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Rapid Reservoir Inundation Causes Complete Extirpation of the Eastern Collared Lizard (Crotaphytus collaris) Along the Shoreline of Bull Shoals Lake in Northern Arkansas

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Abstract

The eastern collared lizard (Crotaphytus collaris) is a large saxicolous predatory lizard, which dwells in patchy, cedar glade environments characteristic of much of the Ozarks. The species can also be found in scattered populations along rocky shoreline habitats of large impoundment reservoirs of northern Arkansas. These lizards time their entrance into and exit from underground, overwintering retreats with decreasing and increasing ambient temperatures of the fall and spring months. During an average spring, several sustained days of warm temperatures from mid-March into April are the primary environmental cues for collared lizards to exit their shelters. Excessive winter/spring precipitation in the Arkansas Ozarks, however, can drastically alter reservoir hydrology of the impoundments on the White River system. In years of catastrophic flood conditions, such as in 2008, the rapid inundation of suitable shoreline habitats preceded the exiting of lizards from hibernation burrows; thus, these populations of collared lizards (i.e., those that occurred along both Bull Shoals and Norfork lakes) were effectively entombed in their hibernation burrows, which putatively resulted in a complete population crash of this species within exposed shoreline environments.

Introduction

During the late 1940s and early 1950s, the U. S. Army Corps of Engineers (USACE) constructed two large hydroelectric dams/flood control impoundments (Bull Shoals and Norfork lakes) on the lower stretches of the White River system. The reservoirs inundated this drainage region in both the Ozarks of northern Arkansas and southern Missouri. Following the construction of dams and their gradual filling, these lakes have routinely experienced fluctuating hydrologies due to the variable amounts of annual precipitation that fall in the Ozarks. Several years, in particular, have experienced severe late winter/early spring rains. For example, the normal power pool level of Bull Shoals Lake is 654 ft. above sea level, and flood pool is 691 ft. Over its history, the lake water levels regularly fluctuate between 630 ft. and 680 ft. Four notable flooding events, however, have occurred on Bull Shoals Lake during its 58+ year history. A water level of 694.4 ft. above sea level was recorded on July 2, 1957, and a similar flood level was reached on May 9, 1990 at 691.4 ft. On June 18, 2002, the lake reached a level of 688.8 ft, and the highest water level ever recorded occurred on April 15, 2008, at 695.03 ft. (http://www.swl-wc.usace.army.mil/mcharts.htm).

The eastern collared lizard, Crotaphytus collaris, inhabits Ozark sandstone or limestone exposed environments, commonly called “cedar glades,” which are scattered throughout the Ozark Highlands in Arkansas and Missouri. These natural habitats occupy around 200,000 hectares in each state (Crawford et al., 1969). The size of individual cedar glades varies greatly from less than 0.1 hectare to many hectares. Cedar glade habitats are mostly dry open areas of exposed, eroded sedimentary bedrock or igneous rocks that are often accompanied by other rocky outcroppings, which exhibit little or no vegetation (Baskin and Baskin 2000). Crotaphytus collaris often dwells in these patchy, cedar glade environments (Angert et al. 2002); this species can also be found in scattered populations along the rocky shoreline habitats of man-made reservoirs.

These lizards time their entrance into and exit from underground, overwintering retreats to decreasing and increasing ambient temperatures of the fall and spring months (Trauth et al. 2004). During an average spring, several sustained days of warm temperatures from mid-March into April, are the primary environmental cues for eastern collared lizards to exit their overwintering shelters.

The objective of the present paper is to provide a historic account of the impact of reservoir inundation on populations of the eastern collared lizard along the...
shoreline of Bull Shoals Lake in northern Arkansas. This information reveals the dramatic effects that periodic flooding episodes can have on shoreline habitats along with the resulting extirpation of lizard populations occupying these shoreline environments.

