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A. Romero
Southern Illinois University Edwardsville, aromerojr123@gmail.com

M. S. Connor
Arkansas State University

G. L. Vaughan
Arkansas State University

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A. Romero[1], M.S. Conner, and G.L. Vaughan

Department of Biological Sciences, Arkansas State University, State University, AR 72467
[1]College of Arts and Sciences, Southern Illinois University Edwardsville, Edwardsville, IL 62026.

Correspondence to: aromero@siue.edu

Abstract

We summarize the results of our study on the status of the southern cavefish (*Typhlichthys subterraneus*) in Arkansas. Its presence in the state represents the western-southern limits of its distribution. Four localities have been confirmed that contain individuals of this species: Richardson Cave (Fulton County), Alexander Cave/Clark Spring (Stone County), Ennis Cave (Stone County), and Lake Norfork (Baxter County). A fifth locality has been cited as a well in Randolph County, but because the exact location is unknown, its presence has not been confirmed. A number of unconfirmed localities for "cavefishes" in the region has not been included in this report. Populations of this species in Arkansas seem to be small (less than 100 individuals) which is common among populations of hypogean amblyopsids elsewhere. All the confirmed localities are in areas either under controlled access by the private owners or by the federal government. No immediate threat to these populations was found by either overcollecting or other anthropogenic causes. Yet long-term monitoring of the recharge zones is recommended.

Introduction

Because of both small population sizes and restriction to one or very few localities hypogean (cave, phreatic) species of fishes are usually considered threatened, if not endangered, taxa worldwide (Romero and Paulson 2001, Romero et al. 2009). In order to understand the conservation status of one of the species of hypogean fishes of Arkansas, we conducted both field and archival research about *Typhlichthys subterraneus* in the state.

Materials and methods

We tried to obtain information on every single record for *T. subterraneus* in the state of Arkansas. Data were compiled from both scientific and nontechnical literature, from collections of museums and similar institutions, and from unpublished sightings by reliable observers, including those using photographs or videotape recordings. We included in this compilation only those reports from scientific publications and popular accounts that provide sufficient information, such as clear descriptions, videorecordings or photographs, to permit unambiguous species identification. Original sources were used wherever possible. All unpublished material has been deposited in the libraries of one of us (Romero). We also tried to verify independently the identification of every specimen in museum collections. We also visited every single locality for which there had been a record of the southern cavefish at least once and interviewed all people who claim to have first hand knowledge of this fish for that locality. Visits to the caves took place during 2006 and 2007 (see Table 1). Every single body of water that might support individuals of the southern cavefish was also visited. Each one of those pools and/or streams was observed by two or more observers for at least 30 min. During that time we used flashlights, infrared goggles (Bushnell) and a digital video camera recorder with infrared capabilities (SONY Wide LCD, 3.0 mega pixels) because responses to light have been reported for this species (Green and Romero 1997). We also looked for any signs of human disturbance that may affect the quality of the underground water in the areas adjacent to the caves visited.

Results

Fulton County: Richardson Cave

This cave also known as Martin Cave has been visited four times in search for *T. subterraneus*. On 3 February 1979 a team from Arkansas State University (ASU) visited and collected one specimen and saw 20 more. The specimen collected is at the fish collection of ASU under the catalog number ASUMZ 9064. The same team visited this cave a week later and could not see a single individual (Paige et al. 1981). Dunivan et al. (1982) reported one individual. We visited this cave twice, on 22 and 23 of June 2007. The second of

these visits consisted in a reconnaissance of the entire cave including all of its bodies of water. No fish were seen.

Randolph County:

This is the most mysterious record for *T. subterraneus* in Arkansas. This is based on at least one specimen at the Museum of Zoology of the University of Michigan (UMMZ 133844). According to the letter accompanying the two specimens originally sent these specimens were collected "from a well, Randolph County, collected in the spring of 1940." Since the letter requested that one of the specimens be returned to the sender, that might explain why despite the fact that two were sent to the museum, only one is in its collection. The letter was signed by Byron C. Marshall, the proprietor of a company called Ozark Biological Laboratories. Their standard length were 53 and 58 mm respectively. The smallest one was returned to Marshall who did not want to divulge the locality of the well where these specimens were collected.

