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The fundamental importance of taxonomy in conservation biology: the case of the eyeless *Cicurina bandida* (Araneae: Dictynidae) of central Texas, including new synonyms and the description of the male of the species

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Abstract. Three eyeless species belonging to the spider genus *Cicurina* Menge are known from five caves located south of Austin, Travis County (Texas, United States). Because adult female cave-dwelling *Cicurina* are not common, and adult males rarely collected, these species were described from a very small sample of individuals (nine females). Recent collections have allowed the examination of a larger series of specimens, providing an opportunity to assess intraspecific variability. This has resulted in the synonymy of *C. cueva* Gertsch and *C. reyesi* Gertsch with *Cicurina bandida* Gertsch. The synonymy is supported by both female and male morphology; the male of the species is described for the first time. *Cicurina bandida* is now known from ~20 caves, restricted to a 10 km × 30 km area. *Cicurina cueva* was proposed to be listed as an endangered species. Because of the special conservation status of troglobitic *Cicurina*, modifications of the original species hypothesis are fertile grounds for confrontation between conservationists and proponents of development. Taxonomy is a dynamic science that progresses by proposing new scientific hypotheses and this conflicts with conservation principles that are embedded in a static framework. The criteria used to assign species a particular conservation status should be based on the best available evidence, and not limited by political considerations. Long-term conservation goals can only be achieved when based on a robust taxonomy, which is still largely unavailable for most Texas cave arthropods.

Additional keywords: cave fauna, *Cicurina cueva*, *Cicurina reyesi*, conservation policies, endangered species, species hypothesis, species limits, troglobite.

Introduction

Cicurina Menge is a speciose Holarctic spider genus of ~130 species (Platnick 2007) that includes an extraordinary radiation of 60 eyeless, cave restricted species. Almost all these troglobites are known exclusively from caves in central Texas (United States) where they have become flagship species for cave conservation. Four eyeless *Cicurina* are included on the Federal list of endangered species (Longacre 2000), while other troglobitic species are classified as species of concern in the State of Texas (Bender *et al*. 2005).

In spider taxonomy, genitalia have traditionally been the most useful morphological feature for defining species because they provide recognisable differences between congeneric taxa (Eberhard 1986). Genitalic structures are only present in adults and male genitalia usually provide more distinctive characters than those of females, but both sexes are widely used in species delimitation, description and identification. Aside from the legal status of the troglobitic members of the genus, *Cicurina* is also remarkable for its morphological variability. As early as 1940, Chamberlin commented that surface dwelling *Cicurina* species display unusual variation among adults, for example, the body size was reported to vary twofold within a single species (Chamberlin and Ivie 1940). Also, genitalic variation was recognised by Gertsch and Mulaik (1940, in Chamberlin and Ivie 1940) who named *Cicurina varians* Gertsch & Mulaik 1940 after the trait. Such variability was recently reaffirmed by Cokendolpher (2004), who provided illustrations of different genitalic morphs of what he considered to be the same species. An important step supporting this unusual intraspecific variation was accomplished when Paquin and Hedin (2004) used molecular data as an independent assessment of species limits. They demonstrated that specimens belonging to minimally divergent

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mtDNA clades may display considerable variation in female genitalia, as previously suspected.

Intraspecific variation in female genitalia is troublesome because most *Cicurina* species were originally described without consideration of possible variability. Also, males have not played a significant role in the taxonomy of the genus due to their rarity in collections. This has resulted in a genus comprised of highly similar species that are distinguished only by minor differences in female genitalia. The validity of many species hypotheses remains questionable (see Brignoli 1979), and taxonomic reassessment represents a challenge in most cases (Paquin 2005). Synonymy has impacts for systematists and students of biodiversity, but when involving endangered species, the consequences are broader. Conservation status and policies are based on species level data, where information on species limits, identification, and distribution is fundamental. The bulk of eyeless *Cicurina* species were described by Gertsch (1992) based on a limited amount of material due to the rarity of adults; for most species, only one or two females were used to establish species limits. In the context of troglobitic animals and given the importance of taxonomy as a basis for determining conservation status, the work of Gertsch was not only essential, but the best that could be done with the data available at that time. Since that seminal work however, the collection of additional material allows for an assessment of variation and re-examination of the taxonomy of some species.

The goal of this paper is the taxonomic reassessment of the eyeless *Cicurina* species occurring south of Austin in southern Travis County, Texas. The objectives are three-fold: *1*, to document and compare the morphology of female genitalia of three named species: *Cicurina bandida* Gertsch, *Cicurina cueva* Gertsch and *Cicurina reyesi* Gertsch (based on these comparisons, we propose new synonyms); *2*, to provide the first description of the male of *C. bandida*; *3*, to discuss the difficult marriage between taxonomy and some conservation principles, particularly for cave invertebrates. This discussion is prompted by our decision to place *C. cueva* in synonymy with *C. bandida*, which is controversial given that *C. cueva* has been proposed as a candidate for listing as an endangered species.

Materials and methods

In 1992, Gertsch examined all eyeless *Cicurina* specimens known to that time. In southern Travis County, a total of nine adult females collected from five different caves were known, from which he described three species: *Cicurina bandida* (Bandit Cave (type locality) and Ireland's Cave), *Cicurina cueva* (Cave X (type locality) and Flint Ridge Cave), and *Cicurina reyesi* (Airman's Cave). Gertsch apparently knew only the county in which the eyeless *Cicurina* were collected and was not aware of the precise cave locations (J. Reddell personal communication). This allowed him to maintain objectivity in delimiting species because geographically proximate caves have more chances to harbor the same species than caves that are distant.