Materials and Methods

Historic collection localities for *Crotaphytus collaris* along the shoreline of Bull Shoals Lake (Fig. 1) have been visited periodically for the presence of lizards since 1971. These localities are described elsewhere (Trauth 1974). Two of these historic habitats have received more scrutiny for lizard activity than others over the years. On occasion, photo vouchers or museum specimens were gathered at these two sites. Historic collection site 1 is located on Promise Land Ridge at the end of Promise Land Road (Marion County: 36°24’20.22”N; 92°34’26.38”W). The shoreline is a southeast-facing exposure of shelf rock that is intermittently vegetated with various annual and perennial grasses and other annual herbaceous plants. This site, until recently, has supported a lizard population for at least 55 years (S. E. Trauth, pers. observ.). This lizard population has also tolerated human traffic and disturbances for the same amount of time. Shoreline vegetation above the flood pool level at this site is a mixture of oak-hickory deciduous hardwoods and, to a lesser extent, some eastern red cedar. Historic site 2 is a southwest-facing, moderately-inclined, rocky tiered-bluff shoreline (Fig. 2) situated along the former White River channel between Howard and Noe creeks (Marion County: 36°23’50.36”N; 92°33’12.37”W). Access to historic site 2 is accomplished only by boat. Shoreline vegetation is minimal here with sparse areas of annual and perennial grasses and annual herbs below the flood pool level. Dominant woody vegetation immediately above the flood pool level is mostly eastern red cedar with some oak-hickory hardwoods.

Results and Discussion

During the past 58 years, populations of *Crotaphytus collaris* have persisted in spite of the unpredictably of the environmentally disturbed rocky shoreline habitats that surround this reservoir. During the reservoir’s early years and following the lake’s initial inundation, a severe drought (1953-1955) in the area depleted the water table level, which created emigration corridors for these lizards as they expanded their populations horizontally from native habitats into newly exposed rocky environments. A critical measure of the sustainability of these new lizard populations, however, still exists today; i.e., the interplay between the timing of the fluctuating hydrology of the lake and the phenological life cycle of the lizard. During the catastrophic flood of 1957 (and in those years immediately following the flood), *C. collaris* undoubtedly survived by moving into higher elevations (native cedar glade environments contiguous to the lake shore) above the flood pool water level and, thereby, the lizards effectively outpaced the rising flood waters, which peaked on July 2 of that year. Favorable habitat conditions above the flood pool level of the young reservoir were presumably remnants of native xeric habitats that were still prevalent at that time above the exposed shoreline. In years following the 1957 flood, the original riparian shoreline vegetation above power pool was now wiped out, thus creating an open environment that allowed for immediate access by lizards, and their populations presumably increased. I repeatedly observed populations of this lizard at historic site 1 throughout the 1960s, a circumstance that actually led me into investigating the biology of this lizard species in Arkansas as well as to document additional populations (via water access) along much of Bull Shoals Lake’s lower shoreline during the lizard activity seasons of 1971 and 1972 (Trauth 1974).

The ability of lizard populations to survive rapid inundation of the lake can also be linked to the exact timing of each flooding episode. The 1957 high water mark was reached during mid summer at a time when most reproductive behaviors were waning, leading possibly to less contact between adult lizards and their predators within the high water line habitats. In addition, adult gravid females were capable of laying their egg clutches in non-inundated microhabitats, thus insuring progeny for the next generation.

Another flooding event similar to the hydrological conditions of 1957 occurred again in 1990 (Fig. 3). As was the case in 1957, the high water mark was reached at a time (May 9) that, presumably, did not interfere with successful courtship and mating activities (for details on the reproductive cycles in this species, see Trauth 1978, 1979). Again, lizards were observed during the spring of 1992 at historic site 1 (photographic confirmation by B. A. Trauth, unpubl.). A third flooding event, recorded in 2002, largely mirrored the previous two described above. In that year the high water mark occurred on June 18. Evidence for lizard survival of this inundation was recorded three years later at historic site 2 on August 9,
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2005 (Fig. 2). My graduate student (Phillip Stewart) and I were able to capture and release several adults perched high on this bluffy shoreline on this date. We did not, however, observe any lizards at other historic sites, and, in particular, none was observed at historic site 1. This paucity of visual recording for this species in August is not totally surprising at this time of the year, given that all adults had ceased reproductive activity, had become mostly lethargic, and had escaped the intense summer heat by retreating into shelters during most of the day.

A fourth flooding event, which occurred in 2008, resulted in the most devastating inundation of all high-water episodes recorded for this lake. It represents the worst case scenario for not only populations of *Crotaphytus collaris*, but also for any poikilothermic vertebrate species unfortunate enough to have overwintered in underground denning sites in shoreline habitat retreats situated below the flood pool level on this lake. Calamitous conditions arose due to severe and unseasonable, late winter/early spring rainfall, which caused a rapid inundation of the reservoir with the high water mark being reached on April 15 (Fig. 4). The greatest amount of rainfall, 6.59 inches, occurred over a 3-day period (March 18-20) and contributed to a rapid rise in the water table from 658.4 ft. to 678.4 ft. in 14 days. Most populations of *C. collaris* had not become active at this time and could not have escaped...
this initial rapid rise in the water table. Presumably, all lizards dwelling within the lower lakeshore habitats were lost by submersion. An additional 6.09 inches of rainfall fell between April 1 and April 15, resulting in a final rise of 16.6 ft. to reach flood pool. During these two weeks, any lizards occupying higher shoreline habitat levels were submerged, forced out of their primary dens into unsuitable hardwood habitats, or became easy prey items for predators. Ultimately, no optimal cover rocks, basking perches, or open habitats were accessible above the flood pool level in virtually all lower lake shorelines; consequently, all populations of this lizard presumably suffered a catastrophic crash.

