and September (0.00 CPUE).

We used data from salamanders captured at Livingston Lake during mid-July (2013 $n = 29$; 2014 $n = 170$, 2015 $n = 32$), late July (2013 $n = 52$, 2014 $n = 195$, 2015 $n = 46$), and mid-August (2013 $n = 12$, 2014 $n = 132$, 2015 $n = 11$) to evaluate annual variation in larval growth rate and timing and size at metamorphosis. We attempted a fourth sampling event during late August each year; however, because of low sample size ($n = 1$, 2013; $n = 3$, 2014; $n = 0$, 2015), we excluded these data from our analyses. Overall, the annual length frequency distributions of larvae measured at Livingstone Lake demonstrated a consistent pattern of growth (Fig. 4). In all years, larvae were first detected in the traps during mid-July, when mean total length was 8.1–12.2

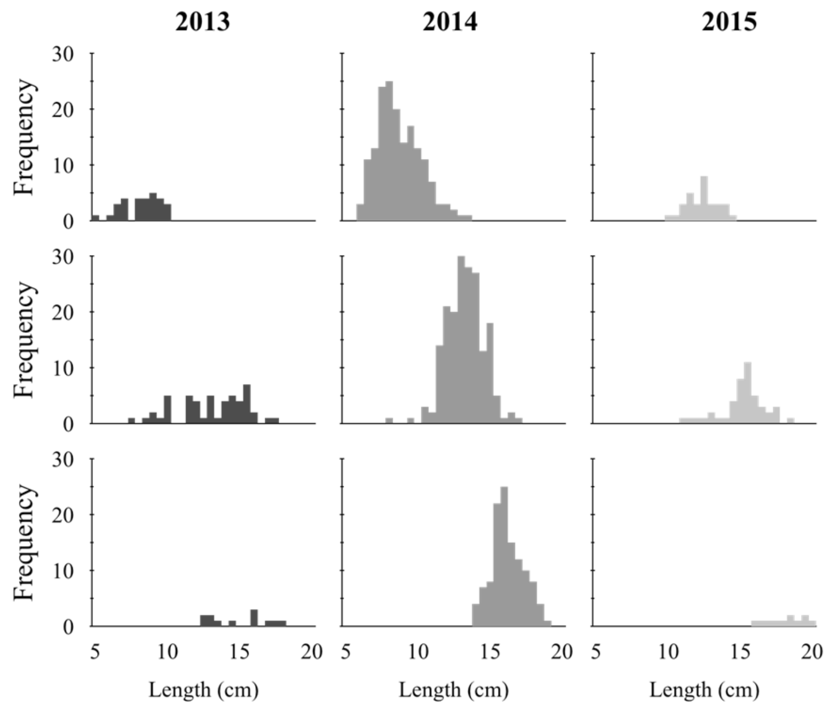

FIGURE 4. Frequency distributions of *Ambystoma mavortium* (Western Tiger Salamanders) lengths in Livingston Lake during 2013, 2014, and 2015. Graphs correspond to sampling events during 2013 (top to bottom: 10 July, 30 July, 16 August), 2014 (top to bottom: 15 July, 31 July, 12 August) and 2015 (top to bottom: 15 July, 31 July, 12 August).

cm. Two weeks later, mean larval length increased to 12.8–15.0 cm. Four weeks later, mean total length had increased, on average, by an additional 2–3 cm. At the onset of metamorphosis during mid-August, larvae averaged 14.8 ± 1.2 cm in 2013, 16.0 ± 0.2 cm in 2014, and 17.9 ± 0.8 cm in 2015.

Overall, there were no significant differences in average larval growth rates among years (2013, 2014, and 2015) at Livingstone Lake, whether we determined the rates with length data or weight data ($F_{2, 364} = 0.164$, $P = 0.852$; $F_{2, 365} = 0.224$, $P = 0.795$, respectively). Although the general pattern of growth was consistent among years at Livingston Lake, larvae metamorphosed at a significantly larger size during 2015 compared to the previous 2 y. Mass at metamorphosis was also significantly higher during 2015 than during 2013 or 2014 ($F_{2, 136} = 39.4$, $P < 0.001$). Similarly, larval length at metamorphosis was significantly higher during 2015 than during the 2 previous years ($F_{2, 135} = 24.9$, $P < 0.001$).

DISCUSSION

We found larval *A. mavortium* at more than half of the 15 sites that we sampled during 2012 and 2013. Although no comparable surveys have been completed within the Canadian part of the species distribution, this occupancy rate lies within the reported range for *A. mavortium* in Wyoming, South Dakota, and the Prairie Pothole Region (Benoy 2002; Corn et al. 2005; Balas 2008). Our data on larval densities cannot be compared with data from other studies because of differences in trapping methods and survey effort. Our survey results suggest that, with the exception of the population in Livingstone Lake, larval *A. mavortium* densities are low in this region of southern Alberta, perhaps because of low rates of larval survival, small adult population sizes, or low rates of adult recruitment into suitable breeding sites.

