



Appendix N | Literature Review—List of Relevant Articles and Reports Completed Since the 2021 Annual Report

Covered Species Literature

- **Edwards, Christa R., and Timothy H. Bonner. 2022. Vegetation Associations of the Endangered Fountain Darter *Etheostoma fonticola*. *Endangered Species Research* 47:1–13.**

The purpose of this study was to quantify fountain darter occurrences and abundances among vegetated habitats using the concept of obligate and facultative habitat use. The study found that fountain darters were often associated with aquatic vegetation but demonstrated both obligate and facultative tendencies. Fountain darters occurred in vegetation more than expected among wadeable and non-wadeable habitat in the majority of reaches within the San Marcos and Comal rivers. Fountain darters were positively associated with bryophytes and negatively associated with Texas wild-rice.

- **Crow, Justin. 2022. Caudata—Salamanders. *Herpetological Review* 53(3):435–436.**

*This note concerns the reproductive phenology of Texas blind salamander (*Eurycea rathbuni*). The researcher analyzed 7 years of continuous oviposition data (2008–2014) to determine if seasonal trends in reproduction occurred. More oviposition events occurred during winter and spring with an increase in mean egg production and mean oviposition events by a factor of two over summer.*

- **Delcid-Morales, Evelyn E., Diana E. Wiebe, Ruben Tovar, David M. Hillis, and Dana M. Garcia. 2022. Expression of Rhodopsin and Opsin in Late-Stage Epigeal and Hypogean Salamander Embryos. *The Journal of the Federation of American Societies for Experimental Biology* 36(S1).**

*Researchers identified retinal rod and cone photoreceptor cells along with their associated visual proteins in one subterranean blind species of salamander (*Eurycea rathbuni*) and in two surface-dwelling salamanders (*Eurycea nana* and *Eurycea sosorum*) with fully developed eyes. Results show that opsin is expressed in the retina of *E. nana* and *E. sosorum*, and rhodopsin is expressed in all three species. The authors conclude that expression of rhodopsin is transient or variable in Texas blind salamanders.*

- **Kosnicki, Ely. 2022. Fecundity of First-Generation Captively Reared *Heterelmis comalensis* (Coleoptera: Elmidae). *Journal of Insect Science* 22(3):1–3.**

This article addresses captive larval production of the Comal Springs riffle beetle. The author constructed chambers made from PVC to house one male and one female Comal Springs riffle beetle in each and monitored larval production monthly until the female in each chamber died. Females were found to be iteroparous and produced 29.3 ± 37.1 larvae. The number of larvae produced was found to be a function of female longevity rather than size.

- **Moon, Linda, Matthew Butler, and Lindsay Glass Campbell. 2022. Evaluation of Tagging Methods for Unique Identification of Individuals in Three Aquatic *Eurycea* Salamander Species. *Ichthyology & Herpetology* 110(1):77–86.**

This article looked at three different tagging methods for Texas blind, San Marcos, and Comal Springs salamanders to determine success of each as a long-term marker of individual animals. The tagging methods assessed were visible implant elastomer (VIE), visible implant alphanumeric tags (VIA), and passive integrated transponder (PIT) tags. VIE tags were retained by all species and had high readability

scores. VIA tags were rejected in all but one San Marcos salamander and all Comal Springs salamanders, but 90 percent of Texas blind salamanders retained them. PIT tags were not tested on San Marcos, Comal Springs, and smaller Texas blind salamanders due to size of tag and low retention rate in larger salamanders. VIE was the most effective method in terms of retention, readability, and ease of insertion.

