# FINAL PERFORMANCE REPORT

FEDERAL AID GRANT NO. T-16-P-1

FAUNAL SURVEY OF OKLAHOMA CAVE AND SPRINGS

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

June 1, 2004 through May 31, 2008

# FINAL REPORT

**State:** Oklahoma **Grant Number:** T-16-P-1

**Grant Program:** State Wildlife Grant

**Grant Name:** Faunal Survey of Oklahoma Caves and Springs

**Grant Period:** June 1, 2004 – May 31, 2008

**Reporting Period:** June 1, 2004 – May 31, 2008

## A. Abstract:

General biological inventories of caves, springs, and other subterranean habitats were performed in at least 101 sites throughout Oklahoma from 2004 to 2008. Additionally, 50 springs throughout Oklahoma were intensively studied and their biological and physio-chemical properties analyzed from 2003 to 2008. The objectives of these studies were: to describe the biodiversity of animal life in subterranean habitats of Oklahoma; to determine the status and distribution of rare and endangered animals in these habitats; to examine habitat variables to determine zoogeographic patterns in subterranean diversity and to rank the inventoried sites in order of biological importance; to provide this information to ODWC to facilitate conservation planning.

Very few cave habitats had a species richness greater than 20 taxa. The most species-rich cave habitats were the cave AD-14 with 80 taxa, and GR-011and DL-39, both with 63 taxa. Species richness in springs was significantly greater because of their connectivity with surface ecosystems. Numerous rare and endangered species utilize subterranean habitats in Oklahoma. There are at least 40 species that are known to be limited to, or adapted to, groundwater habitats (stygobites) or caves (troglobites), including 8 new species that await taxonomic description. The most common subterranean-obligate was grotto salamander (*Eurycea spelaea*) and the second was cave isopod (*Caecidotea* sp.). Overall, arthropods dominated the cave habitats, especially crickets, mosquitoes, spiders, and springtails. The most common invertebrate taxon was cave crickets of the genus *Ceuthophilus*. The most common vertebrates were eastern pipistrelle bat (*Periomyotis subflavus*) and cave salamander (*Eurycea lucifuga*). An accumulation curve was generated, which indicated that sampling effort to date has detected the majority of total species that can be found in cave habitats of Oklahoma, and that future bioinventories will add more species to this cumulative list, but probably at an exponentially slower rate.

Habitat variables data were collected during the fieldwork at each site; these data were compared to each cave site's total species richness and obligate richness to discern any biodiversity patterns. Richness of a cave was directly proportional to its passage length; the longest caves are the most-biologically rich. This constitutes a significant management challenge, as the longest caves are usually the most attractive for recreational caving. Richness was also higher in cave sites with organics present

(especially bat guano), when subterranean streams were present, and when sites had regulated access (especially by gating). However, frequent public use or the presence of vandalism did not correlate to lower richness measurements. Caves were ranked in biological importance using 3 variables: site length, total species richness, and obligate richness. Cave AD-14 ranked highest in Oklahoma, and cave DL-39 was second.

The intensive surveying of 50 springs revealed that Oklahoman springs have a diverse biota, especially with respect to invertebrates (primarily insects); over 200 taxa were found. Spring faunas consist of a combination of generalists species, which are commonly found in area ponds and/or streams, spring specialists (including endemics), and occasional subterranean-obligate crustaceans. Aquatic worms, fly larvae (chironomids and ceratopogonids), water striders, fingernail clams, and pond snails are all common in ponds and streams – as well as in springs. Although Arbuckle and Ozark springs are both limestone-based, their invertebrate faunas are different. In contrast, the invertebrate faunas of Arbuckle and High Plains springs are similar although the High Plains springs are mostly sand-based rather than limestone-based. These results highlight the distinctiveness of the Ozark and Arbuckle faunas.

**B. Need:**

The study of cave and spring faunas is important because of their connection with groundwater and mineral resources, their interest to science, and their rarity. Groundwater supplies 62% of the overall water demands of the United States (Job and Simons, 1994). In Oklahoma, groundwater is withdrawn at an estimated rate of 960 million gallons per day and accounts for over half of the total freshwater withdrawal (Tortorelli, 2002). Despite this high use of groundwater, little is known about groundwater ecosystems (Job and Simons, 1994). In addition to the extensive use of groundwater by humans, groundwater provides crucial ecological services, such as providing a reliable water source for springs and rivers, and altering the mineral and organic content of waters.

Groundwater habitats tend to have highly endemic faunal communities, with many species found only in a single cave or groundwater system. Approximately 90% of cave/groundwater communities have not been surveyed (Culver and Hobbs III, 2000). Cave-limited fauna (troglobites) and ground-water limited fauna (stygobites) represent more than half of the imperiled (G1-G2) animal species listed in the Natural Heritage Program, and include several species in the ODWC Species of Greatest Conservation Need yet, nationally, less than 4% of these species have federal protection status (Culver *et al.* 2000, NatureServe 2002).

Groundwaters produce springs where they reach the surface. Springs contain a combination of spring-adapted, stream-generalist, and groundwater-adapted species and, as a consequence, several spring-dwelling species are included in the ODWC Species of Greatest Conservation Need.

Groundwater, cave, and spring faunas generally share the same threats. Foremost among these is groundwater withdrawal, which destroys these habitats through direct dewatering. Nutrient and toxic pollutants are localized problems which especially affect groundwaters in limestone regions, such as the Ozark Plateau and Arbuckle Range in Oklahoma, because of direct input of chemicals through sinkholes and disappearing streams. Human disturbances, such as trampling and modification of springs, also impact these habitats and their faunas.

In order to conserve springs, caves, and groundwater habitats and their associated fauna, there is a clear need of additional information on the distribution, ecology, and taxonomy of the fauna of these habitats. This proposed project addresses this need by investigating key subterranean and spring habitats; these habitats will be surveyed through species censuses; and the status, distribution, and taxonomy of rare species will be updated.

Among the target species of this bioinventory are several crustaceans, including cave and spring/stream dwelling crayfishes, and cave amphipods and isopods. Cave crayfish in the Ozarks of particular interest because both *Cambarus tartarus* and *C. subterraneus* have very limited known distributions; yet the identification of the crayfish in some Oklahoma caves is unresolved and additional surveys may allow identification of these undetermined crayfish. Also of interest is the federally endangered Benton Cave Crayfish (*Cambarus aculabrum*), which occurs on the Oklahoma/Arkansas border in the Illinois River watershed, but has not been documented in Oklahoma. Investigation of caves in the Oklahoma portion of this watershed should indicate whether *C. aculabrum* occurs in the state. Vertebrates on the target list include the Ozark cavefish and spring dwelling darters, and salamanders found in caves and springs. While the populations of federally threatened Ozark cavefish (*Amblyopsis rosae*) have been surveyed regularly in Arkansas and Missouri, censuses of most cavefish habitats in Oklahoma are a decade old. This study will help bring the Oklahoma censuses up to date, which will contribute to recovery efforts of this species. Most other species encountered will also be inventoried, and this data will provide information on associates of rare species and information on the distribution of cave- and spring- inhabiting species in the state.

## C. Objectives:

The objectives of this project are:

- conduct field surveys of caves and springs, especially in the Ozark and Arbuckle regions of Oklahoma,
- update the status, distribution, and taxonomy of rare cave and spring species in Oklahoma,
- provide information needed for conservation planning for several current and potential Species of Greatest Conservation Need.

## D. Approach:

### Cave Bioinventories

In each cave surveyed, fauna were inventoried using the most unobtrusive methods possible and at times when bats were not hibernating or birthing. Vertebrates and macroscopic invertebrates were counted visually with helmet-mounted lights, using snorkeling gear and dive lights for deep pools. Collections were limited to those fauna that were impossible to identify on site, and where permitted. Voucher specimens were collected by hand, aspirator, or net, and brought back to the Oklahoma Biological Survey for preservation, cataloging, and identification or shipment to taxonomists. The cobble substrate of streams derived from spring sources was examined through "cobble sifting", in which rocks are placed into mesh sieves and moved around and examined for organisms. The mouths of some springs were fitted with temporary drift nets to capture subterranean fauna expelled by the flow of the spring (a method whose efficacy was shown in surveys of groundwater invertebrates of the Edwards Plateau in Texas). Drift nets were set and checked every two to three hours.

At each site, the following habitat parameters were determined and recorded:

- Site category – "Bluff Shelter", "Cave", "Crevice/Talus", "Hyporheos", "Mine", "Pit", "Sinkhole", "Spring", "Well", or "Unknown";
- Degree of use by the public (primarily recreational caving) – "None", "Light", "Moderate", "Heavy", or "Unknown";
- Presence or absence of vandalism: "No" (including "Unknown") or "Yes" (defined as evidence of looting, presence of trash litter, campfire smoke residue, graffiti, animal injury, or damage to speleothems);
- Presence or absence of organics: "No" (including "Unknown") or "Yes" (defined as presence of bat guano or other feces, leaf litter, woody debris, etc.)
- Presence or absence of bat guano: "No" (including "Unknown") or "Yes" (defined as a significant accumulation, such as evidenced by a "guano pile", strong smell of urine/ammonia, or majority of surfaces covered)
- Subterranean water resource category that was dominant at the site – "Dry", "Drip Pool", "Intermittent Stream", "Perennial Stream", or "Unknown"; entrance to site gated (including fenced) – "yes" or "no"
- Degree of public access: "Unrestricted" (access uncontrolled; visitation not necessarily sanctioned by landowner); "By Permit Only" (permission by landowner must be obtained before entry); "Scientific Study Only"; "Closed or Sealed" (entrance sealed shut)
- Site landowner category: "Federal"; "State" (included counties and municipalities), "NGO" non-governmental organization (e.g., church, not-for-profit entity, land trust)", "Commercial" (owned by a business / fee charged to enter cave), "Private", or "Unknown"
- Site geologic unit (surficial geologic unit was determined using geographical information system software and digital USGS geologic maps).
- Site length (in meters): total mapped cave horizontal passage length; default length for wells and springs having no humanly-accessible horizontal extent was 1 m (this data was obtained primarily from unpublished data of members of the National Speleological Society).

### Cavefish and Cave Crayfish Censuses

In caves with cavefish or cave crayfish, faunal censuses were performed using established methods (Graening and Brown, 2000). Surveyors moved slowly upstream and counted individuals as they were sighted, using helmet lights and powerful SCUBA lights. This method is understood to produce fairly reliable quantitative population information with minimal impact on the cave habitats and their inhabitants.

### Spring Inventories

Methods used to sample springs followed those used by Bergey (2002) and included the following components:

- Site description, including TRS coordinates, GPS readings, a site sketch, photos, local land use, modifications of the spring, and directions for re-finding the site.