Study area

Mapping the five caves allowed us to determine the geographical region as a basis for investigation and taxonomic reassessment of the three species (Fig. 1). These caves/localities are found in Travis County, south of the Colorado River, in an

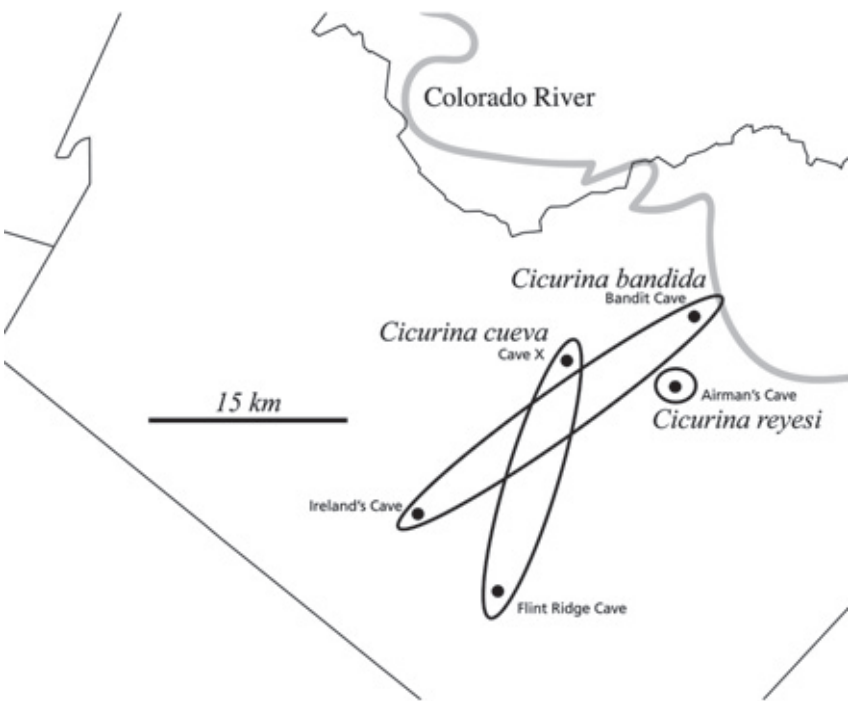


Fig. 1. Distribution of eyeless *Cicurina* species in southern Travis county, following Gertsch (1992).

oblique north to south area of ~30 km × 10 km, which includes ~500 caves and sinkholes (Figs 1, 3). Most caves containing eyeless *Cicurina* are formed in the Edwards Group limestones. Exposures of the Edwards Group can be divided into several units based on their geographical distribution and hydrogeologic affiliation (Woodruff and Abbott 1979). These units include the Edwards Plateau Aquifer, which covers all or parts of more than 20 counties in central Texas, and the Edwards Balcones Fault Zone Aquifer, which stretches 500 km from near Waco south and west through San Antonio to the Mexican Border. The Edwards Balcones Fault Zone Aquifer is further subdivided into the San Antonio, Barton Springs, and Northern Segments based on groundwater movement. The five caves mentioned above occur within the northern quarter of the Barton Springs Segment, which is bounded by essentially non-cavernous rocks to the east and west and by the Colorado River to the north. Karst terrain is continuous to the south, although a groundwater divide distinguishes the San Antonio Segment from the Barton Springs Segment in northern Hays County, ~30 km to the south of the study area. There are several species of eyeless *Cicurina* known from north of the Colorado River in Travis County, but the illustrations provided by Gertsch (1992) indicate that these taxa clearly belong to different species. To the south, the situation is not as clear with three species (*Cicurina ubicki* Gertsch, *Cicurina russelli* Gertsch, *Cicurina ezelli* Gertsch) described from Hays County, the next adjacent political division. These species are somewhat similar to one another and to the species of Travis County, but their identity is not easily determined, and this problem can only be addressed in a further full study. For this reason, we limit the scope of the present study to the species described from Travis County, south of the Colorado River.

Material examined

The known material was divided as follows: *1*, the specimens available to Gertsch (1992) collected by J. Reddell and his collaborators now curated at the AMNH (American Museum of Natural History, New York, USA) or the TMM (Texas Memorial Museum, Austin, Texas, USA); *2*, the material collected after 1992 by J. Reddell and collaborators, curated at the TMM (Texas Memorial Museum, Austin, Texas, USA); a female curated in the private collection of James C. Cokendolpher (JCC), a female collected in Airman's cave (TX-092) used in the genetic assessment of *Cicurina madla* Gertsch (see Paquin and Hedin 2004), and the material collected by the first author and his collaborators for the genetic assessment of the *Cicurina* species of southern Travis county curated in the Collection Paquin-Dupérré (CPAD, Shefford, Québec, Canada). The prefix TX-, CIC-, and TMM found in the material data refer to individual specimen numbers.

Specimens were examined in 70–100% ethanol under a SMZ-U Nikon dissection microscope (Nikon, Tokyo, Japan). A Nikon Coolpix 950 digital camera attached to the microscope was used to photograph all structures to be illustrated. The digital photo was then used to trace proportions and the illustration was detailed and shaded by referring back to the structure viewed under the microscope. Female genitalia were excised using a sharp entomological needle and transferred to lactic acid to clear non-chitinous tissues. A temporary lactic acid mount was used to examine the genitalia under an AmScope XSG Series T-500 compound microscope (AmScope, Chino, CA, USA), where genitalia were photographed and illustrated as explained above. All measurements are expressed in millimetres and were made using an ocular micrometer. The measurements given represent the extremes of the observed variation. All available specimens were measured. Halogen lighting conditions were used to view specimens for colour descriptions using traditional colour names. Subsequently, we matched the colour of the specimen to a reference Pantone chart (Pantone Formula Guide, solid matte; Pantone Inc., Carlstadt, NJ, USA) and added the colour code to the description. General morphological terminology follows Ubick *et al*. (2005) and terminology for genitalia follows Bennett (1992, 2005) and Cokendolpher (2004). However, we are refining the spermathecal base definition as follows: the spermathecal base includes all structures located beyond the external aperture of the dictynoid pore and is sometimes divided into two distinct regions: *1*, the primary lobe characterised by the presence of the internal portion of the dictynoid pore, the fertilisation canal and the fertilisation duct attachment (Fig. 4*d*, *e*), and *2*, the secondary lobe that may be attached to the primary lobe, but lacks the structures previously mentioned.

Latitudes and longitudes are not provided and exact cave locations are purposely vague to preserve confidentiality. In the Taxonomy section below, we have only included references to peer reviewed literature (i.e. the synonymy sections do not include references to 'grey' literature, reports etc.).

