

A NEW *GLYPHOPSYCHE* BANKS (TRICHOPTERA: LIMNEPHILIDAE)  
FROM SOUTHEASTERN TENNESSEE

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**Abstract.**—*Glyphopsyche sequatchie* Etnier and Hix, new species, is described from Owen Spring Branch, Sequatchie, Marion County, Tennessee. The male differs from the other two species in the genus, *G. irrorata* and *G. missouri*, in having far more elaborate genitalia and in having two rather than three patches of black spines on the dorsum of segment 8. Adult females, pupae, and larvae are also easily separable from these species. A second population of *Glyphopsyche*, known from two larvae collected on 9 May 1998 from Martin Spring run, 12.0 air miles WNW of the type locality, was confirmed as representing the same species based on adults reared in November 1998. *Glyphopsyche* larvae have not been found in other spring-type habitats in the area, and *G. sequatchie* has been recommended for protected status under the Endangered Species Act.

**Key Words:** Trichoptera, Limnephilidae, *Glyphopsyche*, Tennessee, spring habitats, endangered species

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On 21 March 1994, the junior author collected a single limnephilid larva from Owen Spring Branch in Sequatchie, Marion County, Tennessee, that appeared to represent the distinctive genus *Glyphopsyche* Banks (Trichoptera: Limnephilidae). As this genus is currently known to contain only the boreal *G. irrorata* (F.) and *G. missouri* Ross, a species restricted to Meramec Springs, St. James, Phelps County, Missouri, the find created considerable excitement. We subsequently reared numerous adults from pupae and last instar larvae collected from Owen Spring Branch.

On 9 May 1998, the senior author collected two *Glyphopsyche* larvae from Martin Spring, 7620 Martin Springs Road, 12.0 air miles WNW of Owen Spring. Pupae/prepupae were collected from Martin Spring on 25 October 1998, and adults reared from these were found to be conspecific

with those from Owen Spring. These Tennessee *Glyphopsyche* differ trenchantly from the two nominal species in characteristics of the male and female genitalia, pupae, and larvae, and are described below as a new species.

***Glyphopsyche sequatchie* Etnier and Hix, new species**

(Figs. 1, 2)

**Types.**—Holotype ♂, Owen Spring Branch, Old Tennessee Highway 28, Sequatchie, Marion County, Tennessee, collected 27 September 1996, D. A. Etnier, emerged 31 October 1996; deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM). Allotype ♀, same data, emerged 11 December 1996 (USNM). Paratypes, all collected with the holotype: USNM, ♂, emerged 31 December 1996; Clemson Uni-

versity, ♂, emerged 11 November 1996; Illinois Natural History Survey, ♂, emerged 7 November 1996, ♀, emerged 14 January 1997; Royal Ontario Museum 27361, ♂, emerged 11 November 1996; California Academy of Sciences (Ex UT 7.447), ♂, emerged 31 December 1996; University of Tennessee 7.448, ♂, 2 mature ♀ pupae, preserved 13 January 1997. Larval sclerites and pupal exuviae are included in all of the type lots. Larvae collected at the type locality on 3 June 1995 have been deposited in all of the above repositories.

Additional specimens examined.—Martin Spring run, J. K. Kelly property, 7620 Martin Springs Road (just east of I-24, Martin Springs exit), Battle Creek system, Marion County, Tennessee: 9 May 1998, 2 larvae, UT 7.495; 25 October 1998, 16 pupae/prepupae, 14 of which emerged as winged adults or mature pupae that failed to complete the final ecdysis, 6–20 November 1998, 7 ♂, 7 ♀. A male and female (imago or mature pupa) have been deposited with each of the following: A. P. Nimmo collection, Carnegie Museum of Natural History, Marshall University, Ohio State University Museum of Biological Diversity, S. C. Harris collection, University of Minnesota, and UT 7.506.

Diagnosis.—Separable from males of both nominal species of *Glyphopsyche* in (1) having two rather than three patches of black spinules on the posterior margin of the eighth abdominal tergite (Fig. 1a); (2) having an elongate projection on the inferior appendage of segment 10 (Figs. 1a, b, 2a); (3) having three pairs of elongate sclerotized dorsal and intermediate processes (Figs. 1a, b, 2a) on segment 10 (versus 2 pairs of short processes); (4) having the length of the phallic parameres (Figs. 1c, d) more than twice the diameter of the phallus versus subequal to the diameter of the phallus; and (5) virtually lacking a partial crossvein between veins Sc and R1 at the cord (Fig. 2) versus with a crossvein extending from Rs more than halfway to Sc. Characters that appear to be diagnostic for the fe-

male, pupa, and larva appear in their descriptions.