- Discharge information (flow width, depths, and mean velocities). Velocity was measured with a Marsh-McBirney electromagnetic flowmeter.
- An owner questionnaire, used to get information on land use changes, changes in discharge, and historical use of springs (when possible).
- Fish sampling, using seines or dipnets. Only one or two fish of each species were collected. Dr. William Matthews (Department of Zoology, University of Oklahoma) verified identifications and specimens will be deposited at the Sam Noble Oklahoma Museum of Natural History at OU.
- Invertebrates sampling, using hand nets for qualitative sampling and a small corer for quantitative sampling. Samples were preserved in the field and returned to the Bergey laboratory for sample sorting and invertebrate identification.

**Taxonomy**

Collected specimens were identified at the University of Oklahoma by the authors, or sent to taxonomic specialists, including: Dr. Jeffrey Barnes (UAF Dept. of Entomology) for dipterans and other Insecta, Dr. Kenneth Christiansen (Grinnell College) and Dr. Jeffrey Battigelli (Earthworks Research Group) for collembolans; Dr. Horton Hobbs III (Wittenburg University) for decapods; Dr. John Holsinger (Old Dominion University) for amphipods; Dr. Jerry Lewis (Lewis Consulting) for isopods and diplopods; Dr. Jeffrey Battigelli for acari; Dr. William Muchmore (University of Rochester) for pseudoscorpions; Dr. Henry Robison (Southern Arkansas University) or Dr William Matthews and staff at the Oklahoma Museum of Natural History (University of Oklahoma) for fishes; Dr. Stewart Peck (Carleton University) or Dr. John Epler (Independent consultant) for coleopterans; Dr. James Cokendolpher (Museum of Texas Tech University) and Dr. Darrell Ubick (California Academy of Sciences) for opilionids; Dr. Lynn Ferguson (Longwood College) and Mark Muegge (Texas Cooperative Extension) for diplurans; Dr. Gerald Walsh for gastropods; and Dr. Theodore Cohn (University of Michigan) for orthopterans, Dr. Peter Adler (Clemson University) for dipterans, Dr. Donald Klemm (USEPA-Cincinnati) for leeches. Adult aquatic insects were sent to Dr. Boris Kondratieff (Colorado State University) for mayflies and stoneflies and Dave Ruiter (EPA, Colorado) for caddisflies. Collected specimens will be curated in the US National Museum, the Oklahoma Biological Survey, or the Sam Noble Oklahoma Museum of Natural History, or they reside in the personal collections of taxonomists.

**Permits held by Dr. Graening:**

- Oklahoma Department of Wildlife Conservation Scientific Collector's Permit 3982;
- USFWS Special Use Permit 43590 – HLB-1-01; and
- USFWS Recovery Permits RT-834518, TE834518-1, TE834518-2, and TE834518-3.

**Permits held by Dr. Bergey**

- Oklahoma Department of Wildlife Conservation Scientific Collector's Permit 3571;
- University of Oklahoma, project-specific approved AUS protocols; file number R04-010 (for working with cave/spring fishes and salamanders)

**Location**
This project focused primarily on the limestone (karst) areas of Oklahoma, which are the Ozark Plateau (e.g., Adair, Delaware and Ottawa Counties) and the Arbuckle Range (e.g., Murray County and Pontotoc County), with their relatively high densities of caves and springs. Previous spring and cave surveys have concentrated primarily on the Ozarks and relatively little work has been done in the Arbuckles. Other appropriate areas in the state that include suitable habitat for cave and spring -associated species (e.g., the Ouachita Mountains) were included as time and site access permitted.

## E. Results and Discussion:
Because of the differences in methods and types of data collected, the two subsections – Part 1 Cave Survey and Part 2 Spring Survey - are presented separately.

**Part 1. Cave Survey.**

**Bioinventory Effort**

For this grant period (6/2004 to 6/2008), 219 inventory events (including some repeated trips) were been performed in 101 subterranean sites in Oklahoma. This does not include 41 springs that were intensively studied by Dr. Bergey. The locations of these 101 subterranean habitats are shown graphically in Figure 1 (gray squares). Appendix 1 summarizes the faunal inventory checklists generated during this grant period.

This ODWC-funded study is part of a larger biodiversity study – the Subterranean Biodiversity Project, which started in 1999. Data generated from this study was pooled with other data from the Subterranean Biodiversity Project and previous studies from other authors. This combined data set produced the following: 5,122 total faunal occurrence records in subterranean sites in Oklahoma, with dates spanning from 1924 to 2007; 289 inventory events performed in 458 sites (including some repeated inventories); and a faunal checklist of approximately 750 unique taxa, including morphospecies not defined to the generic or specific level.

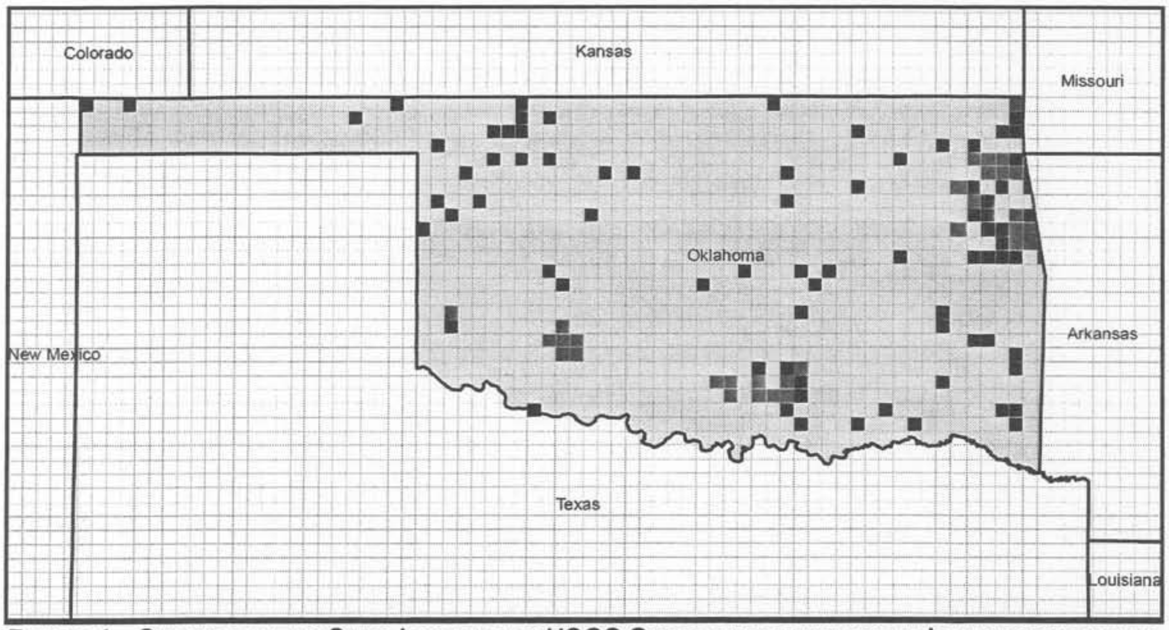


**FIGURE 1. SUBTERRANEAN SITES LOCATED BY USGS QUADRANGLE THAT WERE INVENTORIED IN THIS ODWC STUDY (GRAY SQUARES) AND OTHER STUDIES (BLACK)**

## Site-specific Biodiversity Estimates

Very few caves site had a species richness greater than 20 taxa; the number of sites decreases exponentially as the richness increases (Figure 2).

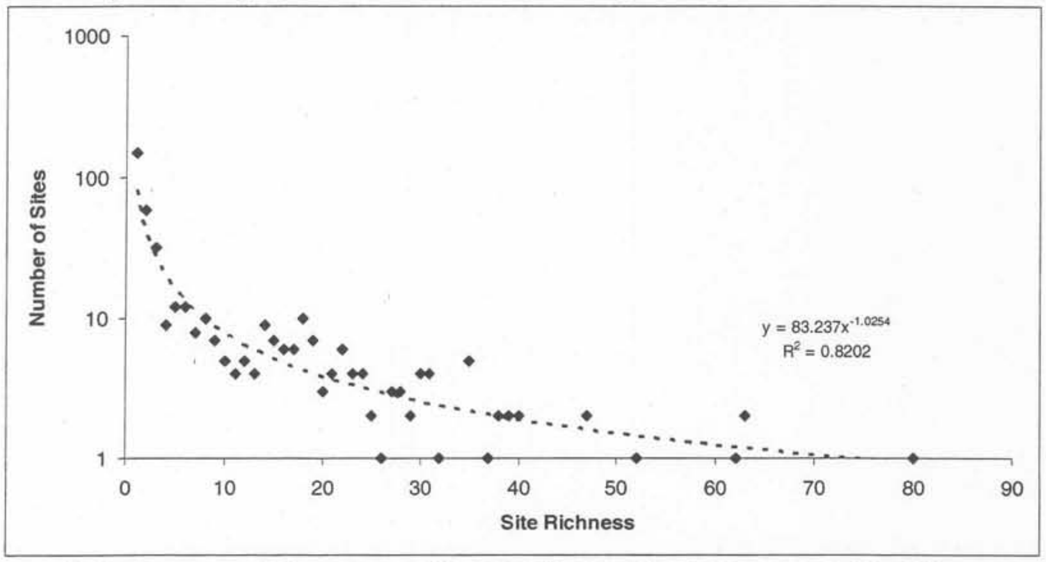


FIGURE 2. EXPONENTIAL RELATIONSHIP BETWEEN RICHNESS AND NUMBER OF SITES HAVING THAT RICHNESS

All of the subterranean sites were ranked by species richness; springs were excluded because their connectivity with surface habitats inflates their site richness with species that are not strongly associated with subterranean ecosystems. Table 1 lists the top 40 most species-rich subterranean sites (primarily caves) in Oklahoma. The most species-rich cave currently is AD-14 with 76 taxa, with Jester Cave and the J. Selman Cave System very close behind (75 and 69 taxa, respectively).

