The Herpetological Bulletin 171, 2025: 12–19
RESEARCH ARTICLE

https://doi.org/10.33256/hb171.1219

Initial field data for the Critically Endangered Alchichica salamander *Ambystoma taylori* from Lago Alchichica, Mexico

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ABSTRACT – The Lake Alchichica salamander *Ambystoma taylori* is a Critically Endangered, neotenic inhabitant of a single, hyposaline lake in Puebla, Mexico. Between 2015 and 2018, initial field data were collected for this understudied species, to inform future conservation action. Using unbaited submerged passive traps at depths of 0–<10, 10–<20 and 20–30 m, we captured 240 salamanders (137 males, 82 females, 18 juveniles) over 32 visits, for which length and mass were collected, and which were individually identified. Generalised linear models showed that males were captured at greater rates than females, and capture rates were lower in the dry-warm and wet-cold seasons than the wet-warm and dry-cold seasons. Salamanders were more likely to be captured at depths of 20 and 30 m than 10 m, but this effect was not detected when using only presence/absence data, suggesting clustering of animals in the lake. No evidence was found that depth of capture was predicted by size, sex or season. No eggs and only a small number of juveniles were detected, which were found in all seasons and without a clear trend in size across the year, meaning that a clear breeding season could not be identified. It is noteworthy that hatchling larvae would be able to escape the traps due to mesh size. Adult mass had a significant, positive cubic relationship with SVL, but females were heavier for their lengths, especially at larger sizes. Conversely, males were slightly but significantly longer than females for their weight (despite shorter absolute SVLs than females). These trends are typical in salamanders and likely associated with investment in eggs. Approximately 12% of animals carried an unidentified ectoparasitic burden and endoparasites *Hedruris siredonis* were detected in opportunistically encountered dead animals that were necropsied. Data reported here provide an initial insight into the biology and phenology of this species, as well as offering viable survey methods in a challenging environment.

INTRODUCTION

The Lake Alchichica salamander *Ambystoma taylori* is an ambystomatid salamander endemic to a single, hyposaline crater lake (Lago Alchichica) on the border of Puebla and Veracruz states, Mexico. This obligate neotene is assessed as Critically Endangered on the IUCN Red List (IUCN SSC ASG, 2015), is an Evolutionarily Distinct and Globally Endangered (EDGE) species (Safi et al., 2013) and is threatened by pollution, increasing salination and water extraction from its native lake, as well as regional anthropogenic water stress, and habitat damage from tourism (IUCN SSC ASG, 2015). The stromatolite-rich nature of the lake bed, which limits access to and use of nets in the lake, the extreme depth of the lake (64 m), and hyposaline conditions protect the population from overharvesting and introduction of non-native fish, two important threats for ecosystems in neighbouring freshwater lakes (CJM & JAHD, pers. obs.). The lake is a complex environment, with thermally driven, seasonal cycles of water circulation and stagnation, and associated oxygenated and anoxic periods, and phyto- and zoo-plankton blooms (Lugo et al., 1999). Besides the salamander, the lake hosts a unique ecosystem, with widespread endemism of organisms including algae, zooplankton, invertebrates and silverside fish (Alcocer et al., 2007; 2015; Chiappa-Carrara, 2022; Macek et al., 2008; Vilaclara et al., 2022).

Beyond its neoteny, and limited work investigating phylogeny (Percino-Daniel et al., 2016), parasitology (Michaels et al., 2016) and more broadly concerning its ecosystem (Kaźmierczak et al., 2011), little is known about the salamander. A Conservation Needs Assessment (CNA) for the species recommended, among other actions, that in-situ research is conducted in order to better understand the biology of the species (Marcec, 2019). Between 2015 and 2018, surveys sponsored by Africam Safari and ZSL EDGE of Existence Programme were conducted for *A. taylori* at Lago Alchichica to estimate salamander abundance in the lake and investigate species biology. Results of these surveys are summarised herein.

MATERIALS & METHODS

Ethics and legality

All methods complied with the British Herpetological Society Ethics Policy and with local laws and regulations. The following permits were in place for all fieldwork: SGPA/DGVS/07294/15 and SGPA/DGVS/09323/16; all work was ethically approved by the Zoological Society of London.