Conservation Biology Relevant Literature

- **Adcock, Zachary C., Andrew R. MacLaren, Ryan M. Jones, Andrea Villamizar-Gomez, Ashley E. Wall, Kemble White IV, and Michael R.J. Forstner. 2022. Predicting Surface Abundance of Federally Threatened Jollyville Plateau Salamanders (*Eurycea tonkawae*) to Inform Management Activities at a Highly Modified Urban Spring. *PeerJ* 10:e13359. <https://doi.org/10.7717/peerj.13359>.**

*Using generalized linear models, researchers modeled the occurrence of Jollyville Plateau salamanders (*Eurycea tonkawae*) within the surface habitat of Brushy Creek Spring (Williamson County, Texas). The authors intend for their results to inform when maintenance should occur (i.e., during environmental conditions when salamanders are less likely to be observed in surface habitat).*

- **Bryant, Amanda R., Caitlin R. Gabor, Leah K. Swartz, Ryan Wagner, Madaline M. Cochrane, and Winsor H. Lowe. 2022. Differences in Corticosterone Release Rates of Larval Spring Salamanders (*Gyrinophilus porphyriticus*) in Response to Native Fish Presence. *Biology* 11(4):484.**

Researchers measured glucocorticoids at baseline and in response to a novel stressor in free-living salamanders that either live with or without fish predators naturally. They found that salamanders living with fish predators had lower measures of glucocorticoids than those without fish predators. The study indicates that predator presence alters glucocorticoid regulation, which may allow species to better cope with native and introduced predators.

- **Browne, Robert K., Svetlana A. Kaurova, Karthikeyan Vasudevan, Dale McGinnity, Govindappa Venu, Manuel Gonzales, Victor K. Utesheve, and Ruth Marcec-Greaves. 2022. Reproduction Technologies for the Sustainable Management of Caudata (Salamander) and Gymnophiona (Caecilian) Biodiversity. *Reproduction, Fertility, and Development* 34(6):479–497.**

This article reviews the use of reproduction technologies to support the sustainable management of threatened salamander and caecilian biodiversity in conservation breeding programs or through biobanking. Technologies include (1) exogenous hormonal induction of spermatozoa, eggs, or mating, (2) in vitro fertilization, (3) intracytoplasmic sperm injection (ICSI), (4) the refrigerated storage of spermatozoa, (5) the cryopreservation of sperm, cells, or tissues, (6) cloning, and (7) gonadal tissue or cell transplantation into living amphibians to eventually produce gametes and then individuals. Exogenous hormone regimens have been applied to 25 species of Caudata; in vitro fertilization was successful in 8 Caudata species, and spermatozoa have been cryopreserved in 7 Caudata species.

- **Fujiwara, J., K. Maeto, and M. Yoshima. 2022. Effect of Environmental Factors on the Abundance of Riffle Beetles (Coleoptera: Elmidae) and Co-Inhabiting Aquatic Insects with a Reach Scale, in Japan. *Journal of Insect Conservation* 26:893–906.**

In this article, researchers evaluated the effects of substrate size structure, water depth, current velocity, and distance from terrestrial areas for adult and larval abundance of three common riffle beetles. In summer (August), the three elmid species tended to be more abundant in the shallow quadrats of coarse-grained substrates, and substrate preference differed among species and stages. Current velocity and proximity to the terrestrial area were not significant for Stenelmis nipponica and Zaitzevia brevis, whereas adult Zaitzevia awana preferred faster-flowing currents and needed to the distance from the terrestrial areas. In winter (December), only the substrate size structure affected the abundance of adult elmid beetles. Although elmid beetles require highly sensitive habitats, they are easily surveyed and are therefore convenient indicators of riverbed environments.

- **Gladstone, Nicholas S., Matthew L. Niemiller, Benjamin Hutchins, Benjamin Schwartz, Alexander Czaja, Michael E. Slay, and Nathan V. Whelan. 2022. Subterranean Freshwater Gastropod Biodiversity and Conservation in the United States and Mexico. *Conservation Biology* 36(1):e13722. <https://doi.org/10.1111/cobi.13722>.**

This article describes the biology, diversity, and conservation status of subterranean gastropods (stygosnails) in the United States and Mexico, including within the Edwards Aquifer region. Formal conservation status assessments evaluating threats were conducted for stygosnails in the Edwards Aquifer.

