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SHORT COMMUNICATION

Egg sacs of *Liocranoides* Keyserling, 1881 (Araneae: Zoropsidae) cave spiders

Mary Elizabeth Yancey[1], **Nathaniel C. Mann**[2], **Marc A. Milne**[3] and **Kirk S. Zigler**[1]: [1]Department of Biology, University of the South, Sewanee, Tennessee, 37383, USA; E-mail: kzigler@sewanee.edu [2]Spencer Mountain Grotto, Spencer, Tennessee, 38585, USA; [3]Department of Biology, University of Indianapolis, Indianapolis, Indiana, 46227, USA

Abstract. Little is known about reproduction in most cave spiders, including reproductive behaviors, seasonality, and fecundity. In the course of fieldwork in Tennessee caves, we observed aspects of reproduction in three populations of *Liocranoides* Keyserling, 1881 (Araneae: Zoropsidae) spiders. We observed egg sacs of *L. archeri* Platnick, 1999, as well as egg sacs and spiderlings of *L.* cf. *gertschi* Platnick, 1999**.** The spiders produced a spherical egg sac that hung from the cave ceiling by a single cord of silk. The egg sacs were covered by foreign material including sediment, rocks, and plant roots. Egg sacs were observed in June and July, and spiderlings were observed in July. Three egg sacs that were collected contained 26, 42, and 53 eggs. This is the first description of reproduction in *Liocranoides*.

Keywords: Subterranean, reproductive behavior, reproduction

Spiders are members of subterranean communities around the world. More than 1000 spider species representing ~50 families exhibit morphological adaptations to subterranean life and many more species are associated with caves to varying degrees (reviewed in Mammola & Isaia 2017). Most cave spiders are poorly known, and little is known about their reproduction, including seasonality, fecundity, and reproductive behaviors. Here we describe egg sacs and observations of spiderlings from *Liocranoides* Keyserling, 1881 (Araneae: Zoropsidae) spiders in caves in Tennessee. This is the first description of reproduction in this genus.

Liocranoides consists of five described species (World Spider Catalog 2018). *Liocranoides unicolor* Keyserling, 1881 was described first, based on specimens from Mammoth Cave, Kentucky. Platnick (1999) revised the genus and extended the range of *L. unicolor* into north-central Tennessee. He also described four additional species from the southern Appalachians: *L. tennesseensis* Platnick, 1999 (from central and eastern Tennessee), *L. coylei* Platnick, 1999 (southwestern Virginia, western North Carolina, and eastern Tennessee), *L. archeri* Platnick, 1999 (south-central Tennessee and northeastern Alabama), and *L. gertschi* Platnick, 1999 (northern Alabama and northwestern Georgia). However, there are multiple undescribed *Liocranoides* species present throughout the Appalachian region and members of this genus may exist as a species complex similar to *Nesticus* Thorell, 1869 (Araneae: Nesticidae) cave spiders found in Appalachia (Milne unpublished data; Hedin 1997). All five described species have been collected in caves, and two (*L. unicolor* and *L. archeri*) are known only from caves (Platnick 1999).

During a visit to Keith Cave (Franklin County, Tennessee; Tennessee Cave Survey (TCS) #FR14) on 1 June 2017, we observed nine *L. archeri* individuals (Fig. 1A), as well as three egg sacs hanging from the ceiling of the upper chambers of the cave. These spherical egg sacs were ~1 cm in diameter and hung from the ceiling by a thick cord of silk ~2 cm in length. The egg sacs were covered by fragments of sediment, rock, and plant roots (Fig. 1B). Two egg sacs had mature female *L. archeri* in close association (within 10 cm). We collected one egg sac (Tennessee Wildlife Resources Agency permit #1605) and found 53 cleavage stage embryos inside. Although foreign materials were attached to the outside of the egg sac, no foreign material was observed inside the egg sac (Fig. 1C). During a second visit to Keith Cave on 20 June 2017, we observed one egg sac and what appeared to be the remnant of an egg sac still attached to the ceiling (Fig. 1D).