Field methods

Thirty-two surveys were conducted from an inflatable boat, manoeuvred by paddle. Torpedo Crawfish Traps from Heavy-Duty Steel Mesh (USA) (Fig. 1) were used to trap salamanders; bait was not required to trap animals. On each survey visit, 21 traps were distributed around the lake and lowered to the substrate at three different ranges of depth; 0–10 m, 11–20

Figure 1. (Top left) *Ambystoma taylori* adult in habitat, Lago Alchichica, Mexico; (top right) stromatolithic habitat both above and below the water line harbours salamanders readily snags traps and precludes drag netting; (bottom) salamander in minnow trap, having been slowly drawn up from the bottom of the lake

m and 21–30 m depth, measured by marking strings attached to the traps signifying depth. Trap location was previously determined by using a bathymetric map of the lake to randomly distribute traps within appropriate depth zones (Kaźmierczak et al., 2011). Each trap was equipped with a plastic bottle as a buoy at the end of the string, and small pieces of polystyrene were attached along the string every 3 metres to avoid it sinking and tangling around stromatolites. Traps were deployed in the morning and retrieved after 24 hours. Visits were scheduled in each of four climatic seasons (cold-dry: November to February; warm-dry: March to May; warm-wet: June to August; cold-wet: September to October, all inclusive).

During the first surveys, traps were retrieved slowly (~6 metres/minute) to avoid potential deleterious effects of depressurisation on salamanders. During some surveys, however, the strong wind made it impossible to retrieve the traps at a slow rate, so they were retrieved quickly without any apparent deleterious effects on salamanders. Trapped salamanders were handled with nitrile gloves and were processed at the lake shore. Animals were sexed (female, male or juvenile) through inspection of secondary sex characteristics including cloaca shape and size, then measured (total length [TTL]; snout-vent length [SVL]) and weighed. To aid in individual identification, animals were photographed dorsally in a standardised manner, and marked with Visible Implant Elastomer (VIE; Moon et al., 2022); animals were also compared to historical records held by JAHD of opportunistically photographed animals to identify any recaptures. Salamanders were checked for external parasites and deformities, recording the number of affected animals. Individuals were then released into the lake, in the closest possible spot to the trap where they were caught, close to aquatic shelters in which they could hide.

Statistical methods

Recorded data were subject to the analyses presented in Table 1, with an alpha of 0.05 used throughout. These models comprised: 1) a Poisson generalised linear model (GLM) investigating the effect of sex, season and depth on counts of captured salamanders, allowing for variation in trapping effort between seasons (visits were not evenly distributed by season – see Table 2); 2) a logistic regression investigating the influence of season and depth on presence/absence (i.e. empty nor non-empty traps) of salamanders; 3) a multinomial regression investigating the influence of sex, season and weight of salamanders on the depth at which they were captured; 4) a linear regression investigating the effect of SVL and sex on mass; 5) a linear regression investigating the effect of mass and sex on SVL. Analyses were conducted in R 4.2.3. using the stats package (R Core Team, 2023) for all analyses other than the fitting of multinomial models, for which the nnet package was employed (Venables & Ripley, 2002). Residuals for all models were checked using the DHARMa package (Hartig, 2022) to ensure that model assumptions were met. A backwards elimination approach to hypothesis testing was used, with initial models fitted with interactions and non-significant terms removed; non-significant main effects were retained

Table 1. Research questions posed and analyses performed to answer them using the collected data

Analysis ID	Research question	Response variable	Explanatory variables	Type of model used
1	Do encounter counts differ between sexes, seasons and depths?	Count of captures per visit	Main: Sex (male; female); season; depth (10; 20; 30 m) Offset: number of traps by season	Poisson generalised linear model
2	Is presence/absence related to season or depth?	Empty or non-empty trap	Season; depth (10; 20; 30 m)	Logistic regression
3	Is depth predicted by season, sex or size of salamander?	Depth category (10; 20; 30 m)	Sex (male; female), season or weight	Multinomial regression
4	How is mass related to length, and is this different between sexes?	Mass	Sex (male; female), SVL (cubic)	Linear regression
5	How is length related to mass, and is this different between sexes?	SVL	Sex (male; female), Mass (cubic)	Linear regression

