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A Previously Undocumented Locality of Eastern Hellbenders (*Cryptobranchus alleganiensis alleganiensis*) in the Elk River, Carter County, TN

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Abstract - *Cryptobranchus alleganiensis alleganiensis* (Eastern Hellbender) is a large, imperiled aquatic salamander found in rocky upland streams from New York to Alabama. Although widespread, many Hellbender populations are now highly fragmented by impoundments and degraded habitats. Hellbenders likely require specific stream habitats with relatively low anthropogenic impacts in order to maintain population viability. The Elk River is a small (5th order), high-gradient tributary of the Watauga River drainage that originates in Avery County, NC and flows northwest to Watauga Reservoir in northeastern Tennessee. Although the Elk River's headwaters are heavily impacted by development in the resort towns of Banner Elk and Sugar Mountain; its lower reaches flow through portions of the Pisgah and Cherokee National Forests and over several large waterfalls before reaching the reservoir. Hellbender presence was undocumented in the Elk River prior to 2010. We learned that Hellbenders were likely present in the lower Elk River from anecdotal reports of sightings in Tennessee. In 2010 and 2011, we surveyed for Hellbenders at 10 sites in the Elk River drainage. We observed multiple size classes, including larvae and juveniles, present in the lower Elk River. Development in headwater regions of the Elk River in North Carolina may have caused habitat degradation in the upper Elk River causing the extirpation of Hellbenders in the upper reaches.

Introduction

Cryptobranchus alleganiensis Daudin (Hellbender) is a species of large aquatic salamander endemic to the Appalachian and Ozark Mountains. Two subspecies are currently recognized, *C. a. bishop* Grobman (Ozark Hellbender) and *C. a. alleganiensis* (Eastern Hellbender), both of which are considered imperiled (Briggler et al. 2007a, Mayasich et al. 2003, Petranka 1998, Sabatino and Routman 2009). Adult Hellbenders are typically found under large rocks in high-quality, fast-flowing, upland streams Dundee and Dundee 1965, Hillis and Bellis 1971, Smith 1907). Larval encounters during surveys are rare, possibly because (1) larvae have high mortality rates (and are thus uncommon); (2) larvae utilize habitats that are difficult to search effectively e.g., stream margins, aquatic macrophytes, and interstitial areas in gravel); or (3) survey methods do not target larval habitat (Nickerson and Krysko 2003). Conversely, some sites yield larval encounters regularly though not usually in large quantities (Nickerson and Mays 1973; Nickerson et al. 2003; Petranka 1998; M.W. Pugh, unpubl. data).

The Ozark sub-species is restricted to the Ozark Mountains of Arkansas and Missouri and is listed by the US Fish and Wildlife Service as an endangered species

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(USFWS 2011). The Eastern Hellbender occurs across a much broader range from southern New York to northern Alabama and central Missouri (Petranka 1998). Although the Eastern subspecies is still widely distributed, many populations have undergone significant declines (Briggler et al. 2007b, Wheeler et al. 2003), including possible extirpation in Alabama streams (Graham et al. 2011). The Eastern Hellbender is not federally protected, so the sub-species' conservation status is determined by state governments (Briggler et al. 2007, Mayasich et al. 2003). In North Carolina, the Eastern Hellbender is considered a species of concern which are protected from being killed, harassed, harmed, or illegally collected and are considered a priority species (NCWRC 2005). Tennessee lists Eastern Hellbenders as a species in need of management (Mayasich et al. 2003).

Historically, Hellbenders were abundant in upland streams throughout the Eastern and Central United States (Nickerson and Mays 1973). During the 20th century, many Hellbender populations declined dramatically (Briggler et al. 2007b, Mayasich et al. 2003, Petranka 1998, Wheeler et al. 2003). Most researchers conclude that these declines are attributable to land-use change causing habitat degradation, stream impoundment, removal of riparian flora, stream channelization, siltation, and pollution (Briggler et al. 2007b, Nickerson et al. 2003, Petranka 1998, Sabatino and Routman 2009, Wheeler et al. 2003). There have also been instances of illegal collection for the pet trade as well as deliberate killing of Hellbenders due to the mistaken belief that they are "poisonous" and primarily consume large percentages of game fish and their eggs Nickerson and Briggler 2007, Nickerson and Mays 1973).

