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Temperature effects on the feeding rate of larval Lake Patzcuaro salamanders, *Ambystoma dumerilii*

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Abstract. Predatory behavior modification is related to physiological and/or environmental factors. Understanding how these factors influence predation success in dynamic ecosystems, whether as a result of natural variations or anthropogenic changes, can provide information to elucidate population responses in a changing world. In aquatic environments, prey availability and the physiological signals associated with predatory behavior are linked to changes in water temperature. We examined predatory behavior and predation performance of *A. dumerilii* during critical larval and juvenile stages (i.e., first 10 weeks of life), at different temperature regimes. The objective was to identify the optimal temperature for prey consumption and predation efficiency under controlled conditions. The experimental design included three temperature treatments (18 °C, 21 °C, and 25 °C) with five replicates each, and a 12/12 photoperiod. Encounters, attacks, captures, ingestions, rejections, and prey escapes were quantified using video recordings and direct observations. Results showed that at 18 °C, individuals displayed significantly higher activity levels and improved predation success, whereas higher temperatures (21 °C and 25 °C) reduced both activity and predation efficiency. Our results also showed that the per capita growth rates were lower at the highest temperature. These findings suggest that the increase in temperature can reduce growth rates, subsequently limiting the ability of the predator to consume prey. Regarding temperature changes in aquatic ecosystems related to global warming, our results provide valuable insights for identifying priority conservation areas, thereby promoting the preservation of *A. dumerilii* and the trophic networks.

Key words. Amphibia, Caudata, predatory behavior, water temperature, growth rate, conservation.

Introduction

Predator–prey interactions regulate trophic cascades and energy flow across food webs and are considered central mechanisms shaping population dynamics, community structure and ecosystem functioning (Schmitz 2010, Pace et al. 1999). These interactions are promoted (or diminished) by environmental conditions, related to natural dynamics (e.g., seasonality) and anthropogenic disturbances (Blaustein et al. 2011, Wong & Candolin 2015). Among these drivers, global warming is regarded as a critical factor influencing predator foraging behavior, metabolic performance, and overall efficiency of energy transfer between trophic levels related to changes in environmental temperature (Laws 2017, Vucic-Pestic et al. 2011). In terrestrial ecosystems, the increase in temperature accelerates metabolic rates and short-term feeding activity and reduces assimilation efficiency, increasing the risk of predator starvation, modifying the structure in both predator and prey population (Rall et al. 2010). However, in terrestrial environments, individuals are generally better able to disperse to refuges from high temperatures, in contrast to species in aquatic ecosystems, where thermal conditions directly affect physiological rates, locomotion, and prey encounter probabilities since environmental factors are directly in the surroundings in the form of water (Fuller et al. 2016, Öhlund et al. 2015). In freshwater ecosystems, the projected surface water temperature will rise 1.5–5.8 °C by the year 2100 and is expected to restructure biotic interactions and alter energy pathways (Moore & Jara 2021, Woodward et al. 2010, IPCC 2021). The increase in temperature in aquatic ecosystems enhances metabolic rates and primary productivity. However, this process may also lead to reduction in total biomass, restructuring of population and community composition, and alterations in higher trophic levels, which collectively affect the regulation and stability of the ecosystem (Archibald et al. 2022).

Amphibians are experiencing severe population declines and elevated extinctions risks worldwide. This phenomenon is recognized as a broader diversity crisis. (Stuart el at. 2004). There are multiple factors causing this decline, including habitat loss and fragmentation, emerging infectious diseases, pollution, invasive species, and climate change (e.g., Wake & Vredenburg 2007, Blaustein et al. 2010). Among these factors, rising temperatures are particularly relevant for ectothermic organisms and is the factor we are going to be studying in this paper. In cold-water predators, warming may drive a preference toward smaller or deeper-dwelling prey, ultimately lowering growth rates and body condition (Guzzo et al. 2017). These changes have cascading consequences, as top predators often exert disproportionate influence on food web resilience and nutrient cycling (Estes et al. 2011). Ectothermic predators which rely on external temperatures to regulate metabolic processes are particularly vulnerable to thermal fluctuations that can reduce locomotion performance, prey capture success, and survival-effects that are often critical for surviving during early life stages (Haubrock et al. 2020, Feder et al. 1982). For example, elevated temperatures cause lethargy or inefficient predatory behavior in amphibians and fishes, while low temperatures in some cave-dwelling salamanders trigger dormancy strategies that minimize reliance on active foraging (Sydlowski 2000, Hervant et al. 2001).