Results

Type material

The types of *C. bandida*, *C. cueva* and *C. reyesi* were studied and the female genitalia reillustrated (Fig. 2). The holotype vial of *C. reyesi* also contained the damaged male mentioned by Gertsch (but not formally described). Comparisons of the new illustrations and those of Gertsch allow us to recognise that they are of the same specimen (Fig. 2). Gertsch (1992) provided a dorsal view of the spermatheca for *C. bandida* (fig. 80 of Gertsch), a view that could only be obtained with a dissection of the genitalia. Surprisingly, the specimen that bears the holotype label of *C. bandida* was not dissected. This indicates that some illustrations of Gertsch (1992) are not of the holotype, but of other specimens. There are more differences between the new illustration of the type of *C. reyesi* and the Gertsch illustration, especially the distance between the copulatory ducts (see arrows; Fig. 2). This is most likely an artefact of temporary mounting: the tissue between the two halves of the spermathecae is rather soft and could be easily distorted with the addition of a coverslip during preparation.

Additional material

In addition to the type material (three females and one male paratype), we were able to study the non-type material that Gertsch examined (seven females) and the material collected after his 1992 publication, consisting of 16 females and two males (see details in the Taxonomy section below). In total, all 26 females and three males were studied; illustrations of the genitalia of all females are provided (Fig. 3) and the male from Flint Ridge Cave is described and illustrated (Fig. 4).

Taxonomy

Family **DICTYNIDAE** O. Pickard-Cambridge

Genus ***Cicurina*** Menge

Subgenus ***Cicurella*** Chamberlin & Ivie

Diagnosis

Members of the subgenus *Cicurella* can be distinguished from other *Cicurina* by combination of the following characters: eight, six, or no eyes. In a few troglobitic species the eyes are reduced to remnant pale spots (six, four) that are difficult to properly assign to a number, but vary from six eyes to totally absent. Female epigynum with single atrium, large, bare to partly filled by dorsal plate; bursa variable, not fused (eyeless species) to fused (eyed species and *C. wiltoni* Gertsch); copulatory ducts rounded, simple, never exceedingly convoluted, slightly constricted and enlarging at the location of the primary pores; stalk rather short joining the spermathecal base upon the aperture of the dictynoid pore; spermathecal base with primary lobe present, sometimes constricted, secondary lobe absent in most species (except *C. coahuila* Gertsch, *C. holsingeri* Gertsch and *C. wiltoni*). Male genital bulb with apex of tegulum notched (Fig. 4*f*); simple retrolateral tibial apophysis (Fig. 4*g*).

Cicurina (Cicurella) bandida Gertsch

(Figs 2, 3, 4*a–g*, 5*a*)

Cicurina bandida Gertsch, 1992: 107, figs 79–80. – Jackman, 1997: 162, 171.

Cicurina cueva Gertsch, 1992: 107, chart 2, figs 81–82, **syn. nov.** – Jackman, 1997: 162, 171; Reddell, 2005: 557.

Cicurina reyesi Gertsch, 1992: 107, figs 85–86, **syn. nov.** – Jackman, 1997: 162; Paquin & Hedin, 2004: 3243–3245, 3254.

Material examined

Holotype. ♀ *Cicurina bandida* Gertsch, 'Texas, Travis County, Bandit Cave, May 26 1966, J. Reddell and J. Fish colls.' (AMNH).

Holotype. ♀ *Cicurina cueva* Gertsch, 'Texas, Travis County, Cave X, 6 miles south of Austin, Sept., 1962, 200 feet inside cave, Bill Bell and Sharon Woosley 1966.' (AMNH).

Holotype. ♀ *Cicurina reyesi* Gertsch, 'Texas, Travis County, Airman's Cave, 3 Sept. 1989, J. Reddell, M. Reyes.' (AMNH).

Paratypes. **USA: Texas:** 1♂, 5 juveniles. *Cicurina reyesi* Gertsch, 'Texas, Travis County, Airman's Cave, 3 Sept. 1989, J. Reddell, M. Reyes.' (AMNH).

Additional material. **USA: Texas: Travis Co.: Airmans Cave:** 1♀ [TX-092] (CPAD); 1♀ [CIC-1049] (CPAD). **Blowing Sink:** 1♀ [CIC-1534] (TMM). **Driskill Cave:** 1♀ [CIC-1512] (TMM); 1♂ [CIC-1511] (TMM). **Cave X:** 1♀ [TMM #11788] (TMM); 1♀ [TMM #11786] (TMM); 1♀ [CIC-801] (CPAD); 1♀ [CIC-1516] (JCC); 1♀ [CIC-1010] (CPAD). **Flint Ridge Cave:** 1♀ [TMM #11792] (TMM); 1♀ [TMM #11787] (TMM); 1♂ [CIC-1026] (CPAD). **Get Down Cave:** 2♀ [CIC-1041, 1042] (CPAD). **Ireland's Cave:** 1♀ [TMM #11790] (TMM); 2♀ [TMM #11785], (TMM); 3♀ [CIC-1294, 1295, 1296] (CPAD). **Lost Gold Cave:** 1♀