Table 2. Survey, capture and morphometric summary of *Ambystoma taylori* from Lago Alchichica, Mexico; lengths and weights are given as mean(standard deviation)[a]

			Count			SVL (cm)		TTL (cm)		Weight (g)		Number with ectoparasites	
Season	Number of visits	Depth (m)	Males	Females	Juveniles	Male	Female	Male	Female	Male	Female	Male	Female
Cold-dry	11	10	11	5	3	8.54 (1.47)	7.66 (1.38)	16.35 (3.07)	14.25 (2.67)	28.32 (14.23)	18.5 (7.7)	3	1
		20	34	10	0	7.95 (1.37)	7.68 (1.34)	14.85 (3.24)	13.94 (2.91)	20.66 (11.17)	22.76 (11.51)	3	3
		30	21	12	3	8.49 (1.65)	8 (0.58)	15.12 (3.42)	14.9 (1.51)	23.38 (14.01)	22.15 (10.36)	0	3
Warm-dry	7	10	2	4	2	10.57 (3.11)	7.94 (0.65)	20.39 (6.7)	15.37 (1.8)	57 (49.5)	25.25 (7.27)	0	1
		20	6	3	4	8.2 (1.69)	8.6 (2.48)	15.77 (3.89)	17.03 (6.08)	28.33 (17.52)	34.67 (29.14)	0	0
		30	3	4	0	8.53 (0.88)	8.7 (1.09)	15.98 (1.7)	16.61 (1.59)	20.67 (6.51)	31.75 (11.21)	0	0
Cold-wet	5	10	1	0	0	-	-	-	-	-	-	0	0
		20	2	1	0	8.22 (1.43)	-	15.86 (3.08)	-	15 (1.41)	-	0	0
		30	3	5	0	8.86 (0.28)	7.84 (0.62)	16.63 (0.45)	15.12 (1.61)	25.67 (5.03)	26 (8.94)	0	0
Warm-wet	9	10	14	8	2	7.74 (0.69)	8.53 (1.54)	14.87 (1.81)	16.39 (3.23)	18.5 (6.75)	47.4 (24.64)	2	3
		20	13	18	3	7.43 (1.1)	7.35 (1.23)	14.22 (2.49)	14.41 (1.93)	20.77 (7.91)	22.69 (10.9)	2	2
		30	27	12	1	7.62 (0.78)	8.29 (1.48)	16.01 (5.82)	15.85 (3.12)	21.05 (8.13)	29.4 (16.66)	2	0

[a] single animal for which sex was not recorded was captured in the warm wet season, with and SVL of 6.994cm, and a TTL of 13.531cm; weight was not measured.

in models. Only final models are presented. Visits were necessarily treated as independent, which is an assumption of the analysis, but a reasonable one given that no recaptures were detected (see Results). Random effects models treating year as a random effect were explored as potential means of controlling for any year-level effects that may influence repeated measures, but could not be fitted due to insufficient observations across seasons for some years.

Juveniles were removed from the analysis due to small sample size and the impossibility of sexing animals. For model 1, the use of an offset was validated by checking that the correlation coefficient between the number of traps and counts was close to 1. There were too few observations of ectoparasites for a robust formal analysis.

RESULTS

In the research period, 32 survey visits were made with a mean(SD) duration between visits of 38.6(91.5) days. A total of 240 live salamanders were encountered in traps, from which useable data were collected for 237 and for which full data (collection date, TTL, SVL, weight and depth) were available for 207. These are summarised in Table 2. No recaptures were documented across any surveys and population size estimates could therefore not be made, although it might be inferred to be large (see Discussion). Moderate prevalence of ectoparasites was detected, with about 12% (29/242) of captured animals having a visible ectoparasitic burden, with no clear seasonal pattern (formal analysis was not feasible). Separate to trapped individuals, two animals were found dead near the lake shore, without apparent cause. These animals were subject to a necropsy, and parasites of the digestive tract were found: the gastro-intestinal nematode *Hedruris siredonis*. No emaciated animals as described in the context of nematodiasis (Michaels et al., 2016) were captured. Several other dead animals were found floating on the lake surface, primarily during the spring; no cause of death or other pathology could be ascertained.