Liocranoides archeri is known from ~20 caves in south central Tennessee and adjacent northeast Alabama (Platnick 1999; Lewis 2005; Dixon & Zigler 2011; Wakefield & Zigler 2012). *Liocranoides archeri* has only been collected from caves and so has been considered a cave-obligate species (Niemiller & Zigler 2013). It is pale and largely uniformly colored, which may be an adaptation to cave life (Fig. 1A). It does not, however, exhibit other obvious morphological adaptations to cave life (Platnick 1999). The spiders *Nesticus barri* Gertsch, 1984 (Araneae: Nesticidae) (Lewis 2005) and *Meta ovalis* (Gertsch, 1933) (Araneae: Tetragnathidae) are also known from Keith Cave. Both have egg sacs that are quite distinct from those described here (e.g., Carver et al. 2016; egg sacs of *M. ovalis* are similar to those of the European *M. menardi* (Latreille, 1804), as described in Lepore et al. 2012).

We observed a similar egg sac in Shinbuster Crawl Cave (Rutherford County, Tennessee; TCS #RU88) on 14 July 2017. Although there was no spider in attendance, we collected immature *Liocranoides* from the cave and assume it was a *Liocranoides* egg sac. We collected and dissected the egg sac and found 26 eggs inside. The material inside the egg capsules was disorganized, suggesting these eggs failed to develop and were degenerating. Last, we observed two intact egg sacs in East Fork Cave (Dickson County, Tennessee; TCS #DI27) on 29 July 2017. One egg sac was collected and contained 42 cleavage stage embryos. A third egg sac in the cave was apparently recently hatched, with approximately 30 spiderlings on the ceiling surrounding the remnant of the egg sac. The spiderlings were nearly transparent with bodies 1–2 mm in width. We collected immature and mature *L.* cf. *gertschi* from the cave. The genitalia of the mature spiders differed slightly from the description of *L. gertschi*. All collected spiders have been retained by one of the authors (MAM) for further systematic study.

There are similarities between the egg sacs of *Liocranoides* and some other zoropsid taxa. Most notably, *Titiotus gertschi* Platnick & Ubick, 2008 hangs spherical egg sacs by a cord of silk from the ceiling of caves in California (Platnick & Ubick 2008). *Tengella perfuga* Dahl, 1901, from Nicaraguan forests, covers its spherical egg sacs with pieces of substrate including bark, soil, and leaves (Mallis & Miller 2017). Some other zoropsid spiders, including members of *Griswoldia* Dippenaar-Schoeman & Jocqué, 1997 and *Austrotengella* Raven, 2012, encrust the egg sac with dirt and debris, but not all do (e.g., *Zoropsis* Simon, 1878) (Griswold 1991; Thaler & Knoflach 1998; Raven 2012).