Considering projected temperature changes in aquatic ecosystems over the coming decades, conservation efforts for various amphibian species (e.g., harlequin frogs) have focused on both in situ actions (e.g., identification of priority areas for conservation and restoration) and ex situ strategies (e.g., captive breeding in zoos, farms, and wildlife management units) (Stuart et al. 2004, Gascon et al. 2005). However, for many priority amphibian species, the thermal range that maximizes predatory performance and energetic efficiency remains poorly defined, limiting the ability to accurately identify priority areas and to maintain suitable thermal conditions in captive breeding systems outside their natural aquatic habitats (Carey & Alexander 2003). In this context, the neotenic salamander *Ambystoma dumerilii* Dugés, 1870, an endemic amphibian species of the Lake Pátzcuaro in Central Mexico and cataloged as critically endangered (IUCN 2020, SEMARNAT 2019), represents an ideal model for investigating temperature-mediated changes in predatory performance. Also, field studies on the diet of this genus indicate that adult individuals prey primarily on aquatic invertebrates, particularly zooplanktonic microcrustaceans such as cladocerans, copepods and ostracods: however, little is known about the effect of temperature on feeding rates on critical early stages (Chapparro et al. 2011, Mccoy 2004, Struecker et al. 2021). This species comes from a Nearctic lineage which diversified in North America and is associated with cold and temperate waters, which suggest that current and future environmental conditions may place it close to the limits of its thermal optimum (Shaffer & McKnight 1996, Lyons et al. 2023, Orille et al. 2020). Its strong dependence on thermal conditions for metabolic and behavioral regulation make it especially relevant for experimental studies on temperature changes (García 2017, Chaparro et al. 2019, Secor & Diamond 2000). Understanding how warming affects the feeding performance of *A. dumerilii* not only addresses a significant knowledge gap in amphibian thermal ecology but also provides valuable insights for conservation planning, captive breeding, and habitat restoration strategies in freshwater ecosystems facing climate-driven thermal shifts (Blaustein et al. 2011, Soto-Rojas et al. 2017, Ramírez-López et al. 2023). Therefore we aimed to identify the optimal temperature for prey consumption and predation efficiency under controlled conditions.

Materials and methods

Study site and experimental facility

The experiment was conducted at the Aquatic Biology Laboratory, Facultad de Biología, Universidad Michoacana de San Nicolás de Hidalgo, Mexico. All procedures were authorized by the Wildlife Management Unit ("Predio o Instalación que Manejan Vida Silvestre", PIMVS; registration no. PIMVS-2018-MICH/21). Experiments were carried out in a temperature-controlled room with a 12:12 h light:dark photoperiod regulated by automatic timers.

Animal husbandry and prey culture

A total of 420 fertilized eggs of *A. dumerilii* were obtained from the PIMVS facility. Eggs were incubated at 18 °C for 16 days in 200 L geomembrane tanks with daily partial water exchanges (30–50 L). Eggs were visually inspected daily to detect potential pathogens (e.g., bacteria, fungi). Upon hatching (approximately 72 h post-incubation), 210 larvae without visible malformations or disease symptoms were selected and randomly assigned to three temperature treatments: 18 °C, 21 °C, and 25 °C. Each treatment consisted of five replicates, with five individuals per replicate (25 individuals/treatment). Replicates were maintained in 600 mL glass containers (20 × 7 × 3 cm) suspended in water baths within 80 L aquaria supported by PVC frames. Aeration was provided via evenly distributed air stones. Throughout the experiment, dissolved oxygen and pH were monitored every 24 hours using a multiparameter probe (HANNA HI9829-01042). Temperature control systems were as follows: 18 °C: RESUN Mini 200 water chiller (flow rate: 100 L h^{-1}); 21 °C: ambient room temperature controlled by air conditioning; 25 °C: AQQA GUS-AQ029 1000 W submersible heaters. Temperatures were continuously recorded using HOBO UA-002-64 real-time data loggers.

