Salado Salamander Monitoring Final Report 2018

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Acknowledgements

We would like to thank the staff at Camp Tahuaya, in particular Ranger Dennis, and the Longhorn Council of the Boy Scouts of America, along with the Williamson County Conservation Foundation for access to the springs. We appreciate the assistance of Justin Crow from the San Marcos Aquatic Resources Center for help with collections. We appreciate the support from Bell County, the Village of Salado, and Clearwater Underground Water Conservation District for funding this work.

Executive Summary

Monitoring of the Salado salamander (*Eurycea chisholmensis*) concluded in December of 2018 finalizing the fourth year of monitoring by the Texas Fish and Wildlife Conservation Office (TXFWCO) at the Salado Downtown Spring Complex (DSC) and at Robertson Springs in Bell County. A total of 32 Salado salamanders were detected this year. Almost all salamanders were detected at the DSC (n = 24). Within the DSC, Side Spring produced the most salamanders over the course of the year. Only eight detections were documented at Robertson Springs during 2018, due to the loss of discharge from springs on the property. When discharged returned to Robertson Springs, salamanders were detected from three different spring zones: five in the Middle Springs zone, one in the Headwater Spring zone, and two in the the Ludwigia Spring zone (one in the upper spring and one in the middle spring). Ten salamanders were captured using drift nets this year, while the remaining salamanders were captured during active searches. In addition to the above mentioned collections at Robertson Springs, two salamanders were collected in drift nets from Anderson Spring in the DSC.

In addition to the regular monthly monitoring at the historic locations, monthly monitoring was added at Tahuaya Springs, just north of the Village of Salado. Tahuaya Spring has been sporadically searched for salamanders in the past, but no regular monitoring has occurred up to this point. Tahuaya Springs was monitored to collect data, either in support or opposition, to the currently established known northern range of the Salado salamander, which Tahuaya is north of. Drift nets were deployed to passively sample the spring orifice within the area. Four nets were used to sample the springs for a total of 89 days during the year. The spring run was searched on a number of occasions. No salamanders were detected during the efforts at Tahuaya Springs this year. We appreciate the cooperation from the staff at Camp Tahuaya and the Longhorn Council of the Boy Scouts of America for access to Tahuaya Springs.

Additional work associated with monitoring in 2018 included the collection of genetic material for a population genetics project in collaboration with Dr. Chris Nice and Corina Mier Y Turan at Texas State University. Material was collected from Anderson, Big Boiling, Side, Robertson, Solana, Cowan, and Twin springs over the course of 2018 with the aid of Justin Crow from the San Marcos Aquatic Resources Center. An attempt to collect genetic material was done at Batwell Cave as well, however no salamanders were detected there. A total of 183 samples

were collected for genetic analysis. Results from the population genetics project will be available by December of 2019.

Introduction

The Salado salamander (*Eurycea chisholmensis*) was first described as a species in 2000 (Chippendale et al. 2000). Although the salamander had been discovered earlier and was in a collection kept at Baylor University by B.C. Brown, no formal description had been made. In addition, collecting individuals from this population proved to be difficult (Chippendale et al. 2000). Due to the limited knowledge about the species (population density, life history patterns), potential threats (dewatering and urbanization), and limited geographical range, this species was listed as threatened by the U.S. Fish and Wildlife Service on February 21, 2014. The USFWS designated the downtown spring complex, the Robertson estate spring, and a few sites upstream in the Salado creek watershed, as critical habitat.

The Salado salamander is highly restricted geographically and is hypothesized to have a very low population within Central Texas (Norris et al. 2012). It has been proposed recently, that a much more streamlined phylogenetic hypothesis may apply to Central Texas *Eurycea*, (Forstner et al. 2012) and that the additional *Eurycea* within the Central Texas area had not been analyzed in context with congeners, but that is not the case. A peer-reviewed publication by Pyron and Weins (2011) genetically examined all Spelerpines, a subfamily under the family Plethodontidae, which included all *Eurycea*, including the ones in question at the time (*E. chisholmensis, E. naufragia, and E. tonkawae*), suggest that the phylogenetic analysis by Chippendale et al. (2004) was appropriate and that indeed these are distinct species. In addition, a recent study, funded through a section six grant (#443022), by Dr. Hillis of the University of Texas, shows the species designation was indeed scientifically valid (Devitt et al. 2019).

Before monitoring by TXFWCO there was no active research or monitoring program that was working with this particular species. The TXFWCO proposes to conduct long term monitoring of the species within its known geographical range. A long term data set will eventually provide a statistically valid sample size to base future management decisions. This program began in 2015 and is in fifth year of monitoring.

Methods

Sampling was conducted monthly in 2018 at the DSC and at Robertson Springs (Figure 1). Timed searches were conducted at Big Boiling and Robertson springs, while Side Spring and Anderson Spring were searched entirely due to their small areas. During timed searches, all mesohabitats were searched for salamanders. Passive sampling was conducted using drift nets with 250 µm mesh at a number of locations at Robertson, Anderson and Tahuaya springs. Nets were set in place for seven days. Aquatic invertebrates captured during drift netting were taken back to the lab sorted and identified. Aquatic invertebrate data presented will include analysis of certain spring communities from 2015 to 2018. Most taxa were photographed using a dissecting scope. Certain taxa with questions about taxonomic placement were sent to experts for species identification. Other passive sampling techniques were deployed when necessary due to the lack of discharge at spring locations. When discharge became negligible, but water still remained bottle traps and mop heads were used to passively collect salamanders. When salamanders were found, they were photographed and taken to the San Marcos Aquatic Resources Center for study. All measurements were acquired using Image J software.