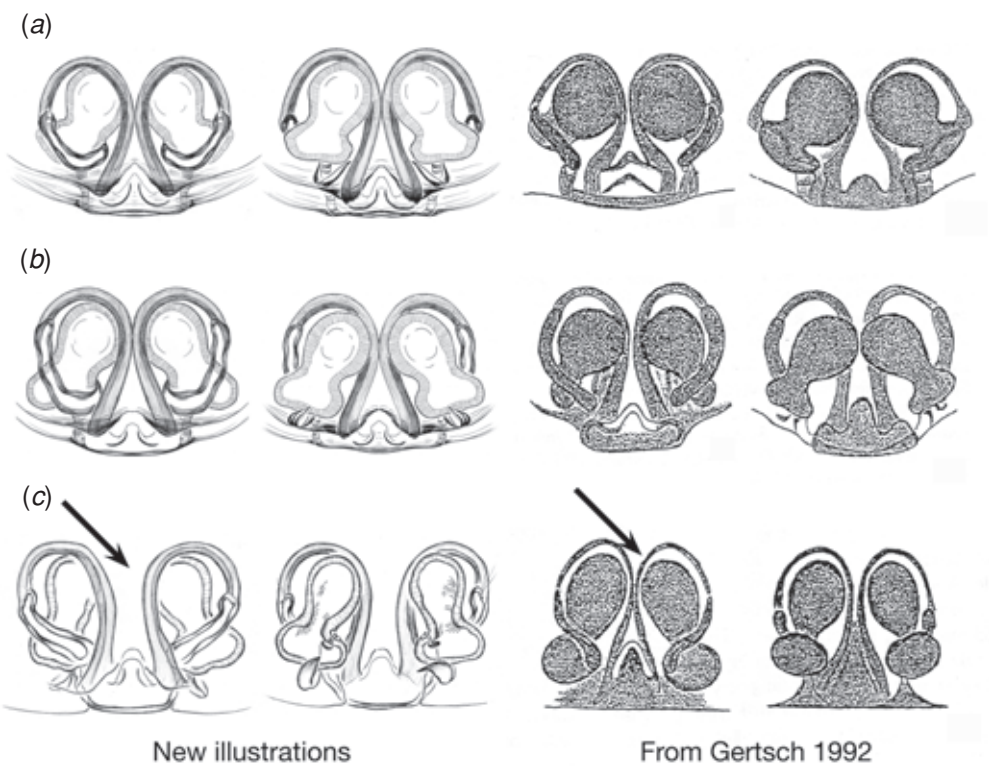


Fig. 2. Illustrations of type specimen genitalia (ventral and dorsal views) of *a*, *Cicurina bandida*; *b*, *C. cueva* and *c*, *C. reyesi* compared with the illustrations given by Gertsch (1992) as representative of these species. Gertsch (1992) illustrations are reproduced here with permission of the Texas Memorial Museum Speleological Monographs editor.

[CIC-796] (CPAD). **Lost Oasis Cave:** 1♀ [CIC-1119] (CPAD). **Maple Run Cave:** 1♀ [CIC-1336] (CPAD).

Diagnosis

Females of *Cicurina bandida* can be distinguished from other species in the subgenus *Cicurella* by a combination of the following characters: eyeless, bursa not enlarged nor fused; copulatory ducts rounded never reaching more than twice their width over or under primary lobe apex; primary pores present at enlargement, never situated basally in relation to primary lobe; primary lobe hat-shaped. Males differ from other known *Cicurella* by a combination of the following characters: eyeless, rounded retrolateral tibial apophysis (RTA), P'/TA' ratio of 0.4, tegular apophysis (TA) rugose.

Description (based on alcohol specimens)

Female (n = 26)

Total length: 4.00–6.12; carapace length: 1.07–3.06; carapace width: 1.10–2.25; carapace smooth, shiny, off white (7506M) to light yellow (7508M); scattered setae along midline and radiating lines; cephalic region darker, orange-brown (145M), eyes absent (Fig. 4*a*). Chelicerae light yellow-orange (131M) to orange-brown (145M), one larger seta situated meso-apically, series of long curved setae near fangs; emboss off white (7500) (Fig. 4*c*); cheliceral teeth and denticles variable often not symmetrical, promargin with 1–2 teeth and 1–2 small denticles; retromargin with 4–6 teeth and 2–3 denticles (Fig. 4*b*). Sternum orange-brown (145M). Legs off white (7506M) metatarsus and tarsus darker (7508M). Palpus light orange-brown (472M), with one claw. Leg I total length: 5.49–10.91; femur: 1.44–3.15; patella: 0.63–1.08; tibia: 1.35–2.79; metatarsus: 1.26–2.43; tarsus: 0.81–1.46. Leg IV: total length: 6.64–11.97; femur: 1.71–3.15; patella: 0.63–1.08; tibia: 1.53–2.88; metatarsus: 1.75–3.15; tarsus: 0.99–1.71. Claw IV total length: 0.165–0.246. Abdomen off white (7506M) to light grey (cool grey 3M) densely covered in long semi-erect setae. Epigynum length: 0.25–0.39; ventral epigynal plate with inverse V- to U- shaped slit; dorsal plate triangular extending into atrium, nearly reaching ventral plate, going over or under. Atrium (A) simple; bursa not enlarged, nor fused; copulatory ducts (CD) often touching at midline to slightly separated, rounded, copulatory duct constriction with (2–4) primary pores (PPo) located dorsally; stalk (St) straight or recurved, obliquely oriented, joining spermathecal base upon aperture of dictynoid pore (DPo); primary lobe (PL) with large internal dictynoid pore; secondary lobe (SL) absent; fertilisation canal (FC) positioned outwardly from dictynoid pore; fertilisation duct (FD) internally attached to primary lobe base (Fig. 4*e*).

Male (n = 3)

Total length: 3.06–3.10; carapace length: 1.35–1.55; carapace width: 1.08–1.16. Overall coloration as in female; carapace smooth, shiny, scattered setae along midline and median line; eyes absent; chelicerae with one larger seta situated meso-apically, series of long curved setae near fangs; emboss present; promargin with 1–2 teeth and 1–2 denticles; retromargin with 2–3 teeth and 3–6 denticles. Leg I total length: 4.70–5.24; femur: 1.30–1.44; patella: 0.50–0.54; tibia: 1.10–1.26; metatarsus: 1.10–1.17; tarsus: 0.70–0.83. Leg IV: total length: 5.63–5.70; femur: 1.50–1.56; patella: 0.50–0.54; tibia: 1.28–1.26; metatarsus: 1.44–1.45; tarsus: 0.85–0.90. Claw IV total length: 0.088–0.11. Abdomen densely covered in long semi-erect setae. Palpus length: 0.73–0.76; apex of cymbium 1.6× longer than wide (Fig. 4*f*); genital bulb with tegular apophysis (TA) rugose with 8–9 wrinkles before widening proximally into a small heavily sclerotised plate; proximal end (P) short, slim, curved and pointed (Fig. 4*f*); ratio P'\TA' = 0.40 (Fig. 4*g*); retrolateral tibial apophysis (RTA) apical end rounded, simple, only one fold and bearing 3–5 setae; spur (Spu) straight to slightly triangular (Fig. 4*g*).

Variation

Both sexes show variation in size. Female genitalia show variation in the orientation and degree of curvature of the spermathecal stalk, from recurved to straight. The primary lobe of the spermathecae shows only minor variation. Male palps show very little variation, only minor differences in the apex length of the cymbium.

Distribution

Central Texas, Travis County, south of the Colorado River to northern Hays County. The species is known from the caves located in a small area of ~30 km × 10 km (see Fig. 3).