Statistical results of analyses are presented in Table 3. Analysis 1 estimated a relatively low rate of capture in the reference state (dry-cold, female salamander at 10 m depth), at 0.0953 captures per trap (exponentiated -2.35). The model found that males were captured at a significantly higher rate than females (rate ratio of 1.65 – nearly twice as frequently), and salamanders were captured at significantly higher rates at depths of 20 and 30 metres than 10 metres (rate ratios of 1.89 for both depths); parameters for 20 m and 30 m were almost identical. Capture rates were significantly lower in the dry-warm and wet-cold seasons than in the dry-cold season (rate ratios of 0.37 and 0.31, respectively – approximately a third as frequently), with no significant difference observed in the

Table 3. Statistical outcomes of models. For each model, the intercept estimate represents the outcome when all variables are at their reference level, and the estimates for other terms indicate changes to the intercept based on other categories (categorical variables) or a 1-unit change in continuous variables. Log odds and rate ratios may be converted to natural scales by exponentiation. Significant p-values are in **bold**. Note that the p values given for models 4 and 5 are derived from an overall likelihood ratio test for the major terms as it was not necessary to dissect the cubic term into each constituent polynomial; for other models, p values are Wald Chi-squared tests of regression coefficients.

Analysis ID	Response	Term	Reference	Estimate scale[a]	Estimate (SE)	P-value
1	Count of captured salamanders	Intercept	N/A	Log rate ratio	-2.35 (0.19)	**<0.0001**
		Season: dry-warm	Dry-cold		-0.99 (0.24)	**<0.0001**
		Season: wet-cold	Dry-cold		-1.18 (0.31)	**<0.0001**
		Season: wet-warm	Dry-cold		0.19 (0.15)	**<0.0001**
		Sex: Male	Female		0.5 (0.14)	**<0.0001**
		Depth: 20m	10m		0.64 (0.18)	**<0.0001**
		Depth: 30m	10m		0.64 (0.18)	**<0.0001**
2	Likelihood of non-empty trap	Intercept	N/A	LogOR	-1.52 (0.24)	**<0.0001**
		Season: dry-warm	Dry-cold		-0.81 (0.32)	**0.01**
		Season: wet-cold	Dry-cold		-1.63 (0.49)	**<0.001**
		Season: wet-warm	Dry-cold		-0.34 (0.26)	0.19
		Depth: 20m	10m		0.30 (0.28)	0.28
		Depth: 30m	10m		0.16 (0.28)	0.57
3	Likelihood of capture at given depth vs 10 m	Intercept	N/A	LogOR	20m: 1.12 (0.43) 30m: 0.92 (0.43)	**20m: 0.009** **30m: 0.034**
		Season: dry-warm	Dry-cold		20m:-0.44 (0.63) 30m:-0.49 (0.66)	20m: 0.48 30m: 0.46
		Season: wet-cold	Dry-cold		20m: 0.07 (1.20) 30m: 1.31 (1.11)	20m: 0.95 30m: 0.24
		Season: wet-warm	Dry-cold		20m:-0.48 (0.43) 30m:-0.18 (0.44)	20m: 0.27 30m: 0.69
		Sex: Male	Female		20m:-0.17 (0.42) 30m:-0.28 (0.42)	20m: 0.68 30m: 0.51
		Weight	Mean Weight		20m:-0.02 (0.01) 30m:-0.01 (0.01)	20m: 0.08 30m: 0.274
4	Mass	Intercept	N/A	Response scale	26.856 (0.80)	**<0.0001**
		SVL	Mean SVL		191.48 (11.38)	**<0.0001**
		SVL^2			37.49 (13.12)	
		SVL^3			-22.17 (11.76)	
		Sex: Male	Female		-4.25 (0.96)	**<0.0001**
		SVL^{1*} sex : Male	N/A		-53.85 (13.83)	**<0.001**
		SVL^{2*} sex : Male			11.28 (15.98)	
		SVL^{3*} sex : Male			19.81 (15.20)	
5	SVL	Intercept	N/A	Response scale	7.82 (0.09)	**<0.0001**
		Mass	Mean Mass		15.63 (0.71)	**<0.0001**
		Mass^2			-2.54 (0.70)	
		Mass^3			0.05 (0.70)	
		Sex: Male	Female		0.38 (0.11)	**<0.001**