As in the 2017 report, the overall dataset has been updated to include the 2018 detections within the running long-term data set for substrate, vegetation, and lengths. For length data, salamanders were grouped into seasonal blocks for a size distribution analysis. The relative abundance of the salamanders was calculated for each season based upon size classes. Size classes are from 0-19, 20-29, 30-39, 40-49, 50-59, 60-69 mm. Finally, associated substrate and vegetation percentages were updated to reflect the new collections.

Other monitoring at Cowan and Twin springs was conducted in coordination with Cambrian Environmental, as these sites are part of the Cambrians regular monthly monitoring regime. The springs were searched thoroughly, and salamanders were collected, tail clipped, photographed and returned to the spring. Cowan and Twin springs were searched monthly from February through July as part of the genetics project. Passive monitoring techniques to collect salamander genetic material from Bat Well Cave took place from March 27 to April 12 of 2018, using drift nets placed within the cave. Sampling was conducted at Solana Ranch Spring #1 in September of 2017 and again in April of 2018, to gather additional genetic material. At the beginning of the genetics project 18 salamanders were collected and preserved from the field. To mitigate the loss of these salamanders and maximize the data gained from them, gut contents were examined from these 18 individuals.

Results

A total of 32 salamanders were detected in 2018 during all collections. Of these 32, 21 were juveniles (<30 mm) and 11 were adults (Table 1). A total of 15 salamanders were detected during monthly monitoring at the DSC and Robertson springs. Most salamanders were captured this year from the DSC at Side Spring (n = 11). A total of 10 salamanders were captured passively using drift nets deployed over a combined 585 days of drift netting. Middle Spring within Robertson Springs had the most detections of salamanders using the drift nets (n = 5), followed by Anderson Spring (n = 2), Ludwigia Spring zone (n = 2), and one from the Headwaters Spring. Bottle traps and mop heads were used as the spring discharge decreased at Robertson Springs in Creek Spring and at Big Boiling Spring, however, no salamanders were captured using these methods.

Most salamanders were captured in the first half of the year during regular monthly monitoring (Table 2) with all the detections occurring within the DSC. Robertson Springs continued a downward trend in discharge from the end of 2017 to October 2018. By April, only four mapped springs were flowing along with a seep that had taken the place of the headwaters which were now below Middle Spring (Figure 2). All springs above the new seeping headwaters were now dry, including Beetle and Middle springs. By July, discharge from all mapped springs had completely stopped. This cessation in discharge lasted until early October, 2018. On October 17, 2018 nets were deployed to detect salamanders leaving the aquifer to recolonize the surface habitat and were left in place for the duration of the year. During that time, eight salamanders were captured at Robertson Springs. Middle Spring was the most productive in producing salamanders to the surface (n = 5; over 80 days of netting).

Some salamanders escaped without a photo, therefore, a total of 107 Salado salamanders that have been captured and measured since 2015 were used for the updated seasonal dynamics. A classic size progression from smaller to larger salamanders, over the course of the year is shown (Figure 3). In winter, the majority of salamanders captured were in the smallest size class ranging from 10 to 19 mm. In spring, the smallest size class was still dominant, however, the measurable population had spread out to include representation in the fourth and fifth size classes. In summer, the most prevalent size class was in the 30 – 39 mm size class with all other size classes including at least one capture (Table 7). In the fall, the largest number of individuals observed were within the fourth size class (40 – 49 mm). Overall, the most salamanders were detected in the spring than are detected in winter (Figure 4; Table 7).

A total of 113 Salado salamanders have been detected since 2015. One salamander, captured in April of 2018, does not have substrate or vegetation data recorded, so 112 salamanders were used to examine the substrate and vegetation associations. A total of 73 salamanders were detected on the surface (67%), while 39 (36%) were captured in drift nets, presumably from the aquifer. Of the 73 salamanders detected on the surface, 43 (58%) have been captured in gravel as the primary substrate and 22 (30%) have been captured in cobble as the primary substrate (Table 3). Salamanders were detected in many types of vegetation, but 31 (42%) of the 73 were shown to associate with watercress (*Nasturtium* sp.) and 25 (34%) have been captured in areas with no vegetation.

Examination of the gut contents from 18 Salado salamanders showed similarities to other Eurycea from across the Edwards Plateau (Diaz 2010). Only one salamander out of the total 18 had an empty digestive tract. A total of 162 aquatic invertebrates were identified from the 18 salamanders. On average nine aquatic invertebrates were present within the gut tract. The Class Ostracoda (seed shrimp), represented by at least six genera, were the most common taxa encountered within the gut tract of the salamanders (Table 4). Following Ostracoda in abundance were Copepods and then the amphipod *Hyalella* sp. (Figure 5).

Drift net sampling at a number of springs within the Robertson property and at Anderson Springs was conducted to examine recruitment of the salamanders to the surface. These activities have also provided a detailed data set of the karst invertebrates present at each spring opening or complex. Surface recruitment of salamanders at Robertson Springs from the aquifer to the surface habitat has been calculated at 0.029 salamanders per day, derived from drift netting data from major springs within the Robertson property and at Anderson Spring. This rate was calculated using data from a total 1,302 days of drift net sampling from 2015 to 2018. Surface taxa were collected from the drift nets and include three genra of riffle beetles (Elmidae), *Microcylloepus* sp., *Stenelmis* sp., and *Heterelmis* sp., which are considered good indicators of water quality. Robertson Springs, in general has more diversity with regards to aquifer taxa than Anderson Spring at the DSC (Table 5). Within Robertson Springs, Creek and Ludwigia springs contain the most diversity of aquifer taxa.