**TABLE 1. TOP 40 MOST SPECIES-RICH CAVES IN OKLAHOMA**

| Richness | Site Name (or Code) | County |
|---|---|---|
| 76 | AD-14 | Adair |
| 75 | Jester Cave | Greer |
| 69 | J. Selman Cave System | Woodward |
| 63 | DL-39 | Delaware |
| 63 | CZ-9 | Cherokee |
| 47 | MU-2 | Murray |
| 47 | DL-91 | Delaware |
| 39 | AD-19 | Adair |
| 38 | AD-7 | Adair |
| 37 | DL-3 | Delaware |
| 35 | DL-8 | Delaware |
| 35 | DL-41 | Delaware |
| 34 | AD-8 | Adair |
| 33 | Nescatunga Cave | Major |
| 32 | AD-137 | Adair |
| 31 | AD-9 | Adair |
| 31 | DL-32 | Delaware |
| 31 | Coal Creek Cave | Pontotoc |
| 30 | DL-102 | Delaware |
| 30 | DL-148 | Delaware |
| 30 | AD-15 | Adair |
| 28 | DL-59 | Delaware |
| 27 | SQ-1 | Sequoyah |
| 25 | WA-012 | Washita |
| 25 | AD-29 | Adair |
| 25 | CZ-18 | Cherokee |
| 24 | DL-38 | Delaware |
| 23 | OT-4 | Ottawa |
| 23 | CZ-11 | Cherokee |
| 22 | DL-79 | Delaware |
| 22 | CZ-12 | Cherokee |
| 22 | Doolin Cave | Seminole |
| 21 | Washita Bat Caves | Washita |
| 21 | DL-51 | Delaware |
| 21 | Lost Turtle Cave | Adair |
| 20 | AD-13 | Adair |
| 20 | CZ-19 | Cherokee |
| 19 | Little Crystal Cave | Murray |
| 19 | DL-1 | Delaware |
| 19 | AD-17 | Adair |
| 19 | AD-220 | Adair |

## Rare Species

Numerous rare and endangered species utilize subterranean habitats in Oklahoma. Table 2 lists these species (taxa awaiting species description are not listed), where "rare" is defined as a species having a Natural Heritage / NatureServe ranking of G1, G2, S1, or S2 (see http://www.natureserve.org/explorer for an explanation of the ranking system and further data). There are at least 40 known subterranean-obligates in Oklahoma (Table 3), including 8 new species that await taxonomic description. Culver et al. (2000) reported 27 subterranean-obligates from Oklahoma – we expanded the list to 40. In Oklahoma, the most common troglobite was grotto salamander (*Eurycea spelaea*) with at least 74 occurrences in 43 sites (second most common were cave isopods [*Caecidotea* sp.]). In the USA, the most common obligate reported was a cave dung fly (*Spelobia tenebrarum*) found in at least 50 counties and 12 States (Culver et al. 2000).

**TABLE 2. RARE AND ENDANGERED SPECIES REPORTED IN SUB. HABITATS OF OKLAHOMA**

| Scientific Name | Common Name | ESA Status | Global Rank | State Rank |
|---|---|---|---|---|
| *Allocrangonyx pellucidus** | Oklahoma Cave Amphipod | Not Listed | G2G3 | S1? |
| *Amblyopsis rosae** | Ozark Cavefish | Threatened | G2G3 | S1 |
| *Arrhopalites jay** | Cave Globular Springtail | Not Listed | G2G3 | SNR |
| *Bactrurus hubrichti** | Kansas Well Amphipod | Not Listed | G4 | S2? |
| *Caecidotea acuticarpa** | Cave Isopod | Not Listed | G2G3 | SNR |
| *Caecidotea adenta** | Cave Isopod | Not Listed | G1G2 | SNR |
| *Caecidotea macropropoda** | Bat Cave Isopod | Not Listed | G2G3 | SNR |
| *Caecidotea oculata* | Water Slater | Not Listed | G2G3 | SNR |
| *Caecidotea simulator** | Springfield Plain Groundwater Isopod | Not Listed | G2G3 | SNR |
| *Cambarus subterraneus** | Delaware County Cave Crayfish | Not Listed | G1G2 | S1 |
| *Cambarus tartarus** | Oklahoma Cave Crayfish | Not Listed | G1G2 | S1 |
| *Coragyps atratus* | Black Vulture | Not Listed | G5 | S2B |
| *Corynorhinus townsendii ingens* | Ozark Big-eared Bat | Endangered | G4T1 | S1 |
| *Etheostoma craginii* | Arkansas Darter | Candidate | G3 | S2 |
| *Eurycea lucifuga* | Cave Salamander | Not Listed | G5 | S2S3 |
| *Miktoniscus racovitzai** | Racovitza's Cave Isopod | Not Listed | G3G4T1T2 | SNR |
| *Myotis grisescens* | Gray Bat | Endangered | G3 | S2 |
| *Myotis leibii* | Eastern Small-footed Bat | Not Listed | G3 | S1 |
| *Myotis lucifugus* | Little Brown Bat | Not Listed | G5 | S1 |
| *Myotis septentrionalis* | Northern Long-eared Bat | Not Listed | G4 | S2 |
| *Myotis sodalis* | Indiana Bat | Endangered | G2 | S1 |
| *Myotis yumamensis* | Yuma Myotis (Bat) | Not Listed | G5 | S1 |
| *Orconectes meeki* | Meek's Crayfish | Not Listed | G4 | S2S3 |
| *Plethodon angusticlavius* | Ozark Zigzag Salamander | Not Listed | G4 | S2 |
| *Plethodon ouachitae* | Ouachita Salamander | Not Listed | G2G3 | S2 |
| *Pseudosinella dubia** | Cave Springtail | Not Listed | G1G2 | SNR |
| *Rana palustris* | Pickerel frog | Not Listed | G5 | S2S3 |
| *Spilogale putorius* | Eastern Spotted Skunk | Not Listed | G5 | S2 |
| *Stygobromus bowmani** | Bowman's Cave Amphipod | Not Listed | G1G2 | S1? |
| *Stygobromus ozarkensis** | Ozark Cave Amphipod | Not Listed | G3G4 | S1 |
| *Stygobromus onondagaensis** | Onondaga Cave Amphipod | Not Listed | G1 | SNR |
| *Vulpes velox* | Kit Fox | Not Listed | G3 | S1 |

Note: Asterisk (*) indicates that the species is adapted or restricted to subterranean habitats.

**TABLE 3. SUBTERRANEAN-OBLIGATE ANIMALS OF OKLAHOMA. AT LEAST 40 SPECIES ARE KNOWN TO BE LIMITED TO, OR ADAPTED TO, GROUNDWATER HABITATS (STYGOBITES) OR CAVES (TROGLOBITES) OF OKLAHOMA.**

| Scientific Name | Common Name | Global Rank | State Rank | # of Sites |
|---|---|---|---|---|
| *Allocrangonyx pellucidus* | Oklahoma Cave Amphipod | G2G3 | S1? | 18 |
| *Amblyopsis rosae* | Ozark Cavefish | G2G3 | S1 | 13 |
| *Amerigoniscus centralis* | Cave Isopod | GNR | SNR | 1 |
| *Arrhopalites jay* | Cave Globular Springtail | G2G3 | SNR | 2 |
| *Arrhopalites* sp. nov. | New Species of Globular Springtail | GU | SU | 1 |
| *Bactrurus hubrichti* | Kansas Well Amphipod | G4 | S2? | 2 |
| *Caecidotea acuticarpa* | Cave Isopod | G2G3 | SNR | 20 |
| *Caecidotea adenta* | Cave Isopod | G1G2 | SNR | 1 |
| *Caecidotea ancyla* | Cave Isopod | G3G4 | SNR | 9 |
| *Caecidotea antricola* | Cave Isopod | G5 | SNR | 2 |
| *Caecidotea mackini* | Long's Cave Isopod | GNR | SNR | 1 |
| *Caecidotea macropropoda* | Bat Cave Isopod | G2G3 | SNR | 6 |
| *Caecidotea simulator* | Springfield Plain Groundwater Isopod | G2G3 | SNR | 6 |
| *Caecidotea steevesi* | Steeves' Cave Isopod | G3G4 | SNR | 3 |
| *Caecidotea stiladactyla* | Cave Isopod | G3G4 | SNR | 9 |
| *Cambarus subterraneus* | Delaware County Cave Crayfish | G1G2 | S1 | 4 |
| *Cambarus tartarus* | Oklahoma Cave Crayfish | G1G2 | S1 | 3 |
| *Causeyella* sp. | Cave Millipede | GU | SU | 2 |
| *Chaetaspis* sp. | Cave Millipede | GU | SU | 1 |
| *Chaetaspis* sp. nov. # 2 | New Species of Cave Millipede | GU | SU | 1 |
| *Crosbyella* sp. | Cave Harvestman | GU | SU | 7 |
| *Eurycea spelaea* | Grotto Salamander | G4 | S3 | 43 |
| *Hesperochernes occidentalis* | Cave False Scorpion | G4G5 | SNR | 2 |
| *Islandiana unicornis* | Cave Spider | G3G4 | SNR | 1 |
| Japygidae | Two-pronged Bristletail | GU | SU | 3 |
| *Litocampa* sp. | Cave Two-pronged Bristletail | GU | SU | 5 |
| *Litocampa* sp. nov. | New Species of Cave Two-pronged Bristletail | GU | SU | 1 |
| *Miktoniscus racovitzai* | Racovitza's Cave Isopod | G3G4T1T2 | SNR | 1 |
| *Nesticus pallidus* | Cave Spider | GNR | SNR | 3 |
| *Nicoletia* sp. | Cave Silverfish | GU | SU | 2 |
| *Porrhomma cavernicola* | Appalachian Cave Spider | G4G5 | SNR | 1 |
| *Pseudosinella dubia* | Cave Springtail | G1G2 | SNR | 1 |
| *Pseudosinella* sp. nov. # AB | New Species of Cave Springtail | GU | SU | 1 |
| *Spelobia tenebrarum* | Cave Dung Fly | GNR | SNR | 2 |
| *Stygobromus alabamensis* | Alabama Cave Amphipod | G4G5 | SNR | 24 |
| *Stygobromus bowmani* | Bowman's Cave Amphipod | G1G2 | S1? | 1 |
| *Stygobromus onondagaensis* | Onondaga Cave Amphipod | G1 | SNR | 9 |
| *Stygobromus ozarkensis* | Ozark Cave Amphipod | G3G4 | S1 | 13 |
| *Stygobromus* sp. nov. | Arbuckle Mountains Cave Amphipod | GU | SU | 1 |
| *Trigenotyla blacki* | Black's Cave Millipede | GNR | SNR | 5 |

Based upon the findings of this study, we suggest changes to Natural Heritage / NatureServe global and subnational (or "state") ranks as summarized in Table 4.