[a] for intercepts, this is equivalent to a log rate for model 1, log odds for analyses 2 and 3, and mean measurement for analyses 4 and 5

wet-warm season (Fig. 2; Table 3). There were no significant interactions between variables, so the effect of sex, season and depth did not depend on one another. No overdispersion was detected for the Poisson model. Analysis 2, which was designed to control for any clustering effect by reducing the count response variable to a binary response (whether any salamanders were caught or not), produced consistent results for season. The likelihood of capturing at least one salamander was significantly lower in the dry-warm and wet-cold seasons than in other seasons (odds ratios of 0.44 and 0.20, respectively; i.e. approximately 56% and 80% less likely). However, for depth, although the same trends were identified as in analysis 1, differences in the likelihood of captures at each depth were not significant (Table 3). The Poisson GLM suggested approximately 30 traps (95% confidence interval (CI): 22 to 47, calculating CIs from standard error of estimates)

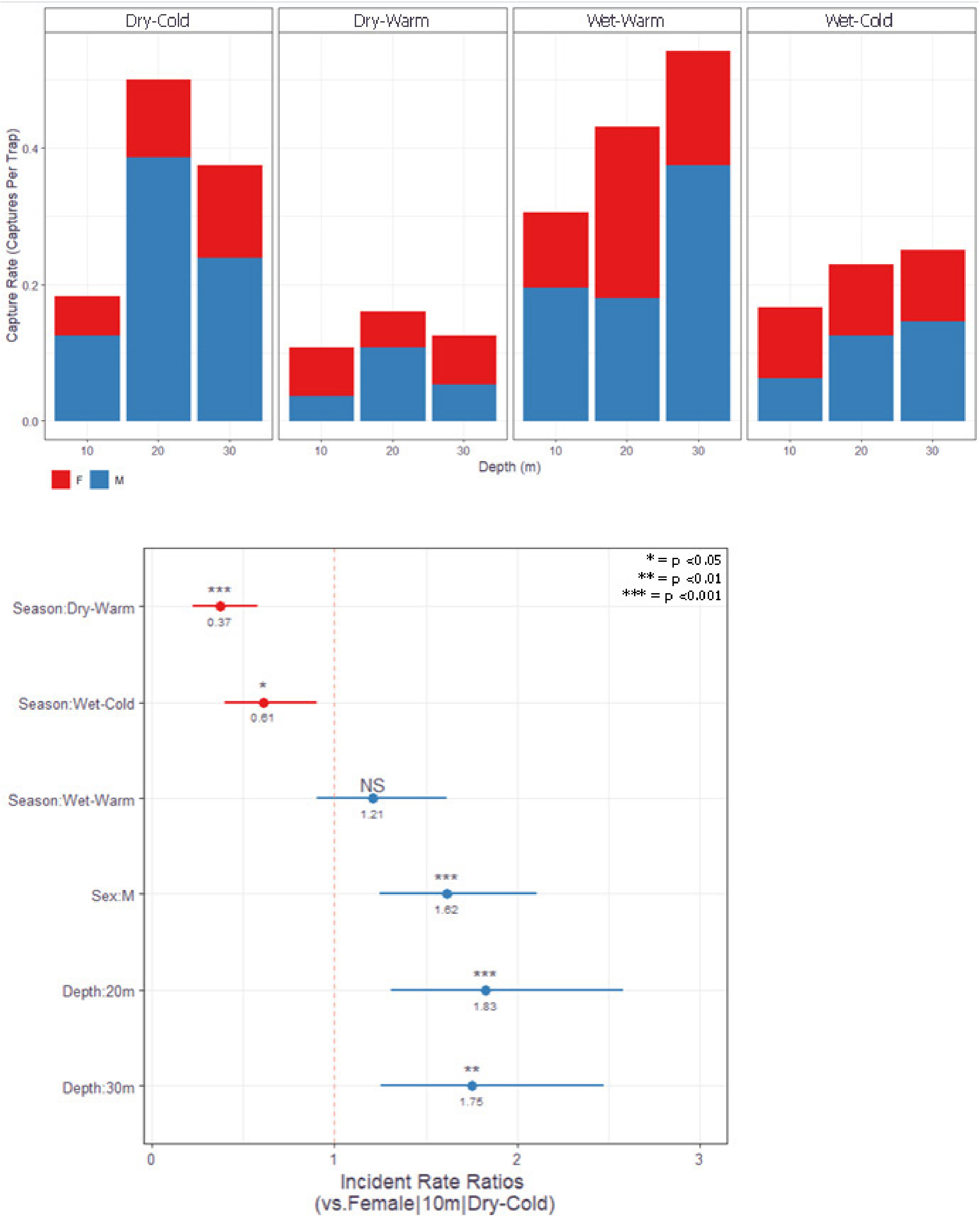

Figure 2. Capture rate ratios (captures per trap) of male and female *Ambystoma taylori* from Lago Alchichica, Mexico, (top) across depths and seasons; (bottom) incident rate ratios estimated from analysis 1, associated with seasons, sex and depth relative to captures of female salamanders at 10 m during the dry-cold season

are needed to ensure a 95% probability of capturing at least one female salamander in the dry season at 10 m depth (i.e. at reference), while the logistic regression model suggested that approximately 15 traps (CI: 10 to 28) are needed under the same conditions. The overlapping confidence intervals indicate