Description.—*Adult male*: Length 18 mm. Head yellow with yellow warts slightly lighter in color than remainder of head. Setae on head yellow to light brown unless otherwise indicated. Two oval warts, each bearing about five setae, located between each lateral ocellus and anterior ocellus; two more linear warts, each bearing four or five setae, located slightly posterior and medial to lateral ocelli. Occiput with a pair of large, oval warts medially, each with about 15 setae, and another pair laterally behind eyes, each with about 20 dark brown setae. Labial and maxillary palpi yellow; length of middle (longest) segment of three-segmented maxillary palp subequal to diameter of eye. Antenna yellow at base and grading to black at tip, with about 60 segments. Antenna and palpi clothed with appressed brown setae. Front of head with two oval warts along inner margin of each eye, each with about 12 setae, and with a linear wart on each side of midline with about 20 setae. Labrum with a transverse cluster of setae across middle.

Thoracic sclerites and associated warts and setae yellow, with warts paler yellow. Legs yellow, grading gradually to brown distally on tarsi, except fore leg brown on tarsus, dorsal margin of tibia, and ventral margin of femur. All legs with fringes of yellow setae on coxae and with black spines forming two irregular rows on tibiae and two well defined rows on tarsi. Fore and middle femora each with a single black spine distally. Fore tibia (the following counts based on five males) with 4–7 black spines; middle tibia with 21–26 black spines; hind tibia lacking black spines on proximal third and with 12–14 black spines on distal two-thirds. Proximal (first) tarsal segment with 5–9 black spines on fore leg and 20–27 black spines on middle and hind legs. Second tarsal segment with 4, 12–20, and 10–15 black spines on fore, middle, and hind legs, respectively. Third tarsal segment with 3–4, 9–10, and 7–11 black