The prey species, *Artemia franciscana* Kellogg, 1906 (hereafter "prey"), was cultured independently. Commercially sourced cysts (Cystemia) were hydrated in 5 mL distilled water and 5 mL chlorine solution, stirred for 1 min, filtered through a 24 μm mesh, and rinsed in the same container. Cysts were incubated in seawater (25 g L^{-1} ma-

Table 1. Description of the recognition of behavioral events based on Lindquist & Bachmann (1980).

Event	Acronym	Description
Encounters	E	The individual detects the presence of a potential prey visually or with its snout thorough a movement of the head or body. A slight head tilt or adjustment toward the area where the prey is located is observed.
Attacks	A	A rapid movement of the head or body toward the prey, accompanied by a rapid opening of the mouth.
Captures	C	The attack is successful, and the prey is inside the individual's mouth. It is accompanied by a raping sucking or snapping movement of the jaw.
Ingestions	I	Once the prey is captured, swallowing is observed by an adjusting movement of the head and body.
Rejections/ Escapes	R/E	After contact with the prey, the attack is unsuccessful, as the prey escapes after being momentarily trapped. It results as the Ambystoma opens its snout posterior to the capture

rine salt) with constant aeration in vertical containers. After 48 h, newly hatched nauplii were harvested to be used in the experiment and transferred to geomembrane tanks with salinity adjusted to 36–40 mg L^{-1}. Nauplii were fed with baker's yeast (0.2 g L^{-1}) twice weekly and maintained at 25–26 °C until use in experiments. Newly hatched artemia nauplii were used as standardized prey due to their uniform size among individuals, their synchronous hatching, and the ease of density control. Even when at this stage of life the prey selection and handling in *A. dumerilii* depends more on the mouth size than on the taxonomic identity of the prey (Werner & Gilliam 1984), the use of artemia allowed a reduction in the experimental effect associated with heterogeneous size and morphological characteristics of the prey.

Behavioral trials

Behavioral observations were conducted weekly for 10 weeks. Before each trial, salamanders were fasted for 45 min. A single individual was isolated in a Petri dish containing 5 mL of water from its treatment tank and placed in the same thermal system to maintain temperature conditions. After a 5 min acclimation period, a predetermined number of nauplii were introduced. During the first three weeks, 25 nauplii were provided per salamander; from week four onward, this was increased to 50 nauplii (mean prey length: 6500 ± 2654 µm) due to complete consumption in earlier trials. Prey were counted under a stereomicroscope (Swift Microscope world, Carlsbad, USA) before introduction.

Data collection and statistical analysis

Predatory behavior was recorded using three vertically mounted digital cameras (Hayve USB Digital Microscope 1600X, Fremont, USA) positioned 15 cm from the Petri dish. Each trial lasted 25 min, and events were considered following Lindquist & Bachmann (1980): Encounters (E), attacks (A); captures (C), ingestions (I), rejections/escapes (R/E; see Table 1 describing the recognition of events). At the end of each trial, remaining prey were removed, and salamanders were photographed alongside a micrometric ruler for morphometric measurements. Total length (TL) and snout length (SL) were determined using IMAGEJ v1.46r (Schneider et al. 2012)

To assess the stability of each treatment, a one-way analysis of variance (ANOVA) was used to evaluate differences among oxygen, pH and temperature treatments. Prior to ANOVA, data were tested for normality using the Shapiro–Wilk test and for homoscedasticity using Bartlett's test (significance level: $p \leq 0.05$). If temperature data violated assumptions of normality or homoscedasticity, a non-parametric ANOVA was applied, followed by pairwise comparisons (Tukey–Kramer HSD or Wilcoxon rank-sum test). The relationship between *A. dumerilii* growth and prey consumption across the three temperature treatments was examined using nested generalized linear models (GLMs) with a Poisson distribution and log link function, with treatment included as a grouping factor. Additionally, GLMs (Poisson distribution, log link) were applied to detect significant differences in the number of behavioral events recorded. In cases where significant effects were detected, pairwise post-hoc comparisons were conducted by treatment. Predation success was evaluated using the ratios of: Attacks/Encounters, Captures/Attacks, Ingestions/Attacks, Escapes/Captures. Since these ratios are proportions, GLMs with a binomial distribution were applied, weighting the independent event in each case (e.g., for Attacks/Encounters, weighting was based on the number of encounters).