D.W. Nelson (*pers. comm.*) reported to us that "Interestingly, Marshall had previously sent to Hubbs two specimens (of 4 total) of *Amblyopsis rosae* from a collection that he had made in Downer's Cave, Sarcoxie, Missouri." We may never learn what is the exact location for this (these) specimen(s). We visited Pocahontas on 18 June 2007 and interviewed several local officials and archivists. Nobody has heard of any well from which blind/depigmented fish have been pumped out.

Stone County: Alexander Cave

Also known as Castle Cave, this is the location in which *T. subterraneus* has been seen more frequently and in larger numbers for the state of Arkansas. This cave is connected with a water resurgence known as Clark Spring that has been explored in several occasions using SCUBA equipment and that has resulted in several sightings including some recorded on video tape. The first recorded sighting is from 1975 by Mr. Tim Ernst (Harvey 1975 cited in Robison and Buchanan 1988). The largest numbers of individuals were seen when scuba diving through Clark Spring and the sightings at the pool location in the cave produces numbers between two and five.

Stone County: Ennis Cave

This is the most recent locality record for *Typhlichthys* in Arkansas. This cave is owned by the Rose Family and the steward is Mr. Tim McClain. This is a gated cave with a perennial stream where the fish can be seen. Ennis Cave was visited by G.O. Graening, D. Fenolio and E. Corfey on 7 May 2004 and one individual collected (Graening et al. 2005). We visited it on 26 May 2007 and observed one fish which quickly disappeared through a crevice.

Baxter County: Lake Norfork

On 20 February 2009 an individual of *T. subterraneus* was collected at Lake Norfork (15S 560987.4mE 4030555.0mW) by Steve Teems and deposited at the ASU museum collection under number 13067. This is an unusual finding since obligatory cave fish species are rarely collected outside the hypogean environment.

Conservation status

T. subterraneus is classified as Vulnerable (VU D2) by the World Conservation Monitoring Centre (WCMC) (Romero 1998). Global Rank: G4 apparently secure. The global rank of G4 is usually assigned to species that have been recorded from more than 100 localities. Although this species is known from sufficient localities to merit the rank of G4, its position in cave ecosystems as a predator suggests a lower (G3) rank.

Its protection status in the United States is as follows: Alabama: Threatened, Protected; Arkansas: Inventory Element; Georgia: Rare; Indiana: Endangered; Kentucky: Special concern; Missouri: Watch List; Oklahoma: record extirpated because of misidentification; Tennessee: Deemed in need of management (Noltie and Wicks 2001). Harvey (1975) considered in 1975 that *T. subterraneus* in Arkansas was not really endangered because the only locality known there besides the unnamed well was Alexander Cave that was well protected.

Potential threats

Potential threats to aquatic hypogean fauna in general and cave fishes in particular have been listed by Keith (1988). Below we present a modified version of that list:

1. Water quantity: changes in the hydrological regime due to impoundments, quarrying, welling and/or water extraction.
2. Water quality:

a.) Groundwater pollution by agrochemicals, sewage, accidental spills of hazardous materials, oil and/or gas exploration/exploitation, and intentional dumping of hazardous waste into sinkholes and sinking streams.

b.) Sedimentation and runoff as a consequence of farming activities, logging and/or deforestation, road and building construction (urbanization) as well as runoff and erosion from rainfall.

3. Overcollecting

4. Cave habitat alteration to either facilitate recreational activities and/or gating that may prevent bats and other fauna to come into the cave and carry with them potential nutrients.

