

Prevalence of Physical Abnormalities in Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*) Populations of Middle Tennessee

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Abstract - We surveyed tributaries of the Cumberland and Tennessee Rivers for populations of the Eastern Hellbender during the early 1990s. We captured 42 Hellbenders at the Collins River (Warren County), 28 at the Buffalo River (Lawrence County), four at the Calfkiller River (White County), and three at the Duck River (Coffee County). All Hellbenders collected from the Collins, Calfkiller, and Duck Rivers were sexually mature; by contrast, 25% of the Hellbenders collected at the Buffalo River were juveniles. We found that 41% of all mature Hellbenders had gross abnormalities; whereas, no physical abnormalities were noted on any juvenile Hellbenders. The abnormalities noted were similar at each river and included the absence of one or more digits, supernumerary digits, bifurcate manus or pes, absence of one or more limbs, and truncated tails. Fresh wounds (abnormalities) were found only during August and September. We interpret these data as an indication that the injuries were caused by either 1) intraspecific aggression between adult Hellbenders for diurnal retreats or nesting sites, or 2) predatory attacks that resulted in injury to large Hellbenders and death by ingestion to smaller Hellbenders. Regardless of the cause, the large percentage of injured individuals inhabiting middle Tennessee streams merits further study.

Introduction

The Hellbender (*Cryptobranchus alleganiensis* Daudin) is one of the largest salamanders in the New World, reaching lengths of 740 mm (Fitch 1947) during a life span that exceeds 25 years (Peterson et al. 1983, Taber et al. 1975). Hellbenders are totally aquatic and inhabit clear, rocky streams throughout the central Appalachians from southern New York to northern Georgia and extending westward through the major river drainages of Tennessee and Kentucky to the swift flowing streams in the Ozarks of Missouri and Arkansas (Dundee 1971). Hellbenders are habitat specialists confined to the relatively narrow niche of highly oxygenated, cool, swift-flowing streams by several adaptations of structure, morphology, and physiology (Nickerson and Mays 1973).

Several investigators have suggested that Hellbender populations throughout the range are declining (Nickerson and Mays 1973, Trauth et al. 1992, Wheeler et al. 2003, Williams et al. 1981). Habitat degradation is typically cited as the major cause of the declines. In particular, impoundment, channelization, siltation, acid mine drainage, and thermal pollution have all reduced habitat for the Hellbender. Hellbender populations in the

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Ozarks of Missouri and Arkansas are composed of large, sexually mature adults (Nickerson and Mays 1973; Peterson et al. 1983, 1988), and have declined significantly during the past three decades (Wheeler et al. 2003). Wheeler et al. (2003) suggest that populations dominated by sexually mature adults may be an indication of either reproductive failure or low survival of eggs or young. Unger (2003) found that males in these populations have lower sperm counts than in males from eastern populations not experiencing declines. Regardless of the cause, the documented decline of Hellbender populations during the last few decades has concerned biologists and wildlife officials in states in which populations are known to occur. Because the relatively recent decline in Hellbender abundance throughout much of its range likely has multiple causes, information on the health, including physical trauma, of individuals forming populations is critical for appropriate management practices to be implemented.

Physical abnormalities apparently occur in high percentages of individuals in some Hellbender populations (Pfungsten 1990, Wheeler et al. 2002), but have not been associated with the decline in Hellbender populations. Pfungsten (1990) reported that 25% of the 121 Hellbenders he examined in Ohio had signs of injury. Also, Wheeler et al. (2002) found that at least 8% of the 215 Ozark Hellbenders (*C. a. bishopi* Grobman) studied in Arkansas and Missouri had physical abnormalities. Here, we report on the type and prevalence of gross physical abnormalities noted while conducting mark-recapture studies of Hellbenders in the Collins, Calfkiller, Duck, and Buffalo Rivers in middle Tennessee (Miller and Miller, unpubl. data).

Materials and Methods

We searched for Hellbenders in a 0.50-km section of the Collins River (Warren County), a 0.35-km stretch of the Buffalo River (Lawrence County), a 0.20-km stretch of the Calfkiller River, (White County), and a 0.10-km stretch of the Duck River (Coffee County). Hellbenders were collected during daylight hours by turning slab rocks and boulders in water 0.5–2.0 m deep. We used swim masks to aid visibility when lifting rocks, and the Hellbenders we uncovered were grabbed by hand and placed in cloth sacks. Hellbenders were taken to shore, anesthetized with tricaine methylsulfonate, measured (total length [TL]) to the nearest mm using a meter stick, massed to the nearest gram using a pan balance, and sexed. We sexed Hellbenders only during August and September when mature individuals were identified as male if the cloaca was swollen or as female if the cloaca was not swollen and the abdomen distended with eggs. We noted any external physical abnormality of the head, trunk, tail, or limbs. Hellbenders were then heat-branded, as part of a mark-recapture study also underway, with a unique three-digit number as described by Clark (1971). This branding technique has been utilized successfully on Hellbenders in several other studies (e.g., Peterson et al. 1983, 1988; Taber et al. 1975). After branding, Hellbenders

were released into the stream and allowed to recover; no attempt was made to return the Hellbenders to their collection site. We visited the Collins River site 15 times from late June 1990–mid-July 1992, the Calfkiller River site three times from mid-June–late July 1991, the Buffalo River site eight times from mid-July 1992–mid-September 1993, and the Duck River once during September 1990.

