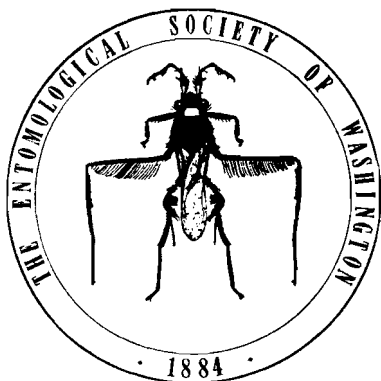


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**ADULT DIPTERA FROM OZARK CAVES**

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*Abstract.*—The Diptera fauna of Ozark caves is fairly typical of that found elsewhere in the United States east of the Great Plains. The sphaerocerid *Spelobia tenebrarum* is the only troglotic dipteran found in Ozark caves. Probable troglophiles include the mycetophilid *Macrocera nobilis*, the psychodids *Psychoda* spp., and the phorid *Megaselia cavernicola*. The tipulids commonly found in Ozark caves, such as *Dactylolabis montana*, *Dolichopeza* spp. and *Limonia* spp. are probably all troglonexes, as are the Trichoceridae and Heleomyzidae. The mycetophilids, *Exechiopsis umbratica* and *Rymosia* sp., and the culicids are among the most common cave dipterans in the study area. The culicids overwinter in caves and other protected places; they are properly classified as troglonexes. The main sources of food for cave Diptera are other insects, carrion, guano, and allochthonous plant debris.

*Key Words:* cavernicolous, Tipulidae, Mycetophilidae, Sciaridae, Cecidomyiidae, Psychodidae, Trichoceridae, Culicidae, Empididae, Drosophilidae, Dolichopodidae, Phoridae, Heleomyzidae, Sphaeroceridae, Anthomyiidae, Bibionidae, Calliphoridae

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Until recently, little research has been published on cavernicolous Ozark Diptera. Most papers that have appeared list species found in individual caves, giving few data on collection dates or sexes encountered and little indication of the ecological status of the species or their geographical distributions. Hubricht (1950) listed only species that appear to be able to live and breed in the total darkness of caves, including the Diptera species *Megaselia cavernicola* (Brues) and *Spelobia tenebrarum* (Aldrich). Black (1971) summarized the cave life of

Oklahoma and included records for 23 Diptera, but most identifications were not beyond family level. McDaniel and Smith (1976), McDaniel et al. (1979), and Dunivan et al. (1982) reported on life forms found in Arkansas Ozark caves, including 16 species of Diptera, most of which are also reported here. Peck and Lewis (1978) reported on the invertebrate fauna of caves in Illinois and eastern Missouri Ozarks. They had very few Missouri Diptera records. Peck and Peck (1982) found five species of flies in the sandstone crevice caves at Devils Den State Park, Arkansas, but they identified only the mycetophilid

\* Accepted by David R. Smith

*Macrocera nobilis* Johnson to species level. Gardner (1986) inventoried organisms from more than 400 caves in 38 Missouri counties. Many of the 25 Diptera reported were identified only to family or genus level. Sutton (1993) published lists of cave species from a mineral prospecting area in southern Missouri. Again, many of the Diptera were identified only to family or genus level. Graening et al. (2003, 2006) listed some Diptera from caves in the Sylamore Ranger District of Ozark National Forest and the Buffalo National River in North Central Arkansas, and they suggested ecological classifications for some of the taxa. Barnes (2004) reported on overwintering cave mosquitoes of the Arkansas and Missouri Ozarks. Elliott (2007) reported on the zoogeography and biodiversity of Missouri caves and karst and included *Spelobia tenebrarum* in his list of troglobites and phreatobites in Missouri but otherwise mentioned Diptera only briefly.

Here we report on additional collections made by M. E. Slay, G. O. Graening, and D. Fenolio in Arkansas and Oklahoma and by S. J. Taylor and M. E. Slay at Fort Leonard Wood (FLW), Pulaski County, Missouri as part of a study of the cave fauna of that military installation (Proffitt 2005).

It is difficult to assess the true ecological classifications of many of the taxa discussed in this paper. Most Ozark cave Diptera can probably be regarded as troglonexes. These are species that enter caves, perhaps for shelter, but do not reproduce in caves and are not entirely dependent on the cave environment. Troglaphiles, on the other hand, complete their life cycles in caves, but they can also occur in certain environments outside the cave. Troglobites must live their entire life underground (Jackson 1997). Troglotic and even trogliphilic Diptera species are rare (Vandel 1965), although a few species may represent a

large percentage of the total biomass in a given cave. The following records add to the growing body of evidence that might one day allow better judgments about how Diptera use caves.

#### MATERIALS AND METHODS

Names of major collectors are abbreviated in the text: C. J. Bitting (CJB), C. Brickey (CB), G. Graening (GG), D. Fenolio (DF), M. E. Slay (MES), and S. J. Taylor (SJT). Specimens were collected opportunistically during visual surveys of caves and by using baited pitfall traps. Pitfall traps were baited with rancid Limburger cheese spread and left in place for one to six days.

Identifications were made by the senior author except as noted in the acknowledgments. Specimens were identified to genus using the keys found in the *Manual of Nearctic Diptera*, volumes 1 and 2 (McAlpine et al. 1981, 1987). Species level identifications were made using keys cited in the *Manual* or more recent literature as appropriate. Specimens are preserved in 70% ethanol in vials. Arkansas and Oklahoma specimens are deposited at the University of Arkansas Arthropod Museum, while Missouri specimens will be deposited in the Illinois Natural History Survey. In addition to the taxa recorded here, adult and immature Chironomidae were also found in some caves. No attempt has yet been made to identify these specimens.

#### RESULTS AND DISCUSSION

##### Tipulidae

*Austrolimnophila* sp.—ARKANSAS: Madison Co.: Hunter's Cave, 28-Apr-01, GG, J. Gunter, R. Honebrink, B. Wagner, D. Wagner (1 ♀).

*Dactyolabis montana* (Osten Sacken).—ARKANSAS: Stone Co.: Bud Wallis Cave, 28-Apr-02, GG, MES, CB, M. Covington (2 ♂, 2 ♀). MISSOURI: Pulaski Co.: FLW: cave no. 23PU280,

11-May-04, SJT, MES (1 ♀); cave no. 23PU286, 11-May-04, SJT, MES (2 ♀♀); cave no. 23PU213, 10-May-04, SJT, MES (1 ♂); cave no. 23PU493, 10-May-04, SJT, MES (2 ♀); Deadman Cave, 19-Apr-03, SJT, MES, V. Block (1 ♂); Little Freeman Cave, 9-Apr-04, SJT, MES, J. Jacoby (1 ♀).

*Dactyloplabis montana* males and females were found in Ozark caves in the spring and were collected by hand from bedrock walls and ceilings. Peck and Lewis (1978) reported it from Mystery Cave, Perry County, Missouri, and Peck (1988) found it in Ontario caves and mines. These authors classified the species as a troglophile. Alexander (1966) described the species of *Dactyloplabis* as "eminently lithophilous," frequenting the vertical faces of shaded cliffs and rock exposures, where it rests in crevices. The larvae are associated with algal growths amid percolating water in these rocky situations. *Dactyloplabis montana* is among the most common and widely distributed species of the genus in eastern North America. It is probably a troglaxene.

*Dolichozeza (Orozeza) obscura* (Johnson).—MISSOURI: Pulaski Co.: FLW: cave no. 23PU309, 13-May-04, SJT, MES (2 ♂); New Arch Cave, 5-Sep-04, SJT, MES, C. Melhart (1 ♂, 1 ♀).

*Dolichozeza (Orozeza) tridenticulata* Alexander.—ARKANSAS: Marion Co.: Forest Trail Ridge Cave, 6-Jun-02, MES, CJB (2 ♂), 5-Jun-04, MES, E. Frank (1 ♂, 1 ♀); Long Ear Mine, 25-May-04, MES, CJB (2 ♂); Morning Star Mine # 5, 26-May-04, MES, CJB (2 ♀); Morning Star Mine # 7, 4-Jun-04, MES, E. Frank (1 ♀); Saltpeter Cave, 6-Jun-04, MES, W. Baker (2 ♂); Toney Bend Mine # 2, 24-May-04, MES, CJB (4 ♂); Toney Bend Mine # 3, 23-Jul-04, MES, CJB (1 ♂); Newton Co.: Dear Buster Cave, 28-May-06, W. Baker (1 ♀). MISSOURI: Pulaski Co.: FLW: cave no. 23PU280, 11-May-04, SJT, MES (1 ♂); Camp Vista Cave, 13-May-04, SJT, MES (3 ♂); Davis Cave #2, 17-Jun-04,

SJT, MES (1 ♂, 1 ♀); Flat Roof Cave, 10-May-04, SJT, MES (1 ♂, 1 ♀); Lirceus Shelter, 13-May-04, SJT, MES (1 ♂, 2 ♀); McCann Cave, 12-May-04, SJT, MES (3 ♂); New Arch Cave, 5-Sep-04, SJT, MES, C. Melhart (1 ♂, 1 ♀).