that the baseline estimates of likelihood of capture from both models are not statistically different. Analysis 3 found no evidence that the likelihood of capturing salamanders at each depth (10, 20 or 30 m) was significantly predicted by size, sex or season (Table 3). Analysis 4 showed that mass had a significant cubic relationship with SVL, but that males had a significantly shallower curve than females, indicating that females were heavier for their length than males (by around 4 g on average), especially at longer SVLs (Fig. 3; Table 3). Analysis 5 showed that, adjusting for the effect of mass, males were slightly but significantly longer on average (by about 0.4 cm in animals of average weight) than females and that there was a significant cubic relationship between SVL and mass; no significant interaction between mass and sex was detected (Table 3). Importantly, accounting for the effect of mass provided a more accurate insight into differences in SVL between sexes (showing that males are slightly longer for their mass) than a simple comparison of means (which appeared to show that males were smaller).

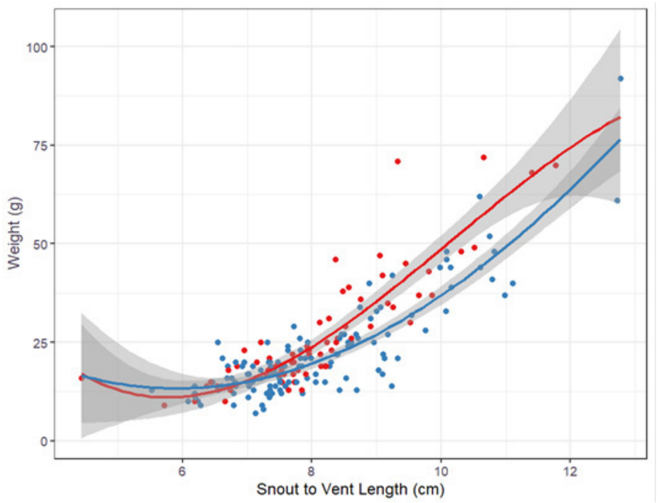

Figure 3. Masses of male (blue) and female (red) *Ambystoma taylori* from Lago Alchichica, Mexico plotted against their snout-vent length. Curves represent smoothed estimates of the relationship between variables based on model estimates, with their standard errors plotted in grey. The trends demonstrate the interaction between snout-vent length and sex in their effects on weight, such that females are heavier than males at larger sizes, but more similar at smaller sizes. Lines diverge at ~7 cm SVL, which may indicate the point at which sexual dimorphism becomes apparent; this was not formally investigated.