All analyses were conducted in R v. 4.4.2 (R Core Team 2022) using the emmeans (Lenth 2023) and ggplot2 (Wickham 2016) packages for statistical modeling and graphical representation.

Results

Physicochemical variables (Oxygen and pH) deviated from normality ($P > 0.05$) in all cases, and non-parametric analyses (Kruskal-Wallis) indicated no significant differences among treatments (Table 2.). Therefore, both variables were excluded as potential sources of variation in the

Table 2. Results of normality, homoscedasticity and treatment paired comparisons for dissolved oxygen, pH and temperature for the three experimental treatments (18, 21 and 25 °C).

Variable	Shapiro-wilk	Homoscedasticity	Statistics (df =2)	Mean (mg/L) ± SD for treatment
Oxygen	W = 0.85 P < 0.001	P < 0.001	P= 0.54	18 °C: 5.5 ± 0.49 21 °C: 5.56 ± 0.51 25 °C: 5.51 ± 0.40
pH	W = 0.95 P < 0.001	P = 0.08	P = 0.86	18 °C: 8.96 ± 0.68 21 °C: 9.03 ± 0.58 25 °C: 8.99 ± 0.62
Temperature	18 °C: W = 0.92; P < 0.01 21 °C: W = 0.96; P < 0.01 25 °C: W = 0.81; P < 0.01	P < 0.001	χ^2 = 1468.4 P < 0.001 Paired comparisons P < 0.001	

experimental design. Temperature differed significantly among treatments (Kruskal–Wallis test, P < 0.001), with post-hoc comparisons confirming significant pairwise differences between all groups (Bonferroni-corrected Wilcoxon tests, P < 0.001).

Larval total length increased through the experimental period. At week 1, mean TL was 12.8 ± 2.2 mm at 18 °C, 13.4 ± 2 mm at 21 °C, and 11.94 ± 1.1 mm at 25 °C (n = 5 per treatment). By week 10, mean TL reached 22.7 ± 1.9 mm at 18 °C, 22.1 ± 1.7 mm at 21 °C, and 22.8 ± 0.4 mm at 25 °C.

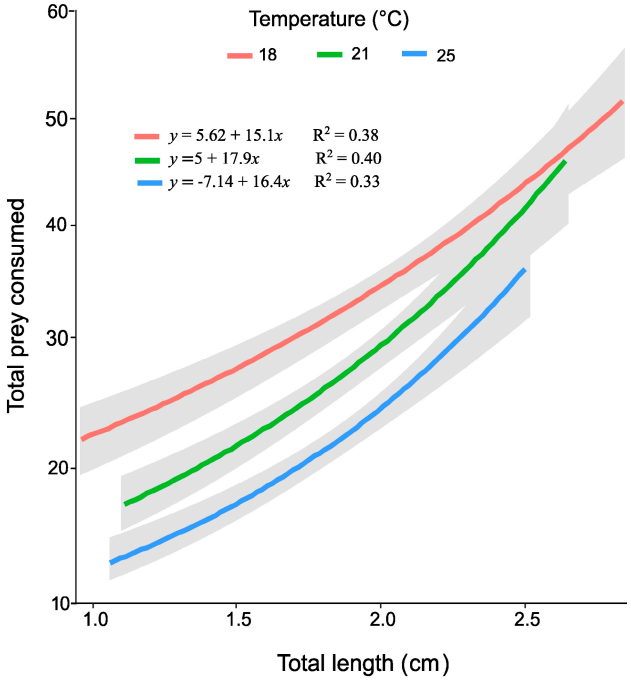

Figure 1. Total length and total prey consumed relationship of *A. dumerilii* for the three temperature treatments. The regression models are represented in colors. Shaded area represents 95% Confidence Interval (CI) of the model.