*Dolichozeza (Orozeza) walleyi* (Alexander).—ARKANSAS: Marion Co.: Toney Bend Mine # 2, 24-May-04, MES, CJB (1 ♂).

Species of *Dolichozeza* live only a few days as adults, perhaps for a week or two, during which time their main activities relate to reproduction. Many species appear to have peaks of adult emergence in late spring and late summer. The species found in Ozark Caves were collected from ceilings and walls of entrance and twilight zones and are characteristic of rocky gorges and ravines in North America east of the Great Plains from just north of the Canadian border to the northern reaches of the Gulf States. Adults are nocturnal, leaving their shelters only when alarmed. During daylight hours, they rest in protected places. In cool, mesic forests they frequent tree cavities, undercut banks, and similar shaded areas (Byers 1961). *Dolichozeza tridenticulata* and *D. walleyi* were previously reported from Georgia caves, the former being found only during late summer (Reeves et al. 2000). Peck (1988) reported *D. dorsalis* (Johnson), *D. tridenticulata*, and *D. venosa* (Johnson) from cave and mines in Ontario. It appears from the data presented here that at least *D. tridenticulata* commonly uses Ozark caves as daytime shelter in spring. It is primarily a rock gorge species, and it is also found under overhanging banks and in culverts and other man-made structures. The other two species reported here have less specific habitat requirements and are also found in moist woodlands and wetlands. *Dolichozeza tridenticulata* and *D. obscura* have been characterized as the species of *Dolichozeza* that seek the

deepest shade by day. Adult *Dolichopeza* leave their shelters at night to mate and oviposit. Females lay eggs in mosses and liverworts. The youngest larvae consume material scraped from leaf surfaces. Older larvae consume leaves of mosses and liverworts (Byers 1961). *Dolichopeza* species found in caves probably can be classified as troglonexes.

*Epiphragma* sp.—ARKANSAS: Stone Co.: Herald Hollow Cave, 23-Mar-01, GG, MES (1 ♂).

*Limonia (Dicranomyia) humidicola* (Osten Sacken).—ARKANSAS: Marion Co.: Morning Star Mine #7, 4-Jun-04, MES, E. Frank (2 ♂). MISSOURI: Pulaski Co.: FLW: Davis Cave #2, 17-Jun-04, SJT, MES (1 ♂, 1 ♀); Joy Cave, 15-Jun-04, SJT, MES (2 ♂). OKLAHOMA: Delaware Co.: East Hollow Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♂); Long's Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♂).

*Limonia (Dicranomyia) stulta* (Osten Sacken).—ARKANSAS: Marion Co.: Morning Star Mine #6, 26-May-04, MES, CJB (2 ♂, 1 ♀); Toney Bend Mine #2, 24-May-04, MES, CJB (3 ♂, 2 ♀). MISSOURI: Pulaski Co.: FLW: cave no. 23PU286, 11-May-04, SJT, MES (1 ♂); cave no. 23PU309, 13-May-04, SJT, MES (2 ♂, 2 ♀); Camp Vista Cave, 13-May-04, SJT, MES (1 ♂); Lirceus Shelter, 13-May-04, SJT, MES (2 ♂, 2 ♀); Lone Man Shelter, 11-May-04, SJT, MES, K. Lohraff (1 ♂, 1 ♀); Lower Hooten Cave, 11-May-04, SJT, MES, K. Lohraff (1 ♂); Schmoeler Cave, 10-May-04, SJT, MES (3 ♂, 1 ♀).

*Limonia* spp.—ARKANSAS: Madison Co.: Hunter's Cave, 28-Apr-01, GG, J. Gunter, R. Honebrink, B. Wagner, D. Wagner (1 ♀); Wounded Knee Cave, 27-May-01, GG, CB (1 ♂); Washington Co.: Granny Parker's Cave, 16-Jun-00, GG, S. Longing (1 ♂). MISSOURI: Pulaski Co.: FLW: Flat Roof Cave, 10-May-04, SJT, MES (1 ♀); New Arch Cave, 5-Sep-04, SJT, MES, C. Melhart (1 ♂); Tin Can Shelter, 12-May-04,

SJT, MES (1 ♀); cave no. 23PU309, 11-May-04, SJT, MES (1 ♀).

Both sexes of *Limonia* were collected from Ozark Caves. The vast majority of specimens were collected from April to July, with most collections being taken in May. They are probably troglonexes. There are many species of *Limonia (Dicranomyia)*, and the subgenus is distributed worldwide. Adults are often abundant, flying about or resting on rocky ledges, cliffs, gorges and revines near streams, often in association with *D. montana*, *Dolichopeza (Oropeza)* spp., and other tipulids. The larvae are found in many kinds of habitats. Some species are fully aquatic, forming silken tubes among submerged mosses. Others live in decaying wood or beneath tree bark, and still others are leaf miners (Alexander 1919, 1920).

Few records exist in the literature for *Limonia* spp. taken from North American caves. Peck (1988) reported on seven species of *Limonia* collected in Ontario caves from May to September. McDaniel and Smith (1976) found *Limonia (Dicranomyia) stulta* in the twilight zone of Center Cave, Sharp County, Arkansas.

*Shannonomyia lenta* (Osten Sacken).—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (3 ♂).

*Tipula (Schummelia) friendi* Alexander.—MISSOURI: Pulaski Co.: FLW: Little Freeman Cave, 9-Apr-04, SJT, MES, J. Jacoby (1 ♂).

*Tipula* sp.—ARKANSAS: Marion Co.: Toney Bend Mine #3, 23-Jul-04, MES, CJB (1 ♂, 1 ♀); Square Cave, 22-Jul-04, MES, CJB (1 ♀); Washington Co.: Snyder Cave, 16-Sep-2001, MES, R. Honebrink, B. Potter (1 ♀). MISSOURI: Pulaski Co.: FLW: Cave 23PU493, 10-May-04, SJT, MES (1 ♀); Crawlsbad Cavern, 4-Sep-04, MES, C. Melhart, SJT (1 ♀).

#### Mycetophilidae

*Allodiopsis* sp.—ARKANSAS: Marion Co.: Toney Bend Mine #3, 26-Jul-04,

MES, CJB (1 ♀). MISSOURI: Pulaski Co.: FLW: Chuck's Virgin Cave, 20-Apr-03, SJT, MES (1 ♀).

*Boletina* sp.—ARKANSAS: Stone Co.: Janus Pit, 1-Feb-03, GG, MES, D. Kampwerth, E. Corfey (1 ♂).

*Brevicornu* sp.—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (1 ♂).

*Cerotelion johannseni* (Fisher).—MISSOURI: Pulaski Co.: FLW: Camp Vista Cave, 13-May-04, SJT, MES (1 ♂).

*Exechia* sp.—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (1 ♂).

*Exechiopsis umbratica* (Aldrich).—ARKANSAS: Marion Co.: Forest Trail Ridge Cave, 6-Jun-02, MES (3 ♂, 3 ♀), 5-Jun-04, MES, E. Frank, J. Terry (10 ♀); Overlook(ed) Cave, 5-Jun-04, MES, E. Frank, J. Terry (8 ♀), 8-Jun-04, MES, CJB (1 ♂, 3 ♀); Toney Bend Mine #2, 24-May-04, MES, CJB (4 ♀, 1 ♂); Newton Co.: Jaw Bone Cave, 16-Sep-04, MES, CJB (1 ♀); Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (8 ♂); Rowland Cave, 12-Jun-01, GG, CB (1 ♂, 2 ♀). MISSOURI: Pulaski Co.: FLW: Cave 23PU493, 10-May-2004, SJT, MES (3 ♂, 9 ♀); Breeden Cave, 25-Oct-03, SJT, MES (1 ♂, 1 ♀); David's Crawl Cave, 12-Apr-04, SJT, MES (2 ♂, 1 ♀); Eight Cave, 19-Apr-03, SJT, MES (2 ♂, 4 ♀); Jasper Cave, 11-Apr-04, SJT, MES, J. Jacoby (3 ♂, 4 ♀); Joy Cave, 15-Jun-04, SJT, MES (1 ♂); King Cave, 28-Mar-03, SJT, V. Block (1 ♂); McCann Cave, 12-May-04, SJT, MES (1 ♂); small cave near Lohraff Cave, 28-Mar-03, SJT, MES, V. Block (2 ♀); Turtle Trap Cave, 6-Sep-04, MES, C. Melhart (2 ♀); Wolf Den Cave, 16-Jun-04, SJT, MES (3 ♂, 3 ♀). OKLAHOMA: Delaware Co.: Surprise Cave, 27-Jul-05, GG, DF, W. Puckette (1 ♀).