Collection for the population genetics project during 2018 was very productive at most sites. Sampling sizes (~ 30 individuals) were met for genetic material collected at Cowan and Twin springs on the Williamson County Conservation Foundation land. Collections at Solana Ranch were also successful from Solana Spring #1 yielding 29 salamanders. Collections at all historic Salado salamander locations were accomplished in 2018 within ranges of the maximum genetic target of 30 salamanders per site. Two sites that would have been of interest to the population genetics project were not represented in this data set by genetic material due to lack of access (Cobbs Spring) or the inability to capture any animals (Bat Well Cave). A total of 183 genetic samples were collected from seven locations (Table 6). Most of these are going to be unique collections, however, there may be a few repeat captures. This collection is the largest data set of genetic material taken from the Salado salamander's range (Table 6). Recently, DNA was extracted from 180 tail clipped tissue samples of salamanders. Reduced representation genomic libraries for all 180 samples were prepared in the Nice lab at Texas State University. These libraries were then combined and an aliquot was shipped to the Genomic Sequencing and Analysis Facility at the University of Texas, Austin where size selection of fragments and one lane of Illumina HiSeq 2500 sequencing was performed. This produced 250,208,691 sequence reads. Processing and assembly of these reads is under way currently. We expect to have preliminary results describing patterns of genetic variation within and among populations before May, 2019. We expect to produce a final report by our deadline in December, 2019.

Discussion

Collections of the Salado salamander decreased from the previous year but was comparable to the levels detected in 2016 when discharge was beginning to return to Robertson Springs following the drought. Although collections from Robertson Springs did not happen until October, the collections at the DSC were consistent with past efforts in 2017. Twenty five salamanders were detected in 2017 and 24 were detected in 2018 from the DSC. During drought conditions or times where Robertson Springs is not flowing, it is still be possible to collect and detect salamanders within the DSC. For example, in 2015, four salamanders were detected at the DSC, when the Edwards Aquifer area was just coming out of a severe drought.

With the addition of the 32 salamanders detected this year the sample size of the population dynamics graph (Figure 3) has increased from 75 to 107 salamanders. Other research by Bendik et al. (2017) on the Jollyville Plateau salamander (*E. tonkawae*) and Pierce et al.

(2014) on the Georgetown salamander (*E. naufragia*) both showed a peak time for gravidity in December, with Pierce et al. (2014) showing an additional peak in February or March for the Georgetown salamander. However, gravidity has not been observed in the Salado salamander in the number of observations necessary to elucidate any trends. What would be expected is to see a lag time between the gravid females observed by the two other authors and the observation of the salamanders in the first size class. Growth curves in captive San Marcos salamanders show that it takes about 60 days to reach around 15 mm. Therefore, if there was to be a peak in Salado salamander gravidity in December, the juveniles would be on the surface and up to about 15 mm at the earliest in late February. The Salado salamander population dynamics graph shows the largest percentages of juveniles occur during spring, which runs from March to May. In other words, we might hypothesize that there is some peak in gravidity for the Salado salamander sometime in December or January, although undetected. The calculation for this graph has changed a bit from the 2017 analysis to make it easier to understand and make more sense ecologically. In 2017, the graph was divided by quarters of the year, in 2018 the graph has been changed to represent seasons.

Diet and habitat associations, given the smaller data set collected for the Salado salamander, compared to the other species to the south, is consistent with their reports of habitat associations taken from a larger sample sizes with more robust surface populations present (Bowles et al. 2006; Diaz et al. 2015, Diaz 2010). Due to the small surface populations at the monitoring sites, examining the data is statistically challenging, however, thinking about observed versus expected may be one way to look at the overall Salado salamander data set. Observed would be the data set for the Salado salamander (e.g. habitat associations). Expected would be the larger established and published data sets with more years of collection and then anecdotally examining the congruence of the patterns within the data sets to provide evidence of those observations collected in the Salado. For example, our substrate and diet data collected from 2015 to 2018 mentioned above in the results is congruent with what is known and published about other southern salamander species. This published evidence does provide some further validity to the Salado data given the smaller sample size of salamanders.

Insights into why the surface densities of these salamanders are historically small (Norris et al. 2012), maybe around 10 salmanders at the DSC and Robertson Spring sites could be based on four years of monitoring observations. The hydroperiod of the springs (i.e. the duration of discharge over time) and proximity to larger order streams, (i.e. ecological disturbance) may play a large part in surface densities at historic Salado salamander sites (Robertson Spring and DSC). Salado Creek's hydroperiod includes large pulses of water after large rain events locally and upstream in the watershed. These pulses cause Salado Creek to rise high enough that it floods the spring outlets at the DSC and at Robertson Springs.

The spring flows in the DSC appear to be stable except for Little Bubbly Springs which has been intermittent. However, Robertson Springs has a large fluctuation in hydroperiod and was not flowing in 2015. In 2016 the springs began to discharge water from a number of orifices. In 2017 the discharge began to decline and ceased to flow in 2018. In addition, Robertson and the DSC springs are at the known northern fringe of *Eurycea* distribution in Texas and the Edwards Aquifer. In comparison, the surface population present at Solana Ranch Spring #1, just south of Salado, over the last three visits has always been detectable and consistent with regards to count data. Solana Ranch Spring #1 has had a consistent hydroperiod, is not near a larger order stream or river, and is south of the known northern locations for these salamanders.