Habitat

Known only from caves, most often found under rocks.

Remarks

Cicurina bandida, *C. reyesi* and *C. cueva* were all described in Gertsch (1992). All three species were named on the same page and none of these names have been used extensively in subsequent publications. Nomenclatural stability is equally favoured in selecting any of these names and therefore, the only objective criterion that applies is precedence (in this case, line priority). *Cicurina bandida* is, therefore, the name to retain for this species. The latitudes and longitudes that are given on the holotype labels were purposely not listed here to keep the localities confidential. Gertsch (1992) indicated that two females he examined were aberrant. These are reported here under TMM #11 785 and 11 787 and indicated by arrows on Fig. 3. Sample #11 785 from Ireland's Cave, however, does not contain a single female as indicated by Gertsch, but two. As it is impossible to distinguish which of the two he considered aberrant, we indicate both females by arrows. Gertsch (1992) reported an additional female for *C. bandida* collected in Bandit Cave (data: Bandit Cave, 1 female, 27.v.1963 J. Reddell and B. Frank). This specimen has been located and examined (TMM #11 784), but clearly does not belong to *C. bandida*. This problem will be treated elsewhere.

Discussion

Taxonomy, species limits and synonymy

There are inherent difficulties in defining species based on a limited number of specimens, especially when intraspecific variation is prevalent. In the case of eyeless *Cicurina*, the

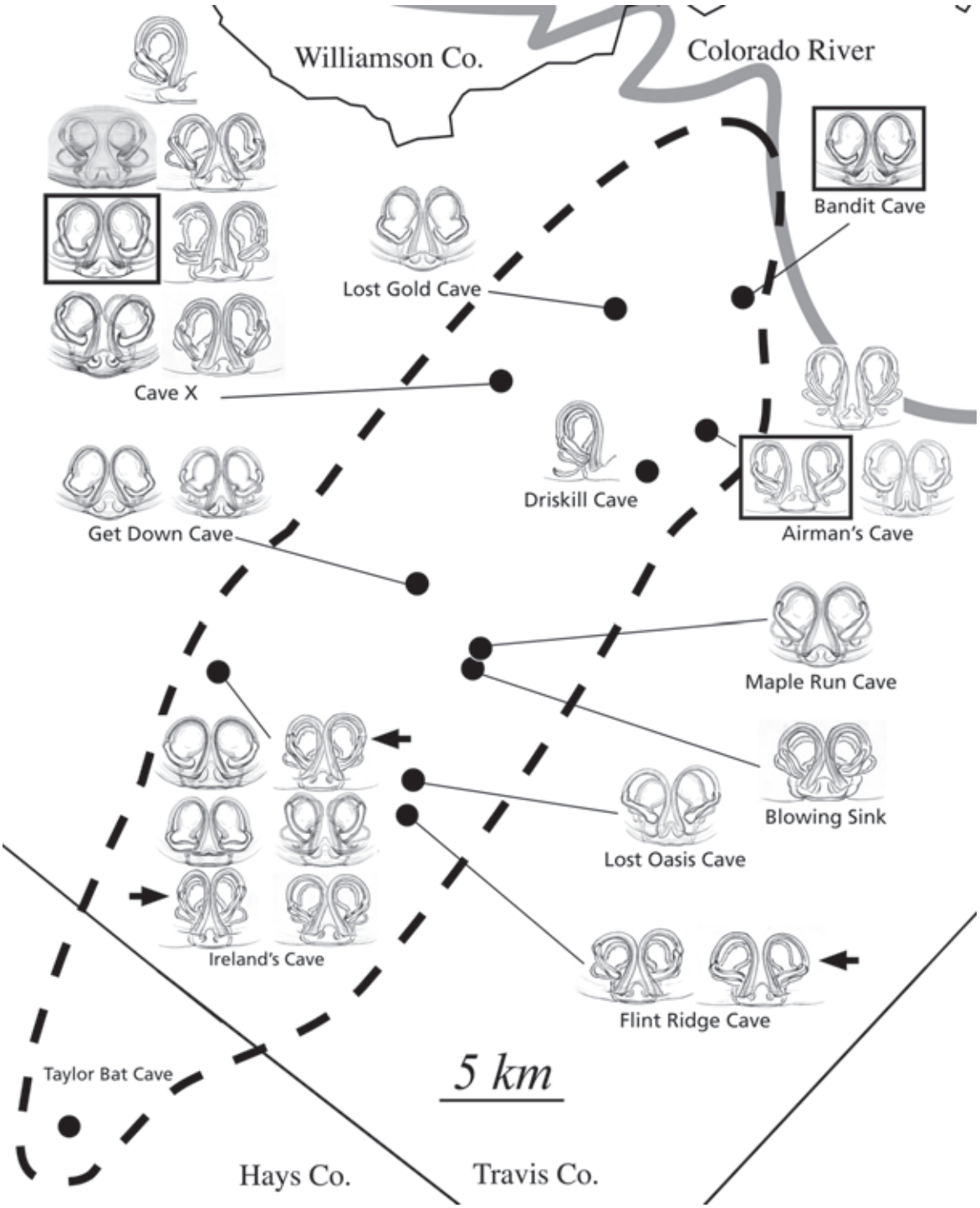


Fig. 3. Variability of the female genitalia of all known *Cicurina bandida* collected in the study area. In some cases, several adults are known from a single cave. The black square boxes refer to the type specimens designated by Gertsch. The black arrows indicate specimens that Gertsch considered aberrant. The dashed line represents the hypothesised distribution of *C. bandida*. Partial illustrations are due to damaged specimens.