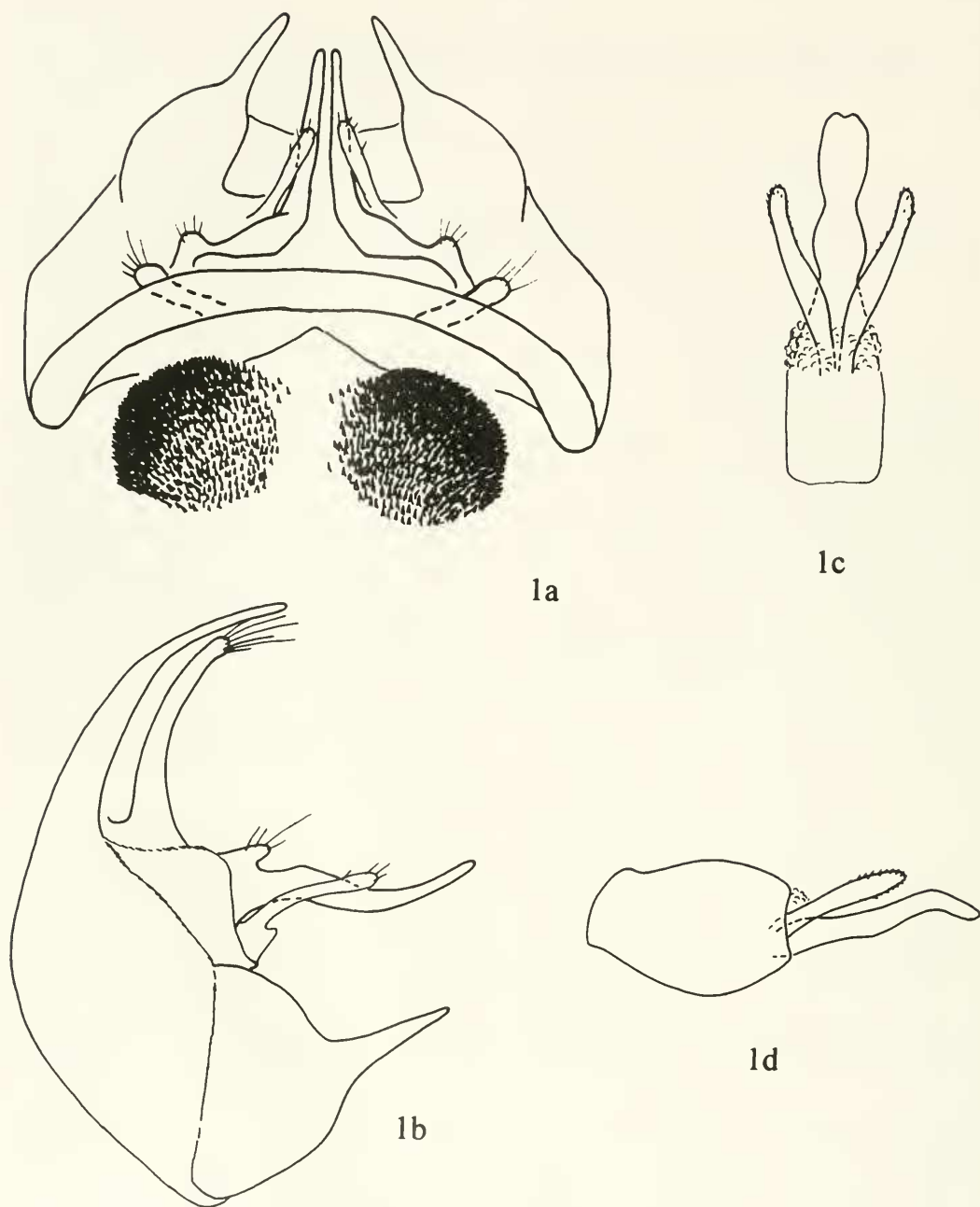


Fig. 1. *Glyphopsyche sequatchie*, male genitalia (setae on inferior appendage not shown). a, Dorsal view. b, Lateral view. c, Phallus, dorsal view. d, Phallus, ventral view.

spines on fore, middle, and hind legs, respectively. Fourth tarsal segment with 2 black spines on fore leg and with 4 black spines on middle and hind legs. Distal (fifth) tarsal segments lacking black spines.

Tibial spurs 1, 2, 2. Tibial spurs and tarsal claws yellow.

Fore wing clear yellow anterior to vein Rs, purple/brown at stigma, clothed with yellow setae anterior to vein Rs and with