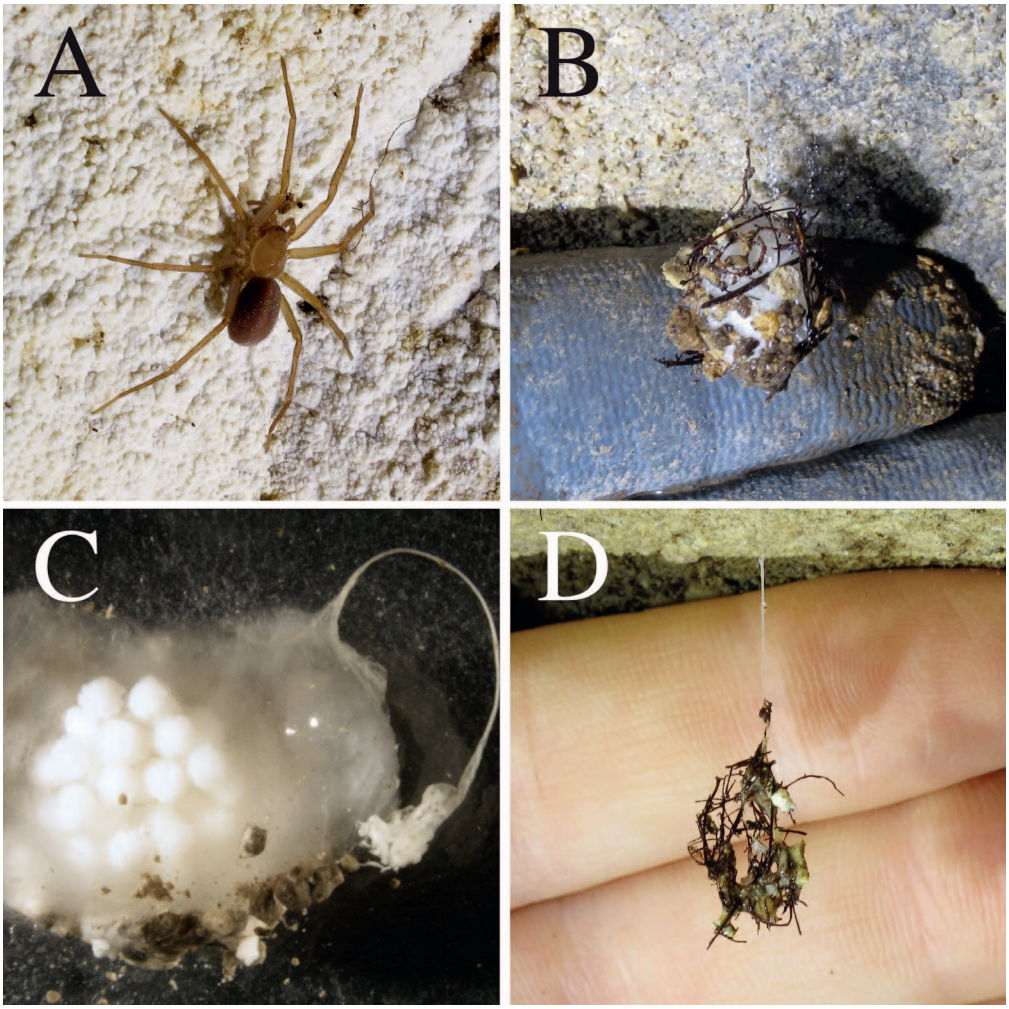

Figure 1.—*Liocranoides archeri* and egg sacs from Keith Cave (Franklin County, Tennessee). A. Mature female on cave wall (photo taken 20 June 2017). B. Egg sac hanging from the cave ceiling (photo taken 20 June 2017). C. Dissected egg sac. The cord of silk that attached the egg sac to the cave ceiling is at right. The egg sac contained 53 embryos and was collected on 1 June 2017. D. Remnant of an egg sac hanging from the cave ceiling (photo taken 20 June 2017).

The *Liocranoides* spiders and egg sacs we observed were in the twilight zone (the area to which some light penetrates) of these caves, rather than in dark zone cave habitats. The spiders were not found in webs and ran rapidly when disturbed. This suggests they are cursorial and hunt in the prevailing low light.

Over the past six years one of the authors (KSZ) participated in 241 visits to caves in Tennessee, Alabama and Georgia. The trips were distributed throughout the year, although fewer visits occurred in the winter (40/241). Across those visits these are the first observations of *Liocranoides* egg sacs, suggesting a brief or sporadic reproductive period for *Liocranoides*. Our anecdotal observations of *Liocranoides* egg sacs and spiderlings in June and July are consistent with observations of reproduction in *Nesticus* cave spiders. *Nesticus* cave spiders from the southern Appalachians exhibit reproductive seasonality with a peak in June and July (Carver et al. 2016). Further observations are required to determine if *Liocranoides* exhibit a similar pattern of reproductive seasonality.

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