A Novel Technique for Invertebrate Trapping in Groundwater Wells Identifies New Populations of the Troglobitic Crayfish, *Cambarus cryptodytes*, in Southwest Georgia, USA

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ABSTRACT

A simple, inexpensive, reusable trap was designed and used successfully to capture the troglobitic crayfish, *Cambarus cryptodytes*, from groundwater wells in the Upper Floridan aquifer. Crayfish were trapped from four different wells at depths ranging from 14 to 26 m below the land's surface, where dissolved oxygen concentrations ranged from 3.6 to 6.3 mg/L. These captures extend the known distribution of *C. cryptodytes* farther northwestward in the Dougherty Plain physiographic region of southwest Georgia. This trap design allows for the collection and study of organisms that would otherwise go undocumented due to their inaccessible subterranean habitat.

INTRODUCTION

Cambarus cryptodytes is a troglobitic crayfish with small vestigial eyes, long antennae, and no pigmentation. It is found in the Upper Floridan aquifer which underlies the Dougherty Plain physiographic region, extending from southwest Georgia into the Florida panhandle. The Upper Floridan aquifer is composed of the upper Eocene Ocala Limestone confined below by the middle Eocene Lisbon Formation, and semiconfined above by the undifferentiated Quaternary overburden (Warner 1997). The combination of these formations has created a subterranean habitat of submerged caves and passageways which are inaccessible by humans accept at spring heads, sink holes and exposed caves.

The type specimens of *C. cryptodytes* were obtained by dipping a bucket into an open groundwater well (Hobbs 1981). Since then, most collections have been made by cave divers and spelunkers (Caine 1978, Franz et al. 1994). Relatively little is known about the life history, population, and distribution of this species due to the difficulty of capturing and observing these creatures in their subterranean habitat. Unlike surface crayfish which typically live no more than four years, troglobitic species have demonstrated life spans as long as 16 years (Streever 1996). Because of this extended life span, they are believed to reproduce infrequently and produce few young at one time (Streever 1995). Therefore, *C. cryptodytes* may be very sensitive to depletion in population size.

C. cryptodytes is ranked as imperiled globally because of its rarity. In Georgia it is ranked as critically imperiled because of extreme rarity (http://georgiawildlife.dnr.state.ga.us/content/specialconcernanimals.asp). Standard methods of capture such as hand collections and minnow traps are only feasible at spring heads, sink holes, and caves where the aquifer is exposed to the surface. Our method and trap design allow trapping anywhere that an open-hole well is available. Pumping wells to retrieve the organism would be expensive and risk injury or death to the crayfish. We present a simple, inexpensive, and safe method for capturing *C. cryptodytes* from groundwater wells.

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METHODS AND MATERIALS

Polycarbonate drink containers (0.6 L) were emptied and cleaned. Sports drink bottles were easier to use in construction; they were sturdier and lasted longer in the field than other bottle types. The top of the bottle was cut off at the widest part and set aside (Fig. 1). Holes (1.5 mm) were drilled in the bottom and the detached top to allow water flow. Holes (1.5 mm) were also drilled in the sides so that lead fishing weights could be attached. Monofilament fishing line (11.3 kg) was used to vertically align lead fishing weights at four places opposite each other inside the bottle. The monofilament line was tied off tightly inside the bottle so that the crayfish could not squeeze behind the weights and become injured. The top was inverted and placed into the bottle and secured with hot glue. Holes (1.5 mm) were drilled from the outside of the upper bottle into the inverted top in three equidistant places and monofilament line was run through and tied to a 6.3 mm flat washer. Enough line was provided so that the washer did not block the opening. Traps were lowered into the wells and then secured at the top of the well casing with nylon line. Traps were baited with tuna in oil, catfish bait, canned cat food, or chicken liver. Bait was placed in small nylon bags which were sealed with hot glue. After a capture the hot glue seal between the inverted top and the side of the bottle was broken allowing the inverted top to slide up the monofilament line to the washer and provide easy access to the crayfish and an easy way to repair the trap for the next use.

Traps were placed in wells located in the Chickasawhatchee Swamp Wildlife Management Area and a well field in southwest Albany, Georgia. Both sites were located within the Dougherty Plain physiographic region. The Chickasawhatchee Swamp Wildlife Management Area is located within Dougherty, Baker and Calhoun Counties. The Albany well field is located entirely within Dougherty County. Trapping was conducted in 23 open-hole wells ranging in depth from 16 to 61 m below the land's surface. Well casings had diameters ranging from 0.1 m to 0.6 m.

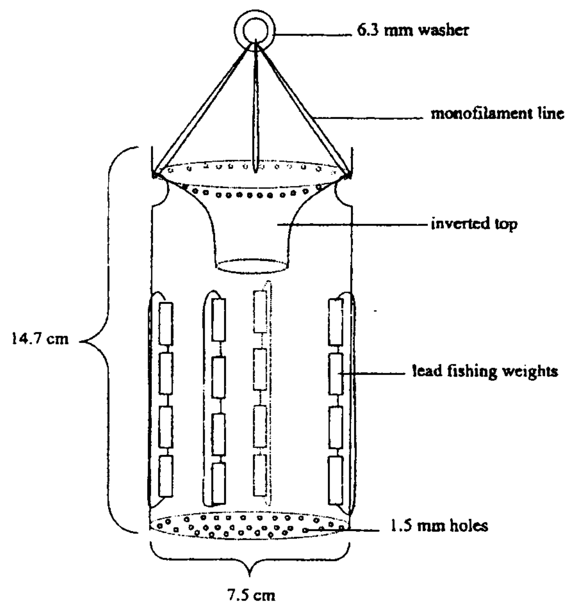

Figure 1. Schematic of polycarbonate trap designed to capture troglobitic crayfish from groundwater wells.