Total length of *A. dumerilii* was positively correlated with prey consumption, and the slope of this relationship differed significantly among treatments (AIC = 1363.5, P < 0.001). The highest prey consumption was recorded at 18 °C, followed by 21 °C, with the lowest predator size–prey–consumed relationship at 25 °C (Fig. 1). Overall, the number of recorded events increased significantly from the third week of larval development. From week six onward, no significant differences were detected among treatments for most behavioral events, and no prey escapes were observed. Specifically, individuals at 25 °C exhibited significantly a lower number of events (e.g., attacks, encounters) compared to those at 18 °C and 21 °C (P < 0.001). Conversely, the highest number of events occurred at 18 °C, significantly exceeding both 21 °C and 25 °C (P < 0.001) (Fig. 2).

Event ratios revealed that Escapes per Capture (E/C) declined with age across all treatments, with the steepest decrease at 18 °C and 25 °C (P = 0.39). Capture per Attack (C/A) ratios increased with age, with the highest rate of increase at 18 °C, significantly greater than at 21 °C (P < 0.001), which in turn was significantly higher than at 25 °C (P < 0.001) (Fig. 3). Ingestion per Capture (I/C) ratios showed no significant differences among treatments (P = 0.25) and were consistently close to 1. Similarly, Escape per Capture (E/C) ratios were near 0 and did not differ significantly among treatments (P = 0.22).

We must highlight that survival differed among the three treatments over the experiment. At 18 °C, larval survival was 70%, whereas both at 21 °C and 25 °C survival was 60%. The mortality rates suggest that cooler conditions may favor early survival in *A. dumerilii* and may have a relation to the vulnerability of this species to future warming scenarios.

Discussion

Our study evaluated changes in predation rates at three different temperatures using larval *Ambystoma dumerilii* as a model. In aquatic vertebrates, prey handling during early

life stages (larval and juvenile) plays a critical role in determining the ability to efficiently acquire and utilize prey (Yaniv et al. 2014). This stage is considered critical as it directly influences the processes of growth, development, and survival (Chaparro et al. 2011). Environmental factors strongly influence the modification and efficiency of foraging strategies, making it essential to understand how aquatic species respond to these changes behaviorally. Such knowledge can help predict medium- and long-term persistence in ecosystems (Laws et al. 2007, Archibald et al. 2022). Our results showed a positive relationship between predator age and the number of prey consumed across all treatments. However, the 18 °C treatment showed the highest prey consumption by the end of the experiment. This response suggests both learning effects and functional physiological development associated with the age where the emergence and growth of limbs in this amphibian species is present (Jara et al. 2012, Leff et al., 2011). Previous studies on amphibian larvae have shown that environmental temperature modulates the development of foraging-related appendages, such as limbs and tail, improving locomotion and enhancing predatory efficiency (e.g. Zhu et al. 2023, Arrighi et al. 2013). In particular, the study of Schreckenberg & Jacbson (1975) demonstrated that in *Ambystoma mexicanum,* correct limb development is well defined when the individuals are maintained at 18 °C, which highlights the relationship between temperature, growth and performance. At lower temperatures, limb development tends to progress in a more effective way, this allowing individuals to archive more precise attacks in a shorter time, which in turn, enhances predation efficiency (Leff et al. 2011). Higher predation rates were presented at 18 °C, suggesting that at this temperature *A. dumerilii* exhibited an increased predatory efficiency (with no prey escapes or predator rejections), this efficiency becoming evident and increased after the sixth week, which was in accordance with limb emergence, improving of motor control, and higher capture efficiency in *Ambystoma* larvae (Leff & Bachmann 2011). Assessing predation efficiency provides insights into the balance between energy expenditure and energy gain, which directly influences growth, development, and long-term survival (Lima & Dill 1990).