**TABLE 4. CURRENT (OLD) GLOBAL (G) RANKS ANS STATE (S) RANKS AND SUGGESTED CHANGES (NEW) TO OLD RANKS**

| Taxon | Common Name | Old G rank | New G rank | Old S rank | New S rank | Comment |
|---|---|---|---|---|---|---|
| *Achaeranea tepidariorum* | Common House Spider | GNR | G5 | SNR | S5 | Common in USA |
| *Acris crepitans blanchardi* | Blanchard's Cricket Frog | G5T5 | | SNR | S5 | Common in OK |
| *Allocrangonyx pellucidus* | Oklahoma Cave Amphipod | G2G3 | G2 | S1? | S2 | Known from less than 200 individuals & 18 sites |
| *Amblyopsis rosae* | Ozark Cavefish | G2G3 | G2 | S1 | | Known from less than 300 individuals |
| *Ameiurus melas* | Black Bullhead Catfish | GNR | G5 | SNR | S5 | Common in OK |
| *Ameiurus natalis natalis* | Yellow Bullhead Catfish | GNR | G5 | SNR | S5 | Common in OK |
| *Amerigoniscus centralis* | Cave Isopod | GNR | G1 | SNR | S1 | Single-site endemic |
| *Argiope aurantia* | Yellow Garden Spider | GNR | G5 | SNR | S5 | Common in OK |
| *Arrhopalites jay* | Cave Globular Springtail | G2G3 | G1 | SNR | S1 | Found in only 2 sites in the world |
| *Bactrurus hubrichti* | Kansas Well Amphipod | G4 | | S2? | S1 | Found in only 2 sites in OK |
| *Caecidotea acuticarpa* | Cave Isopod | G2G3 | G1 | SNR | S1 | Known from less than 100 individuals |
| *Caecidotea adenta* | Cave Isopod | G1G2 | G1 | SNR | S1 | Found in only 2 sites in the world |
| *Caecidotea ancyla* | Cave Isopod | G3G4 | G3 | SNR | S2 | Endemic to Ozarks, rare in OK |
| *Caecidotea antricola* | Cave Isopod | G5 | G3 | SNR | S1 | Endemic to Ozarks, rare in OK |
| *Caecidotea communis* | Water Slater | GNR | G4 | SNR | S1 | See Graening et al. 2008 |
| *Caecidotea mackini* | Long's Cave Isopod | GNR | G1 | SNR | S1 | Single-site endemic |
| *Caecidotea macropoda* | (delete this element - it is a misspelling of C. macropropoda - J. Lewis, pers. comm.) | | | | | See Graening et al. 2008 |
| *Caecidotea macropropoda* | Bat Cave Isopod | G2G3 | G2 | SNR | S1 | See Graening et al. 2008 |
| *Caecidotea oculata* | Water Slater | G2G3 | G1 | SNR | S1 | See Graening et al. 2008 |
| *Caecidotea simulator* | Springfield Plain Groundwater Isopod | G2G3 | G3 | SNR | S2 | See Graening et al. 2008 |
| *Caecidotea steevesi* | Steeves' Cave Isopod | G3G4 | G3 | SNR | S1 | See Graening et al. 2008 |
| *Caecidotea stiladactyla* | Cave Isopod | G3G4 | G3 | SNR | S2 | See Graening et al. 2008 |
| *Cambarus subterraneus* | Delaware County Cave Crayfish | G1G2 | G1 | S1 | | Found in only 4 sites in the world |
| *Cambarus tartarus* | Oklahoma Cave Crayfish | G1G2 | G1 | S1 | | Found in only 3 sites in the world |
| *Ceuthophilus gracilipes* | Cave Cricket | GNR | G5 | SNR | S5 | Common in eastern USA |
| *Crangonyx forbesi* | Amphipod | GNR | G3 | SNR | S2 | See Graening et al. 2006 |
| *Crangonyx pseudogracilis* | Sideswimmer | GNR | G5 | SNR | S2 | See Graening et al. 2006 |
| *Crosbyella spinturnix* | Harvestman | GNR | | SNR | S1 | Found in 3 caves in OK |
| *Cylisticus convexus* | Sow Bug | GNR | G5 | SNR | SNA | exotic species |

| Taxon | Common Name | Old G rank | New G rank | Old S rank | New S rank | Comment |
|---|---|---|---|---|---|---|
| *Dendrocoelopsis americana* | Cave Flatworm | G3G4 | | SNR | S2 | Found in 6 caves in OK |
| *Dugesia dorotocephala* | Flatworm | GNR | G5 | SNR | S5 | Common in eastern USA |
| *Elaphe guttata emoryi* | Great Plains Rat Snake | G5T5 | | SNR | S5 | |
| *Eurycea longicauda melanopleura* | Dark-sided Salamander | G5T4 | | SNR | S3 | Known from 24 caves in OK |
| *Eurycea lucifuga* | Cave Salamander | G5 | | S2S3 | S3 | Known from 59 caves in OK |
| *Folsomia candida* | White Springtail | GNR | G5 | SNR | S5 | Common in eastern USA |
| *Gammarus lacustris* | Sideswimmer | GNR | G4 | SNR | S1 | See Graening et al. 2006 |
| *Gammarus minus* | Sideswimmer | GNR | G4 | SNR | S4 | See Graening et al. 2006 |
| *Gammarus pseudolimnaeus* | Northern Spring Amphipod | G5 | G4 | SNR | S1 | See Graening et al. 2006 |
| *Gerris remigis* | Water Strider | GNR | G5 | SNR | S5 | Common in eastern USA |
| *Hesperochernes occidentalis* | Cave False Scorpion | G4G5 | | SNR | S1 | Found in only 2 sites in OK |
| *Hyalella azteca* | Sideswimmer | G5 | | SNR | S4 | See Graening et al. 2006 |
| *Islandiana unicornis* | Cave Spider | G3G4 | | SNR | S1 | Found in only 1 site in OK |
| *Lirceus garmani* | Water Slater | GNR | G4 | SNR | S4 | See Graening et al. 2008 |
| *Lirceus hoppinae* | Water Slater | GNR | G4Q | SNR | S1Q | See Graening et al. 2008 |
| *Lirceus ouachitaensis* | Water Slater | GNR | G2Q | SNR | S2Q | See Graening et al. 2008 |
| *Lirceus trilobus* | Water Slater | GNR | G1Q | SNR | S1Q | See Graening et al. 2008 |
| *Loxosceles reclusa* | Brown Recluse Spider | GNR | G5 | SNR | S5 | Common in eastern USA |
| *Macrocera nobilis* | Fungus Gnat | GNR | G5 | SNR | S4 | Abundant in caves in OK |
| *Meta americana* | Cave Orb Weaver | GNR | G5 | SNR | S4 | Abundant in caves in OK |
| *Miktoniscus racovitzai* | Racovitza's Cave Isopod | G3G4-T1T2 | G3-T1 | SNR | S1 | Single-site endemic subspecies |
| *Musca domestica* | Common Housefly | GNR | | SNR | SNA | Common in USA; not a conservation target |
| *Narceus americanus* | Millipede | G5 | | SNR | S4 | Common in OK |
| *Orconectes neglectus neglectus* | Ringed Crayfish | G5-T4T5 | | SNR | S4 | Common in OK |
| *Oxidus gracilis* | Greenhouse Millipede | G5 | | SNR | SNA | exotic species |
| *Plethodon albagula* | Slimy Salamander | G5 | | SNR | S4 | Abundant in caves in OK |
| *Porrhomma cavernicola* | Appalachian Cave Spider | G4G5 | | SNR | S1 | Found in only 1 site in OK |
| *Pseudosinella dubia* | Cave Springtail | G1G2 | | SNR | S1 | Found in only 1 site in OK |
| *Ptomaphagus cavernicola* | Round Fungus Beetle | GNR | | SNR | S1 | Found in only 4 sites in OK |
| *Scoliopterix libratix* | Pink Cave Moth | GNR | G5 | SNR | S3 | |
| *Spelobia tenebrarum* | Cave Dung Fly | GNR | | SNR | S1 | Found in only 2 sites in OK |
| *Stygobromus alabamensis* | Alabama Cave Amphipod | G5 | G4 | SNR | S3 | See Graening et al. 2006 |
| *Stygobromus bowmani* | Bowman's Cave Amphipod | G1G2 | G1 | S1? | S1 | See Graening et al. 2006 |
| *Stygobromus onondagaensis* | Onondaga Cave Amphipod | G5 | G3 | SNR | S2 | See Graening et al. 2006 |
| *Stygobromus ozarkensis* | Ozark Cave Amphipod | G4 | | S1 | S3 | See Graening et al. 2006 |
| *Trigenotyla blacki* | Black's Cave Millipede | GNR | G1 | SNR | S1 | Extremely endemic (Shear 2003) |

| Taxon | Common Name | Old G rank | New G rank | Old S rank | New S rank | Comment |
|---|---|---|---|---|---|---|
| *Trigenotyla seminole* | Millipede | GNR | G1 | SNR | S1 | Extremely endemic (Shear 2003) |
| *Trigenotyla vaga* | Millipede | GNR | G1 | SNR | S1 | Extremely endemic (Shear 2003) |

The relationship between total species richness of a site and the richness of subterranean-obligates at the site is significant (Figure 3), indicating that general species richness is an estimator for subterranean obligate diversity (which is the generally-accepted metric of subterranean biodiversity worldwide). The relationship between a site's richness and the number of obligates in the site is directly proportional, with roughly one obligate for every 10 total species. The equation of linear fit is: # of obligates = 1.065 + 0.082 x richness ($r^2 = 0.546$, $p < 0.001$).

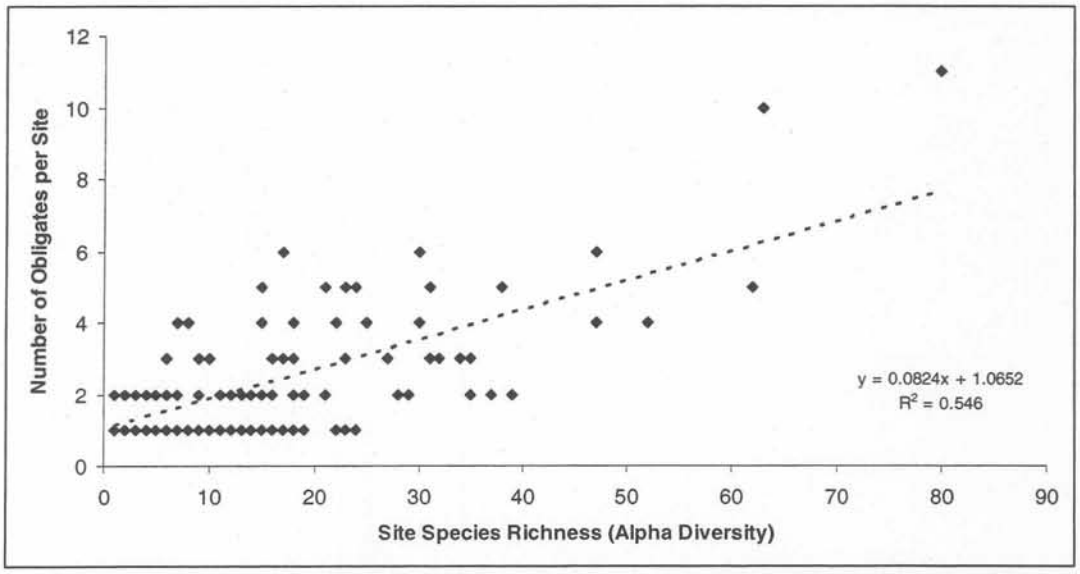


**FIGURE 3. RELATIONSHIP BETWEEN TOTAL RICHNESS AND OBLIGATE RICHNESS IN OKLAHOMA**

## Most Common Species

Overall, arthropods dominated the subterranean habitats, especially crickets, mosquitoes, spiders, and springtails. The most common invertebrate taxon was cave crickets of the genus *Ceuthophilus*. The most common vertebrates were eastern pipistrelle bat (*Periomyotis subflavus*) and cave salamander (*Eurycea lucifuga*). In aquatic habitats, crustaceans dominated (with the majority of occurrences represented by cave isopods (*Caecidotea*). Table 4 lists the most commonly occurring animal Families in subterranean habitats of Oklahoma and the number of sites in which they were found.