We did not detect a pattern of occurrence associated with any of the wetland characteristics measured. Thus, salamanders were present in both the largest and smallest wetlands, in those with and without predaceous fish, and in pristine and anthropogenic habitats. These results indicate that *A. mavortium* are capable of breeding and developing through the larval stage in many of the wetland types available in southwest Alberta. However, many suitable wetlands appear not to be used by breeding adults, at least not in the years sampled. This erratic and inconsistent pattern of occurrence is similar to the pattern reported for *A. mavortium* in 154 wetlands in Colorado, distributed across seven habitat types (Collins 1981).

Ambystoma mavortium in the study area metamorphosed approximately 3 mo after hatching. Delayed metamorphosis through paedomorphism or neoteny has been reported within populations of Western Tiger Salamander in other parts of their range (Bizer 1978; Sexton and Bizer 1978; Routman 1993), including populations in southern Alberta (Cormie 1975). For the population in Livingstone Lake, for which we have the largest sample sizes during the longest period, we have never observed a case of metamorphosis that extended beyond late summer. Paedomorphosis is, apparently, an uncommon life-history strategy at these mid-elevation sites.

Larval densities at Livingstone Lake were up to three times higher than at any other site, with a maximum of 195 individuals captured during a single 48-h sampling event. We captured 19 or fewer larvae in a single sampling event at all other sites. Thus, Livingston Lake is an anomaly, with densities more than triple that of the seven other sites where we detected *A. mavortium*. Similarly, when compared with information reported in the literature, the population at Livingston Lake remains an outlier. Larval *A. mavortium* in Livingston Lake, especially during 2015, were larger at metamorphosis than larvae at other mid- to high-elevation sites throughout the species range (Tanner et al. 1971; Bizer 1978). Only one site, a lower elevation lake in North Dakota, reported comparably high growth rates of *A. mavortium*, and these were associated with years of high prey density (Deutschman and Peterka 1988). Searcy et al. (2015) demonstrated that variation in prey availability is associated with variation in size at metamorphosis in the California Tiger Salamander, *A. californiense*. Our anecdotal observations suggest that aquatic secondary productivity is atypically high in Livingston Lake, even compared to adjacent wetlands that are of a similar size and depth. Perhaps variation in growth rates and size at metamorphosis at Livingston Lake are associated with variation in prey availability.

Our data are too restricted in spatial and temporal scope to assess the population status of larval *A. mavortium* in this region. Similar constraints associated with sampling and with inherent variability in ambystomatid life histories are characteristic of this and other ambystomatid species (Pechmann et al. 1991; Semlitsch et al. 1996; Trenham et al. 2000; COSEWIC 2012 op. cit.). Anecdotal evidence suggests that at least two high-density *A. mavortium* populations have been extirpated from sites in southern Alberta. High densities of paedomorphic *A. mavortium* existed in a wetland 200 km to the southeast of Livingston Lake (Cormie 1975), but have been absent since 1998 (Terry Clayton, personal communication). At another site 70 km south of Livingston Lake in Waterton Lakes National Park, mortality of thousands of larval *A. mavortium* occurred in 2011, with no recovery since then (Barb Johnson, unpublished data). Mortality in the former case is attributed to the annual stocking of fingerling Rainbow Trout (*Oncorhynchus mykiss*) since the 1960s; whereas, mortality in the latter case is attributed to lethal infection with *Ambystoma tigrinum* virus (Barb Johnson, unpublished data). This emerging virus is associated with periodic mass mortality events in Livingstone Lake (Reimer 2015) and is probably widespread throughout the region. These observations indicate that *A. mavortium* populations have declined precipitously at some sites in this region, without recovery.

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Literature Cited

Abràmoff, M.D., P.J. Magalhães, and S.J. Ram. 2004. Image processing with ImageJ. Biophotonics International 11:36−43.

Adams, M.J., D.A. Miller, E. Muths, P.S. Corn, E.H.C. Grant, L.L. Bailey, and S.C. Walls. 2013. Trends in amphibian occupancy in the United States. PLoS ONE 8(5): e64347. doi:10.1371/journal.pone.0064347.

Balas, C.J. 2008. The effects of conservation programs on amphibians of the prairie pothole region's glaciated plain. Ph.D. Dissertation, Humboldt State University, North Dakota, USA. 153 p.

Balas, C.J., N.H. Euliss Jr., and D.M. Mushet. 2012. Influence of conservation programs on amphibians using seasonal wetlands in the Prairie Pothole Region. Wetlands 32:333−345.

Benoy, G.A. 2002. Community consequences of indirect interactions between waterfowl and Tiger Salamanders in prairie potholes. M.Sc. Thesis, University of Guelph, Ontario. 244 p.

Benoy, G.A. 2005. Variation in Tiger Salamander density within prairie potholes affects aquatic bird foraging behaviour. Canadian Journal of Zoology 83:926−934.

Bizer, J.R. 1978. Growth rates and size at metamorphosis of high elevation populations of *Ambystoma tigrinum*. Oecologia 34:175−184.

Collins, J.P. 1981. Distribution, habitats and life history variation in the Tiger Salamander, *Ambystoma tigrinum*, in east-central and southeast Arizona. Copeia 1981:666−675.