- **Hay, Allison, Christopher L. Riggins, Thomas Heard, Collin Garoutte, Yeyetzi Rodriquez, Francesca Fillipone, Kristy K. Smith, Nick Menchaca, Janaye Williamson, and Joshua S. Perkin. 2022. Movement and mortality of invasive suckermouth armored catfish during a spearfishing control experiment. *Biological Invasions* 24:3119-3131. <https://doi.org/10.1007/s10530-022-02834-2>.**

In this study, researchers used PIT tags to follow the movements and fates of non-native suckermouth armored catfish (family Loricariidae) in the upper San Marcos River to assess the efficacy of a community-based spearfishing bounty hunt for population control of the species. Weekly probability of suckermouth armored catfish survival was negatively correlated with the number of fish removed, while probability of the species being speared and reported was positively correlated with the number of fish removed. Majority of suckermouth armored catfish used <25 m² of river over a nine-week tracking period, but the area of river fish used correlated positively with the number of relocations. These findings collectively suggest local-scale suppression of the suckermouth armored catfish population is possible through community engagement in spearfishing, but over longer time periods immigration might offset some of the removal success.

- **Jaruboonyakorn, Phonawin, Thanawan Tejangkura, and Thapana Chontanarth. 2022. Multiplex PCR Development for the Simultaneous and Rapid Detection of Two Pathogenic**

Flukes, *Dactulogyrus* spp. and *Centrocestus formosanus*, in Ornamental Fishes. *Aquaculture* 548.

*This study developed a novel PCR assay, the multiplex polymerase chain reaction (m-PCR) assay, which can detect and amplify the gDNA of *Centrocestus formosanus*—a non-native parasite of the fountain darter—at almost all stages. The assay allows the rapid identification and diagnosis of *Dactulogyrus* spp. and *C. formosanus* simultaneously on target genes in field-collected samples under one reaction. The results demonstrate that the multiplex PCR assay can be used to detect *Dactulogyrus* spp. and *C. formosanus* specifically, without cross-amplification with other parasite-related species and their hosts.*

- **Jihad, Hiba Mohammad, and Zainab A. Makawi. 2022. Review of the Freshwater Snail *Melanoides tuberculata* (O.F. Muller, 1774) (Gastropoda, Thiaridae). *GSC Biological and Pharmaceutical Sciences* 20(1):336–339. <https://doi.org/10.30574/gscbps.2022.20.1.0303>.**

*This review article summarizes existing literature on *Melanoides tuberculata* to highlight the most important aspects of its ecology, reproduction, and impacts. *M. tuberculata* has been reported as a vector and intermediate host for parasitic trematodes. They may also displace local gastropods.*

- **Johnson, Haley M. 2022. Macro and Micro Litter Accumulation in the San Marcos River, San Marcos, Texas, USA. Directed research project completed as part of requirements for Master of Science in Geography. Texas State University.**

This study investigated litter accumulation in the first 8 kilometers of the main stem of the San Marcos River, with a specific focus on the history of the problem and community efforts to clean up the river. Results show that the majority of litter found in all three survey locations are microplastics and plastic of various types.

- **Len Verrett, Christopher. 2022. Going with the Flow: Does Recreational Activity in the San Marcos River Lead to Nutrient Changes? Directed research project completed as part of requirements for graduation in the Honors College Spring 2022. Texas State University.**

In this directed research study, the author assessed correlation between number of people on the San Marcos River and changes in water quality (nitrates, phosphates, and ammonium) and turbidity. Turbidity increased as total recreational activity increased. Correlations between recreational activity and total ammonium, nitrates, and phosphates were not supported by the data.

- **Makherana, Fhatuwani, Ross N. Cuthbert, Cristian J. Monaco, Farai Dondofema, Ryan J. Wasserman, Glencia M. Chauke, Linton F. Munyai, and Tatenda Dalu. 2022. Informing Spread Predictions of Two Alien Snails Using Movement Traits. *Science of the Total Environment* 811.**

*This study quantified in-field densities and compared movement traits between *Tarebia granifera* and *Physa acuta*. *T. granifera* exhibited a significantly greater velocity and covered a significantly larger net distance than *P. acuta*. The study suggests a more rapid capacity to self-disperse in *T. granifera*, which could facilitate spread within and between aquatic systems.*

- **McCready Wright, Kirby L. 2022. Spatial Variation in Macroinvertebrates in Groundwater-Dominated Rivers: Is Community Composition Explained by Discrete or Continuous Riverine Models? December. Directed research project completed as part of requirements for Master of Science in Aquatic Resources. Texas State University.**

This thesis examined benthic macroinvertebrate community composition and biomass among riffles, runs, and pools, and along an upstream to downstream gradient in the Comal and San Marcos rivers. Taxonomic diversity did not vary with distance from springhead but was consistently lower in pool mesohabitats when compared to runs and riffles in both rivers.