Trapping depth was based on the well depth, casing depth, and when available, a vertical profile of the underlying Ocala Formation. Traps were placed in wells at depths with medium to hard limestone which had large cracks and crevices. When the underlying geomorphology was unknown, trap depths were varied between the bottom of the well and the bottom end of the well casing. In most cases two traps were deployed to predetermined depths on a single line and tied off inside the top of the well casing. Traps were checked daily by slowly pulling them up so that the crayfish were not crushed or injured and the trap did not become snagged or lodged inside of the well.

At the Chickasawhatchee Swamp, sampling occurred during three periods between June 2003 and January 2004 for a total of 100 attempts. At the southwest Albany well field, sampling occurred during one period in July 2003 for a total of 91 attempts. At both sites deployment depths and baits were varied when traps were checked.

Dissolved oxygen was measured using a Quantas Hydrolab. Readings were taken after the volume equal to three times the well capacity had been pumped and the Hydrolab readings had stabilized.

RESULTS AND DISCUSSION

At the Chickasawhatchee Swamp, three of 15 wells yielded crayfish (Table 1). Well CH6 yielded six female crayfish at depths ranging from 14 to 21 m below the surface. Well CH7 yielded three females and one second form male (not yet able to reproduce) at depths ranging from 16 to 26 m below the surface. Well CH18 yielded two female crayfish from 18 and 24 m below the surface. At the southwest Albany well field only one out of eight wells yielded crayfish. Well C8 yielded a first form male (able to reproduce) and a female crayfish from 24 and 26 m below the surface.

In this study, *C. cryptodytes* demonstrated the ability to survive in an environment of low oxygen tension (3.6-6.3 mg/L), amounts which were below the saturation point (9.1 mg/L) for dissolved oxygen at an average aquifer water temperature of 20 °C. Caine (1974) reported captures of *C. cryptodytes* in Gerard's cave, a nonsubmerged cave in Jackson County, FL which had an oxygen concentration of 6.9 mg/L. Laboratory research has indicated that the metabolic rate of *C. cryptodytes* is lower than that of surface crayfish, which allows it to survive in low oxygen habitats (Caine 1974). Notably, some traps placed in wells that had enough dissolved oxygen to support *C. cryptodytes* led to no captures. The lack of captures may be attributed to a low

Table 1. Capture data for *C. cryptodytes* from four groundwater wells in southwest Georgia.

Capture Site	Depth (m)	Sex	Bait	Capture Date
CH6	14	Female	chicken liver	06-13-03
CH6	21	Female	chicken liver	06-20-03
CH6	20	Female	wet cat food	08-13-03
CH6	18	Female	wet cat food	08-15-03
CH6	18	Female	wet cat food	08-15-04
CH7	16	Female	chicken liver	06-13-03
CH7	22	Female	chicken liver	06-23-03
CH7	17	2nd form male	catfish bait	06-24-03
CH7	26	Female	wet cat food	08-13-03
CH18	24	Female	catfish bait	06-25-03
CH18	18	Female	chicken liver	06-26-03
C8	24	1st form male	chicken liver	07-18-03
C8	26	Female	tuna in oil	07-22-03

population of the species, exclusion from certain areas due to the underlying geomorphology, or habitat preferences perhaps based on available food resources.

In this study, 11 females and two males were captured. In the nonsubmerged habitat of Gerard's cave, Caine (1974) found the sex ratio to be nearly equal with 31 females and 28 males reported. Observations of another troglobitic crayfish in Sim's Sink found no ovigerous females or females with attached young, leading to the hypothesis that females may sequester themselves during these times (Streever 1996). It is possible that the predominance of females in this population is the result of sequestering farther into the aquifer although none of the females captured was ovigerous or had attached young.

Bait preferences were not readily apparent because all bait types successfully attracted crayfish. As hypothesized for other troglobitic species (Relyea and Sutton 1973), *C. cryptodytes* appears to be an opportunistic feeder in this system. In systems such as sinks and caves, organic material can be washed in during heavy rains and flooding events. In many caves there are bat populations which supply organic material in the form of guano. There have been observations of small and large mammals falling into sink holes which can supply an important short term input of organic carbon into the system. Cave divers have reported flow reversals in riverine springs in this area which can carry material into the system. However, none of these possibilities appears to apply to this part of the aquifer system. Furthermore, there is very little dissolved and suspended particulate organic carbon (DOC ~0.1-0.3 ppm; POC ~0 ppm; Opsahl, unpublished data) in groundwater samples collected from these wells. The challenge remains to identify the food resource for this population of *C. cryptodytes*.

The range of *C. cryptodytes* could potentially extend throughout much more of the limestone formation of the Upper Floridan aquifer in southwest Georgia and Florida. Undocumented observations come from well drillers who have inadvertently pumped them out of groundwater wells. Other observations of this species come from spelunkers and cave divers and also are undocumented. For example, troglobitic crawfish have been observed in at least three submerged caves along the lower Flint River just east of the study area (P. DeLoach[b], personal observations). The closest nonsubmerged cave in which *C. cryptodytes* has been documented is Climax Cave in Decatur County, Georgia. This cave is where the first *C. cryptodytes* were observed in Georgia (Hobbs 1981). In the area of this study there are no access points such as sinks, springs or caves for humans to enter. However, with this method we are now able to trap new areas and have expanded the known distribution of *C. cryptodytes*.

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