Contreras, V., E. Martínez-Meyer, E. Valiente, and L. Zambrano. 2009. Recent decline and potential distribution in the last remnant area of the microendemic Mexican Axolotl (*Ambystoma mexicanum*). Biological Conservation 142:2881−2885.

Cook, J.T., M.A. McNiven, G.F. Richardson, and A.M. Sutterlin. 2000. Growth rate, body composition and feed digestibility/conversion of growth-enhanced transgenic Atlantic Salmon (Salmo salar). Aquaculture 188:15–32.

Cormie, G.W. 1975. An examination of neoteny in *Ambystoma tigrinum* of Tyrrell's Lake, Alberta. MSc thesis. University of Alberta, Edmonton, Canada. 145 p.

Corn, P.S., B.R. Hossack, E. Muths, D.A. Patla, C.R Peterson, and A.L. Gallant. 2005. Status of amphibians on the continental divide: surveys on a transect from Montana to Colorado, USA. Alytes 22:85−94.

Deutschman, M.R., and J.J. Peterka. 1988. Secondary production of Tiger Salamanders (*Ambystoma tigrinum*) in three North Dakota prairie lakes. Canadian Journal of Fisheries and Aquatic Sciences 45:691−697.

Downing, D.J., and W.W. Pettapiece. 2006. Natural Regions and Subregions of Alberta. Government of Alberta. Publication No. T/852.

Fisher, R.N., and H.B. Schaffer. 1996. The decline of amphibians in California's Great Central Valley. Conservation Biology 10:1387−1397.

International Union for Conservation of Nature (IUCN). 2014. IUCN Red List of Threatened species, Version 2014.1. Available from http://www.iucnredlist.org.

Keinath, D.A, M.D. Anderson, and G.P. Beauvais. 2010. Range and modeled distribution of Wyoming's species of greatest conservation need. Wyoming Natural Diversity Database, Wyoming Game and Fish Department, Cheyenne, Wyoming and the U.S. Geological Survey, Fort Collins, Colorado. 15 p.

Mushet, D.M., N.H. Euliss, B.H. Hanson, and S.G. Zodrow. 1997. A funnel trap for sampling salamanders in wetlands. Herpetological Review 28:132−133.

Pechmann, J.H., D.E. Scott, R.D. Semlitsch, J.P. Caldwell, L.J. Vitt, and J.W. Gibbons. 1991. Declining amphibian populations: the problem of separating human impacts from natural fluctuations. Science 253:892−895.

Reimer, S.A. 2015. Epidemiology of an emerging virus in Western Tiger Salamanders (*Ambystoma mavortium*) in southwestern Alberta. M.Sc. dissertation. University of Lethbridge, Lethbridge, Alberta, Canada, 89 p.

Routman, E. 1993. Population structure and genetic diversity of metamorphic and paedomorphic populations of Tiger Salamander, *Ambystoma tigrinum*. Journal of Evolutionary Biology 6:329−357.

Searcy, C.A., H. Snaas, and H.B. Shaffer. 2015. Determinants of size at metamorphosis in an endangered amphibian and their projected effects on population stability. Oikos 124:724−731.

Semlitsch, R.D., D.E. Scott, J.H.K. Pechmann, and J.W. Gibbons. 1996. Structure and dynamics of an amphibian community: evidence from a 16-yr study of a natural pond. Pp. 217–248 *In* Long-term Studies of Vertebrate Communities. Cody, M.L., and J. Smallwood (Eds.). Academic Press, San Diego, California, USA.

Sexton, O.J., and J.R. Bizer. 1978. Life history patterns of *Ambystoma tigrinum* in montane Colorado. American Midland Naturalist 99:101−118.

Sokal, R.R., and F.J. Rohlf. 1995. Biometry: The Principles and Practices of Statistics in Biological Research. 3rd Edition. W.H. Freeman and Company, New York, New York, USA.

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A. Rodrigues, D.L. Fischman, and R.W. Waller. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306:1783−1786.

Tanner, W.W., D.L. Fisher, and T.J. Willis. 1971. Notes on the life history of *Ambystoma tigrinum nebulosum* Hallowell in Utah. Great Basin Naturalist 31:313−322.

Trenham, P.C., H.B. Shaffer, W.D. Koenig, and M.R. Stromberg. 2000. Life history and demographic variation in the California Tiger Salamander (*Ambystoma californiense*) Copeia 2000:365−377.

U.S. Fish and Wildlife Service. 2002. Sonora Tiger Salamander (*Ambystoma tigrinum stebbinsi*) Recovery Plan. U.S. Fish and Wildlife Service, Phoenix, Arizona, USA.

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Cam Goater is a Professor of Biological Sciences at the University of Lethbridge in Alberta, Canada. His interests are in the ecology and evolution of host-parasite interactions, particularly those that involve amphibians, fish, and aquatic invertebrates as hosts. He and his students combine empirical studies on selected animal/parasite model systems, field surveys, molecular population genetics, and modern tools in the earth sciences to understand the complexities of host-parasite interactions. (Photographed by Lori Goater).