*Exechiopsis* sp.—ARKANSAS: Newton Co.: Sherfield Cave, 2-Jun-01, CB, L. Moritz (1 ♀); Tom Watson's Bear Cave, 26-Jan-02, MES, CB, M. Ross (1 ♂);

Washington Co.: Synder Cave, 16-Sep-01, MES, R. Honebrink, B. Potter (2 ♂, 2 ♀). MISSOURI: Pulaski Co.: FLW: Profitt Cave, 24-Mar-03, SJT, K. Lohraff, V. Block (sex unknown); Wolf Den Cave, 16-Jun-04, SJT, MES (3 ♂, 1 ♀).

*Exechiopsis* is a widespread genus, occurring throughout most of the Northern hemisphere. It was, in terms of both species and individuals, the most abundant mycetophilid genus found hibernating in Estonian caves (Kurina 1996). An unidentified species was previously reported from a Sharp County, Arkansas cave by McDaniel and Smith (1976). *Exechiopsis umbratica* was described from a female specimen collected in Shilo Cave, Indiana in July (Johannsen 1912). It is one of the most abundant fly species collected during the course of the present study, and specimens were often collected from bedrock walls and ceilings, sometimes in association with spider webs. Both males and females were collected from March to October. Only one specimen was taken during the winter, so it is doubtful that *E. umbratica* hibernates in the adult stage in Ozarks caves. It seems likely that it is either breeding or aestivating in caves during the warmer months. It is probably either a troglophile or a troglaxene.

*Keroplatus carbonarius* Bosc.—OKLAHOMA: Delaware Co.: Junkyard Cave, 26-Jul-2005, GG, MES (1 ♀).

*Leia* sp.—ARKANSAS: Marion Co.: Toney Bend Mine #2, 24-May-04, MES, CJB (1 ♂, 1 ♀). MISSOURI: Pulaski Co.: FLW: cave no. 23PU248, 23-Oct-03, SJT, MES (1 ♀); New Arch Cave, 5-Sep-04, SJT, MES, C. Melhart (1 ♀).

The Missouri specimens of *Leia* were taken from bedrock ceilings of caves. Evenhuis (1986) reported that two undescribed *Leia* males had been found in Pigeon Cave on Hawaii's big island.

*Macrocera nobilis* Johnson.—ARKANSAS: Marion Co.: Forest Trail

Ridge Cave, 6-Jun-02, MES (1 ♂, 1 ♀), 5-Jun-04, MES, E. Frank, J. Terry (2 ♂); Morning Star Mine #5, 26-May-04, MES, CJB (4 ♂); Overlook(ed) Cave, 6-Jun-02, MES (1 ♀), 5-Jun-04, MES, E. Frank, J. Terry (3 ♀); Pretty Junkyard Spring Cave, 6-Jun-02, MES (1 ♂); Toney Bend Mine #2, 24-May-04, MES, CJB (1 ♂). MISSOURI: Pulaski Co.: FLW: Davis Cave #2, 17-Jun-04, SJT, MES (1 ♀); Wolf Den Cave, 16-Jun-04, SJT, MES (1 ♂).

*Macrocera nobilis* is known as an inhabitant of forests in Alberta, Ontario, New England, and North Carolina. It is also known to occur in caves in Arkansas, Kentucky, Missouri, Oklahoma, Tennessee, and West Virginia (Peck and Russell 1976; Vockeroth 1976; Gardner 1986; Graening et al. 2003, 2006). Individual adults of cave populations are short-lived. They mate year-round at cave entrances and oviposit in the dark zone of caves where larval development and pupation occur. Larvae are more often observed than adults. They construct extensive webs which they can travel in pursuit of captured insect prey, mostly other Diptera and especially the heleomyzid *Amoebaleria defessa* (Osten Sacken). The larval stadia last 9–10 months, and the pupal stage lasts about 2 weeks, but the life cycle is not seasonal. Peck and Russell (1976) hypothesized that during the Wisconsin glacialiation, the species occurred throughout the forests of the southern-central and eastern United States. With retreat of the glaciers, this and other species that are adapted to cool, moist conditions found refuge in caves in warming southern lowland areas. All specimens reported here were adults collected in May and June by hand in entrance, twilight, and dark zones.

*Mycetophila* sp.—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (1 ♂). MISSOURI: Pulaski Co.: FLW: Breeden

Cave, 25-Oct-03, SJT, MES (1 ♂, 4 ♀); Little Freeman Cave, 9-Apr-04, SJT, MES, J. Jacoby (1 ♂).

*Mycomya* sp.—MISSOURI: Pulaski Co.: FLW: Henshaw Cave, 18-Apr-03, SJT, V. Block (1 ♀).

*Neuratelia* sp.—ARKANSAS: Marion Co.: Forest Trail Ridge Cave, 5-Jun-04, MES, E. Frank, J. Terry (1 ♀); Toney Bend Mine #2, 24-May-04, MES, CJB (1 ♀); Sharp Co.: Eckel Cave, 14-Dec-01, GG, DF, B. Sasse (1 ♀).

McDaniel and Smith (1976) reported finding *Neuratelia* sp. near an opening to the surface of Needles Cave, Izard County, Arkansas. They classified it as a troglaxene.

*Pseudobrachypeza bulbosa* (Johansen).—OKLAHOMA: Delaware Co.: Long's Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♀).

*Rymosia* sp.—ARKANSAS: Marion Co.: Reed Cave, 9-Mar-02, GG, S. McGinnis (1 ♀); Morning Star Mine #6, 26-May-04, MES, CJB (2 ♂, 3 ♀); Saltpeter Cave, 6-Jun-04, MES, W. Baker (1 ♂); Toney Bend Mine #2, 24-May-04 (2 ♂, 2 ♀); Newton Co.: Saltpeter Cave, 17-Mar-02, MES, CJB (1 ♂, 2 ♀); Stone Co.: Bud Wallis Cave, 28-Apr-02, GG, MES, C.B. M. Covington (4 ♀); Hammer Springs Cave, 17-Mar-02, GG, CB (1 ♂). MISSOURI: Pulaski Co.: FLW: Big Freeman Cave, 9-Jan-04, SJT, MES (3 ♂, 1 ♀); David's Crawl Cave, 12-Apr-04, SJT, MES (1 ♀); Deadman Cave, 16-Apr-03, SJT, V. Block (1 ♀); Jasper Cave, 11-Apr-04, SJT, MES, J. Jacoby (2 ♀); Phreatic Cave, 24-Oct-03, SJT, MES (1 ♂, 1 ♀); Ramsey Cave, 9-Jan-04, SJT, MES (2 ♂). OKLAHOMA: Cherokee Co.: Crystal Cave, 29-Jan-02 (1 ♀); Delaware Co.: Rock Quarry Cave, 25-Jul-05, GG, MES (2 ♂, 1 ♀).

Peck and Lewis (1978) found *Rymosia* sp. in three southern Illinois caves and characterized it as a troglaxene, but they did not record collection dates. Reeves et

al. (2000) collected *Rymosia* sp. from a Georgia cave in September and classified it as a possible troglophile. Moseley (2007) characterized *Rymosia* sp. as a habitual troglaxene wintering on cave walls in the Canadian Maritime Provinces. The Ozark cave specimens, both males and females, were collected in January, March through July, and October, suggesting that *Rymosia* here is in caves throughout the year. They were collected by hand from entrance, twilight, and dark zones on bedrock ceiling and walls. It is perhaps a troglophile.

The mycetophilids *E. umbratica* and *Rymosia* sp. are among the most common cavernicolous dipterans in the Ozarks. Similarly, Kjaerandsen (1993) found that the mycetophilids *Exechia exigua* Lundstroem, *E. festiva* Winnertz, *Exechiopsis fumbriata* (Lundstroem), *E. subulata* (Winnertz), *Pseudexechia auri-vernica* Chandler, and *Rymosia fasciata* (Meigen) accounted for 95% of the 20,000 Diptera specimens collected from mines and caves in southern Norway.