A number of biotic factors may exacerbate Hellbender declines including introduced predatory fish i.e., *Salmo trutta* L. [Brown Trout]) and *Oncorhynchus mykiss* Walbaum [Rainbow Trout]; Crane and Mathis 2010, Gall and Mathis 2010), reduced prey items (primarily crayfish; Nickerson and Mays 1973, Nickerson et al. 2003), and presence of parasites, disease, or fungal infection including amphibian chytrid fungus (*Batrachochytrium dendrobatidis* Longcore; Briggler et al. 2007a, Nickerson et al. 2011). Extirpation of Hellbenders from streams may have profound effects on ecosystem structure and function because they play significant ecological roles as predators and prey throughout their life cycle (Humphries and Pauley 2005, Nickerson and Mays 1973, Smith 1907). Moreover, because stable Hellbender populations are usually associated with high-quality freshwater ecosystems they are indicators of stream health (Petranka 1998). Thus, detection of isolated populations provides insight on local water-quality conditions as well as baseline population data that may be critical when planning future conservation strategies. Here we report two previously unknown localities and a verification of anecdotal reports of Eastern Hellbenders in the Elk River, TN.

Methods

Surveys were conducted in 7 sites within the Elk River in Avery County, NC and Carter County, TN. Detailed site localities are not disclosed to minimize risk of illegal collections. However, all locality and demographic data have been provided to the US Forest Service, the Tennessee Wildlife Resources Agency, and the North Carolina Wildlife Resources Commission. We conducted searches

for Hellbenders using rock-turning surveys with the aid of log peaveys and mask and snorkel (Nickerson and Krysko 2003). During these surveys in summers 2010 and 2011, we captured 25 individuals (21 adults, 2 juveniles, and 2 larvae) from three localities in the Elk River. We measured length (TL and SVL) and mass, determined sex, and noted physical abnormalities for all specimens. In the second year of surveys, we began tagging animals using passive integrative transponder (PIT) tags (BioMark©) for adults and visible implant elastomers (VIE) for larvae (Northwest Marine Technology Inc.). Hellbenders were classified by 3 separate size classes. We classified larvae as Hellbenders possessing free gills. Hellbenders that no longer exhibited free gills but were less than 22cm in TL were considered juveniles, and any Hellbender with a TL exceeding 22 cm was considered an adult (Nickerson and Mays 1973).

Results and Discussion

The sex ratio was skewed toward males (14:7). We could not determine sex for 2 juvenile and 2 larval Hellbenders. Peterson et al. (1983) and Taber et al. (1975) used linear regression to create age-length growth curves for Hellbenders. Both studies found that Hellbenders grow slowly particularly after metamorphosis. However, no studies have yet quantified long-term Hellbender growth rates. Using TL from all captures, we created a histogram of Hellbender size-classes that we present as a representation of multiple age-classes (Fig. 1). These data suggest this population, although geographically isolated, may still be reproductively viable.

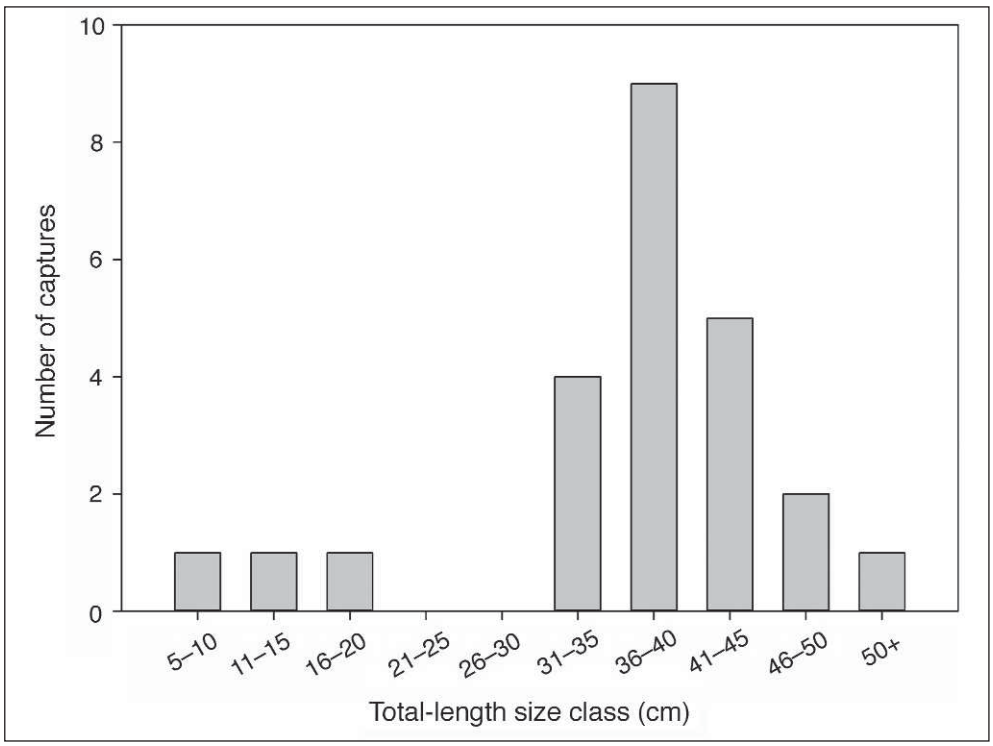

Figure 1. Total-length distribution of Hellbenders captured in the Elk River, 2010 and 2011.