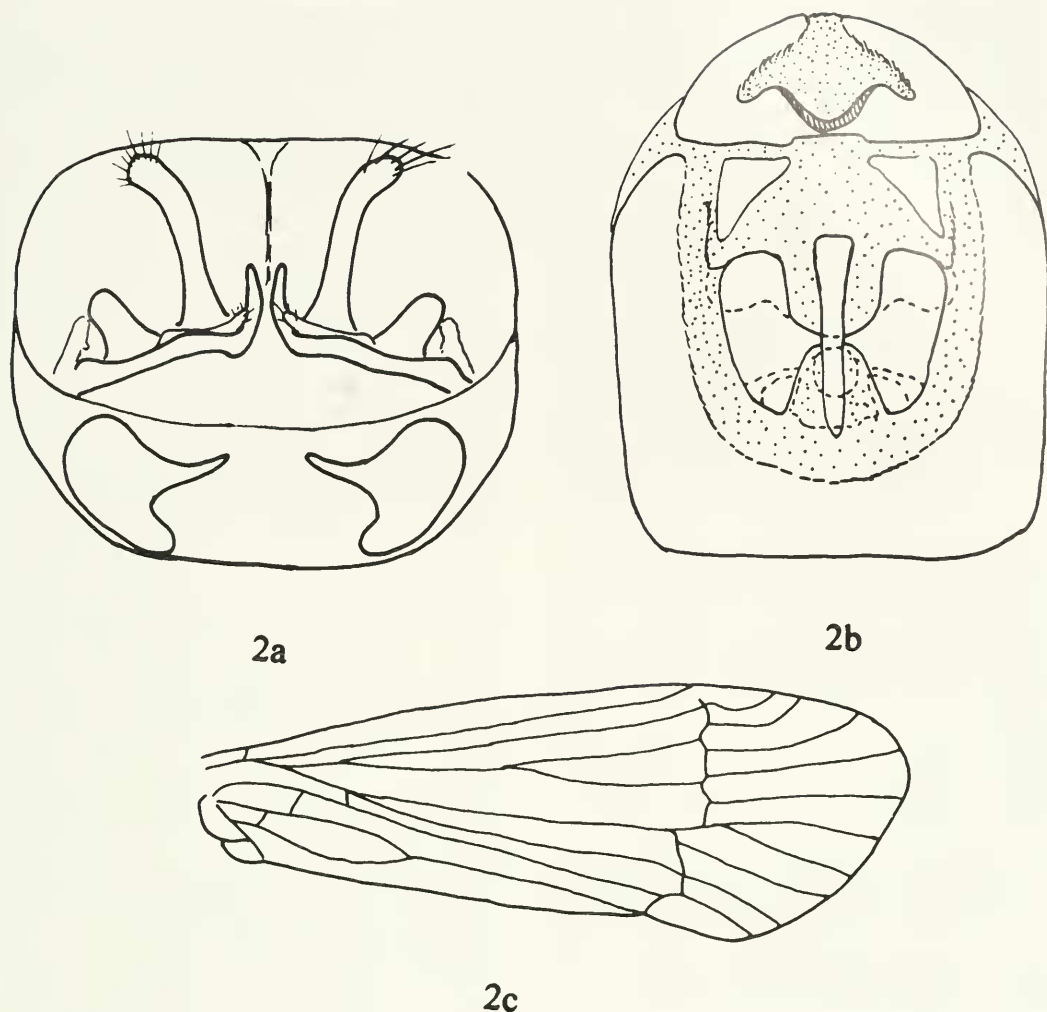


Fig. 2. *Glyphopsyche sequatchie*. a, Male genitalia, caudal view. b, Female genitalia, ventral view (setae not shown). c, Forewing.

dark brown setae elsewhere. Remainder of forewing irrorate purple/brown on yellow background, with darker pigment concentrated in anal area and just distal to cord in two cells between veins R4 and M1. Veins yellow, those distal to the cord with alternating dark markings, especially on R3–R5 and M1.

*Adult female:* Length 20 mm. Differs from male as follows: Head about one-third larger but eyes same size. Maxillary palpus five-segmented, with second and third segments longest, subequal, and about three-fourths of eye diameter. All legs yellow

basally and grading gradually to brown distally. Fore tibia (5 females counted) with 11–17 black spines (only 4–7 in male). Female genitalia (Fig. 2b) with median process on subgenital plate on ventral portion of segment VIII expanded at tip and with lateral processes rounded distally (in *Glyphopsyche irrorata* and *G. missouri* median process not expanded at tip, and lateral processes truncate distally (Ross 1944: 200, fig. 692D; Schmid 1980: 249, fig. 465).

*Last instar larva:* Typical for *Glyphopsyche* as described by Flint (1960) and Wiggins (1996). Length 16–18 mm (14 mm in

*G. missouri*, 15–17 mm in *G. irrorata*, Flint 1960). Left mandible with four apical teeth, right mandible with three well developed and two poorly defined apical teeth. Legs as in *G. missouri*, with dark apical annuli on femora, tibiae, and tarsi. Gills much reduced relative to both *G. missouri* and *G. irrorata*, both in number and number of branches, with branched dorsal gills ending on segment IV and no dorsal gills posterior to V (branched dorsal gills through VII or VIII on other two species). Lateral gills unbranched and only on IIp and IIIa (often branched and on IIp through V (*G. missouri*) or IIp through VII or VIII (*G. irrorata*)). Ventral gills 3-branched only on posterior portions of II through IV (versus 3-branched on both anterior and posterior positions from IIp through Vp and on VIp). Actual gill counts from four larvae as follows, arabic numerals indicate number of branches and anterior and posterior gill counts separated by a comma: Dorsal—II 1–2, 3–4; III 3, 3; IV 1–2, 1–2; V 1, 0–1; lateral—II 0, 1; III 0–1, 0; ventral—II 0–1, 3; III 1–2, 3; IV 1, 2–3; V 1, 1–2; VI 0–1, 1–2; VII 0, 0–1. Chloride epithelium (= ventral rings of Flint 1960) present on segments III–VII, as indicated for *G. irrorata* by Flint (1960) and Wiggins (1996). (We noted a small, often nearly circular patch of chloride epithelium on venter of abdominal segment VIII in all ten larvae of *G. missouri* examined.) As in *G. missouri*, cases extremely variable, ranging from 100% vegetation to 100% mineral, but tending to have higher proportions of vegetation than in *G. missouri*.