*Trichonta* sp.—MISSOURI: Pulaski Co.: FLW: Paleospring Cave, 17-Apr-03, SJT, MES, V. Block (1 ♂).

This specimen was taken from *Neotoma floridana* (Ord) scat in a packrat midden.

#### Sciaridae

Sciaridae.—ARKANSAS: Benton Co.: Cave Springs Cave, 6-Mar-02, GG, MES, B. Wagner (2 ♀); Pigeon Roost Cave, 28-Jun-02, GG, B. Sasse (1 ♂); Rainy Day Cave, 17-Mar-06, MES, C. Slay (1 ♀); Tom Danforth Cave, 28-Jan-06, W. Baker (2 ♀); War Eagle Cavern, 11-May-01, A. Brown, C. Brown (1 ♀); Marion Co.: Forest Trail Ridge Cave, 5-Jun-04, MES, E. Frank, J. Terry (1 ♀); 8-Jun-04, MES, CJB (1 ♀); Morning Star Mine #5, 29-May-04, MES, CJB (2 ♀); Morning Star Mine #6, 29-May-04, MES, CJB (2 ♀); Overlook(ed) Cave, 6-Jun-02, MES (2 ♀); 5-Jun-04, MES, E. Frank, J. Terry (1 ♂, 1 ♀); 8-Jun-04, MES, CJB (13 ♀); Summer

Cave, 25-Jul-04, CJB (1 ♀); Toney Bend Mine #2, 27-May-04, MES, CJB (1 ♀); Newton Co.: Toney Barnes Cave, 16-Sep-04, MES, CJB (1 ♂); Tom Barnes Cave, 11-Dec-04, N. Youngsteadt, J. Youngsteadt (2 ♀); Tom Barnes Cave, 18-Feb-05, N. Youngsteadt, J. Youngsteadt (1 ♂); Walnut Cave, 29-Dec-04, MES, CJB (1 ♀); Searcy Co.: Hurricane River Cave, 14-Apr-02, MES, CB (1 ♀); 15-Jan-06, W. Baker (1 ♂); Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (~102 ♀); Gustafson Cave, 6-Oct-02, GG, S. McGinnis, CB (1 ♀); Hell Creek Cave, 16-Sep-00, GG, MES (1 ♀); Saltpeter Cave, 31-Mar-02, GG, DF, CB (1 ♀). MISSOURI: Pulaski Co.: FLW: Andy's Cave #1, 11-Apr-04, SJT, J. Jacoby (1 ♀); Andy's Cave #2, 11-Apr-04, SJT, J. Jacoby (4 ♀); Brooks Cave, 18-Jun-04, MES (5 ♀); Chuck's Virgin Cave, 20-Apr-03, SJT, MES (3 ♂, 11 ♀); David's Cave, 28-Mar-03, SJT, V. Block (1 ♀); Davis Cave #1, 27-Mar-03, SJT, V. Block (1 ♂, 2 ♀); Davis Cave #2, 17-Jun-04, SJT, MES (1 ♂); Eight Cave, 24-Oct-03, SJT, MES (2 ♂); Folly Cave, 9-Apr-04, SJT, MES, J. Jacoby (2 ♂); Jasper Cave, 11-Apr-04, SJT, MES, J. Jacoby (1 ♂); Joint East Cave, 10-Apr-04, SJT, J. Jacoby (1 ♀); Joy Cave, 18-Jun-04, MES (1 ♀); Kilman Cave, 25-Mar-03, SJT, V. Block (2 ♀); King Cave, 28-Mar-03, SJT, V. Block (4 ♀); Little Freeman Cave, 9-Apr-04, SJT, MES, J. Jacoby (1 ♀); Martin Cave, 29-Mar-03, MES, SJT, V. Block (1 ♂, 17 ♀), 10-Jan-04, SJT, MES (4 ♀), 14-May-04, SJT, MES, K. Lohraff (1 ♀), 6-Sep-04, MES, C. Melhart (1 ♀); Phreatic Cave, 24-Oct-03, SJT, MES (2 ♂); Ramsey Cave, 9-Jan-04, SJT, MES (1 ♂); Saltpeter Cave, 9-Jan-04, SJT, MES (1 ♂, 37 ♀); Wilson Cave, 8-Jan-04, SJT, MES (5 ♀); Wolf Den Cave, 18-Jun-04, MES (1 ♀). OKLAHOMA: Adair Co.: Duncan Field Cave, 29-Apr-06, S. Hensley, W. Baker (1 ♀); Cherokee Co.: Blue Moon Cave, 29-Jan-02, GG, DF, S. Hensley (1 ♀).



Sciaridae, the dark-winged fungus gnats, are among the most commonly collected Ozark cave Diptera. Unfortunately, only about 150 species of Nearctic Sciaridae have been named and described, probably representing less than half of the actual number. Most taxonomic work was done nearly a century ago. Until extensive revisionary studies are made of both genera and species, it will remain nearly impossible to identify our specimens (Steffan 1981). Furthermore, species level identification usually depends on being able to see characters of the male genitalia, but the vast majority of specimens collected in Ozark caves are females. During the course of this study, only 19 males were collected, compared with more than 200 females. Both males and females were collected in all seasons and nearly every month of the year except August and November. Most collections were made in the spring. Male genitalic structure indicates that at least three species are present in the Ozark cave material. Most specimens key to *Corynoptera* in volume 1 of the *Manual of Nearctic Diptera* (McAlpine et al. 1981).

#### Cecidomyiidae

*Bremia* sp.—ARKANSAS: Marion Co.: Morning Star Mine #5, 26-May-04, MES, CJB (1 ♂, 2 ♀); Morning Star Mine #6, 26-May-04, MES, CJB (2 ♀); Morning Star Mine #7, 4-Jun-04, MES, CJB (2 ♂, 1 ♀); Newton Co.: Jaw Bone Cave, 16-Sep-04, MES, CJB (3 ♀). MISSOURI: Pulaski Co.: FLW: cave no. 23PU309, 13-May-04, SJT, MES (1 ♀); Joy Cave, 18-Jun-04, SJT, MES (1 ♀); New Arch Cave, 5-Sep-04, SJT, MES (8 ♀, 2 ♂).

*Coquillettomyia* sp.—MISSOURI: Pulaski Co.: FLW: Davis Cave #2, 17-Jun-04, SJT, MES (2 ♂).

*Lestodiplosis* sp.—MISSOURI: Pulaski Co.: FLW Davis Cave #2, 17-Jun-04, SJT, MES (1 ♀).

*Porricondyla* sp.—ARKANSAS: Marion Co.: Morning Star Mine #5, 26-May-04, MES, CJB (1 ♀).

Micromyini.—ARKANSAS: Newton Co.: Bear Pit, 2-Feb-02, GG, MES (1 ♂).

The genitalia of the male specimens of *Bremia* listed here indicate that several different species are found in Ozark caves. Little is known of their biology, but individuals can often be found roosting on spider webs (R. Gagné pers. comm.). Most specimens were taken in the entrance or twilight zones and occurred on bedrock walls or ceilings but also on wet wood on clay floors. Collection sites ranged from 20.4–22.4°C air temperature, with relative humidity of 86.5–90.5%. Peck (1988) recorded this genus from a mine in Ontario in July. Reeves et al. (2000) recorded specimens from Sitton's Cave, Dade County, Georgia in August. Both males and females were found in Ozark caves in spring and late summer.

#### Psychodidae

*Pericoma signata* (Banks).—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (2 ♂, 4 ♀).

*Psychoda satchelli* Quate.—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (3 ♂, >100 ♀); Washington Co.: Granny Deen Cave, 28-Jan-03, GG, T. Snell, P. Shurgar, Z. Moon (1 ♂, 2 ♀). MISSOURI: Pulaski Co.: FLW: Wolf Den Cave, 18-Jun-04, MES (4 ♀). OKLAHOMA: Cherokee Co.: Blue Moon Cave, 29-Jan-02, GG, DF, S. Hensley (1 ♂, 2 ♀).

*Psychoda setigera* Tonnoir.—ARKANSAS: Marion Co.: Coon Cave, 6-Jun-02, MES (1 ♀).

*Psychoda* sp.—ARKANSAS: Marion Co.: Pretty Junkyard Spring Cave, 6-Jun-02, MES (1 ♀); Newton Co.: Seashell Dome Cave, 11-Dec-04, MES, CB (1 ♀). MISSOURI: Pulaski Co.: FLW:

Davis Cave #3, 23-Oct-2003, SJT, MES (1 ♂); Wolf Den Cave, 16-Jun-2004, SJT, MES (1 ♂, 1 ♀).