These factors may be a large part of why the surface densities are low at the historic Salado salamander sites. In addition, the small surface recruitment of salamanders seen at Robertson and Anderson springs, based on the drift net data, suggest that the populations at these sites may be slow to recover from natural disturbances like a flood or cessation in flows. Given that surface densities are low, but appear to be consistent given the flows over the last three years (2015- 2018), it is likely that a large proportion of the Salado salamander population is below the surface within the aquifer. The ongoing genetics project, mentioned earlier, is likely to provide insights into the subterranean population densities when it is completed. These results will be compared to sites within the Barton Springs and San Marcos salamander populations. In addition, if there is a catastrophic event that affects the aquifer, a long cessation in flows, or there is a need to simply examine changes in the next ten years based on population density, this genetic analysis can be repeated and genetic bottle neck events or recalculation of site population estimates can be reexamined.

Table 1. Collections of Salado salamanders from 2018 timed monitoring and opportunistic collections. DSC = Downtown Complex; CC = Cave conduit; LN = little net, by hand; DN = drift net.

#	Spring	Location	Date	Total Length (mm)	Primary Substrate	Vegetation	Method
1	Side Spring	DSC	1/19/2018	17.11	Gravel	Watercress	LN
2	Big Boiling	DSC	2/26/2018	22.96	Cobble	Leaves	LN
3	Big Boiling	DSC	2/26/2018	23.21	Cobble	Leaves	LN
4	Side Spring	DSC	3/12/2018	19.27	Cobble	none	LN
5	Anderson	DSC	3/20/2018	18.92	CC	Cave	DN
6	Side Spring	DSC	4/12/2018	22.79	Gravel	Watercress	LN
7	Big Boiling	DSC	4/12/2018	19.53	Gravel	none	LN
8	Anderson	DSC	4/16/2018	17.07	CC	Cave	DN
9	Side Spring	DSC	4/16/2018	19.6	Gravel	Watercress	LN
10	Side Spring	DSC	4/16/2018	22.92	Gravel	Watercress	LN
11	Side Spring	DSC	4/16/2018	35.9	Gravel	Watercress	LN
12	Side Spring	DSC	4/16/2018	29.19	Gravel	Watercress	LN
13	Big Boiling	DSC	4/16/2018	16.46	NA	NA	LN
14	Big Boiling	DSC	5/16/2018	19.06	Gravel	none	LN
15	Anderson	DSC	5/16/2018	20.17	Gravel	none	LN
16	Anderson	DSC	5/31/2018	18.53	Gravel	none	LN
17	Anderson	DSC	6/6/2018	24.73	Cobble	none	LN
18	Side Spring	DSC	6/21/2018	54.37	Gravel	none	LN
19	Side Spring	DSC	6/21/2018	29.84	Gravel	none	LN
20	Side Spring	DSC	6/21/2018	18.57	Gravel	none	LN
21	Anderson	DSC	6/28/2018	23.99	Gravel	none	LN
22	Side Spring	DSC	6/28/2018	46.35	Gravel	none	LN
23	Anderson	DSC	9/24/2018	42.93	Gravel	none	LN
24	Anderson	DSC	9/24/2018	27.83	Cobble	none	LN
25	Ludwigia Upper	Robertson	10/30/2018	60.11	CC	Cave	DN
26	Middle Spring	Robertson	10/30/2018	45.24	CC	Cave	DN
27	Middle Spring	Robertson	10/30/2018	12.05	CC	Cave	DN
28	Middle Spring	Robertson	11/7/2018	46.99	CC	Cave	DN
29	Middle Spring	Robertson	11/15/2018	45.56	CC	Cave	DN
30	Ludwigia Middle	Robertson	12/19/2018	31.96	CC	Cave	DN
31	Middle Spring	Robertson	12/19/2018	47.39	CC	Cave	DN
32	New Upper HW	Robertson	12/19/2018	49.03	CC	Cave	DN

Table 2. Data collected from the 2018 timed monitoring events at the Downtown Complex and Robertson springs. Other collections of Salado salamanders occurred during opportunistic sampling events.

Month	Salamanders	Spring
January	1	Side
February	2	Big Boiling
March	1	Anderson
April	5	Anderson and Side
May	1	Anderson
June	3	Side
July	0	-
August	0	-
September	2	Anderson
October	0	-
November	0	-
December	0	-

Table 3. Habitat associations of the Salado salamander determined by 112 salamanders collected from 2015 to 2018 at the downtown springs complex (DSC) and Robertson springs. Substrate and vegetation percentages were calculated only using surface collections.

	#	%
Cave Conduit	39	36.11
Substrate	**#**	**%**
Silt	2	2.74
Sand	2	2.74
Gravel	43	58.90
Cobble	22	30.14
Boulder	4	5.48
Vegetation	**#**	**%**
***Sagittaria* sp.**	1	1.37
***Nasturtium* sp.**	31	42.47
Filamentous Algae	4	5.48
***Ludwigia* sp.**	1	1.37
***Amblystegium* sp.**	4	5.48
***Hydrocotyle* sp.**	2	2.74
none	25	34.25
Organic Debris	4	5.48
Grass	1	1.37

Table 4. Items collected during gut contents analysis of 18 Salado salamanders collected from 2016 to 2018.