*Pupa*: Based on examination of three pupae each of *G. sequatchie* and *G. missouri*; pupae of *G. irrorata* not seen. Length 16–18 mm (12–14 mm for *G. missouri*). Mandible with swollen base and distal blade that lacks serrations. Labrum with two clusters of five short, stout black setae that appear to have been clipped off at their ends, these setae slightly shorter than vertical height of base of mandible (these setae more than twice as long as vertical height

of base of mandible in *G. missouri*, and with their pointed tips bent mesad at right angles). Middle coxa with a black ventral seta at anterior and posterior fourth (middle coxa with a patch of three to five black setae at midlength in *G. missouri*). Proximal four middle tarsal and hind tarsal segments with two dense rows of swimming hairs, these hairs subequal in length to segment on which they occur. Dorsum of abdominal segment I with a median bilobed region that bears sclerotized teeth on its posterior margin. Dorsal hook-bearing plates on abdominal segments Vp, and IIIa through VIIa, those on Vp transverse and with 10–15 hooks loosely arranged into an anterior and posterior row (only 8–12 hooks in *G. missouri*); plates on anterior portions of segments all similar in size, nearly circular, and typically with 3 (2–4) hooks per plate (plate on IIIa absent to weakly developed and linear, with only 1 or 2 hooks in *G. missouri*). Gills (see larval description for explanation of formulae): Dorsal—II 1, 2–3; III 2–3, 2–3; IV 1–2, 1; V 0–1, 0–1; lateral—II 0, 1; III 0–1, 0; ventral—II 0–1, 1–3; III 2–3, 2–3; IV 1, 1–3; V 0–1, 2; VI 0–1, 1–2; VII 0, 1. Gills for *G. missouri*: Dorsal—II 0–2, 2–3; III 3, 3; IV 3, 3; V 2–3, 0–2; VI 1–2, 0–2; VII 0–1, 0; lateral—II 0, 2–3; III 2, 2–3; IV 2–3, 1; V 1–2, 0–1; ventral—II 0–2, 3; III 3, 3; IV 2–3, 3; V 2–3, 3; VI 2, 2–3; VII 0–1, 1–2. Gills much more profuse on *G. missouri*, with lateral gills often branched and extending from IIp through Va, and with segments IV and V with 20+ gill branches per segment; in *G. sequatchie* lateral gills single and only on IIp and IIIa, and segments IV and V have 12 or fewer gill branches per segment. Since *G. irrorata* larvae have gills even more profuse than those of *G. missouri*, and pupal and larval gill formulae appear to be identical, above differences may also separate pupae of *G. sequatchie* and *G. irrorata*.

*Etymology*.—The species epithet is a noun in apposition, referring both to the type locality in the city of Sequatchie, and

to the rich aquatic fauna of the Sequatchie River system.

**Habitat and biological notes.**—Owen Spring emerges from a cave mouth about 200 m west of Old Tennessee Highway 28 in Sequatchie, Marion County, Tennessee. The spring run averages about 12 m wide by 0.5 m deep and flows over substrates of chert gravel, with silt and organic detritus in the pool areas. A small park, owned by the State of Tennessee, surrounds the spring and spring run. About 15 m above Old Hwy. 28 the spring run is joined by a tributary of Little Sequatchie River called The Lagoon to form Owen Spring Branch. Owen Spring Branch acquires another first order tributary prior to entering Little Sequatchie River about 1.3 creek km (0.8 miles) below Owen Spring. *Glyphopsyche* larvae occur in the spring run from about 30 m below the mouth of the cave downstream at least to about 150 m below Old Hwy. 28, a reach of about 300 m. At this point there is a sawdust pile in Owen Spring Branch from a lumber operation that produces hickory handles for hand tools. Larvae were becoming increasingly difficult to find in this area, and the search for larvae was terminated at the sawdust pile. No *Glyphopsyche* larvae were found in the noticeably warmer waters of The Lagoon.