During our visits to the three known localities for *Typhlichthys* in Arkansas, we did not observe any of the above-ground anthropogenic activities listed above. That does not mean that there is no potential for environmental impacts in the future due to water pollution in the recharge zones of surrounding areas (Aley and Aley 1997). Such an occurrence can cause a large mortality event such as the one that took place in November of 1981 when about 1,000 southern cavefish individuals and ca. 10,000 Salem cave crayfish (*Cambarus hubrichti*) were killed in Meramec Spring, Missouri, because of a fertilizer pipeline failure that released 80,000 L of liquid ammonium nitrate (Crunkilton 1982, 1985, Weaver 1992).

Access to all three caves (Alexander, Richardson, and Ennis) is controlled in varying degrees by the cave owners by gating (Alexander), constant human presence (Ennis) or special permit (Richardson). The Clark Spring entrance to Alexander Cave can only be utilized under special permit by the U.S. Forest Service since that entrance is on land under the management of that federal agency. That spring can only be penetrated using SCUBA equipment and because of its characteristics only experienced scuba divers can explore it. Therefore overcollecting does not seem to be a concern. Only Alexander and Ennis caves had been slightly altered by the owners to facilitate exploration and only at certain points. None of those alterations seem to have impacted the bodies of water where the fish could be found.

Conclusions and recommendations

We found no indication that the populations of *Typhlichthys* in Arkansas are in need of urgent actions by either federal or state agencies and/or private individuals. However, because of the potential impact that some activities may have in the future, we recommend periodic monitoring of the anthropogenic activities listed above that may impact the conservation status of those populations.

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Table 1. Confirmed localities of *T. subterraneus* in Arkansas.

County	Location	Date	# of individuals	Source
Fulton	Richardson Cave	3 Feb. 1979	21	Paige et al. 1981
	Richardson Cave	10 Feb. 1979	0	Paige et al. 1981
	Richardson Cave	1982	1	Dunivan et al. 1982
	Richardson Cave	22-23 June 2007	0	This report
Randolph	A well	1940	2	Woods and Inger 1975
Stone	Alexander Cave	1975	20	T. Ernst in Robison and Buchanan 1988
	Alexander Cave/ Clark Spring	1975	3	Harvey 1975
	Alexander Cave/ Clark Spring	27 June 1998	1	Bob Koch (*pers. comm.*)
	Alexander Cave/ Clark Spring	1999	23	T. Ernst (SCUBA)
	Alexander Cave/ Clark Spring	27 Jan. 2001	0	Graening *et al*. 2001
	Alexander Cave	14 Dec. 2002	3	G.O. Graening (*pers. comm*)
	Alexander Cave	22 May 2004	4	M. Slay, pers. comm.
	Alexander Cave/ Clark Spring	16 July 2004	3	Bob Koch (*pers. comm*)
	Alexander Cave/ Clark Spring	6 March 2005	1	Bob Koch (*pers. comm.)*
	Alexander Cave/ Clark Spring	5 June 2005	2	Bob Koch (*pers. comm.*)
	Alexander Cave/ Clark Spring	13 Aug. 2005	5	D. Kampwerth (*pers. comm.*)
	Alexander Cave/ Clark Spring	3 Sept. 2005	6	Bob Koch (*pers. comm.*)
	Alexander Cave/ Clark Spring	11 Nov. 2005	4	Bob Koch (*pers. comm.*)
	Alexander Cave/ Clark Spring	4 March 2006	2	Bob Koch (*pers. comm.)*
	Alexander Cave/ Clark Spring	17 June 2006	1	Bob Koch (*pers. comm.*)
	Alexander Cave/ Clark Spring	15 July 2006	3	Bob Koch (*pers. comm.)*
	Alexander Cave	28 Oct. 2006	2	This report
	Alexander Cave/ Clark Spring	7 July 2007	2	Bob Koch (*pers. comm.)*
	Alexander Cave/ Clark Spring	2 Sept. 2007	12	Ozark Cave Diving Alliance and D. Kampwerth (*pers. comm.*)
	Ennis Cave	7 May 2004	1	G.O. Graening (*pers. comm.*)
	Ennis Cave	26 May 2007	1	This report
Baxter	Lake Norfork	20 Febr. 2009	1	This report

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