Psychodinae.—ARKANSAS: Marion Co.: Morning Star Mine #7, 7-Jun-04, MES (1 ♀); Overlook(ed) Cave, 8-Jun-04, MES, CJB (1 ♀); Toney Bend Mine #2, 27-May-04, MES, CJB (1 ♀); Searcy Co.: Square Cave, 25-Jul-04, MES, CB (1 ♀). MISSOURI: Pulaski Co.: FLW: Breeden Cave, 25-Oct-03, SJT, MES (1 ♂), Wolf Den Cave, 18-Jun-04, MES (2 ♀).

Both sexes of psychodine psychodids were collected from Ozark caves during all seasons of the year, indicating that they are probably true troglaphiles. Specimens were taken by hand or in pitfall traps in the entrance or dark zone from scat on bedrock floors or from bedrock ceiling at air temperatures ranging from 11.9 to 25.2°C and relative humidities ranging from 86.7 to 92.8%. *Psychoda satchelli* was the most commonly encountered species and is the most common species of *Psychoda* in America north of Mexico (Quate 1955).

Adult Psychodidae, which are usually nocturnal, are often found in moist, shaded habitats. Larvae of most species are saprophagous, consuming decaying organic matter. Larvae of Psychodinae live in various moist or subaquatic habitats. Larvae of *P. satchelli* have been found in compost (Quate 1960). Larvae of *Psychoda reevesi* Quate were collected in Georgia caves using sterilized human excrement as bait, and adults were reared from the larvae (Quate 2000). Larvae of *Psychoda pussilla* Tonnoir were collected on chicken liver bait in Georgia caves, and adults were reared in the laboratory. Both *P. reevesi* and *P. pussilla* were classified as troglaphiles by Reeves et al. (2000). Adult *Psychoda* sp. have been found associated with dung in caves in southern Canada. Moseley (2007) classified them as habitual troglaxenes. Peck (1988) reported *Psychoda phalaenoides*

(Linnaeus), *P. satchelli*, *Psychoda umbracola* Quate, and an unidentified *Psychoda* species in Ontario caves in May, June, and August. Gardner (1986) reported unidentified species of *Pericoma* and *Psychoda* from several Missouri caves and classified them as troglaxenes. We suggest that at least *P. satchelli* could be considered a troglaphile.

#### Trichoceridae

*Trichocera brevicornis* Alexander.—ARKANSAS: Madison Co.: Whippoorwill Cave, 29-Sep-02, GG, S. McGinnis (1 ♂); Washington Co.: Joyce Cemetery Cave, 1-Mar-04, MES (1 ♂), 26-Feb-05, M. Ross (2 ♂). MISSOURI: Pulaski Co.: FLW: Breeden Cave, 25-Oct-03, SJT, MES (1 ♂).

*Trichocera* sp. ♀ (not identifiable to species level by morphological means).—ARKANSAS: Marion Co.: Reed Cave, 15-Nov-01, GG, T. Snell, P. Shurgar (1 ♀); Searcy Co.: USFS cave on Road No. 91030A, 12-Dec-01 (1 ♀); Stone Co.: Gunner Cave, 27-Jan-01, MES, CB, J. Zawislak (1 ♀); Washington Co.: Jones Cemetery Cave, 1-Mar-04, MES (4 ♀); Joyce Cemetery Cave, 26-Feb-05, M. Ross (1 ♀). OKLAHOMA: Cherokee Co.: Crystal Cave, 29-Jan-02, GG, DF, S. Hensley (1 ♀).

Winter crane flies of the genus *Trichocera* are often found on sunny days in autumn, winter, and spring. Even on cold winter days when temperatures are above freezing, large swarms of males may be seen dancing above the snow. Females are rarely found in swarms, although our results show they are more readily collected in Ozark caves than are males. *Trichocera brevicornis* apparently has only one generation per year, with adult emergence commencing in September. This species was previously recorded from Vermont, Maryland, North Carolina, South Carolina, Georgia, Florida, and Kansas. Specimens were collected from October to February. Our cave

specimens were collected in Arkansas, Missouri, and Oklahoma from September to March. Females were found in caves during the same season as when males are flying (Pratt 1992, Pratt and Pratt 1984). They are probably utilizing the caves as shelter and are assumed to be troglonexes.

#### Culicidae

*Anopheles punctipennis* (Say).—ARKANSAS: Izard Co.: Needles Cave, 2-Feb-03, GG, MES, D. Kampwerth, E. Corfey (1 ♀); Newton Co.: Jaw Bone Cave, 16-Sep-04, MES, CJB (4 ♀); Willis Cave, 15-Oct-05, N. Youngsteadt, J. Youngsteadt (1 ♀). MISSOURI: Pulaski Co.: FLW: Big Freeman Cave, 9-Jan-04, SJT, MES (4 ♀); Breeden Cave, 25-Oct-03, SJT, MES (3 ♀); Eight Cave, 24-Oct-03, SJT, MES (1 ♀); Flat Roof Cave, 10-May-04, SJT, MES (1 ♀); Lower Hooten Cave, 11-May-04, SJT, MES, K. Lohraff (1 ♀); New Arch Cave, 5-Sep-04, MES, C. Melhart, SJT (1 ♀); Phreatic Cave, 24-Oct-03, SJT, MES (10 ♀); Ramsey Cave, 9-Jan-04, SJT, MES (4 ♀); Wilson Cave, 8-Jan-04, SJT, MES (1 ♀).

*Anopheles quadrimaculatus* Say.—MISSOURI: Pulaski Co.: FLW: 23PU248, 23-Oct-03, SJT, MES (1 ♀).

*Culex erraticus* (Dyar and Knab).—ARKANSAS: Izard Co.: Needles Cave, 2-Feb-03, GG, MES, D. Kampwerth, E. Corfey (5 ♀); Newton Co.: Hutchinson Waterfall Cave, 29-Dec-04, MES, CJB, C. Melhart (6 ♀); Jaw Bone Cave, 16-Sep-04, MES, CJB (3 ♀); Tom Barnes Cave, 11-Dec-04, N. Youngsteadt, J. Youngsteadt (1 ♀), 16-Sep-04, MES, CJB (3 ♀); Willis Cave, 15-Oct-05, N. Youngsteadt, J. Youngsteadt (2 ♀), 18-Nov-05 (7 ♀). MISSOURI: Pulaski Co.: FLW: 23PU248, 23-Oct-03, SJT, MES (2 ♀); 23PU309, 13-May-04, SJT, MES (1 ♀); Eight Cave, 24-Oct-03, SJT, MES (1 ♀); Little Crevice Cave, 24-Oct-03, SJT, MES (1 ♀); Miller Cave, 28-Mar-03,

SJT, MES, V. Block (1 ♀); Phreatic Cave, 24-Oct-03, SJT, MES (1 ♀); Profitt Cave, 24-Mar-03, SJT, V. Block (2 ♀); Wilson Cave, 8-Jan-04, SJT, MES (8 ♀). OKLAHOMA: Delaware Co.: Junkyard Cave, 26-Jul-05, GG, MES (1 ♀); Rock Quarry Cave, 25-Jul-05, GG, MES (1 ♀).

*Culex pipiens* Linnaeus or *C. quinquefasciatus* Say.—ARKANSAS: Benton Co.: Rainy Day Cave, 17-Mar-06, MES, C. Slay (2 ♀); Newton Co.: Pentrance Cave, 4-Mar-06, W. Baker (5 ♀). MISSOURI: Pulaski Co.: FLW: Camp Vista Cave, 13-May-04, SJT, MES (1 ♀); small cave near Lohraff Cave, 28-Mar-03, MES, SJT, V. Block (4 ♀); McCann Cave, 12-May-04, SJT, MES (1 ♀).

*Uranotaenia sapphirina* (Osten Sacken).—MISSOURI: Pulaski Co.: FLW: 23PU248, 23-Oct-03, SJT, MES (2 ♀); small cave near Lohraff Cave, 28-Mar-03, MES, SJT, V. Block (2 ♀); Phreatic Cave, 24-Oct-03, SJT, MES (3 ♀).