Results

We captured 42 Hellbenders at the Collins River site, 28 Hellbenders at the Buffalo River site, 4 Hellbenders at the Calfkiller River site, and 3 Hellbenders at the Duck River site. The Hellbenders collected from the Collins River ranged in TL from 408–545 mm, at the Calfkiller River from 402–545 mm, and at the Duck River from 454–555 mm. Because of their large size, we considered all Hellbenders collected from the Collins, Calfkiller, and Duck Rivers to be sexually mature. By contrast, 25% ($n = 7$) of the Hellbenders collected from the Buffalo River were juveniles (TL range: 111–253 mm). We noted physical abnormalities in 18 of the 42 (43%) Hellbenders from the Collins River, one of the four (25%) from the Calfkiller River, one of the three (33%) from the Duck River, and 9 of the 28 (32%) from the Buffalo River (Table 1). No abnormalities were noted on any of the juvenile Hellbenders collected from the Buffalo River; thus, 9 of the 21 (43%) adult Hellbenders from this site had gross abnormalities.

Fresh wounds were found on two male Hellbenders collected in the Collins River (Table 1). One was captured on 1 August 1990 with a fresh laceration on its right rear leg, and a second was captured on 5 September 1991 with a fresh laceration on its lower jaw. Each of these Hellbenders was also missing either digits or feet, but these abnormalities were healed and unrelated to the recent injuries.

One Hellbender was found dead in the Collins River on 6 June 1991, two days after heavy rains had caused the river to rise rapidly. We attributed its death to physical trauma associated with a large abrasion on the dorsum that penetrated through the epaxial musculature into the body cavity. The Hellbender was preserved and accessioned into the Middle Tennessee State University herpetology collection (MTSU 47C).

Discussion

Physical abnormalities in Hellbenders, particularly of the limbs, are not uncommon. Pfingsten (1990) reported that 25% of the 121 Hellbenders he examined in Ohio had "some sort of injury;" 80% of the injuries involved missing toes, feet, or limbs. The remaining injuries involved scrapes or gashes to the head, flank or tail. Wheeler et al. (2002) found that missing toes, feet, and limbs accounted for 60% (10 of 17) of the recorded physical abnormalities of 215 Ozark Hellbenders collected in Arkansas and Missouri. Other abnormalities that Wheeler et al. (2002) reported for the Ozark Hellbender included

a bifurcate hind limb, blindness resulting from an individual with an empty eye socket and a malformed eye, and tumors. Epidermal papillomas (Trauth et al. 2002) and squamous cell carcinomas (Harshbarger and Trauth 2002) also have been reported in Ozark Hellbenders.

Table 1. Physical abnormalities noted in Hellbenders from four rivers in middle Tennessee. Abbreviations: RFL = right front limb, LFL = left front limb, RRL = right rear limb, LRL = left rear limb, LJ = lower jaw, m = male, f = female.

River	#	TL (mm)	Mass (gm)	Sex	Date of initial observation	Abnormality
Collins						
	101	545	-	-	6/27/90	RFL: missing digits
	103	427	440	m	6/2790	LFL: missing digits
					8/01/90	RRL: fresh laceration
	108	490	765	-	7/02/90	RFL: missing leg
	109	408	405	-	7/02/90	LFL: bifurcate manus
	110	528	466	m	8/01/90	RRL: bifurcate pes; Tail: Truncated
	111	500	690	f	8/30/90	RFL: missing manus
	115	526	1010	-	5/30/91	RFL: missing digits; LRL: missing digits
	116	411	567	-	5/30/91	LFL: missing digits
	120	447	635	-	6/06/91	RRL: missing pes
	122	476	645	-	6/06/91	Tail: truncated
	123	448	571	-	6/06/91	LRL: missing digits
	124	436	473	-	6/06/91	LFL: missing manus; RFL: missing digits; RRL: missing leg
	126	451	579	-	6/20/91	LFL: missing digits
	127	480	665	-	6/20/91	RFL: missing digits; LFL missing digits; RRL: missing digits; LRL: deformed digits
	132	456	675	m	9/05/91	RFL: missing digits; LJ: open laceration
	135	493	460	-	3/05/92	RFL: missing digits
	137	448	545	-	4/16/92	LFL: missing digits
	139	474	765	-	5/11/92	RFL: missing digits
Buffalo						
	701	477	750	-	7/22/92	RRL: missing pes
	702	475	590	-	7/22/92	LRL: missing pes
	703	502	760	-	7/22/92	RRL: missing pes
	704	406	406	-	7/22/92	RRL: missing digits
	713	492	750	m	8/06/92	RRL: missing digits
	719	431	435	m	8/18/92	RRL: missing pes
	724	525	1010	f	9/10/92	RRL: extra digits
	726	421	540	-	7/06/93	RRL: missing digits
	727	484	605	m	7/06/93	LFL: missing digits; RRL: missing digits
Calfkiller						
	303	530	560	-	7/08/91	LFL: missing manus
Duck						
	502	490	555	m	9/06/90	RFL: missing digits

