Ex Situ Conservation and Recovery Efforts for the Western Striped Newt at the Jacksonville Zoo and Gardens

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Introduction

Amphibian communities are experiencing unprecedented declines throughout the world, and today, many of the planet's amphibian species are threatened with extinction (Houlahan et al., 2000; Stuart et al., 2004; Grant et al., 2016). A number of factors have been implicated in these declines, particularly emergent amphibian diseases such as chytrid fungi (*Batrachochitrium dendrobatidis* [B.d] and *B. salamandrivorans [B.sal]*) and Ranavirus, habitat destruction and degradation, and climate change (Young et al., 2001; Stuart et al., 2004; Grant et al., 2016). In light of such significant conservation challenges, there exist many opportunities for zoos and aquariums to join global efforts to study, manage and curtail these declines. Indeed, zoos and aquariums have become important leaders in amphibian conservation and have proven to be valuable assets to these efforts, particularly with regards to establishing ex situ assurance colonies of threatened species and producing captive-bred offspring for repatriation to help bolster and restore wild populations (Gascon et al., 2007; Gagliardo et al., 2008; Griffiths and Pavajeau, 2008; Reid and Zippel, 2008).

The striped newt, *Notophthalmus perstriatus*, is indigenous to Florida and Georgia, USA where it occurs predominantly in longleaf pine sandhill ecosystems (Fig. 1). Although currently recognized as a single species, two genetically- and geographically-distinct variants exist (an eastern and western clade) which are likely to be split into two distinct taxa in the future (May et al., 2011). The eastern clade ranges in Florida east of the Suwanee River and in a few localized areas on the Atlantic Coastal Plain of Georgia, whereas the western clade is distributed along the Gulf Coastal Plain of southwestern Georgia and the eastern panhandle of Florida. Although populations of both clades have been in decline over the last several decades, the western clade has experienced a mysteriously rapid decline since 1999, particularly in Florida where most

sites formerly occupied by the western striped newt are now believed to be devoid of wild populations (Means et al., 2008). The last known Florida stronghold for the species was held in the Munson Sandhills region of the Apalachicola National Forest (ANF); however, less than 10 adults have been observed there since 1998, and the population may now be extirpated (Means et al., 2012).

A Conservation Strategy for the Western Striped Newt

Given its imperiled status throughout its range, efforts are currently underway to assign legislative protections to the striped newt (e.g., it is currently listed as a "candidate species" by the USFWS; Means et al., 2008), and collaborative efforts involving NGOs, governmental agencies, and zoological parks seek to identify factors contributing to its decline as well as develop and implement sound strategies for its conservation and recovery. In 2010, a long-term, multifaceted study was initiated by the Coastal Plains Institute (CPI) and colleagues to investigate causes for the species' decline and suspected extirpation from the Apalachicola National Forest, conduct repatriations with larval newts in prime wetland habitats, and investigate and implement precautionary measures to ensure the success of repatriated individuals (Means et al., 2009).

Seeking assistance from AZA-accredited zoological parks that could establish and sustain captive assurance colonies of the western striped newt, produce captive-bred offspring for repatriation, and investigate aspects of their biology and husbandry, the Jacksonville Zoo and Gardens (JZG) joined the project in 2012, aligning with the Memphis Zoo as ex situ collaborators. Captive-bred offspring produced at the Memphis Zoo and JZG each year are released into selected wetland sites within the ANF, where they are then monitored for survivorship, migration, recruitment and mortality by the Coastal Plains Institute and collaborators. Given JZG's proximity to the ANF, the zoo's herpetology department staff regularly assists with releases and other related field activities (Fig. 2.). More recently, two additional zoos in Florida have joined the project and currently maintain captive colonies of western striped newts with the goal of producing further captive-bred offspring for repatriation.

Ex situ Management

At the Jacksonville Zoo and Gardens, western striped newts are kept separately from the zoo's main herpetological collection in a biosecure laboratory located at its Amphibian Conservation Center to prevent potential exposure of the newts to amphibian pathogens that could then inadvertently be introduced into natural wetlands with repatriated individuals. The laboratory is on full display through large viewing windows, allowing visitors to observe and learn about the project and the ex situ work that is being carried out at the zoo on a daily basis (Fig. 3). Inside the laboratory are a series of metal shelving racks supporting large polycarbonate tanks and their respective filtration systems; several of these tanks have been used to house adult breeding pairs of newts, while others have been used for rearing and head-starting offspring intended for release (for additional husbandry information, see Means et al., 2014, 2015, 2016).

Reproduction typically begins in late fall and early winter and continues into spring, with eggs usually produced between January and May. Once the eggs hatch after about a week, the free-living larvae are grouped and housed together based on their body sizes until their release. Originally, offspring were only repatriated shortly after hatching, but in recent years some of the offspring have been held back for several months of head-starting and are often approaching sexual maturity or have already begun producing eggs at the time of their release. It is hoped that releasing larger sub-adult and young adult individuals will yield better results in terms of survivorship and recruitment in the wild.

Since 2013, more than 1,400 captive-bred newts including both larvae and adults have been repatriated back into the Apalachicola National Forest, with nearly 1,200 of these individuals contributed by JZG (Figs. 4-7). Continued monitoring and periodic surveying for repatriated individuals at recipient wetlands in the ANF by the Coastal Plains Institute have documented and confirmed successful reproduction by repatriated individuals, as well as the migration and return of released individuals to breeding ponds in subsequent seasons (Means et al., 2016). Despite these successes, repatriation efforts would be greatly enhanced by the release of many additional individuals, as this would increase the chances of some repatriated individuals surviving and reproducing, and also allow for additional wetland sites within the ANF to be seeded with repatriated individuals.