These records are in addition to those reported by Barnes (2004). All mosquitoes reported from Ozark caves are adult females, and most were collected during late fall, winter, or early spring. All reported species are thought to winter as fertilized females. They seek shelter from freezing temperatures in caves and other moist, protected habitats. They are properly classified as facultative troglonexes. *Anopheles quadrimaculatus* was not previously reported wintering in an Ozark cave, although it has been collected from caves elsewhere (Hess and Crowell 1949, Ives 1938, Peck 1988). In the southern part of this species' range, females usually winter near human habitations in cellars, crawl spaces, or domestic animal quarters in barns. In the north, they usually winter in more isolated areas, such as storm drains, caves, and hollow trees (Horsfall 1955). *Culex erraticus* and *A. punctipennis* are the most common species found wintering in Ozark caves during the course of this study. Several local species that are

thought to winter as fertilized females have not been collected from Ozark caves, including *Culex peccator* Dyar and Knab, *Culex restuans* Theobald, *Culex salinarius* Coquillett, *Culex tarsalis* Coquillett, *Culex territans* Walker, and *Culiseta inornata* (Williston).

#### Empididae

*Platypalpus* sp.—ARKANSAS: Baxter Co.: Bonanza Cave, 7-Oct-02, GG, S. McGinnis, D. Kampwerth (1 ♀).

*Tachypeza brachialis* (Melander).—ARKANSAS: Newton Co.: Fitton Cave, 13-May-01, GG, CJB, C. Bitting, S. McGinnis (1 ♂); Jaw Bone Cave, 16-Sep-04, MES, CJB (1 ♂); Stone Co.: Bud Wallis Cave, 28-Apr-02, GG, MES, CB, M. Covington (1 ♂).

*Tachypeza* sp.—ARKANSAS: Newton Co.: Fitton Cave, 13-May-01, GG, CJB, C. Bitting, S. McGinnis (1 ♂); Jaw Bone Cave, 16-Sep-04, MES, CJB (1 ♀).

#### Drosophilidae

*Drosophila melanogaster*.—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (4 ♀).

*Drosophila* sp.—ARKANSAS: Marion Co.: Overlook(ed) Cave, 8-Jun-04, MES, CJB (1 ♀); Square Cave, 25-Jul-04, MES, CB (1 ♀). MISSOURI: Pulaski Co.: FLW: Henshaw Cave, 18-Apr-03, SJT, V. Block (1 ♀).

#### Dolichopodidae

*Liancalus genualis* Loew.—ARKANSAS: Madison Co.: Wagonshed Cave, 24-Jan-01 (1 ♂); Wounded Knee Cave, 27-May-01, GG, CB (1 ♂, 1 ♀); Marion Co.: Saltpeter Cave, 6-Jun-04, MES, W. Baker (2 ♂, 2 ♀); Newton Co.: Wolf Creek Cave, 11-Nov-00, GG, CB, J. Gunter (1 ♂, 1 ♀).

*Liancalus* sp.—ARKANSAS: Marion Co.: Long Ear Mine, 25-May-04, MES, CJB (1 ♀).

Reeves et al. (2000) found adults of *L. genualis* on the roof and walls of Yarborough Cave, Bartow County, Georgia on 7 September 1998. They surmised that the flies were avoiding the hot summer day outside. The Ozark records reported here are for all seasons of the year. In addition, there are six pinned specimens in the collection of the University of Arkansas Arthropod Museum. Two males and three females were collected at a cave entrance in Newton County, Arkansas on 26 July 1970. One male was collected at Roaring River, Missouri on 29 July 1941. No other biological data are available for this species. However, Corpus (1986) reports that a related species, *L. similis* Aldrich, was collected from drainage culverts and rock crevices near seeps and waterfalls, usually from shaded, moist, vertical rock surfaces. Adults reared from larvae in the laboratory lived only three days. Larvae were found only on algal mats growing on rock below a waterfall.

*Neurigonella* sp.—ARKANSAS: Washington Co.: Farmer's Cave, 9-Jul-01 (1 ♀).

#### Phoridae

*Mallochphora orphnephiloides* (Malloch).—ARKANSAS: Marion Co.: Reed Cave, 15-Nov-01, GG, T. Snell, P. Shurgar (1 ♀).

*Megaselia cavernicola* (Brues).—ARKANSAS: Benton Co.: Rainy Day Cave, 17-Mar-06, MES, C. Slay (1 ♀); Boone Co.: Big Hole Cave, 10-Nov-01, MES, M. Covington, CB (1 ♀); Newton Co.: Dear Buster Cave, 28-May-06, W. Baker (1 ♀); Stone Co.: Biology Cave, 17-Sep-00, DF, CB, S. Longing (1 ♂); Hammer Springs Cave, 17-Mar-02, GG, CB (1 ♀); Hell Creek Cave, 16-Sep-00, GG, MES (1 ♀); Rowland Cave, 12-Jun-01, GG, CB, J. Disler (1 ♀, 1 ♂); Twin Cave, 28-Oct-05, N. Youngsteadt, J. Youngsteadt (2 ♀); Washington Co.: Jones Cemetery Cave, 1-Mar-04, MES

(4 ♀). OKLAHOMA: Delaware Co.: Long's Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♀); Rock Quarry Cave, 25-Jul-05, GG, MES (1 ♀).

*Megaselia cavernicola* is commonly found in caves in the eastern United States, where both sexes occur through all seasons. It was previously reported from caves in Independence, Marion, Newton, and Stone Counties, Arkansas (McDaniel and Smith 1976, Welbourn 1980, Welbourn and Lindsley 1979). Reeves and Disney (1999) reported *M. cavernicola* larvae on bat carrion and human excrement in the field, and the species was commonly collected in carrion traps. Larvae consume carrion from the bottom up, and they burrow into mud to pupate. Although commonly found in caves, surface populations also have been found (Brues 1950). The species is classified as a troglophile. A similar cavernicolous species, *Megaselia spelunciphila* Disney, was not identified during the course of this study.

#### Heleomyzidae

*Oecothea specus* (Aldrich).—ARKANSAS: Marion Co.: Long Ear Mine, 25-May-04, MES, CJB (1 ♂); Morning Star Mine #5, 26-May-04, MES, CJB (1 ♂); Morning Star Mine #7, 4-Jun-04, MES, E. Frank (1 ♂); Pretty Junkyard Spring Cave, 6-Jun-02, MES (1 ♂); Saltpeter Cave, 6-Jun-04, MES, W. Baker (2 ♂); Square Cave, 22-Jul-04, MES, CJB (1 ♂); Newton Co.: Jaw Bone Cave, 16-Sep-04, MES, CJB (2 ♂); Toney Barnes Cave, 16-Sep-04, MES, CJB (1 ♂); Willis Cave, 15-Oct-05, N. Youngsteadt, J. Youngsteadt (1 ♂); Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (1 ♂); Hidden Spring Cave, 5-Oct-02, CB, T. Breland, C. Breland (2 ♂). MISSOURI: Pulaski Co.: FLW: Big Freeman Cave, 9-Jan-04, SJT, MES (1 ♂); Camp Vista Cave, 13-May-04, SJT, MES (1 ♂); Deadman Cave, 19-Apr-03, SJT, V. Block (1 ♂); Turtle Trap

Cave, 6-Sep-04, MES, C. Melhart (1 ♂); Wolf Den Cave, 16-Jun-04, SJT, MES (1 ♂); Kilman Cave, 25-Mar-03, SJT, V. Block (1 ♂). OKLAHOMA: Delaware Co.: Rock Quarry Cave, 25-Jul-05, GG, MES (1 ♂).

*Oecothea* sp.—ARKANSAS: Marion Co.: Coon Cave, 6-Jun-02, MES (1 ♀); Toney Bend Mine #2, 24-May-04, MES, CJB (1 ♀); Newton Co.: Jaw Bone Cave, 16-Sep-04, MES, CJB (1 ♀); Toney Barnes Cave, 16-Sep-04, MES, CJB (1 ♀); Willis Cave, 18-Nov-05, N. Youngsteadt, J. Youngsteadt (1 ♀); Stone Co.: Blanchard Springs, 27-Apr-02, GG, MES, K. Tinkle (1 ♀); Hidden Spring Cave, 5-Oct-02, CB, T. Breland, C. Breland (1 ♀); Twin Cave, 28-Oct-05, N. Youngsteadt, J. Youngsteadt (1 ♀); Washington Co.: Fincher Cave, 9-Jul-01, GG, J. Gunter, A. Gunter (1 ♀). MISSOURI: Pulaski Co.: FLW: Brooks Cave, 18-Jun-04, MES (1 ♀); Cave 23PU310, 18-Jun-04 (1 ♀); Chuck's Virgin Cave, 20-Apr-03, SJT, MES (1 ♀); Davis Cave #2, 17-Jun-04, SJT, MES (1 ♀); Deadman Cave, 19-Apr-03, SJT, V. Block (2 ♀); Kilman Cave, 25-Mar-03, SJT, V. Block (1 ♀); New Arch Cave, 5-Sep-04, MES, C. Melhart, SJT (1 ♀); Wolf Den Cave, 16-Jun-04, SJT, MES (2 ♀). OKLAHOMA: Delaware Co.: Surprise Cave, 27-Jul-05, GG, DF, W. Puckette (1 ♀).