Class/Order	Family	Genus	Totals	Composition	Frequency
Ephemeroptera	Caenidae	*Caenis sp.*	1	0.62	0.06
Ephemeroptera	Baetidae	*Callibaetis sp.*	1	0.62	0.06
Trichoptera	Leptoceridae	*Nectopsyche sp.*	1	0.62	0.06
Diptera	Chironomidae	Tanypodinae	2	1.23	0.11
Amphipoda	Hyalellidae	*Hyalella sp.*	13	8.02	0.33
Mesogastropoda	Pleuroceridae	*Elimia sp.*	8	4.94	0.28
Mesogastropoda	Hydrobiidae	Phreatodrobia nugax	7	4.32	0.11
Copepoda			22	13.58	0.28
Cladocera			1	0.62	0.06
Ostracoda		*Stenocypris sp*.	26	16.05	0.28
Ostracoda		Cypria -- Green	66	40.74	0.61
Ostracoda		Cypria – Red	4	2.47	0.11
Ostracoda		*S. bellensis*	3	1.85	0.06
Ostracoda		Subterranean	2	1.23	0.11
Ostracoda		Other	2	1.23	0.11
Detris			3	1.85	0.17
All Ostracoda Combined			103	63.58	0.83

Table 5. Presence data of aquifer taxa collected from drift nets at springs in the Salado area from 2015 to 2017. LSL – Ludwigia spring lower, LSM – Ludwigia spring middle , LSU – Ludwigia spring upper.

	Anderson	Beetle	Middle	Creek	LSL	LSM	LSU	Headwaters
Blind Collembola	0	0	0	1	1	0	0	0
Folsomoides sp.	0	0	0	1	1	0	0	0
Blind Dytiscidae	0	1	0	0	0	0	0	1
Curculionidae blind	0	0	1	1	1	0	0	0
Subterranean Ostracoda	1	1	0	1	1	1	1	1
S. bellensis	1	1	1	1	1	1	1	0
Uchidastygacarus sp.	1	1	0	1	1	1	1	0
Mite long appendages	0	1	0	0	0	0	0	1
Big O Mite	0	0	0	1	1	1	0	0
Texanobathynella	1	1	1	1	1	0	0	0
Microcerberidae	0	1	0	0	0	0	0	0
Phreatidobid sp.	1	1	1	1	1	1	1	1
P. nugax	1	0	0	1	0	1	0	0
P. micra	0	1	1	1	1	1	1	1
P. taylori	1	1	1	1	1	1	1	1
M. comal/P. integra	1	0	0	0	0	0	0	0
Lirceolus pilus	1	1	1	1	1	1	1	1
Caecidotea reddelli	1	1	1	1	1	0	0	1
Stygobromus sp.	1	1	1	1	1	1	1	1
Parabogidiella americana	1	0	0	0	0	0	0	0
Totals	12	13	9	16	15	11	8	9

Table 6. Sites where Salado salamanders were collected during 2017 and 2018 for the Salado salamander population genetics project.

Site	Sample Size
Anderson	17
Big Boiling	11
Side Spring	14
Robertson	16
Solana Ranch	29
Cowen	58
Twin	38

Table 7. Cumulative Salado salamander data collected from 2015 to 2018 used to create population dynamics graph.

Size Class	Winter	Spring	Summer	Fall
1	5	26	9	3
2	3	9	5	2
3	2	5	12	1
4	2	4	3	7
5	0	1	2	4
6	0	0	1	1
Size Class	Winter	Spring	Summer	Fall
1	0.416667	0.577778	0.28125	0.166667
2	0.25	0.2	0.15625	0.111111
3	0.166667	0.111111	0.375	0.055556
4	0.166667	0.088889	0.09375	0.388889
5	0	0.022222	0.0625	0.222222
6	0	0	0.03125	0.055556
Totals	12	45	32	18