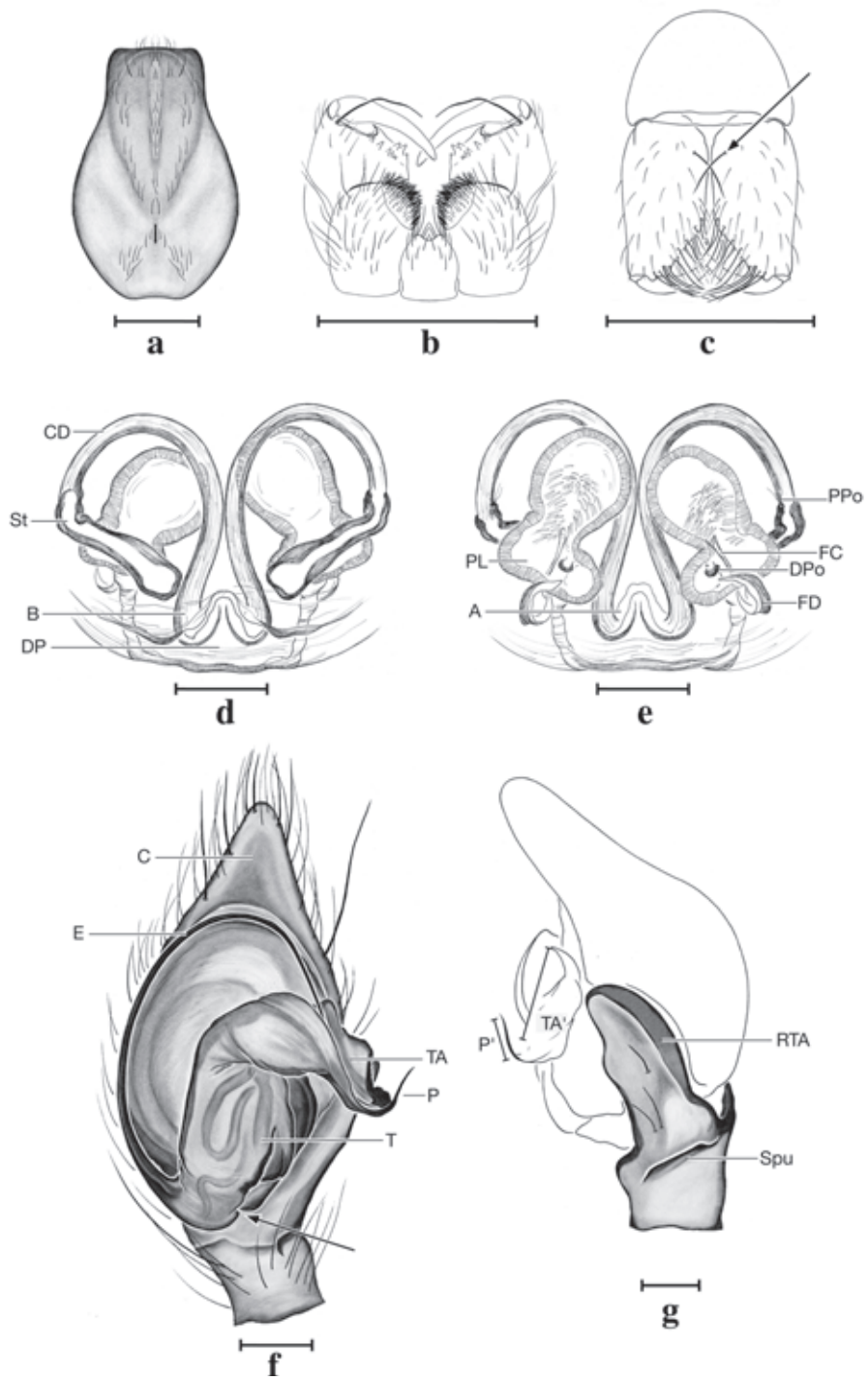


Fig. 4. *Cicurina bandida. a*, female (from Lost Oasis Cave) cephalothorax, dorsal view; *b*, female chelicerae, ventral view; *c*, female cephalothorax, frontal view; *d*, cleared epigynum, ventral view; *e*, cleared epigynum, dorsal view; *f*, male (from Flint Ridge Cave) palpus, ventral view; *g*, male palpus, lateral view. Scale bars: *a–c* = 1.0 mm, d–g = 0.1 mm. Abbreviations used: A, atrium; B, bursa; C, cymbium; CD, copulatory ducts; DP, dorsal plate; DPo, dictynoid pore; E, embolus; FC, fertilisation canal; FD, fertilisation duct; P, proximal end of TA; P', proximal end length; PL, primary lobe; PPo, primary pore; RTA, retrolateral tibial apophysis; Spu, spur; St, stalk; TA, tegular apophysis; TA', tegular apophysis length; T, tegulum; VP, ventral plate.