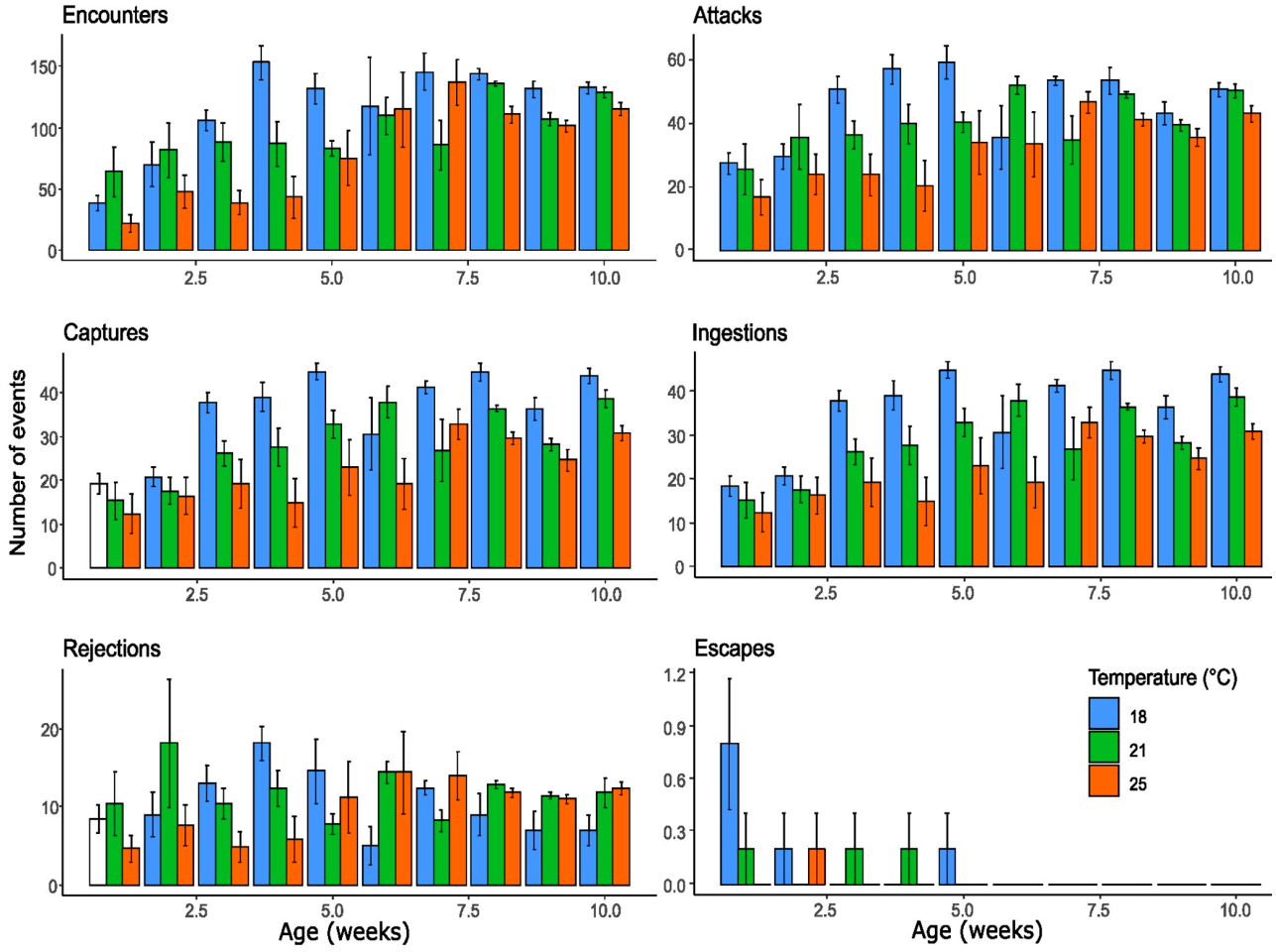

Figure 2. Number of events considered in the prey behavior of larval *A. dumerilii* during the first ten weeks of life. Bars represent the mean value of each event, and vertical lines in the upper section of each bar represent standard deviation.