**TABLE 5. TOP 40 MOST COMMON FAMILIES IN SUBTERRANEAN HABITATS OF OKLAHOMA**

| Scientific Name | Common Family Name | Number of Sites |
|---|---|---|
| Vespertilionidae | Bats | 170 |
| Plethodontidae | Lungless Salamanders | 81 |
| Raphidophoridae | Camel Crickets | 79 |
| Asellidae | Water Slaters & Sowbugs | 117 |
| Crangonyctidae | Sideswimmers | 92 |
| Muridae | Mice | 37 |
| Heleomyzidae | Flies | 34 |
| Cambaridae | Crayfishes | 81 |
| Culicidae | Mosquitoes | 50 |
| Mycetophilidae | Fungus Gnats | 37 |
| Staphylinidae | Rove Beetles | 33 |
| Entomobryidae | Springtails | 20 |
| Chironomidae | Midges | 61 |
| Araneidae | Orb-weaver Spiders | 29 |
| Tipulidae | Crane Flies | 32 |
| Tyrannidae | Flycatchers | 35 |
| Leiodidae | Round Fungus Beetles | 20 |
| Ranidae | Frogs | 34 |
| Carabidae | Ground Beetles | 37 |
| Trichopetalidae | Millipedes | 13 |
| Gerridae | Water Striders | 51 |
| Polygyridae | Land Snails | 14 |
| Campodeidae | Two-pronged Bristletails | 10 |
| Lumbricidae | Earthworms | 29 |
| Veliidae | Broad-shouldered Water Striders | 37 |
| Physidae | Aquatic Snails | 57 |
| Sminthuridae | Globular Springtails | 13 |
| Procyonidae | Raccoons, Skunks, etc. | 26 |
| Dytiscidae | Predaceous Diving Beetles | 38 |
| Sphaeroceridae | Dung Flies | 23 |
| Gammaridae | Sideswimmers | 25 |
| Hyallelidae | Side Swimmers | 52 |
| Phalangodidae | Harvestmen | 12 |
| Hydrophilidae | Water Scavenger Beetles | 37 |
| Paradoxosomatidae | Millipedes | 28 |
| Phoridae | Humpbacked Flies | 5 |
| Pisidiidae | Peaclams | 18 |
| Rhagidiidae | Mites | 9 |
| Planaridae | Flatworms | 33 |
| Sciaridae | Fungus Gnats | 12 |

## Regional Richness Estimates

The bioinventory effort to date may be noteworthy, but it is far from complete. One statistical method for estimating this effort is an accumulation curve, where each new species found during consecutive collecting trips is added to the total number of species found and plotted against total number of collecting trips. This plotted curve usually is steep in the beginning, where early sampling efforts produce many new species, and the curve flattens later, when later sampling efforts produce few, if any, species not previously collected. The collector's curve approaches a theoretical maximum (asymptote), which represents the grand total number of species in that sampled habitat, a value that is sometimes interpreted as the carrying capacity of that ecosystem. A collector's curve for this study was generated (Figure 4), which compared sampling effort (cumulative number of bioinventories) to the growing species list (cumulative number of species), defined as total number of species or total number of obligate species. The flattening trend of the curve suggests that sampling effort to date has detected the majority of total species that can be found in subterranean habitats of Oklahoma, and that future bioinventories will add more species to this cumulative list, but probably at an exponentially slower rate.

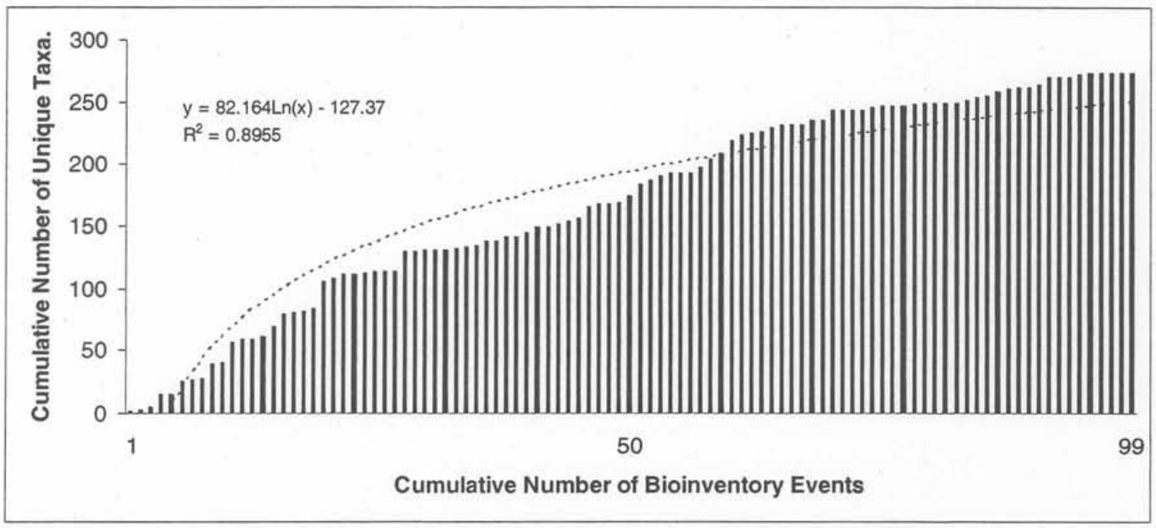


FIGURE 4. STUDY EFFORT AND RESULTING RICHNESS IN OKLAHOMA

## Habitat Correlates Compared to Richness

Habitat variables data were collected during the fieldwork at each site; these data were compared to the site's total species richness and obligate richness to discern any biodiversity patterns. Species richness of a site was directly proportional to its passage length (m)(Figure 5). Linear regression indicates that the relationship is directly proportional, but a poor fit, where roughly one additional species is added for every 200 m of passage added ($r^2 = 0.466$, $p < 0.001$).

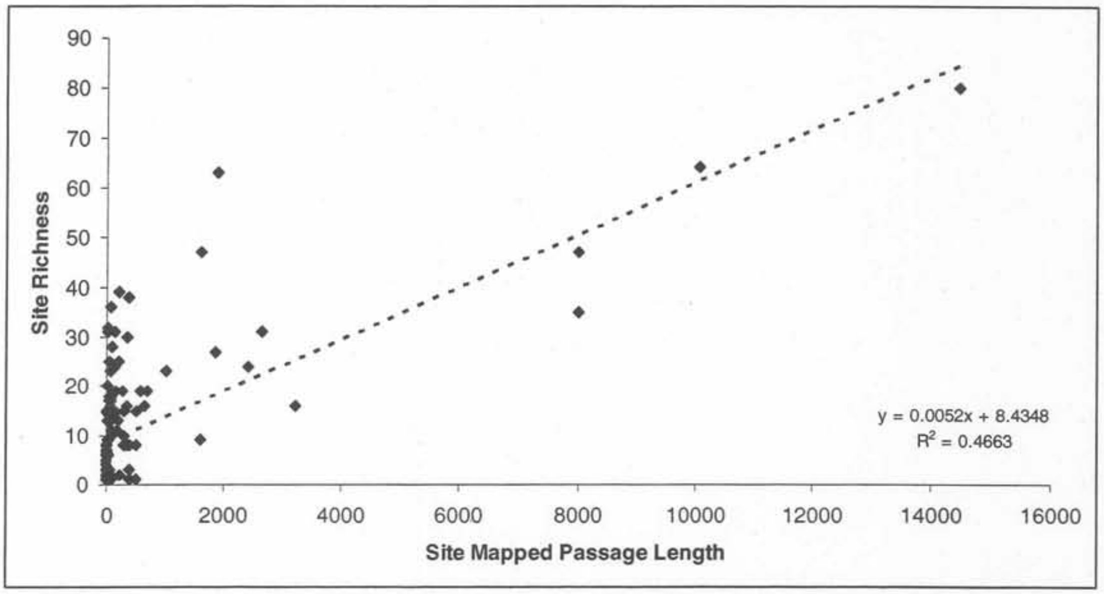


**FIGURE 5. SPECIES RICHNESS OF A SITE WAS DIRECTLY PROPORTIONAL TO ITS PASSAGE LENGTH (METERS)**

Other habitat characteristics were compared to site richness. Most caves did not have appreciable organics and most did not have bat guano, but species richness was significantly greater when organics and/or guano were present (*t*-test on organics, t = -18.157, $p < 0.001$)( *t*-test on guano; t = -14.522, $p < 0.001$). Similarly, richness of obligates was greater with organics present and when guano was present.

Species richness did significantly differ between category of water resource; ANOVA and Tukey-Kramer Honestly Significantly Different (HSD) statistics determined that sites with perennial streams were significantly richer than all other types of sites, and conversely, dry sites were the lowest in richness (ANOVA, n = 664, F= 58.178, $p < 0.001$). Obligate richness followed a similar pattern.

Species richness was significantly different between habitat types (F = 3.882, p = 0.001); but comparison of means by Tukey-Kramer HSD determined that habitat types were not significantly different. When habitat types were collapsed into more general categories ( caves and mines combined; springs and wells combined; hyporheos sites removed; bluff shelter, sinkhole, pit, and crevice/talus combined into "other"), caves (and springs were found to be richer than "other" types of sites (F = 9.924, $p < 0.001$).

For sites having degree of public (recreational) use, most sites ranked "light". Site richness was significantly different between degree of use categories (ANOVA, F = 9.505, $p < 0.001$); comparison of pairs using Tukey-Kramer HSD revealed that sites with moderate and heavy use were significantly more rich than sites with light use or no use. Given the correlation between richness and passage length, this result was not totally unexpected as degree of public use was significantly related to passage length (ANOVA, F= 3.019 p = 0.030). Richness of obligates followed a similar pattern.

Species richness was significantly greater when the site was gated versus ungated caves (including "unknown") ($t$-test, $t = -12.452$, $p < 0.001$). Richness of obligates followed a similar pattern ($t$-test, $t = -11.274$, $p < 0.001$). However, this may be another nested effect because almost all long caves are gated, and we demonstrated earlier that longer caves have greater richness.

Species richness was significantly different between site access types ($F = 27.546$, $p < 0.001$); comparison of pairs using Tukey-Kramer HSD revealed that the category "Scientific Study Only" was the highest in richness and "Unrestricted access" and "closed/sealed" were the lowest in richness.