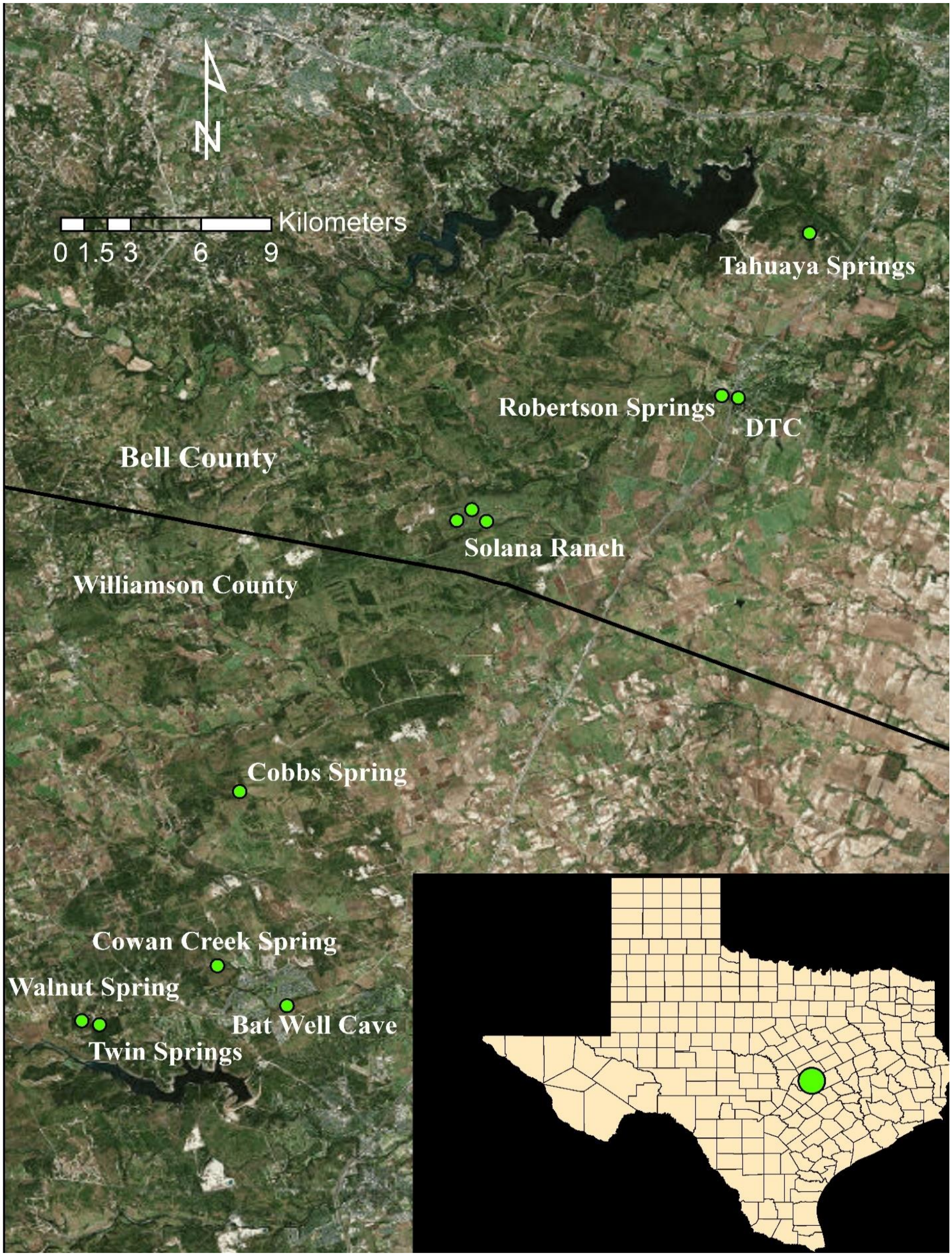

Figure 1. Known geographical range for Salado salamander and monitoring sites used in 2018.