*Amoebaleria defessa* (Osten Sacken).—ARKANSAS: Benton Co.: Civil War Cave, 29-Oct-00, MES, GG, A. Brown (2 ♂); Pigeon Roost Cave, 28-Jun-02, GG, B. Sasse (1 ♂); Rainy Day Cave, 17-Mar-06, MES, C. Slay (2 ♂); Carroll Co.: Cave on Miner's Rock Trail, 12-Aug-00, GG (1 ♂); Marion Co.: Back'o Beyond Cave, 23-Jun-01, GG, CJB (1 ♂); Forest Trail Ridge Cave, 5-Jun-2004, MES, E. Frank, J. Terry (3 ♂); Marble Falls Cave, 7-Sep-01, GG, MES (1 ♂); Morning Star Mine #5, 26-May-04, MES, CJB (1 ♂); Overlook(ed) Cave, 8-Jun-04, MES, CJB (2 ♂); Saltpeter Cave,

24-May-04, MES (1 ♂), 6-Jun-04, MES, W. Baker (1 ♂); Newton Co.: Fitton Cave, 13-May-01, GG, CJB, C. Bitting, S. McGinnis (1 ♂); Toney Barnes Cave, 16-Sep-04, MES, CJB (2 ♂); Willis Cave, 15-Oct-05, N. Youngsteadt, J. Youngsteadt (1 ♂), 18-Nov-05, N. Youngsteadt, J. Youngsteadt (1 ♂); Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (1 ♂); Hammer Springs Cave, 17-Mar-02, GG, CB (1 ♂); Hell Creek Cave, 16-Sep-00, GG (2 ♂); Rowland Cave, 12-Jun-01, GG, CB, J. Disler (1 ♂); Twin Cave, 28-Oct-05, N. Youngsteadt, J. Youngsteadt (1 ♂); Von Wadding's Memorial Cave, 17-Aug-02, GG, R. Schroeder, D. Kampwerth, E. Corfey (1 ♂); Washington Co.: Snyder Cave, 16-Sep-01, MES, R. Honebrink, B. Potter (2 ♂). MISSOURI: Pulaski Co.: FLW: Andy's Cave #2, 11-Apr-04, SJT, MES, J. Jacoby (1 ♂); Andy's Cave #1, 11-Apr-04, SJT, MES, J. Jacoby (1 ♂); Breeden Cave, 25-Oct-03, SJT, MES (1 ♂); Joy Cave, 15-Jun-04, SJT, MES (1 ♀); Turtle Trap Cave, 6-Sep-04, MES, C. Melhart (1 ♂); Wolf Den Cave, 16-Jun-04, SJT, MES (1 ♂). OKLAHOMA: Delaware Co.: January-Stansbury Cave, Summer 2003, DF (2 ♂); Murray Co.: Little Crystal Cave, 2-Aug-05, GG, DF, A. Harris, K. Thomas (1 ♂).

*Amoebaleria sackeni* Garrett.—ARKANSAS: Newton Co.: cave no. NW41bb, 4-Mar-06, W. Baker (1 ♂). MISSOURI: Pulaski Co.: FLW: Davis No. 3 Cave, 23-Oct-03, SJT, MES (1 ♂); Ramsey Cave, 9-Jan-04, SJT, MES (1 ♂); Wilson Cave, 8-Jan-04, SJT, MES (1 ♂). OKLAHOMA: Cherokee Co.: Crystal Cave, 29-Jan-02, GG, DF, S. Hensley (1 ♂).

*Amoebaleria* sp.—ARKANSAS: Benton Co.: James Ditto Cave, 6-Dec-00, GG, CB (1 ♀); Boone Co.: Big Hole Cave, 10-Nov-01, MES, M. Covington, CB (1 ♀); Marion Co.: Elm Cave, 16-Nov-01, GG, B. Sasse (1 ♀); Forest Trail Ridge Cave, 5-Jun-04, MES, E. Frank, J. Terry (4 ♀); Morning Star Mine #6, 26-

May-04, MES, CJB (1 ♀); Pretty Junkyard Spring Cave, 6-Jun-02, MES (1 ♀); Reed Cave, 15-Nov-01, GG, T. Snell, P. Shurgar (1 ♀); Square Cave, 22-Jul-04, MES, CJB (1 ♀); Toney Bend Mine #2, 24-May-04, MES, CJB (1 ♀); Newton Co.: Jaw Bone Cave, 16-Sep-04, MES, CJB (1 ♀); Saltpeter Cave, 17-Mar-02, MES, M. Covington (1 ♀); Sherfield Cave, 6-Jun-01, CB, L. Moritz (1 ♀); Sprite Cave, 16-Mar-02, MES, M. Covington (1 ♀); Tom Watson's Bear Cave, 26-Jan-02, MES, CB, M. Ross (1 ♀); Toney Barnes Cave, 16-Sep-04, MES, CJB (1 ♀); Tweet's Cave, 26-Oct-01, MES, M. Covington (1 ♀); Searcy Co.: Hurricane River Cave, 14-Apr-02, MES, CB (1 ♀); Sharp Co.: Eckel Cave, 14-Dec-01, GG, DF, B. Sasse (1 ♀); Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (1 ♀); Bud Wallis Cave, 28-Apr-02, GG, MES, CB, M. Covington (1 ♀); Janus Pit, 1-Feb-03, GG, MES, D. Kampwerth, E. Corfey (1 ♀); Martin Hollow Cave, 14-Oct-00, GG, MES, M. Covington, CB, J. Gunter (1 ♀); Saltpeter Cave, 31-Mar-02, GG, DF, CB (1 ♀); Washington Co.: Fincher Cave, 9-Jul-01, GG, J. Gunter, A. Gunter (1 ♀); Joyce Cemetery Cave, 26-Feb-05, MES (1 ♀). MISSOURI: Pulaski Co.: FLW: Andy's Cave #1, 11-Apr-04, SJT, MES, J. Jacoby (6 ♀); Andy's Cave #2, 11-Apr-04, SJT, MES, J. Jacoby (1 ♀); Davis Cave #3, 23-Oct-03, SJT, MES (1 ♀); Henshaw Cave, 18-Apr-03, SJT, V. Block (1 ♀); Lohraff Cave, 30-Mar-03, SJT, V. Block (1 ♀); Wilson Cave, 8-Jan-04, SJT, MES (1 ♀). OKLAHOMA: Delaware Co.: Peachtree Cave, 27-Jul-05, GG, MES, W. Puckette (1 ♀); Surprise Cave, 27-Jul-05, GG, DF, W. Puckette (1 ♀).

*Heleomyza brachypterna* (Loew).—ARKANSAS: Benton Co.: Congo Crawl, 4-May-01, MES, A. Brown (1 ♂); Stone Co.: Von Wadding's Memorial Cave, 17-Aug-02, GG, R. Schroeder, D. Kampwerth, E. Corfey (1 ♀). MISSOURI:

Pulaski Co.: FLW: Joy Cave, 15-Jun-04, SJT, MES (2 ♀); Wolf Den Cave, 16-Jun-04, SJT, MES (1 ♀).

Most of these collections were taken by hand and occasionally from pitfall traps. Heleomyzids were taken mainly on bedrock ceilings and walls, but some collections were associated with rock, clay, soil, and gravel floors of caves. Unidentified female specimens of *Oecothea* sp. were collected under rocks and on floors or on clay or soil floors. Recorded temperatures ranged from 12.4 to 15.9°C for air and 11.8 to 14.1°C for soil, with humidity of 92.1 to 99.4%. Specimens of *O. specus* were recorded from under rock, on bedrock walls, and on clay or gravel floors in the twilight and darks zones of caves. Recorded temperatures ranged from 12.2 to 12.8°C for air and 11.1 to 12.2°C for soil, with humidity of 91.7 to 94.0%. *Amoebalaria defessa* and *A. sackeni* were recorded primarily from bedrock ceilings and walls in the twilight and dark zones of the caves.