Most sites were not vandalized; however, those that were vandalized had greater richness ($t$-test, $t = -13.716$, $p < 0.001$). Richness of obligates followed a similar pattern ($F = 159.457$, $p < 0.001$). Again, due to the correlation between richness and length, this result was not totally unexpected. Vandalized caves were significantly longer than caves not vandalized ($t$-test, $t = -5.391$, $p < 0.001$). Contingency analysis of vandalism by degree of public use revealed a significant relationship (Pearson $X^2 = 136.790$, $p < 0.001$). Most sites having light use or no use had no vandalism but those sites rated "moderate" and "heavy use" (18 and 19 respectively) were more often vandalized.

Owner class was compared to richness and found to be significantly different by class ($F = 4.525$; $p = 0.001$). This was a confusing result, as the "federal" and "state" classes were lower in richness than "commercial" and "private" classes.

**Ranking of Cave Sites in Terms of Biological Importance**

Sites were ranked in biological importance using 3 variables: site length, total species richness, and obligate richness. Caves have often been likened to islands due to their insular features, especially their hydrologic and geologic barriers (e.g. Culver, 1970). As a general pattern, larger islands carry more species than smaller ones, and this species-area relationship is well documented in diversity studies (e.g. MacArthur and Wilson, 1967). Similarly, the largest caves (measured as passage length) are often the most diverse - the world's longest cave, Mammoth Cave, at over 571 km of passage, has the greatest known number of stygobites and troglobites (Culver and Sket, 2000). Longer caves imply more habitat types and trophic resources, which may increase the few niches available, and increase carrying capacity (Culver and Sket, 2000). Cave length was significantly correlated to richness in this study; for this reason, length was used as primary criterion for biological significance ranking. The richness of obligate species is often used to rank the importance of the world's caves (e.g. Culver and Sket, 2000), and this criterion was also used in this study. The third criterion was total species richness, which is a common measure of biological significance, and in this study, significantly fewer caves had high species counts. Sites that had been bioinventoried adequately were ranked according to these three criteria, with a minimum of at least 1 obligate species to pass; Table 5 shows the top 40 ranking caves according to their score, where Score = total richness + (10 x obligate richness) + square root of length (m).

**TABLE 6. TOP 40 HIGHEST RANKING CAVE SITES IN OKLAHOMA**

| Site Name (or Code) | Total Richness | No. of Obligates | Mapped Length | Score | Rank |
|---|---|---|---|---|---|
| AD-14 | 76 | 11 | 14494 | 306 | 1st |
| DL-39 | 63 | 10 | 1891 | 206 | 2nd |
| J. Selman Cave System | 69 | 1 | 8000 | 134 | 3rd |
| MU-2 | 47 | 3 | 8000 | 166 | 4th |
| DL-91 | 47 | 6 | 1600 | 147 | 5th |
| CZ-9 | 62 | 5 | 604 | 138 | 6th |
| AD-9 | 32 | 5 | 2641 | 133 | 7th |
| DL-148 | 30 | 6 | 352 | 109 | 8th |
| AD-7 | 38 | 5 | 370 | 107 | 9th |
| Mystic Cave | 16 | 3 | 3220 | 103 | 10th |
| SQ-1 | 27 | 3 | 1854 | 100 | 11th |
| DL-32 | 31 | 5 | 137 | 93 | 12th |
| Nescatunga Cave | 33 | 1 | 2400 | 92 | 13th |
| DL-21 | 17 | 6 | 100 | 87 | 14th |
| DL-38 | 24 | 5 | 130 | 85 | 15th |
| OT-4 | 23 | 3 | 1000 | 85 | 16th |
| DL-74 | 15 | 5 | 300 | 82 | 17th |
| CZ-11 | 23 | 5 | 75 | 82 | 18th |
| CZ-18 | 25 | 4 | 200 | 79 | 19th |
| OT-19 | 9 | 3 | 1600 | 79 | 20th |
| AD-8 | 34 | 3 | 214 | 79 | 21st |
| DL-119 | 18 | 5 | 100 | 78 | 22nd |
| DL-8 | 35 | 3 | 107 | 75 | 23rd |
| AD-19 | 39 | 2 | 200 | 73 | 24th |
| DL-51 | 21 | 5 | | 71 | 25th |
| DL-102 | 30 | 4 | | 70 | 26th |
| AD-137 | 32 | 3 | 30 | 67 | 27th |
| Coal Creek Cave | 31 | 3 | 30 | 66 | 28th |
| DL-41 | 35 | 3 | | 65 | 29th |
| DL-3 | 36 | 2 | 80 | 66 | 30th |
| DL-1 | 19 | 2 | 567 | 63 | 31st |
| DL-79 | 22 | 4 | | 62 | 32nd |
| DL-59 | 28 | 2 | 100 | 58 | 33rd |
| DL-104 | 15 | 2 | 500 | 57 | 34th |
| DL-47 | 10 | 3 | 300 | 57 | 35th |
| AD-54 | 17 | 3 | 100 | 57 | 36th |
| AD-220 | 19 | 2 | 281 | 56 | 37th |
| DL-64 | 18 | 3 | 50 | 55 | 38th |
| MY-12 | 15 | 4 | | 55 | 39th |
| DL-19 | 17 | 3 | 50 | 54 | 40th |

Note: Score = total richness + (10 x obligate richness) + square root of length (m)

**Other Findings and Resulting Publications**

This grant project produced many other findings, which have been presented separately in various journal articles listed below (with the State Wildlife Grant Program acknowledged). Likewise, results of individual status surveys of some rare and endangered fauna of Oklahoma caves were published in the following articles:


- Bergey, E., W. Matthews, and FJ. Fry. In press. Springs in time: fish fauna and habitat changes in springs over a 20-year interval. Aquatic Conservation: Marine and Freshwater Ecosystems

- Graening, G., M. Slay, D. Fenolio, and H. Robison. 2008. Annotated checklist of the Isopoda (Subphylum Crustacea: Class Malacostraca) of Arkansas and Oklahoma, with emphasis upon subterranean habitats. Proceedings of the Oklahoma Academy of Science.

- Graening, G., J. Holsinger, D. Fenolio, E. Bergey, and C. Vaughn. 2006. Annotated checklist of the amphipod crustaceans of Oklahoma, with emphasis on groundwater habitats. Proceedings of the Oklahoma Academy of Science 86:65-74.

- Lewis, J., G. Graening, D. Fenolio, and E. Bergey. 2006. Caecidotea mackini, new species, with a synopsis of the subterranean asellids of Oklahoma (Crustacea: Isopoda: Asellidae). Proceedings of the Biological Society of Washington 119(4):563-575.

- Graening, G., H. Hobbs III, M. Slay, W. Elliott, and A. Brown. 2006. Status update for bristly cave crayfish, Cambarus setosus (Decapoda: Cambaridae) and range extension into Arkansas. Southwestern Naturalist 51(3):382-391.

- Fenolio, D., G. Graening, and J. Stout. 2006. Coprophagy in a cave-adapted salamander. Proceedings of the Royal Society of London, B, 273(1585):439-444.

- Graening, G., and D. Fenolio. 2005. Status update of the Delaware County crayfish, Cambarus subterraneus (Decapoda: Cambaridae). Proceedings of the Oklahoma Academy of Science 85:85-89.

- Fenolio, D., G. Graening, and J. Stout. 2005. Seasonal movement pattern of pickerel frogs (Rana palustris) through an Ozark Cave and ecological implications supported by stable isotope evidence. Southwestern Naturalist 50(3):385-389.


Other publications related to the authors or this project can be found at:
http://research.naturalinvestigations.com/Cave_Pubs.htm

**Part 2. Spring Survey.**

*Habitat characterization.* Forty-one springs were sampled. Additionally, samples from 9 springs sampled previously were also processed. The survey included springs in 17 counties, and 6 named and 2 alluvial aquifers (Fig. A). Chemically, most of the sampled springs had circum-neutral pH (Table A). The four gypsum springs (springs SPR06-01 through -04) tended to have higher pH. These four springs also had elevated conductivity (over 2000 µS/cm). One sulphur spring (SPR04-7), which had very high conductivity, was included in the survey.

Discharge, or the amount of water flowing from the spring, is an important determinant of the spring's biota. The higher discharge springs (> 10 l/s) were primarily associated with aquifers in limestone areas – the Arbuckle-Simpson and Ozark Plateau. These aquifers included springs with both high and low discharge; for example the discharge range among the 13 Arbuckle springs was 0.08 to 90.6 l/s. One high discharge spring, McCorkle Spring (SPR05-08), was found in western Oklahoma. This spring has diffuse outlets and supports a large wetland with a diverse assemblage of vascular plants; the other sampled springs associated with the High Plains Aquifer were either linear springs along streams, hillslope seeps, or a seep are supporting a cattail marsh.

The water temperature of springs is almost constant and often reflects the average annual temperature of the region. The temperature of most of the sampled springs was in the 15 to 20 °C range. Higher temperatures were found in the High Plains Aquifer springs (Table A), which ranged from 20 to 28 °C. Springs with deep water sources may have somewhat higher temperatures than shallow-source springs (Förster et al., 1994); alternatively, higher temperatures may result from surface heating when temperatures are taken in the springbrook downstream of the source, especially where and discharge is low or the water is pooled and thus retained. Both of these factors may contribute to the higher temperatures in the High Plains Aquifer springs, which originate low in the aquifer (Pete Thurmond, personal communication) and often occur as seeps that have shallow water that can be quickly warmed.

*Rare fish, crayfish and invertebrates.* Although rare fish (e.g., *Etheostoma cragini*) and crayfish have been found in similar surveys of different springs (Bergey, unpublished data), no rare species of fish or crayfish were found in this survey of 41 springs (Table B). An as-yet-unidentified cave amphipod was collected in an Okfuskee County spring.

The most exciting find was a single specimen of a freshwater polychaete, which has been provisionally identified as *Manayunkia speciosa*, based on its known distribution and resemblance to illustrations. Polychaetes are segmented worms and are in the same phylum (the Annelida) as oligochaetes, the common freshwater worms, and leeches. Nearly all polychaetes are marine. In the USA, freshwater polychaetes are found almost entirely in habitats along the East and West coasts. (Pennak, 1989). *Manayunkia speciosa* is found in the Great Lakes, and in states bordering both coasts and the Gulf of Mexico. It's occurrence in NE Oklahoma, if substantiated, is a significant range extension.

*Invertebrate biodiversity.* Despite their patchy distribution, relative isolation and cool summer temperatures, Oklahoma springs have a diverse biota, especially with respect to invertebrates. Over 200 taxa were found among the 41 springs (Appendix 2). Insects were especially diverse, with over 30 taxa of aquatic beetles (Coleoptera) and flies (Diptera), and over 20 taxa of true bugs (Hemiptera). Rudisill and Bass (2005) likewise found diverse and abundant insect populations in springs. Common non-insects included crustaceans such as amphipods and crayfish, and various snails and worms.