I visited historic sites 1 and 2 (Fig. 5) as well as five others on May 18, 2010; the power pool level of the lake then was 660.3 ft. Upon habitat inspection, normal shoreline features of the past were evident. A preponderance of driftwood along the flood pool mark was present; otherwise, I saw no obvious indication that a flood had occurred two years prior in these exposed shorelines. I examined the dominant rocky ledges and outcroppings where lizards had been common in the past. I found no lizards or traces of \textit{Crotaphytus collaris} scats (an indication of recent saurian surface activity) in any of the historic sites. Thus far in May, the lake region had experienced 10 days of over 24.0° C (75.0° F) temperatures, more than sufficient, thermally, for \textit{Crotaphytus collaris} activity.

As Bull Shoals Lake has aged over its six decades of existence, natural vegetational succession as well as succession exacerbated by human intervention has greatly modified native glade habitats lying above the flood pool mark. A major cause for alarm regarding lizard population survivorship is directly related to the overall loss of remnant shoreline glades, largely absent today due to a combination of continual encroachment of the hardwood forests and the overgrowth of cedar thickets in former glade environments. The suppression of fire is a major contributing factor leading to loss of native glade habitats (Trauth 1989, Brisson et al 2003).

A complete population crash would seem to be a rare event for these lizards along Bull Shoals Lake. One would generally assume that some lizards should have survived by escaping into remote or marginal habitats above the flood pool level. The most representative habitat to possess a combination of suitable above flood-pool features for \textit{Crotaphytus collaris} is located along the shoreline at historic site 2. Several sheer rocky, bluff exposures (as shown in Fig. 2), however, could not have easily accommodated lizards in 2008. Moreover, an examination of average daytime and nighttime temperatures as well as total precipitation for the 17-day time period (March 1-17) prior to the 2008 flood surge strongly suggest that most lizards would not have ventured far out of their local denning sites, making escape to higher ground highly unlikely. For example, the average nighttime low temperature was 0.8° C (32.9° F), and the average daytime high temperature was 14.0° C (57.4° F) during this time period. In addition, during the first week of March, 3 snowfalls occurred and only on 2 consecutive days (13th and 14th) did daytime high temperatures reach beyond 21°C (70° F). Collared lizards generally require 2-3 days of intense sunshine at this time of year to initiate departure from overwintering retreats and provide sufficient warmth for the onset of territorial, basking, and predatory behavior.

Few land use/management practices or glade rehabilitation efforts have been conducted on Bull Shoals Lake to enhance the historic native environments that immediately surround the lake shore. One notable exception can be found on the Point 6 peninsula in Big Sister Creek (Marion County: 36°25′44.63″N; 92°34′26.08″W), where USACE biologists and fire management personnel have begun restoring a native glade with the use of prescribed burns (Jon Hiser and Bruce Caldwell, \textit{pers. comm.}). Another possible exception would be Jones Point Wildlife Management Area (36°26′24.43″N; 92°42′38.90″W), a mostly isolated upland (757 ft.) peninsula where populations of \textit{Crotaphytus collaris} still exist on native glades.
Conclusions

Catastrophic reservoir inundation, like the one that occurred on Bull Shoals Lake in 2008, presumably resulted in the localized extirpation of the eastern collared lizard, *Crotaphytus collaris*. This lizard species had become adapted to a highly disturbed ecosystem by its occupation of a flood-prone, semi-natural shoreline habitat. Vegetative succession through time had essentially eliminated any potential ecological corridor for escape or avoidance of an unfavorable environmental condition, such as a flood. The ecological instability of this lizard’s linear habitat dramatizes the need to maintain biodiversity in man-made semi-natural ecosystems for the preservation and well-being of native species. (Addendum: Following the submission of this manuscript in April 2011, Bull Shoals Lake set a new record high water level at 696.46 ft. on May 28, 2011.)

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Literature Cited