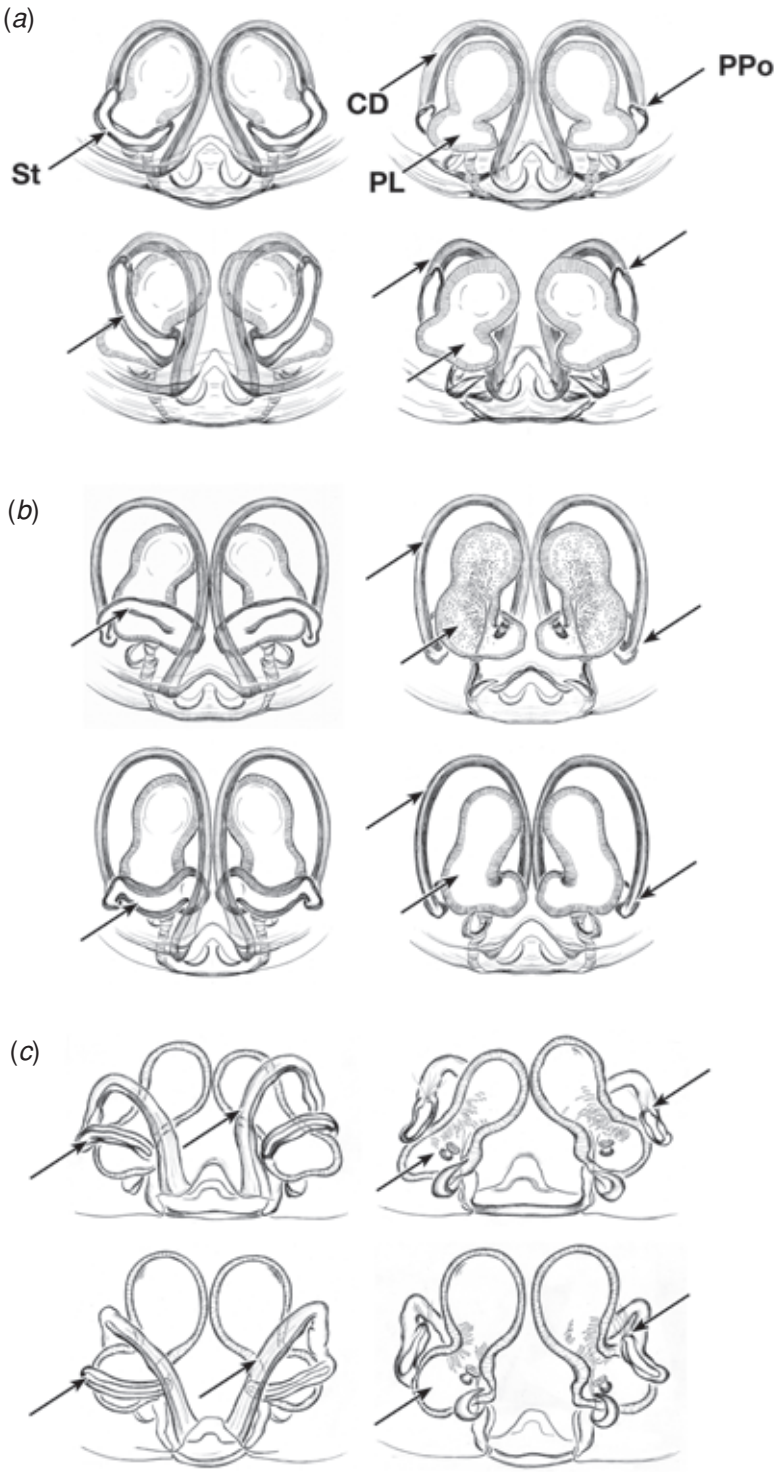


Fig. 5. Illustration of intra- and interspecific genitalic variation, ventral and dorsal views. From top to bottom: *a*, *Cicurina bandida* [Getdown Cave (CIC-1042) and Ireland's Cave (CIC-1295)]; *b*, *Cicurina* cf. *travisae* [McDonald's Cave (CIC-1099, CIC-1102)]; *c*, *Cicurina* cf. *browni* [Little Demon Cave (CIC-1220) and Temple of Thor Cave (CIC-1230)]. Abbreviations used: CD, copulatory ducts; PPo, primary pore; PL, primary lobe; St, stalk.

unusual variability created major confusion in determining species boundaries. Gertsch defined his species on the premise that only one troglobitic *Cicurina* species could be found in a given cave; this premise is supported by available data for cave-dwelling *Cicurina*, and is also generally true for cave-dwelling arthropods. The known cases of congeneric *Cicurina* species found in the same cave involve a surface species in contact with a derived troglobitic form. For example, *C. varians* is a species commonly found in most Texas caves where it coexists with troglobitic *Cicurina* species. These represent cases for which contact within a genus occurs after speciation (Barr and Holsinger 1985; Sbordoni *et al*. 2000) or involves taxa that are not sister-species. Evidence for the coexistence of troglobitic sister-species, suggesting sympatric speciation resulting in multiple species occurring in the same cave, still remains to be found and demonstrated.

The examination of a larger series of specimens from type localities and nearby caves (26 females in total, Fig. 3) allows clarification of the taxonomic situation. First, the larger series reveals important *intra* cave variability (e.g. Cave X, Get Down Cave, Ireland's Cave, Flint Ridge Cave, and Airmans Cave). No adult females found within the same cave are identical; genitalia vary from one individual to another and sometimes even show slight asymmetry within an individual. Second, the variation observed within a given cave is comparable to the variation found among caves, including caves from which only single females are known. Third, the established variation does not support the distinctiveness of species as hypothesised by Gertsch. Differences among type specimens (square boxes, Fig. 3) are no greater than intraspecific variability observed elsewhere. The three species described by Gertsch fall within the range of variation established with this larger series of specimens. A morphological interpretation that admits little or no variation would assign 'species' to many morphs illustrated in Fig. 3. This would, in many cases, conflict with the single eyeless species per cave concept because multiple specimens that display variation were found in the same cave. To support the validity of multiple species in the study area, a given morphotype would have to be at least consistent within the same cave, or shared across adjacent caves. The mapping of the genitalia (Fig. 3) clearly shows that there is no consistent relationship between the different morphs and their distributions. This suggests the existence of a single, somewhat variable species in the study area.

Given Gertschs' interpretation of genitalic variation, it is not surprising that he concluded that some specimens were aberrant. The re-examination of these aberrant specimens (identified on Fig. 3 by arrows) shows that the variability is comparable to that observed in the series, and that they belong to *C. bandida*. Although female morphology varies within and between cave populations of *C. bandida*, the extent of this variation is much less than that observed between clearly distinct species identified by gaps in the morphological ranges of variation. For example, Fig. 5*a* shows two extreme morphs of *C. bandida*, compared with two other eyeless species referred as *Cicurina* cf. *travisae* Gertsch (Fig. 5*b*) and *Cicurina* cf. *browni* Gertsch (Fig. 5*c*). These three morphologically defined species are easily distinguished by the combination of several characters (see below), but each species nonetheless shows intraspecific variability. In particular, the shape of the spermathecal stalk (St) varies, even displaying variation from individuals collected in the same cave (Fig. 5*b*). The following combination of characters nonetheless allows the distinction of the species: *1*, the shape and curvature of the copulatory ducts (CD); *2*, the shape and orientation of the primary lobe (PL); *3*, the constriction of the primary lobe (PL); *4*, the spatial relationships between the primary lobe (PL) and the copulatory ducts + spermathecal stalk (CD + St), and *5*, the position of the primary pores (Ppo).

Another line of evidence to support the synonymy is provided by the cohesive geographical distribution proposed here for the species. Paquin and Hedin (2004) used molecular evidence to show that distributions of eyeless *Cicurina* species from the vicinity of San Antonio, Texas are contiguous and do not overlap. The mapping of Gertsch's data following the original species limits (Fig. 1) reveals suspicious overlapping distributions for two species, while *Cicurina reyesi* was a single cave endemic. The caves in the study area all belong to the Barton Springs Segment hydrological unit (Collins and Laubach 1990; Small *et al*. 1996). The physical proximity of the type localities (Figs 1 and 3) and the geological homogeneity of this small area also support the single species hypothesis.