Richness, or the number of species present, ranged from a low of 10 taxa to a high of 51 taxa (Appendix 2). These counts are conservative because they do not include microcrustaceans (ostracods, copepods, and cladocerans), and several groups were not identified to genus (e.g., naidid and tubificid worms, water mites, and chironomid midges). The highest richness was found in Lowrance Spring (SPR04-01), which is made up of several 'boils' in a spring pond with vegetated edges and an extensive, well-vegetated springbrook. Lowrance Spring also had the highest flow (90.6 l/s) among the 41 sampled springs, which suggests a relationship between discharge and richness. Regression analysis showed a relationship ($F = 9.62$, $p = 0.004$); however the relationship is weak, accounting for only 22% of the variability of the data ($R^2 = 0.216$). The wide range in the number of taxa present in low-discharge springs weakened the relationship and occurred, in part, because the microhabitat structure of springs affects richness (Rudisill and Bass 2005).

One of the low-richness springs was a sulphur spring (SPR04-07) where the harsh chemical conditions supported 13 species. Several of the other springs with few taxa were found in the Ozarks; where some of the sampled streams were quite small. Drought conditions undoubtedly reduced habitat space and variation within some of these springs and affected the number of taxa.

A comparison of the invertebrate composition among springs using non-metric multidimensional scaling (NMDS) is shown graphically in Figure B. Springs from each aquifer-association grouped together, indicating similar taxonomic composition. Although clusters of many of the aquifer-groups have considerable overlap, some pairs of aquifer groups differ. Differing pairs of aquifer-springs were identified using ANOSIM (Analysis of similarity; PRIMER). Included among the differing pairs were the Arbuckle-Simpson and Ozark springs ($R = 0.566$, $p < 0.001$) and the High Plains and Ozark springs ($R = 0.729$, $p < 0.001$). Significant differences in 5 other spring-group pairs were found (using the aquifer-group abbreviations from Fig. B: C-H, H-a, H-T, a-O, H-R), but the number of springs in each set were considered too small for accurate analysis.

This NMDS pattern is caused by a combination of taxa that are present in most springs (= characteristic taxa, occurring in 50% or more of the springs) and groups of taxa that are characteristic of specific aquifer-groups of springs. Characteristic taxa for all springs and for springs associated with the Arbuckle-Simpson, Ozark, and High Plains aquifers are shown in Table C.

Spring faunas consist of a combination of generalists species, which are commonly found in area ponds and/or streams, spring specialists (including endemics), and occasional subterranean crustaceans. Most of the characteristic taxa in the surveyed springs are generalists, a pattern that has been noted in other surveys of Oklahoma springs (Gaskin and Bass 2000, Rudisill and Bass 2005). Aquatic worms, fly larvae (chironomids and ceratopogonids), water striders, fingernail clams, and pond snails are all common in ponds and streams – as well as in springs. Three of the characteristic taxa are apparently specialized for springs: planarians, the damselfly genus *Argia* and the scud *Hyalella azteca*. Planarians included the large black *Dugesia dorotocephala* and also smaller species; all were typically found in large numbers. The possibility of *Argia* as a spring indicator-species has been noted by David Bass (personal communication). *Hyalella azteca* is a species complex and molecular studies have indicated that more than one species occurs in springs. Although *Hyalella* can be found in a variety of other aquatic habitats, densities in springs are often very high.

Ozark springs were uniquely characterized by three crustaceans: the amphipod *Gammarus*, the isopod *Lirceus* and the ringed crayfish *Orconectes neglectus*. In Ozark springs, *Gammarus* replaced *Hyalella azteca*, which was the common amphipod in all the other groups of springs. Isopods were common only in the Ozark springs, where they were often abundant. Although the distribution of the ringed crayfish in Oklahoma is primarily in the Ozark Plateau, hence it's presence in Ozark springs, the species also occurs as a disjunct population in the Blue River, within the Arbuckle-Simpson area. However no ringed crayfish were found in the sampled Arbuckle springs, indicating that the species is restricted within the Arbuckles.

Although Arbuckle and Ozark springs are both limestone-based, their invertebrate faunas are different (Fig. B and Table C). In contrast, the invertebrate faunas of Arbuckle and High Plains springs are similar although the High Plains springs are mostly sand-based rather than limestone-based. These results highlight the distinctiveness of the Ozark and Arbuckle faunas.

**Figure A.** Maps showing the locations of sampled springs by sampling year. Circled springs sampled in 2003, 2004, 2005 are associated with the Arbuckle-Simpson aquifer; circled springs sampled in 2006 are Ozark-associated springs.

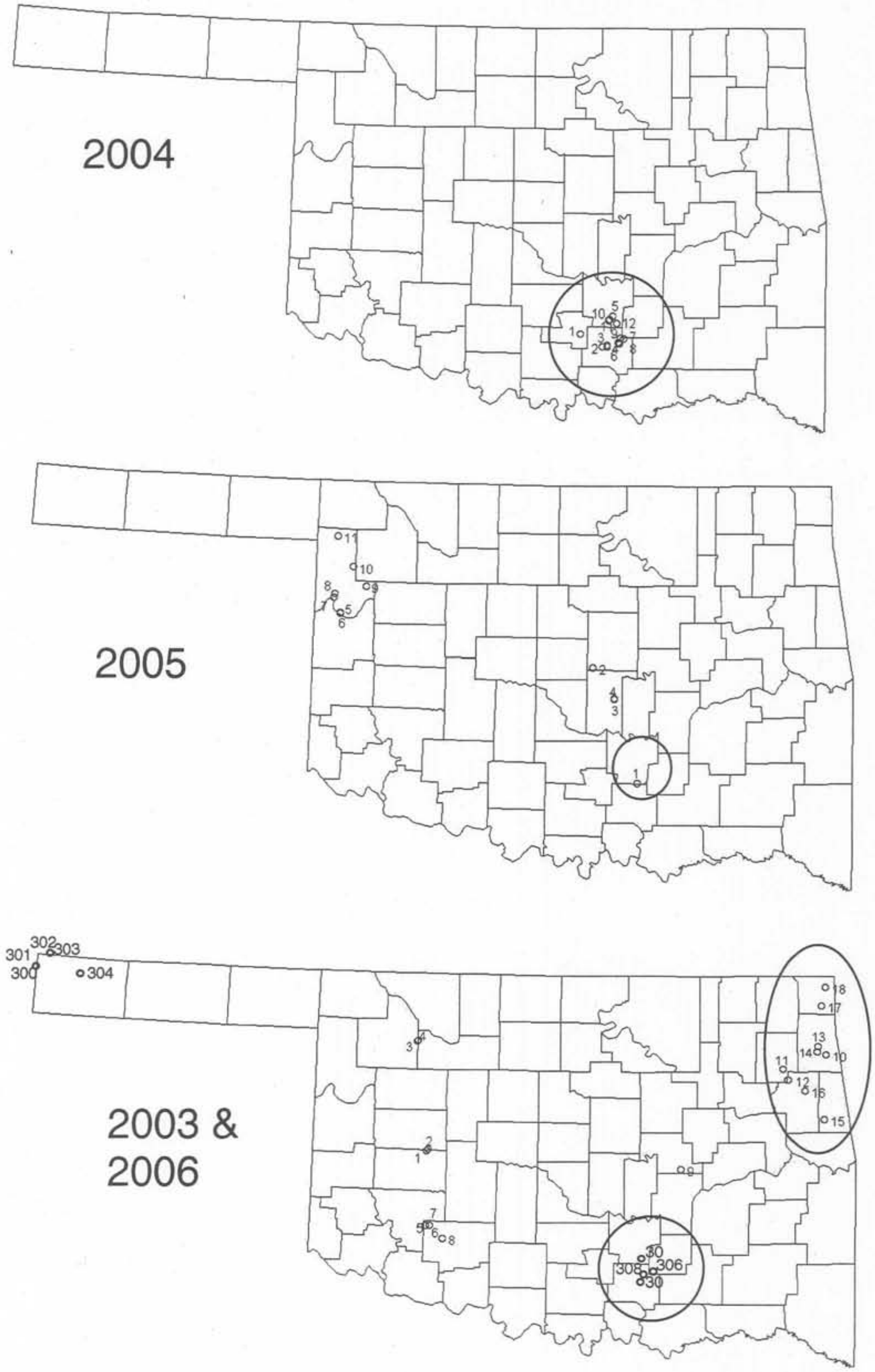

**Table A.** Springs surveyed in 2004-2006, including locations and water quality characteristics.

| Code (#) | Site name | County | Aquifer | Sampling date | Discharge (l/s) | Temp. (˚C) | pH | Conduct. (µS/cm) |
|---|---|---|---|---|---|---|---|---|
| SPR04-01 (1) | Lowrance Spring | Murray | Arbuckle-Simpson | 17-Jun-04 | 90.62 | 18.3 | 7.2 | 187 |
| SPR04-02 (2) | unnamed | Johnston | Arbuckle-Simpson | 17-Jun-04 | 2.34 | 20.6 | 7.2 | 594 |
| SPR04-03 (3) | Three Springs | Johnston | Arbuckle-Simpson | 22-Jul-04 | 7.08 | 18.0 | 7.2 | 591 |
| SPR04-04 (4) | Wolf Spring | Johnston | Arbuckle-Simpson | 22-Jul-04 | 3.17 | 18.1 | 7.3 | 559 |
| SPR04-05 (5) | unnamed spring | Pontotoc | Arbuckle-Simpson | 23-Jul-04 | 0.67 | 18.1 | 7.2 | 696 |
| SPR04-06 (6) | Rutherford Spring | Johnston | Arbuckle-Simpson | 24-Jul-04 | 15.53 | 18.3 | 6.9 | 758 |
| SPR04-07 (7) | Rotten Egg Spring | Coal | Arbuckle-Simpson | 24-Jul-04 | 0.52 | 20.5 | 6.9 | 12.4 mS |
| SPR04-08 (8) | Viola Spring | Johnston | Arbuckle-Simpson | 25-Jul-04 | 11.38 | NA | 7.1 | 1795 |
| SPR04-09 (9) | Houghtubby Spring | Coal | Arbuckle-Simpson | 25-Jul-04 | 0.08 | 18.5 | 7.1 | 708 |
| SPR04-10 (10) | Sheep Creek Spring | Pontotoc | Arbuckle-Simpson | 25-Jul-04 | 44.04 | 17.1 | 7.2 | 605 |
| SPR04-11 (11) | unnamed spring | Pontotoc | Arbuckle-Simpson | 26-Jul-04 | 2.33 | 17.0 | 7.2 | 616 |
| SPR04-12 (12) | Wildcat Spring | Pontotoc | Arbuckle-Simpson | 02-Aug-04 | 1.82 | 19.4 | 6.9 | 557 |
| SPR05-01 (13) | Coal Cave Spring | Pontotoc | Arbuckle-Simpson | 17-May-05 | 0.19 | 16.8 | 7.1 | 684 |
| SPR05-02 (14) | Doddehl Spring | Lincoln | Central Oklahoma | 18-May-05 | 0.5 | 14.8 | 6.6 | 257 |
| SPR05-03 (15) | Trevor Spring | Pottawat. | Central Oklahoma | 19-May-05 | 0.08 | 16.2 | 6.0 | 121 |
| SPR05-04 (16) | unnamed spring | Pottawat. | Central Oklahoma | 19-May-05 | 0.15 | 16.6 | 7.3 | 872 |
| SPR05-05 (17) | unnamed seeps | Ellis | High Plains | 07-Jun-05 | NA | 24.4 | 8.1 | 646 |
| SPR05-06 (18) | unnamed seep | Ellis | High Plains | 07-Jun-05 | 0.13 | 27.9 | 7.6 | 895 |
| SPR05-07 (19) | Word Spring | Ellis | High Plains | 08-Jun-05 | 3.50 | 20.6 | 7.8 | 792 |
| SPR05-08 (20) | McCorkle Spring | Ellis | High Plains | 08-Jun-05 | 13.12 | 22.1 | 7.7 | 413 |
| SPR05-09 (21) | Bowman Spring | Ellis | High Plains | 08-Jun-05 | 5.00 | 25.9 | 7.8 | 692 |
| SPR05-10 (22) | Reininger Spring | Ellis | High Plains | 09-Jun-05 | 1.18 | 20.6 | 7.4 | 630 |
| SPR05-11 (23) | Dugger Spring | Ellis | High Plains | 09-Jun-05 | NA | 25.0 | 8.1 | 694 |