A ubiquitous problem for many zoos and aquariums (i.e., Mendyk, 2014), space has proven to be a limiting factor affecting the total number of newt offspring that are produced and available for repatriation each year. In particular, limited housing facilities for larval newts at JZG have led to greater stocking densities of offspring in rearing tanks. Larval newts are voracious and indiscriminate feeders; at higher densities they can become cannibalistic, ultimately affecting survivorship and

Fig. 1. (opposite page) An adult striped newt returning to a breeding pond. Photo by: Ryan Means.
Fig. 2. (below) Jacksonville Zoo and Gardens (JZG) herpetology staff in the field assisting with newt releases. *Photo by: JJ Vitale.*

Fig. 3. Striped newt conservation breeding laboratory at JZG. *Photo by: Robert W. Mendyk.*

Fig. 4. Dozens of captive-bred striped newts awaiting release. *Photo by: Robert W. Mendyk.*

Fig. 5. JZG herpetology staff releasing captive-bred striped newts back into the wild. *Photo by: Robert W. Mendyk.*

the total number of offspring available for release. Rearing larvae in smaller groups would inevitably reduce instances of cannibalism and improve survivorship. Along similar lines, limited holding space at JZG has also restricted the number of adults that can be maintained for breeding at any given time. Incorporating additional tanks would allow for more breeding pairs to be maintained and likely increase the total number of offspring produced each year for repatriation.

The Jacksonville Zoo and Gardens was recently able to expand upon and enhance its ex situ holding facilities for *N. perstriatus* through the generous support of AAZK's 2015 Conservation, Restoration and Preservation Grant. This $997.86 in funding facilitated the purchase of equipment and materials needed to construct an additional rearing system for larval striped newts at JZG. The new 12-tank system (Fig. 8), replete with filtration, will facilitate the rearing and head-starting of up to 600 striped newt larvae in lower densities, while also freeing up several existing tanks formerly earmarked for larval rearing and head-starting. By transferring larval offspring to the new system, existing enclosures will be repurposed for additional breeding adults. With some minor modifications and updates to the infrastructure and life support system of these enclosures, JZG will have more than doubled its holding capacity for adults, which will hopefully maximize total reproductive output. In addition to directly benefiting repatriation efforts, increased production can benefit the captive population by enabling additional facilities to establish assurance colonies and eventually contribute offspring of their own to recovery efforts.

Outlook

As one of its most successful and important conservation projects, the Jacksonville Zoo and Gardens is committed to the recovery of the western striped newt, and will continue to work together closely with the Coastal Plains Institute and other partnering organizations and agencies to refine and maximize these efforts. Since the western striped newt has been extirpated from most historical wetland sites throughout its range and known breeding populations are becoming increasingly scarce, the future of the species may be entirely dependent on the continued support of ex situ breeding programs like the one at JZG. The recent financial assistance from AAZK in support of this project will enable JZG to increase its contributions to recovery efforts for this important species.

Beyond its direct conservation implications for the species, this conservation project also exemplifies the importance and value of collaborative research and inter-zoo partnerships. Moreover, it provides a successful collaborative model for bridging the gap between in situ and ex situ research that zoos seeking involvement in reptile and amphibian conservation can follow and replicate. Through cooperation and collaboration with other zoological parks on striped newt husbandry and reproduction, particularly the Memphis Zoo, and rigorous in situ monitoring by the Coastal Plains Institute and partnering agencies, we are optimistic about future recovery efforts for the western striped newt in Florida and across its range. We welcome correspondence and inquiries from colleagues and zoological facilities that may be interested in joining this important initiative or offering logistical support.

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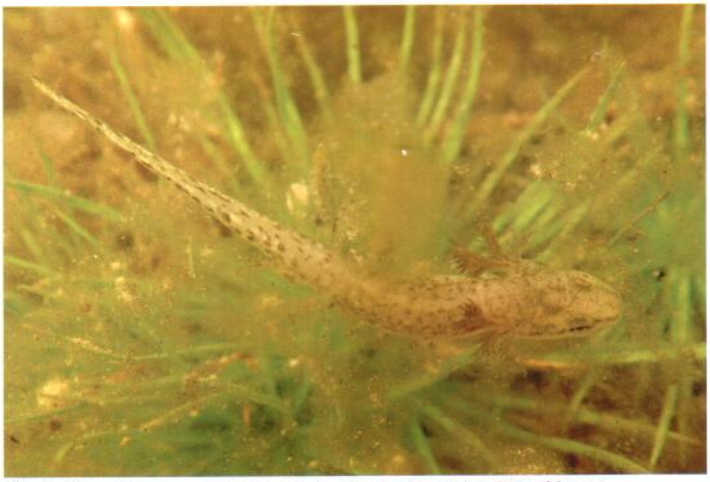

Fig. 6. Recently released larval striped newt. *Photo by: Ryan Means.*

Fig. 7. Recently released adult striped newts. *Photo by: Ryan Means.*

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Fig. 8. New larval newt rearing system, made possible by an AAZK grant. *Photo by: Robert W. Mendyk.*