A third source of support for the synonymy is provided by the males collected in the study area. The male palps of three specimens (Flint Ridge Cave, Airmans Cave and Driskill Cave) were carefully studied. All palps were essentially identical (like Fig. 4*f*–g), and did not justify individual illustrations. Male genitalia of eyeless *Cicurina* appear less variable within species than female genitalia, and therefore they constitute a valuable and independent tool for the assessment of species limits. Comparison of the male of *C. bandida* with undescribed males of other eyeless *Cicurina* species reveals clear differences. However, the extreme rarity of eyeless males is a serious obstacle to propose their use as a practical option for all taxa.

Conservation, cave fauna and taxonomy

A fundamental principle of taxonomy is that species represent scientific hypotheses that can be tested (Agnarsson and Kuntner 2007) via new data, larger samples, new types of analyses, or alternative species criteria. Species considered for special conservation status because of rarity and/or high dependence on threatened habitats are not immune to these principles. The criterion of rarity is a double-edged sword because it may also imply that very few specimens were available to the taxonomist who defined a given species. Therefore, it is not surprising that the gathering of additional data often leads to different species hypotheses, especially when important intraspecific variation is involved.

Modifications of original species hypotheses—either by splitting or proposing synonymies—lead to conflicts as these new scientific hypotheses are either perceived as favourable or negative for conservation. In the present case, *Cicurina cueva* was a candidate for federal listing as an endangered species because it only occurred in two caves, one of which was likely be subject to ecological disturbances induced by modifications to an existing road. The establishment of a legal status for a spider inhabiting these caves would provide a tool to contest, limit and even stop a project that might alter the integrity of these habitats. Based on additional material, the present study

led to the synonymy of this name (along with *C. reyesi*) under *C. bandida*. An interpretation of this taxonomic act could be that *C. bandida* is now known from several localities and therefore, is not rare enough to deserve special conservation attention or status. However, the species hypothesis presented here does not substantially change the original distributional range (compare Figs 1 and 3), nor decrease its global rarity: *Cicurina bandida* was not considered a single cave endemic, nor was *C. cueva*. We question the basis for arguments that consider this species (despite a name change) not rare enough to deserve protection or an enhanced conservation status. The present hypothesis states that *C. bandida* is found in the caves of southern Travis County and restricted to a region of ~30 km × 10 km. The entire distribution of the species is minute and constitutes a clear case of narrow endemism in an urban area under severe development pressure.

The dynamic nature of knowledge acquisition can potentially conflict with conservation principles that are statically embedded in a species name or in the evaluation of rarity at a given time. For any taxon, the robustness of knowledge is proportional to the attention that it has received; for many troglobites, the lack of sufficient data results in weak species hypotheses. In conservation debates, poorly defined species and inadequate sampling are easy targets to use to question the relevance of either development or conservation approaches. The conflicts generated by the modification of an initial species hypothesis (or distribution) would be greatly minimised by the acquisition of sound data *before* the establishment of conservation or development strategies. Shrader-Frechette and McCoy (1999) reported that most cases of controversy in conservation biology arise from incomplete and uncertain scientific data. For taxonomic studies involving endangered species, Berg and Berg (2000) favour the *status quo* when not enough information is available because of the risk of 'losing' species with inadequate taxonomic changes. While we could not agree more with such virtuous comments, one could also ask from which objective point enough data will be considered sufficient. It will always be possible to argue that not enough evidence is gathered to conclude anything, especially in controversial political contexts. Mulvey and Lydeard (2000) contest that a situation involving numerous, weakly defined species is not a more enviable option. In the case of eyeless *Cicurina*, there is an obvious bias in the existing taxonomy of the group created by unrecognised morphological variability and the rarity of adults that have limited sound species hypotheses.

The modification of species hypotheses related to eyeless *Cicurina* is fertile ground for argumentation that largely favours advocacy rather than objective scientific discussion (Brown 2000; Mulvey and Lydeard 2000). We would like to share the optimism expressed by Shrader-Frechette and McCoy (1999) who suggested that the protection of human and environmental welfare should play a major role under biological uncertainty or by Noss (2007) who points out that 'good values' should play an important part in decision making for conservation. Unfortunately, in the case of the difficulties surrounding eyeless *Cicurina* in a context where financial profit and development will obviously conflict with conservation goals, the recommendations of these prior authors are difficult to apply. As pointed out by Shrader-Frechette and McCoy (1999), humans benefit from both development and conservation, thus deciding which of these serves the best interests remains arguable.

In the process of species listing, budget limitations, public opinion, threats to a particular habitat (real or not), and various political considerations largely influence the final decision, but remain subjective criteria. In contrast, well supported biological hypotheses such as the synonymy reported here (including the important number of specimens studied, sound geographical data, and evidence from both male and female morphology) leaves little room for optional interpretations and debates. We claim that sound taxonomy and biological data should be the prevailing level of information in the attribution of conservation status.

Despite important efforts carried out in Texas over the last 40 years, particularly the remarkable inventorial work of James Reddell and his collaborators (see Reddell 1994), most cave-limited invertebrates are still insufficiently known. Several factors help explain this situation: *1*, the physical difficulty of sampling in caves; *2*, rarity of specimens; *3*, multiple problems related to cave access; *4*, political controversy related to endangered species and conservation debates, and *5*, legal considerations that limit the sampling. In addition, the numerous associations and political entities involved with caves, cave access and conservation aspects, are playing an important role by either providing or refusing access to data or caves, depending on their agendas and acquaintances. To a certain extent, such practices are limiting the access to the data needed to answer scientific questions. The difficulties listed above and the lack of scientific objectivity induced by the different political groups involved is not attracting taxonomists and systematists to a research area that otherwise, badly needs expertise.

The case of eyeless *Cicurina* highlights an interesting combination of problems related to the listing of endangered species, taxonomic inadequacy, political conflicts and application of conservation principles. The present paper reports a synonymy of eyeless *Cicurina*, elucidated with a new and important collection effort and the use of complementary lines of evidence. It is likely that comparable conservation/development dilemmas involving listed and non-listed troglobites will occur again, as such endemic species are found throughout areas that are subject to development in central Texas. Developing a sound taxonomic framework should be the first goal accomplished in developing conservation strategies and achieving long-term objectives.

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