- **Minnig, Brittany. 2022. North American Beaver, *Castor canadensis*, and River Otter, *Lontra canadensis*, Distributions within Texas with a Focus on Habitat Use in the San Marcos River, Texas. May. Directed research project completed as part of requirements for Master of Applied Geography. Texas State University.**

*This study provided a status report on distribution of *Castor canadensis* and *Lontra canadensis* in Texas and includes a case study of the San Marcos River where both species have recently reoccupied and are integrating into the urban river setting. Evidence of beavers and otters was observed in the upper San Marcos River (between Spring Lake and IH-35), at JCK Amphitheater on the Texas State University campus, and in Spring Lake.*

- **Post, Jason M., Rachael J. Reasch, and Emily S. Bailey. 2022. Detection of Trematodes from the Host Exotic Aquatic Snail *Melanoides tuberculata* in an Urban Stormwater System. *Zoonotic Diseases* 2:258–266.**

*In this article, researchers collected snails from an urban stream in Los Angeles that drains into a fragile, protected wetland. They used molecular analysis to detect and identify exotic species of trematodes that use *M. tuberculata* as a host. The study documents novel occurrences of trematode species in North America.*

- **Potter, Patrice, Hsien-Yung Lin, Rachel R. Y. Oh, Pietro Pollo, A. Nayelli Rivera-Villanueva, Jose O. Valdebenito, Yefeng Yang, Tatsuya Amano, Samantha Burke, Szymon M. Drobniak, and Shinichi Nakagawa. 2022. A Comprehensive Database of Amphibian Heat Tolerance. *Scientific Data* 9. <https://doi.org/10.1038/s41597-022-01704-9>.**

The authors of this article produced a comprehensive dataset on amphibian upper thermal limits. The database is a useful tool to evaluate the vulnerability of amphibians, and ectotherms more generally, to changing temperatures. San Marcos salamander is one of the species addressed in this article.

- **Ribas, Maria P., Paula Alonso-Almorox, Johan Espunyes, Albert Martinez-Silvestre, and Oscar Cabezón. 2022. Evaluation of Passive Integrated Transponder Tags for Marking Urodeles. *Ecological Indicators* 145. <https://doi.org/10.1016/j.ecolind.2022.109690>.**

In this study, researchers analyzed existing literature on the use of PIT tags in salamanders (Urodeles) to determine whether species characteristics and PIT tagging methods influence PIT tag rejection across studies and experimentally assessed the adequacy of subcutaneous PIT tags without anesthesia

on European urodele species. The majority of studies assessed presented incomplete information on factors that could influence the probability of PIT tag rejection as well as impact individual welfare. The subcutaneous PIT tagging method proved reliable in *Salamandra salamandra* and *Pleurodeles waltl*, whereas it did not seem a suitable technique for *Calotriton asper*.

- **Stehle, Matthew. 2022. Seasonal Influence of Light Availability on Metabolism in an Urban, Spring-Fed River. December. Directed research project completed as part of requirements for Master of Science in Aquatic Resources. Texas State University.**

This study examined the effects of seasonal light availability on both gross primary production (GPP) and ecosystem respiration (ER), macrophyte community dynamics, and autotrophic metabolism in the San Marcos River. The author found that GPP and ER in the upper San Marcos River were strongly correlated with seasonal light availability, indicating autotrophic respiration as a substantial portion of ER. Additionally, it was observed that reach-scale macrophyte coverage and biovolume are largely controlled by recreational activity and not seasonal light availability.