The variety of abnormalities reported indicates that multiple causes are responsible and different hypotheses have been proposed for specific abnormalities. Nickerson and Mays (1973) attributed gashes found in the head of Hellbenders to canoe traffic; they speculated that canoes hit rocks with enough force to inflict damage on Hellbenders hiding beneath them. Pfingsten (1990) discounted such an explanation for the injuries he observed; he collected injured Hellbenders from streams too small for canoe traffic. Pfingsten (1990) found Hellbenders with fresh wounds only during months corresponding with the breeding season in Ohio (August and September), and he attributed these wounds to injuries incurred during intraspecific combat. Pfingsten (1990) also stated that one injury on the snout resembled a bite-mark from another Hellbender. Likewise, Wheeler et al. (2002) suggested that intraspecific aggression was responsible for most of the injuries they observed; however, they further suggested that some of the abnormalities, such as the bifurcate feet and blindness, were the result of developmental anomalies.

We are not certain what caused the physical abnormalities noted in our samples, nor do we know why populations in middle Tennessee have such seemingly high rates (41% of adults) of abnormalities. We assume that the Hellbender found dead was a casualty of a flood. Presumably, the abrasion occurred when raging waters dislodged rocks and boulders and tumbled them downstream, striking, abrading, and fatally injuring the Hellbender. However, fishermen in the Smoky Mountains and in Missouri reportedly have stomped on Hellbenders after catching them and while removing hooks (M. Nickerson, Florida Museum of Natural History, University of Florida, pers comm.). Also, we had searched the Collins River site one week before finding the dead Hellbender. Possibly, we inadvertently crushed the Hellbender while lifting rocks. Regardless of the cause, the abrasion was very different from the abnormalities found on the living Hellbenders.

As with the Ohio and the Ozark Hellbender populations, most abnormalities in the Tennessee populations involve the limbs, particularly the digits. We interpret the lack of limb abnormalities in juvenile Hellbenders as an indication that they are not the result of abnormal development. Rather, we believe that most of the abnormalities result from injury occurring after hatching, either from predatory encounters or during intraspecific combat.

Predators of Hellbenders are not well documented, but fish, turtle, and watersnakes are reported to consume Hellbenders (Nickerson and Mays 1973, Rhoads 1895, Surface 1913). We are not certain if attacks by any of these predators could result in loss of digits or limbs. However, Hellbenders are cannibalistic and may be significant predators in some populations (Nickerson and Mays 1973). Anecdotal evidence indicates that Hellbenders are capable of rapidly rotating their body when combating large prey (Beck 1965). Also, while removing a hook embedded in the esophagus of a Hellbender captured by a local fisherman in Percy Priest Reservoir at the Spring Creek inflow, one of us (B.T. Miller) experienced first-hand

the effectiveness of this technique in lacerating flesh. Although lethargic from hours of mistreatment, the Hellbender resisted having an index finger pushed into its esophagus by closing its mouth and rapidly twisting its body several times. This action resulted in a laceration that completely encircled the index finger and penetrated nearly to the bone. This behavior should enable Hellbenders to remove appendages from large conspecifics, either during a predatory attack or during a battle for a nest site or diurnal retreat. Hellbenders are territorial and will vigorously defend shelters, particularly during the breeding season (Bishop 1941, Peterson and Wilkinson 1996, Smith 1907). We found fresh wounds on male Hellbenders with swollen cloacae (August and September), supporting the suggestion of Pflingsten (1990) that some wounds might be associated with male-male combat. Consequently, juveniles lack physical abnormalities either because they do not survive predatory encounters (they are engulfed whole) that result in injury to adults, or they do not engage in territorial defense activities that, in adults, could result in injury, including digit, foot, or limb loss.

Physical abnormalities are the visible manifestation of past trauma. However, trauma could also have less obvious physiological consequences, such as a decrease in reproductive potential. Many of the abnormalities we detected, particularly digit loss, seem minor and probably have a negligible impact on the function of the limb during locomotion. Nonetheless, seemingly minor trauma associated with toe-clipping, even with sterile supplies, has a measurable negative impact on overall health and reproduction of amphibians (Davis and Ovaska 2001, Golay and Durrer 1994, Reaser and Dexter 1996). Although such data are not available for Hellbenders, we suspect that the trauma associated with appendage loss, particularly the entire limb, is potentially great and could reduce the reproductive effort of an afflicted individual. The abnormalities and associated potential decrease in reproduction probably are not themselves responsible for the decline in Hellbender populations in Tennessee or elsewhere. However, such trauma could exacerbate the situation in already declining populations. Similar to Ozark populations of Hellbenders, the four streams studied in middle Tennessee are composed largely of sexually mature adults. Currently, these streams harbor small (low density), potentially declining Hellbender populations (Miller and Miller, unpubl. data). The reason for the low densities is unknown, but the large percentage of individuals with evidence of injury is intriguing and merits further study.

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