This concept is one of the paradigms in the optimal foraging theory, which predicts that organisms maximize the energy cost-benefit ratio. In *A. dumerilii*, predation efficiency was lower at higher temperatures (e.g, 25 °C) than at lower temperatures (18 °C) suggesting that this response was influenced by motor discoordination and increased fatigue under less favorable thermal conditions (Bennett 1990). The reduction in feeding performance can lower survival rates as the larvae become more vulnerable to physiological stress. Warming has been shown to damage locomotor performance as it increases metabolic demands and alters muscle contractile efficiency, which may generate an effect on its fitness and survival (Li et al. 2025). Experimental evidence in larvae of other amphibian species demonstrate that warming during this life stage decreases swimming performance and survival (Niu et al. 2024). In the context of Lake Patzcuaro, the projected warming trends may elevate the mortality rate in *A. dumerilii* larvae by compromising the effectiveness of predatory performance, which acts as a factor for growth and population persistence. Larval total length increased significantly during the first ten weeks of life related to prey consumption and predation efficiency. This pattern is consistent with feeding behavior reported for species of the genus, where somatic growth enhances locomotor coordination. Growth dynamics represent a mechanistic component linking temperature, developmental performance and survival probability (Leff & Bachman 2011).

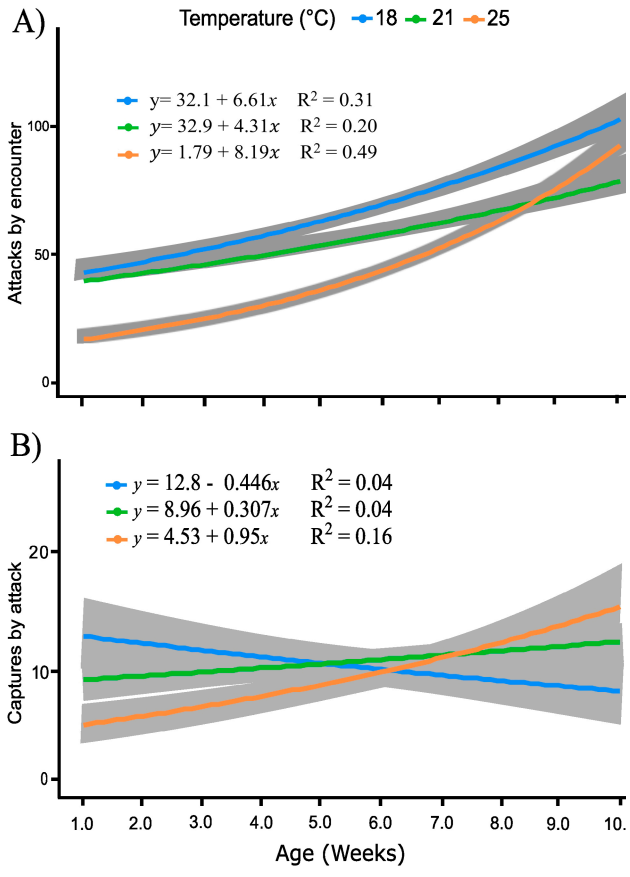

Figure 3. Predatory success ratios considering behavioral events in *A. dumerilii* during the first ten weeks of life. The regression models are represented in colors. (A) Attacks by encounter; (B) captures by attack. Shaded area represents 95% Confidence Interval (CI) of the model. Only statistically significant ratios are shown (non-significant ratios were consistently close to 1).

Artemia franciscana was selected as an experimental prey for experimental and handling reasons, but also for potential ecological functions and morphometric similarities (e.g. size) reported for several zooplanktonic crustaceans inhabiting Lake Pátzcuaro such as *Daphnia pulex* (size: 1.0–3.0 mm), *Mastigodiaptomus montezumae* (size: 1.0–2.0 mm) and *Ceriodaphnia dubia* (0.5–1.5 mm), the size of *A. franciscana* in culture conditions ranging 0.4–2.0 mm (Cervantes et al. 2023, CONABIO 2015, Gómez et al. 2016). We must highlight that *A. franciscana* does not occur naturally in Lake Pátzcuaro, but the morphometric similarities with natural prey supports functional comparability in terms of prey detectability, handling and ingestion capacity. Even when the present study is unable to extrapolate absolute consumption rates in the wild, our results based on the evaluation of the relative changes in predation performance across different temperatures under controlled experimental conditions can be used to elucidate the predator behavioral responses on prey in the wild in a climate change scenario.