DISCUSSION

We present some initial field data for *A. taylori*, a species about which little is known of its biology. Our data suggest fluctuations in capture rates, but not in depth selection by salamanders, with season as well as potential aggregation of animals, rather than an even distribution of individual animals. Males were captured at a higher rate than females. Females were heavier than males for their length, especially at larger sizes, while males were conversely longer for their weight. Despite the capture of a large number of individuals, no recaptures were made. These results are discussed and contextualised below.

The field methods developed for surveys may be useful for conducting further work on the species. Animals were collected successfully in traps without bait. This suggests that trapping relied on passive interception of animals and therefore indicates relatively high density of animals, given the routine success of traps and their random placement. It is unclear whether use of bait might improve trap efficiency, but preliminary informal experience of trialling dead fish as bait did not result in any apparent change in numbers of captured salamanders. One methodological point of note is the ease with which traps´ string snag irretrievably on the rough stromatolites; polystyrene pieces attached along the string every three metres helped us solve this problem to avoid damage to or loss of equipment. Although slow retrieval of traps to avoid damage to salamanders was generally employed out of caution, where this was not possible, no deleterious effects were encountered, suggesting that rapid retrieval may be safe. However, caution is encouraged, and slow retrieval should be employed wherever possible to avoid potential problems that may not be immediately noticeable. Due to the rough, snagging stromatolites and the depth of the lake, other means of survey (e.g. drag netting or visual encounter surveys) are not feasible in the lake (netting) or would only detect animals in the very shallow margins (visual encounters).

Our data suggest that males were captured at higher rates in traps than females, that trapping was more successful for both sexes at depths of 10–20 and 20–30 m than 0–10 m and was less successful in the dry-warm and wet-cold seasons than the wet-warm and dry-cold seasons (all allowing for trapping effort variation between seasons). It is unclear whether the difference between sexes in trapping success is indicative of a male-skewed population, or a higher trapping rate for males. If it were the case, the latter could be caused by higher activity in males, which, although not yet investigated in *A. taylori*, is often reported in male salamanders across the caudate phylogeny, including the Ambystomatidae (Finkler et al., 2003; Verell & Palton, 1996; Helfer et al., 2012), though not ubiquitously (Schulte et al., 2007). Given that the population is restricted to the single lake, and animals live for more than year, seasonal differences in trapping success must reflect differences in capture rate rather than in the presence of animals. This is perhaps caused by seasonal variation in activity of salamanders and/or of weather conditions affecting trap drift, and consequently in the rate at which animals encountered traps. Movement of animals into depth zones outside of those sampled in this study (i.e. deeper than 30 m) should also be considered, given that the anoxic zone of the lake is strongly influenced in size and depth by seasonal changes in temperature that determine circulation cycles in the lake (Lugo et al., 1999). The anoxic zone, which would exclude salamanders, is largest during the period of the year (Lugo et al., 1999) when highest salamander trapping rates were recorded in the present study, which may indicate that salamanders are driven into higher concentrations in shallower water and, consequently, are more readily trapped. Trapping at greater depths may help to elucidate this and survey work of this sort is encouraged. Notably, when presence/absence rather than count data were analysed, the effect of depth was no longer significant. This may indicate that while seasonal and sex differences are linked directly to changes in animal activity and occupation, the effect of depth may be influenced by clustering of animals, with depths >10 m supporting higher concentrations of salamanders, thereby exaggerating the observed differences in capture rates between depths. Further survey work may disentangle these hypotheses and determine whether or not the apparent aggregation may be the result of an attractant effect of already trapped animals.

The 18 juveniles collected ranged from ~6–15 cm TTL and were found in all seasons, with no clear pattern in size across months. Eggs were never encountered, despite the fact that in other species (e.g. *Ambystoma lermaense*), eggs are often attached to traps by trapped females (CJM, pers. obs.). Further fieldwork is recommended to better understand the reproductive cycle of this species and whether it forms a distinct pattern, or if reproduction occurs throughout the year in this relatively stable aquatic system. Observations from captive populations may augment insights from fieldwork, as well as data for other species. Other lake-dwelling neotenic species from Mexico have been documented to breed in the warm-wet season and so, in the absence of other information, this period may be the most likely candidate for the breeding period of *A. taylori* (Brandon, 1973; Zambrano & Reynoso, 1993; Sanchez-Herrara, 1980).