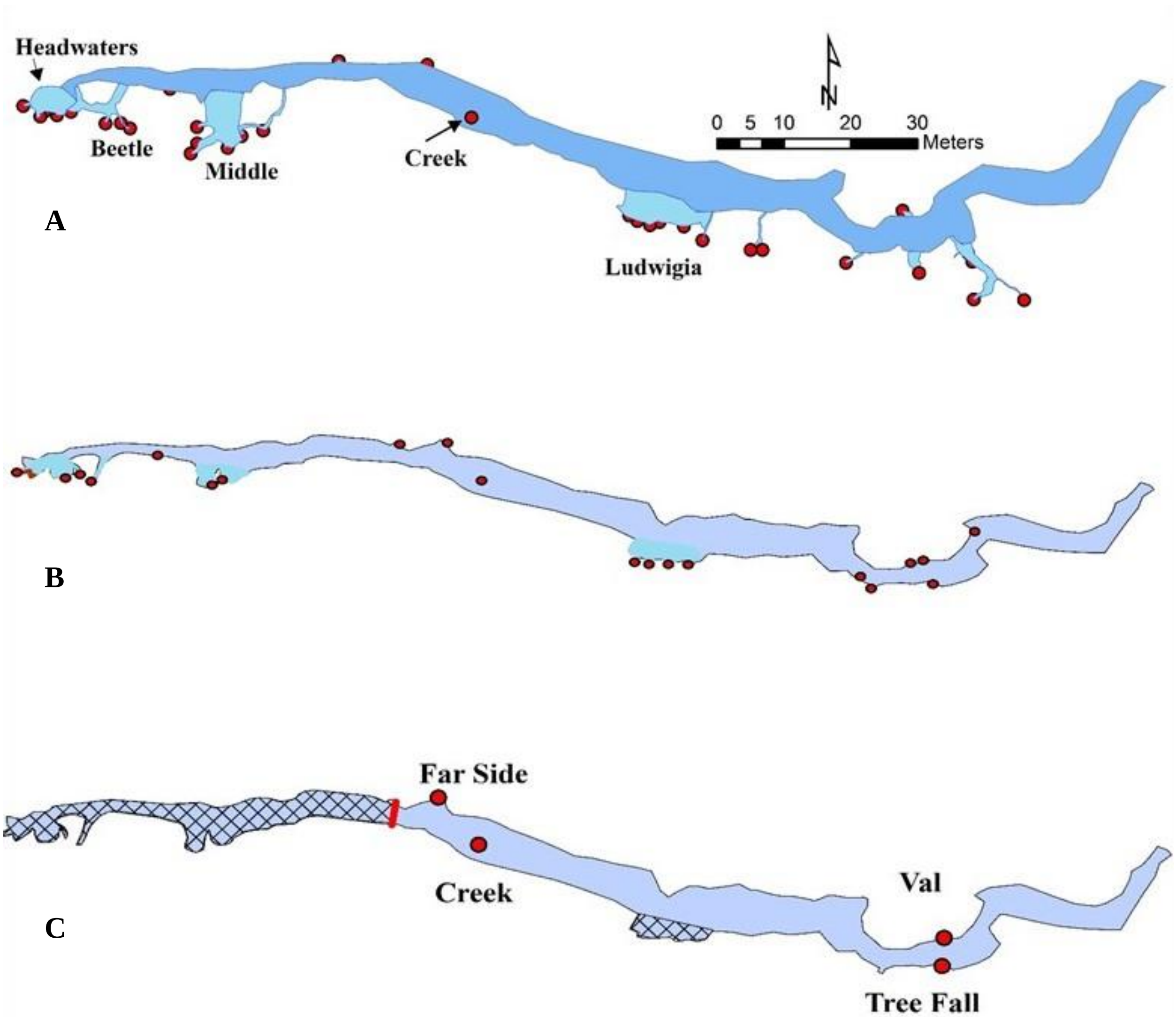

Figure 2. Robertson Springs starting in March of 2016 (A) into July of 2017 (B) and finally in April of 2018 (C). Hashed areas are places where there was no longer water. Red dots or lines are spring locations. Lighter blue sections are considered spring zones.

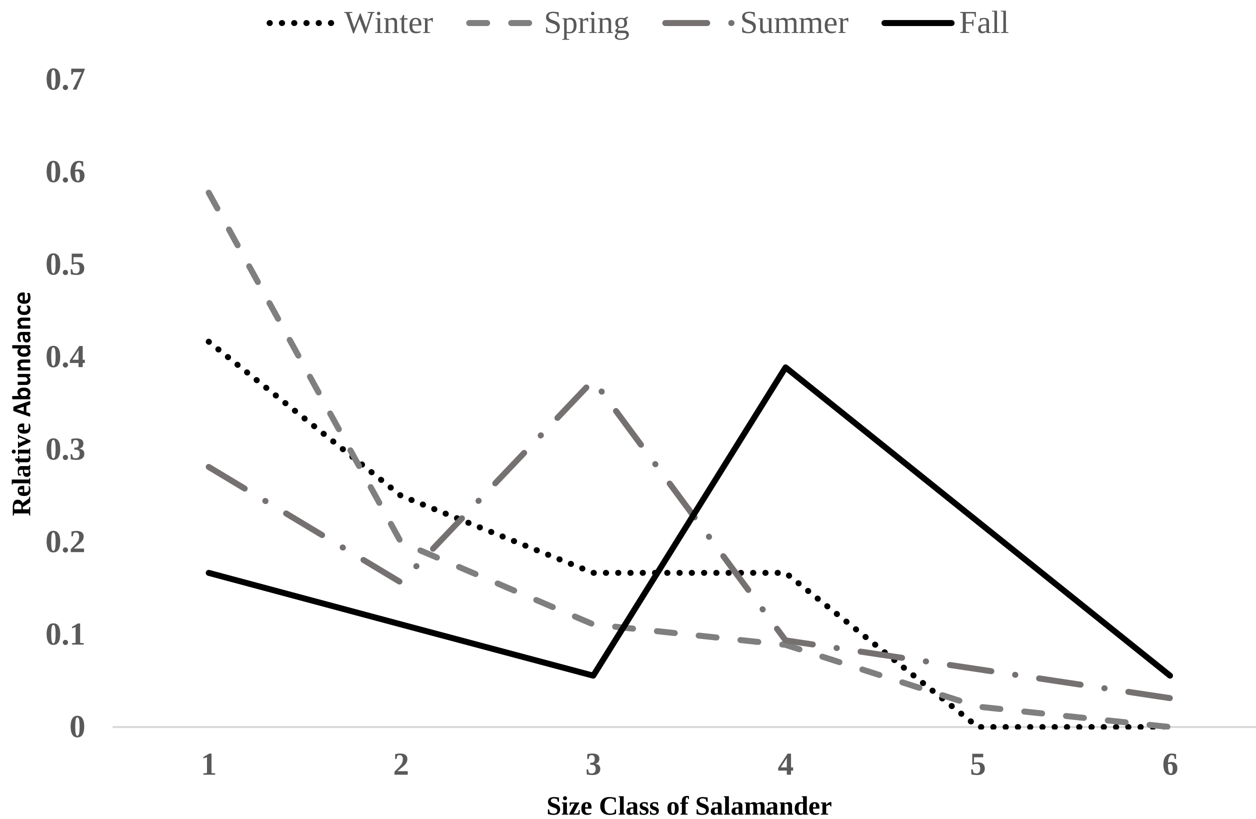

Figure 3. Relative abundance of size class for 107 Salado salamanders captured quarterly from 2015 - 2018 (1 = 10 - 19 mm; 2 = 20 - 29 mm; etc.).