Environmental factors alter both physiological and behavioral responses in predators, directly affecting predation efficiency (Wong & Candolin 2014). In our study, *A. dumerilii* showed a positive relationship between mouth size and the number of prey consumed. Although prey type and size were kept constant, this pattern is consistent with the morphological limitations documented in other species of the genus *Ambystoma*, where gape size limits the capacity to successfully ingest larger and more diverse prey (Secor & Diamond 2000, Smith & Petranka 1987). At 18 °C, larvae exhibited more direct attacks and had a higher predation success. On the other hand, at 25 °C, less precise strikes and more failed attacks were observed. These behavioral patterns suggest that better thermal conditions are linked to optimal development and effective motor coordination in relation to higher rates of successful predation events. At 25 °C, reduced efficiency was likely linked to thermal stress and impaired prey-handling capacity. The above mentioned is highly related to the temperatures present in the Lake Pátzcuaro, which are reported in a range of 14 °C to 26 °C in the more northern and deeper area in the lake (Córdova-Tapia et al. 2015, Chacón-Torres, 1993, Buschoff et al. 2004, Villela et al., 2012). Predation efficiency, defined as the proportion of successful captures relative to the number of attacks, was significantly lower at 25 °C than in the control treatment (18 °C). While encounter rates did not differ substantially among temperature treatments, individuals that grew on a higher temperature had fewer attacks and lower capture success, suggesting that warmer temperatures reduce the motivation to attack and/

or the capacity to have strikes be more effective (Bennet 1990, Birdie et al. 2017). Similar effects have been documented in other salamander species, where muscle contraction rates decrease, and attack latency increases under warm conditions. For example, Anderson & Devan (2014) reported that in *Eurycea* spp, muscle movements are essential for predation slow and reaction times lengthen with rising temperatures. In *A. dumerilii*, this thermal condition (25 °C) reduced the number of successful captures, suggesting that predatory performance is not static along time but varies according to ontogenetic development and thermal conditions. It is important to notice that this reduction may not be only related to worse locomotive coordination but also to a longer reaction time or propensity to initiate attacks under thermal stress (Grigaltchik et al 2012, Islam et al 2020, Sentis 2022)

The present study was conducted under controlled conditions where results can give information on how *A. dumerilii* responses in the natural environment (e.g. Lake Pátzcuaro) as predators. However, we should notice that *in situ*, predator-prey interactions are influenced by multiple additive and/or synergetic factors, such as prey availability, intra- and interspecific competition (of prey and predators), and habitat structural complexity (Tilman 1980, Froneman & Cuthbert 2022, Orrick et al 2024, Wasserman et al 2024). Nevertheless, our results provide valuable evidence on the effects of temperature during early developmental stages, which can be contextualized within the ecological and environmental dynamics of Lake Pátzcuaro to better understand the potential impacts of climate change on this endemic species. Overall, our findings suggested that lower temperatures (18 °C) enhanced predation efficiency in *A. dumerilii*, likely due to optimal physiological performance within a favorable thermal range. These results provide key elements for conservation and management planning, both in situ and ex situ, to safeguard *A. dumerilii* populations under changing environmental conditions.

The behavioral observations we reported were not an evidence of prey preference or functional response. We demonstrated temperature-dependence variation in predation performance under standardized conditions, representing behavioral components that influence but do not define predator functional responses (Chesson 1983, Holling 1959). Natural zooplankton availability in Lake Pátzcuaro is responsive to temporal and spatial variation. Microcrustacean assemblages fluctuate in response to changes in temperature, eutrophication process and anthropogenic pressures among other factors (Moss et al. 2011, Meerhoff et al. 2007). This promotes reduction in prey density, which alters predator energetic balance by increasing search time and reducing encounter rates and net energy intake. For *A. dumerlii*, prey availability is a factor that can interact with thermal stress. Our results showed that *A. dumerilii* presents higher predation efficiency at temperatures of 18 °C; however, if microcrustacean densities decline in the wild due to warming or nutrient-driven trophic imbalances, the benefits of optimal thermal performance may not translate into improved growth or survival in natural environments. On the contrary, at higher temperatures (e.g., 25 °C) predation efficiency was reduced, which may be translated into energetic constraints and potentially increase in mortality risk. Future research integrating prey density with thermal treatment can assess functional responses in situ, which may provide approximations of changes in trophic dynamics and population persistence of this species in the wild in climate change scenarios.

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