Each of the species of heleomyzid flies reported here was found previously in Ozark caves (Barnett 1970, Black 1971, Peck and Lewis 1978, McDaniel et al. 1979, Welbourn and Lindsley 1979, Gardner 1986). Heleomyzid flies are frequently found on walls and ceilings of caves, and they are usually classified as troglaphiles or troglaxenes (Gill 1962, Holsinger and Culver 1988, Peck and Lewis 1978, Sutton 1993). We know little about their biology or why they enter caves in such great numbers. The few heleomyzine species for which larval food habits are known are thought to feed on dung, carrion, and other decaying materials. *Oecothea specus* (previously known as *Aecothea specus* [International Commission on Zoological Nomenclature 1995]) occurs throughout North America, and it is common in collections from caves and mammal burrows (Garnett and Foote 1966). Adults have been collected at traps

baited with fish meal, fermented syrup, and beef liver. *Amoebalaria defessa* and *A. sackeni* have been observed at tree sap in wooded areas, but probably most specimens have been taken deep within caves where they occur throughout the year (Gill 1962). Busacca (1975) found *A. defessa*, *H. brachypterna*, *H. serrata* (Linnaeus), and *O. specus* most heavily concentrated 40–50 m from the entrance of an Indiana cave in October, November, and January. He examined bat guano, decaying organic matter, dead bats, and meat bait for heleomyzid larvae but found none. Reeves and McCreadie (2001) found no heleomyzid immature in hundreds of carrion baits placed in two caves in Georgia. Larvae of the widespread North American and European species *H. brachypterna* have been found in bird nests in Great Britain (Blair 1931). Collin (1939) reported having seen specimens bred from the nest of a brown owl, from the debris of an owl's nest in a tree hollow, and from nests of kestrels, carrion crows, and rooks. Both male and female heleomyzids are present in Ozark caves throughout the year. Most *A. sackeni* specimens were taken in winter, and most *H. brachypterna* specimens were taken in late spring.

#### Sphaeroceridae

*Leptocera caenosa* (Rondani).—ARKANSAS: Newton Co.: John Eddings Cave, 19-Oct-01, MES, CJB (1 ♀); Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (1 ♀). OKLAHOMA: Delaware Co.: East Hollow Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♂, 1 ♀).

*Limomyza cavernicola* Marshall.—ARKANSAS: Stone Co.: Hammer Springs Cave, 17-Mar-02, GG, CB (1 ♀). OKLAHOMA: Delaware Co.: Long's Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♂); Rock Quarry Cave, 25-Jul-05, GG, MES (1 ♂).

*Spelobia chunipes* (Meigen).—OKLAHOMA: Delaware Co.: Rock Quarry Cave, 25-Jul-05, GG, MES (1 ♂).

*Spelobia* sp. prob. *chunipes* (Meigen).—ARKANSAS: Washington Co.: Granny Parker's Cave, 16-Jun-00, GG, S. Longing (2 ♀). OKLAHOMA: Delaware Co.: Long's Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (3 ♀).

*Spelobia tenebrarum* (Aldrich).—ARKANSAS: Baxter Co.: Bonanza Cave, 7-Oct-02, GG, D. Kampwerth, S. McGinnis (1 ♂); Benton Co.: Pigeon Roost Cave, 28-Jun-02, GG, B. Sasse (1 ♂); War Eagle Cavern, 11-May-01, A. Brown, C. Brown (1 ♀); Boone Co.: Big Hole Cave, 10-Nov-01, MES, M. Covington, CB (2 ♀); Marion Co.: Marble Falls Cave, 7-Sep-01, GG, MES (2 ♂); Pretty Junkyard Spring Cave, 5-Jun-02, MES (2 ♀); Reed Cave, 9-Mar-02, GG, S. McGinnis (1 ♂); Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (3 ♂, 1 ♀); Hammer Springs Cave, 17-Mar-02, GG, CB (1 ♂); Rowland Cave, 12-Jun-01, GG, CB, J. Disler (1 ♂, 2 ♀); Twin Cave, 28-Oct-05, N. Youngsteadt, J. Youngsteadt (4 ♀). MISSOURI: Jasper Co.: Sarcxie Cave, 8-Feb-02, GG, T. Snell, J. Foresman, J. Hinsey (1 ♀). OKLAHOMA: Cherokee Co.: Crystal Cave, 29-Jan-02, GG, DF, S. Hensley (3 ♂, 2 ♀); Delaware Co.: East Hollow Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♀); January-Stansbury Cave, Aug. 2002, DF (1 ♀).

*Telomerina flavipes* (Meigen).—ARKANSAS: Newton Co.: John Eddings Cave, 19-Oct-01, MES, CJB (1 ♂).

Sphaerocerids have been reared from dead bats and meat bait placed in caves (Busacca 1975). *Leptocera caenosa* is associated primarily with plant detritus in caves and is opportunistically associated with many cavelike environments. It also invades cellars, mines, urinals, abattoirs, and septic tanks (Conn and Marshall 1991). Reeves et al. (2000) found it in association with carrion,

cheese, and dung baits in a cave in Georgia. *Limomyza cavernicola* was recently described from in or near caves in Missouri, Kentucky, Oklahoma, and Colorado. It is regarded as troglophile (Marshall 1997).

*Spelobia tenebrarum*, known only from caves, is the most abundant of the Nearctic cave sphaerocerids. It occurs in the south-central United States, south of the southern limits of the Wisconsin glacial ice sheet. Like some other cave flies, it has reduced eyes and an elongated antennal arista. It seems to have reduced powers of flight, leaping rather than flying when disturbed. The species is commonly associated with fecal material, especially bat guano, and decaying organic matter (Marshall and Peck 1984, 1985; Marshall 1985). It is considered a true troglobite (Lewis et al. 2003, Marshall and Peck 1984, Marshall and Fitzgerald 1997) or possibly a troglophile (Holsinger and Culver 1988). Marshall and Reeves (2003) reported adults and immatures of the facultative cavernicolous species *Spelobia pickeringi* Marshall to be associated with bat guano in caves in South Carolina. Adults were also collected in epigeal Malaise and mushroom-baited traps in Georgia and Maryland.

According to Marshall and Peck (1984), the entire genus *Telomerina* is characterized by apparently hypogean characters, such as reduced eye size. It is not surprising that some species are found in caves. They characterized *T. flavipes* as a cosmopolitan, necrophagous, synanthropic species that is not predominantly trogliphilic. It also has been collected from caves in Europe, Africa, South America, Australia, and New Zealand and from Devil's Den Cave, Washington County, Arkansas. It is commonly collected in carrion traps, dung, decaying fungi, and mammal burrows (Marshall and Roháček 1984).



## Anthomyiidae

*Pegomya* sp.—MISSOURI: Pulaski Co.: FLW: David's Crawl Cave, 12-Apr-04, SJT, MES (1 ♀); Flat Roof Cave, 10-May-04, SJT, MES (1 ♀); Joint East Cave, 10-Apr-04, SJT, MES (1 ♀); Kilman Cave, 25-Mar-03, SJT, V. Block (1 ♂); Little Crevice Cave, 24-Oct-03, SJT, MES (1 ♀). OKLAHOMA: Delaware Co.: Long's Cave, 26-Jul-05, GG, MES, S. Hensley, J. Pruett (1 ♀).

Missouri specimens of *Pegomya* were found on bedrock ceilings or on packrat feces in habitats characterized subjectively as having dry to normal moisture condition. Larvae of *Pegomya* are typically leaf and stem miners. *Pegomya affinis* Stein and *P. dissecta* Meigen have been found in caves in Ontario during summer and fall (Peck 1988).

## Bibionidae

*Biblio albipennis* Say.—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle, (1 ♀).

## Calliphoridae

*Calliphora livida* Hall.—ARKANSAS: Newton Co.: Squirrel Pit, 2-Feb-02, GG, MES (1 ♀).

*Calliphora vicina* Robineau-Desvoidy.—ARKANSAS: Stone Co.: Blanchard Springs Caverns, 27-Apr-02, GG, MES, K. Tinkle (2 ♂, 1 ♀). MISSOURI: Pulaski Co.: FLW: Joy Cave, 18-Jun-04, SJT, MES (1 ♀).

*Cynomya cadaverina* Robineau-Desvoidy.—OKLAHOMA: Delaware Co.: Twin Cave, 5-Mar-01, GG, MES, S. Feirer, DF (1 ♂).

Peck and Lewis (1977) found *C. vicina* in a cave in Illinois. Reeves and Disney (1999) reported finding *Calliphora* sp. larvae competing with *M. cavernicola* larvae on carrion in caves. Reeves et al. (2000) reported *C. vicina* and *Calliphora vomitoria* (Linnaeus) associated with chicken liver bait placed in caves in Georgia. All species of *Calliphora* are

saprophagous. *Cynomya cadaverina* is attracted to excrement and putrid carrion. Adults are also found in kitchens, pantries, and cellars of homes in early spring and late fall. The larvae have been implicated in cases of subdermal myiasis in warm-blooded animals (Hall 1948).

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