- **Thiels, Sabrina E., Christa R. Edwards, and Timothy H. Bonner. 2022. Assessing Effects of Impounded Water on Life History, Reproduction, and Diets of a Fluvial Specialist Fish. *The American Midland Naturalist* 187(2):225–242.**

*This article assessed the effects of impounded water on fluvial specialist greenthroat darter (*Etheostoma lepidum*) by quantifying differences in life history, reproduction, and stomach contents between a population taken from a lake environment and a river environment. Differences in reproduction were not detected between populations. Darters taken from the lake site exhibited lower condition factors, corresponding to a greater number of parasites for the lake population.*

- **Tolley-Jordan, Lori R., Michael A. Chadwick, and Jimmy K. Triplett. 2022. New Records of Digenetic Trematodes Infecting *Melanoides tuberculata* (O.F. Muller, 1774) in Florida, USA. *Bioinvasions Records* 11(1):149–164.**

*In this study, researchers collected live *M. tuberculata* snails from sites in Florida. Individuals from six sites were infected with trematodes. The study documents infection of *M. tuberculata* by *C. formosanus* and the first record of infection by *Haplorchis pumilio* in Florida. *M. tuberculata* is established in the San Marcos and Comal rivers. The trematodes that *M. tuberculata* hosts may cause diseases in fishes, waterfowl, or humans.*

Other Relevant Literature

- **Banaduc, Doru, Vladica Simic, Kevin Cianfaglione, Sophia Barinova, Sergey Afanasyev, Ahmet Oktener, Grant McCall, Snezana Simic, and Angela Curtean-Banaduc. 2022. Freshwater as a Sustainable Resource and Generator of Secondary Resources in the 21st Century: Stressors, Threats, Risks, Management and Protection Strategies, and Conservation Approaches. *International Journal of Environmental Research and Public Health* 19(24).**

This paper is a synthetic review of some of the threats, risks, and integrated water management elements in freshwater ecosystems. The paper provides some discussion of human needs and water conservation issues related to freshwater systems: (1) introduction and background; (2) water basics and natural cycles; (3) freshwater roles in human cultures and civilizations; (4) water as a biosphere cornerstone; (5) climate as a hydrospheric ‘game changer’ from the perspective of freshwater; (6) human-induced stressors’ effects on freshwater ecosystem changes (pollution, habitat fragmentation, etc.); (7) freshwater ecosystems’ biological resources in the context of unsustainable exploitation/overexploitation; (8) invasive species, parasites, and diseases in freshwater systems; (9) freshwater ecosystems’ vegetation; and (10) the relationship between human warfare and water. The authors conclude that only internationally integrated policies and conservation initiatives can diminish and hopefully stop the long-term deterioration of freshwater resources and their secondary resources.

- **Snyder, Grant L., R. David G. Pyne, Kevin Morrison, and Kirk Nixon. 2022. San Antonio Water System, Texas Carrizo Aquifer Storage Recovery Program. *Ground Water* 60(5):641–647.**

This article describes the Aquifer Storage Recovery (ASR) program operated by the San Antonio Water System, discussing lessons learned over 18 years of ASR implementation.

- **Tashie, Arik, Tamlin Pavelsky, and Mukesh Kumar. 2022. A Calibration-Free Groundwater Module for Improving Predictions of Low Flows. *Water Resources Research* 58, e2021WR030800.**

This article describes the novel Groundwater for Ungauged Basins (GrUB) module developed to simulate low flows in physically based land surface models (LSMs) and conceptual rainfall-runoff models. GRuB uses only widely available physically based properties, allowing its application without the need for calibration.

- **Wade, Madeline. 2022. *Blue Index San Marcos: Emotional Experiences, Values, and Use Patterns of Waterscapes in San Marcos, TX*. Directed research project completed as part of requirements for Master of Science in Geography. Texas State University.**

This article describes how the San Marcos River and its tributaries provide economic, social, and environmental benefits to the community of San Marcos, Texas and surrounding areas. The researchers used photo stations with QR codes to collect online survey data from 567 volunteer participants. Results showed that people value waterscapes for ecological benefits and felt a relationship with place, rather than solely for recreation and tourism.