Larvae were large enough to be identified with ease by early June, and were in final instar in early September. Ten larvae collected on 1 September 1996 were returned to the University of Tennessee and were reared in individual 8-oz jars in an incubator at 18° C, 12 h light/12 h dark. When these showed no inclination to pupate, an additional collecting trip was made on 27 September. On that date, 50 last instar larvae and 5 pupae or prepupae (anterior end of case closed) were found by the senior author in an exhaustive search throughout the reach occupied by *Glyphopsyche*. Most larvae were found in pools or gently flowing runs on dead limbs 5–10 cm in diameter with bark still attached. Additional larvae were found on larger logs, with and

without bark, and in wads of root hairs. The occasional boulders in the reach were not used by *Glyphopsyche* larvae. Nine of these larvae and the five prepupae were kept for rearing. These larvae were occasionally removed from their 8-oz jars and placed in a shallow pan of spring water with crumbs of dry dog food provided. Many of the larvae fed eagerly, and they were allowed to feed about a half day before being returned to their individual jars. All of the larvae collected on 1 September died before pupating. All but one of the larvae collected on 27 September survived to adulthood (9) or to become mature pupae that exited their larval case but failed to complete their final molt (4).

Emergence dates extended from 31 October through 4 February. While this extended late fall and winter emergence may be an artifact of laboratory rearing, we suspect that a similar emergence pattern might prevail under natural conditions. The boreal *Glyphopsyche irrorata* is known from adults throughout the winter months (Nimmo 1970, Wiggins 1996) and they apparently overwinter as adults. Ross (1944), suggested that emergence of *G. missouri* is concentrated in early October. The sample of *G. missouri* we have seen from 3 September includes mature pupae as well as mid-instar larvae, suggesting that emergence extends considerably later into the fall and perhaps into winter.

On 9 May 1998 a second population of *Glyphopsyche* was located 12.0 air miles (19.3 air km) WNW of the type locality by DAE. This locality, Martin Spring run at the J. Kenneth Kelly residence, 1620 Martin Springs Road, is on the east side of Interstate 24, 1.4 road miles northwest of the Martin Springs exit, Marion County, Tennessee. The spring run emerges from a cave about 300 m above the Kelly residence, and has approximately twice the width and discharge of Owen Spring run. Although only two *Glyphopsyche* larvae were found in a half-hour search, the amount of apparently suitable habitat is several times greater than

at Owen Spring. On 25 October 1998 17 pupal cases (one had already emerged) were found in about 1 hour of effort and returned to the laboratory for rearing. Fourteen of these (seven males, seven females) emerged from 5–20 November as imagoes or mature pupae. Adults, pupae, and larvae from this site are not separable from those from Owen Spring, except that the cross-vein (see Diagnosis) at the cord between Rs and Sc is barely detectable.

Status.—Etnier (1997) listed sites in the vicinity of Owen Spring that had been unsuccessfully searched for populations of *Glyphopsyche*, but indicated that additional springs in the area needed to be examined. The 9 May 1998 discovery of a second and apparently much larger population of *G. sequatchie* causes the species' status to be much less imperiled than originally believed, and justifies some optimism that additional populations may exist in the many springs in the lower bend of the Tennessee River. At this time it does not seem likely that enough additional populations will be found to change our opinion that *G. sequatchie* deserves protection under the Endangered Species Act as an endangered or threatened species.

Long term protection of the Owen Spring type locality would also protect one of only three known populations of the endangered royal springsnail (*Pyrgulopsis ogomorphae* Thompson) located by Gordon (1991). During the 27 September 1996 collection, I (DAE) attempted to locate all of the *Glyphopsyche* larvae in the approximately 300 m reach of Owen Spring Branch where they were known to occur. If the total of 55 individuals located in about three hours of effort represents somewhere between one and ten percent of the population, as seems reasonable, the total population that could be expected to survive to adulthood would be somewhere between 500 and 5,000. Thus, the known population is probably tiny to moderate, and trichopterists are urged to treat this population as endangered until such time as official protection is afforded

it. The population in Martin Spring is estimated (by DAE, based on two brief visits) to be some two to ten times higher than that of Owen Spring Branch.

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