Though one of the localities was a verification of anecdotal reports of Hellbenders, the species had not been documented in the Elk River prior to our surveys (Redmond and Scott 2011). We are aware of only one previous Hellbender survey targeting the Elk River. The North Carolina Wildlife Resources Commission and the North Carolina Zoo surveyed 2 locations in the Elk River in Avery County, NC in 2009 but did not capture or encounter any Hellbenders (J.D. Groves and L.A. Williams, unpubl. data). Surveys in the upper Elk River revealed habitats that appear suitable for Hellbenders (i.e., abundance of large stream particles with large cavities, numerous prey items, clear fast-flowing water) (Dundee and Dundee 1965, Hillis and Bellis 1971, Smith 1907). Nonetheless, much of the upper Elk River had what we would characterize as poor habitat (i.e., low substrate heterogeneity and stability, no interstitial space, embedded particles; Nickerson and Mays 1973). These observations suggest that Hellbenders may be extirpated or never occurred in the upper Elk River. Local land use appeared important to Hellbenders in the lower Elk River. Surveys at 2 sites with intensive riparian disturbance (road-bed encroachment and stabilization, residential dwellings) resulted in few Hellbenders ($n = 2$). In contrast, surveys at a remote site with high percentages of vegetative cover within riparian zones produced the vast majority of captures ($n = 23$). Regardless, there are sections of the Elk River which are privately owned which we were not granted access to so there is still the possibility that Hellbenders still persist in parts of the upper Elk River. We also recognize that Hellbenders exploit cryptic habitats and can occupy cavities of boulders and bedrock where field technicians cannot reach and some stream particles in the sites were too large to lift.

One hypothesis, which would explain the absence of Hellbenders in the upper Elk River, is that human-mediated water-quality impairment led to the extirpation of Hellbenders. The species' extreme sensitivity to poor habitat and water quality possibly caused Hellbenders to migrate to less-afflicted stretches of the Elk River. Presence of heavy metals (i.e., Co, Cd, Cr, Pb, Hg; Huang et al. 2010) or excessive levels of pesticides and fertilizers from current or previous land use in the region (Freake and Lindquist 2008) may have contributed to Hellbender extirpations in the upper Elk River. Large falls exist on the Watauga River, and Hellbenders have colonized much of the upper reaches of this sub-watershed. However, Ball (2001) found that Hellbenders in the Watauga River exhibit little if any within-stream migration, suggesting that Hellbender dispersal rates are very low. Although large waterfalls (>15 m) on the Elk River do not likely pose an insurmountable barrier to Hellbenders, they may impede re-colonization of the upper Elk River. An alternative hypothesis is that Hellbenders may have been unable to colonize the Elk River upstream from the falls and never occurred in the upper Elk River. However, in September of 2011, we received an anecdotal report and picture of a captured Hellbender from two trout anglers suggesting that there is at least one Hellbender in Cranberry Creek; a 1st order tributary of the upper Elk River in North Carolina. If this observation is confirmed with specific locality data, the alternative hypothesis is rejected. Continuing research will test these hypotheses by investigating the linkages between stream physiochemical habitat parameters and Hellbenders, providing empirical population estimates (using mark-recapture) for the Elk River and Watauga River drainage, map dis-

tributions of hellbenders in the Elk River, and assess the effect of local land use on populations of this increasingly rare aquatic salamander.

The discovery of previously unrecognized populations is important to Hellbender management because it suggests that other undocumented populations may persist in remote, high-quality streams in the southern Appalachian Mountains. Recent phylogenetic analysis using mitochondrial DNA documented extensive cryptic diversity in Hellbenders (as much as 5.7% divergence; Sabatino and Routman 2009). Isolated populations, such as the Elk River, may contain unique elements of genetic or behavioral diversity, which would increase understanding of Hellbender phylogeography and possibly enhance the success of propagation or population augmentation efforts in this region.

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