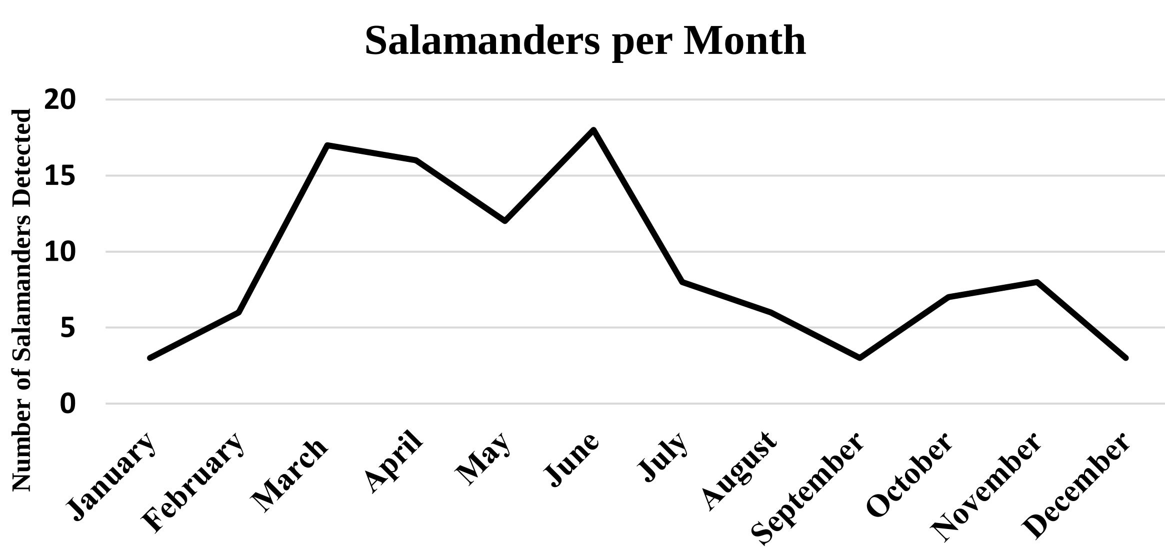

Figure 4. A cumulative depiction of when Salado salamanders are being caught using data from 2015 to 2018.

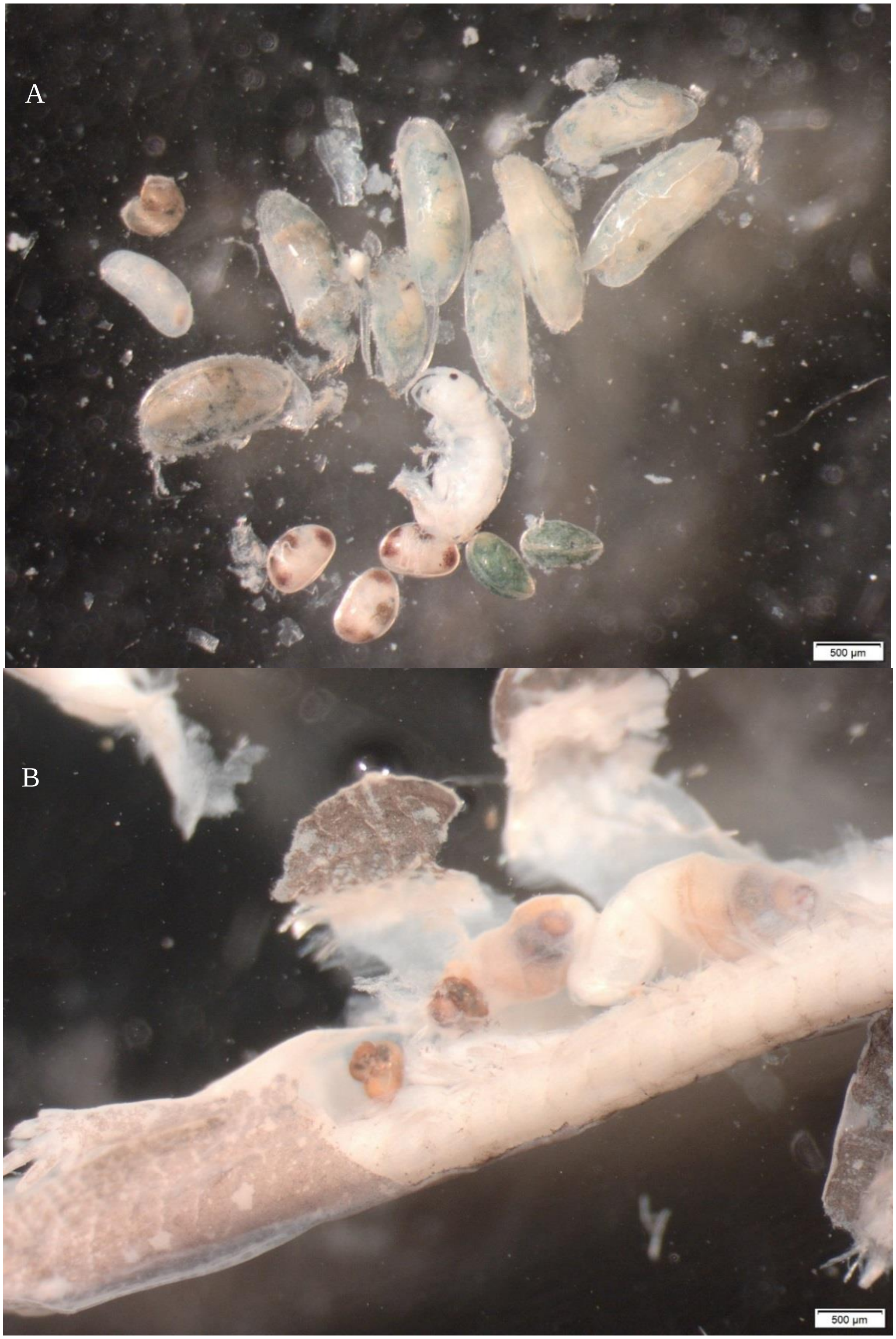

Figure 5. Gut contents of the Salado salamander. Photograph A shows dietary items pulled from a Salado salamander. Photograph B shows gastropods in the digestive tract of a Salado salamander.

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