We detected a typical cubic relationship between length and mass (Peig & Green, 2010), and evidence for size-dependent sexual dimorphism in length and mass. While smaller (and therefore likely younger) females shared a similar relationship between length and mass with males, larger (and therefore likely older) females were heavier for their length than males. Additionally, male salamanders were longer for their mass than females; this trend was statistically disentangled as the higher mass of females generated a higher raw mean SVL for this sex. Salamander females in general are typically more heavily bodied due to carrying eggs and the fat stores necessary to produce them, while males are typically more elongate for their mass (e.g. Bruce, 2000; Church, 2008; Howard, 1983; Jakob & Marx, 1992; Scott & Fore, 1995; Semlitsch, 1985) . The point at which trend lines for mass separate may therefore indicate the point at which sexual maturity occurs in females, as this may correspond with production and storage of eggs. This divergence typically occurred at around 7 cm SVL (see Figure 3, where trend lines for males and females diverge), but was not subject to formal analysis in the scope of this work. Data are not available to indicate the age at which animals reach this size and may be different for males and females, given the existence of sex-specific growth patterns in the genus (Blackwell et al., 2003). Body condition is a variable of particular interest in captive populations of amphibians (Ferrie et al., 2014), which exist for this species (Marcec, 2019). However, monitoring body condition is constrained by access to body condition data for wild populations (e.g. Jayson et al., 2018). Consequently, the data presented in the present work may provide a robust dataset of population norms against which comparisons could be made.

Ecto- and endo-parasitism was detected in the salamanders; a reasonable estimate for prevalence of ectoparasitism of about 12% could be made, but endoparasites were detected by chance in a small number of dead individuals and so a robust endoparasitosis prevalence estimate cannot be calculated. It was not possible to identify ectoparasites as these were left intact on animals to avoid injuries associated with their removal, given the absence of appropriate veterinary resources, and could not be properly visualised in identification photographs. Endoparasites were identified as *H. siredonis*, which has been previously reported from the salamander in emaciated individuals (Michaels et al., 2016), and extends detection to animals of apparently normal body condition, albeit still found dead near the shore with no apparent cause. Further work (either in the field or using museum specimens) to understand the prevalence of this parasite and its relationship with salamander health is recommended. Characterisation of the ectoparasites of this species is of particular interest and should be the subject of future work in order to inform understanding of their potential impacts on salamander biology and interactions in the ecology of the lake.

There were no recorded recaptures despite overall capture of 240 adults between 2015 and 2018. The use of a combination of photographic and VIE methods suggests that this is not a case of undetected recaptures. The apparent absence of recaptures may result from one of a number of reasons including a very large population of salamanders, and effect of capture on recapture (e.g. animals becoming wary of traps), or high population turnover (this latter is highly unlikely given the strictly closed population and long lifespan of *Ambystoma* salamanders (e.g. Trenham et al., 2000)). It is considered unlikely that field methods resulted in the death of all captured animals given that none of methods used were novel for amphibians and no signs of distress or injury were noted in any animals on release. Further fieldwork is encouraged to better understand population size, but given all available data, a large population of this range-restricted species seems likely, highlighting the pivotal role of point endemism in driving conservation status.

Overall, our data provide an initial insight into the biology, distribution and phenology of *A. taylori* and provide suggested methods for successful surveying of this species in a challenging environment. Further surveys are required to fully elucidate species biology, which may be importantly supplemented by observations from animals in existing populations in captivity.

ACKNOWLEDGEMENTS

The authors thank ZSL EDGE of Existence Programme, Stiftung Artenschutz and Mohamed Bin Zayed for the financial support to our project. We want to acknowledge several people who participated in fieldwork: Carmen Carmona, Damián Villaseñor, Edher Padilla, Laura Aceves, Fernando Martínez, Fernando Rugerio, Daniel Vázquez, Meghan Zolá, Fernanda Bautista, Michelle Oliver and Braulio Camacho. We would also like to thank the EDGE and Herpetology teams at ZSL for input and support of the project.

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Accepted: 9 September 2024