| Code (#) | Site name | County | Aquifer | Sampling date | Discharge (l/s) | Temp. (˚C) | pH | Conduct. (µS/cm) |
|---|---|---|---|---|---|---|---|---|
| SPR06-01 (24) | Gyp Crk springs | Washita | Rush Spring | 15-May-06 | NA | 16.5 | 8.1 | 2810 |
| SPR06-02 (25) | Gyp Crk springs | Custer | Rush Spring | 15-May-06 | NA | 17.6 | 8.0 | 2900 |
| SPR06-03 (26) | Inman Spring | Major | Cimmaron River* | 16-May-06 | 0.06 | 15.1 | 8.0 | 3075 |
| SPR06-04 (27) | Bat Cave Springs | Major | Cimmaron River* | 16-May-06 | 0.05 | 13.6 | 7.4 | 2800 |
| SPR06-05 (28) | Time-of-Day | Comanche | Arbuckle-Timbered Hills** | 17-May-06 | 1.72 | 17.0 | 7.5 | 630 |
| SPR06-06 (29) | Baker Peak Spr | Comanche | Arbuckle-Timbered Hills** | 17-May-06 | 0.24 | 16.6 | 7.0 | 346 |
| SPR06-07 (30) | Sugar Creek Spr | Comanche | Arbuckle-Timbered Hills** | 17-May-06 | 0.06 | 18.4 | 8.3 | 399 |
| SPR06-08 (31) | White Sulphur Spr | Comanche | Arbuckle-Timbered Hills** | 18-May-06 | 0.01 | 17.7 | 8.0 | 287 |
| SPR06-09 (32) | Burden Spring | Okfuskee | N. Canadian R.* | 19-Jun-06 | 0.12 | 17.8 | 6.1 | 137 |
| SPR06-10 (33) | January-Stansbury Spr | Delaware | Ozark Plateau | 19-Jun-06 | 18.36 | 14.5 | 7.0 | 223 |
| SPR06-11 (34) | Roadside Park Spr | Mayes | Ozark Plateau | 20-Jun-06 | 1.15 | 15.5 | 7.2 | 359 |
| SPR06-12 (35) | Cave Spring | Cherokee | Ozark Plateau | 20-Jun-06 | 5.84 | 15.4 | 6.8 | 183 |
| SPR06-13 (36) | Everitt Spring | Delaware | Ozark Plateau | 20-Jun-06 | 64.54 | 15.3 | 6.9 | 235 |
| SPR06-14 (37) | Krause Spring | Delaware | Ozark Plateau | 20-Jun-06 | 0.60 | 18.5 | 7.4 | 195 |
| SPR06-15 (38) | Cave Spring | Adair | Ozark Plateau | 21-Jun-06 | 0.19 | 15.6 | 7.7 | 341 |
| SPR06-16 (39) | PumSpkin Spring | Cherokee | Ozark Plateau | 21-Jun-06 | negligible | 21.1 | 7.7 | 220 |
| SPR06-17 (40) | Cave Spring | Ottawa | Ozark Plateau | 22-Jun-06 | negligible | 16.5 | 7.8 | 405 |
| SPR06-18 (41) | Cave Spring | Ottawa | Ozark Plateau | 07-Jul-06 | 0.82 | 15.4 | 7.0 | 333 |
| SPR03-300 | unnamed | Union, NM | High Plains | 19-May-03 | negligible | 16.8 | 7.8 | 1083 |
| SPR03-301 | Chet Springs | Union, NM | High Plains | 19-May-03 | negligible | 17.9 | 7.6 | 593 |
| SPR03-302 | unnamed | Baca, CO | High Plains | 20-May-03 | 0.04 | 17.1 | 7.9 | 963 |
| SPR03-303 | unnamed | Baca, CO | High Plains | 20-May-03 | negligible | 26.6 | 8.1 | 246 |
| SPR03-304 | Flagg Springs | Cimarron | High Plains | 21-May-03 | 0.04 | 15.0 | 9.0 | 321 |
| SPR03-305 | Desperado Spring | Johnston | Arbuckle-Simpson | 24-Jul-03 | 0.09 | 18.0 | 6.9 | 668 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SPR03-306 | Pot Spring | Pontotoc | Arbuckle-Simpson | 25-Jul-03 | 1.94 | 17.7 | 7.3 | 459 |
| SPR03-307 | Wide Spring | Coal | Arbuckle-Simpson | 25-Jul-03 | unknown | 17.5 | 7.2 | 535 |
| SPR03-308 | Deadman Spring | Johnston | Arbuckle-Simpson | 26-Jul-03 | 1.10 | 17.8 | 7.1 | 678 |

* alluvial springs along major rivers

** closest named aquifer to the springs in the Wichita Mountains National Wildlife Refuge

Notes:

1. High Plains Aquifer is also the Ogallala Aquifer and the Ozark Plateau Aquifer is also called the Ozark Aquifer or the Roubidoux Aquifer.
2. NA = data missing or not available (e.g., discharge of small linear springs along streams)

**Table B**. Occurrence records of crayfish and fish in the 2003-2008 survey of 41 Oklahoma springs.

| Code (#) | Site name | Aquifer | Crayfish | Fish |
|---|---|---|---|---|
| SPR04-01 (1) | Lowrance Spring | Arbuckle | *O. virilis* | *G. affinis, E. radiosum, E. gracile, Etheostoma sp.* |
| SPR04-02 (2) | unnamed | Arbuckle | *O. virilis* | *G. affinis, Campostoma anomalum, E. spectabile, Lepomis macrochirus* |
| SPR04-03 (3) | Three Springs | Arbuckle | *P. simulans* | *E. spectabile* |
| SPR04-04 (4) | Wolf Spring | Arbuckle | *O. nais* | *G. affinis, E. spectabile, Micropterus salmoides* |
| SPR04-05 (5) | unnamed spring | Arbuckle | unidentified juv. | |
| SPR04-06 (6) | Rutherford Spring | Arbuckle | | *G. affinis* |
| SPR04-07 (7) | Rotten Egg Spring | Arbuckle | | |
| SPR04-08 (8) | Viola Spring | Arbuckle | *O. palmeri longimanus* | |
| SPR04-09 (9) | Houghtubby Spring | Arbuckle | | |
| SPR04-10 (10) | Sheep Creek Spring | Arbuckle | *O. palmeri longimanus* | *C. anomalum, E. radiosum, Etheostoma sp.* |
| SPR04-11 (11) | unnamed spring | Arbuckle | unidentified juv. | |
| SPR04-12 (12) | Wildcat Spring | Arbuckle | | *G. affinis* |
| SPR05-01 (13) | Coal Cave Spring | Arbuckle | *O. palmeri longimanus, P. simulans* | *E. radiosum* |
| SPR05-02 (14) | Doddehl Spring | Central OK | | |
| SPR05-03 (15) | Trevor Spring | Central OK | *P. simulans* | |
| SPR05-04 (16) | unnamed spring | Central OK | *P. simulans* | |
| SPR05-05 (17) | unnamed seeps | High Plains | unidentified juv. | |
| SPR05-06 (18) | unnamed seep | High Plains | | *Gambusia affinis* |
| SPR05-07 (19) | Word Spring | High Plains | | |
| SPR05-08 (20) | McCorkle Spring | High Plains | | *Gambusia affinis* |
| SPR05-09 (21) | Bowman Spring | High Plains | | |
| SPR05-10 (22) | Reininger Spring | High Plains | | *Gambusia affinis* |
| SPR05-11 (23) | Dugger Spring | High Plains | unidentified juv. | |
| SPR06-01 (24) | Gyp Crk springs | Rush Spr. | *Orconectes* sp. (juveniles) | |
| SPR06-02 (25) | Gyp Crk springs | Rush Spr. | *Procambarus* sp. (juveniles) | |
| SPR06-03 (26) | Inman Spring | Cimmar. R. | | |
| SPR06-04 (27) | Bat Cave Springs | Cimmar. R. | *Procambarus* sp. (juveniles) | *Pimephales promelas, Lepomis macrochirus* |
| SPR06-05 (28) | Time-of-Day | Timbered Hills | | *Lepomis cyanellus* |
| SPR06-06 (29) | Baker Peak Spr | Timbered Hills | *Procambarus simulans* | |
| SPR06-07 (30) | Sugar Creek Spr | Timbered Hills | *Orconectes* sp. (juveniles) | |

| Code (#) | Site name | Aquifer | Crayfish | Fish |
|---|---|---|---|---|
| SPR06-08 (31) | White Sulphur Spr | Timbered Hills | | *Gambusia affinis* |
| SPR06-09 (32) | Burden Spring | N. Can. R. | | |
| SPR06-10 (33) | January-Stans. Spr | Ozark Plat. | *Orconectes neglectus* | |
| SPR06-11 (34) | Roadside Park Spr | Ozark Plat. | | |
| SPR06-12 (35) | Cave Spring | Ozark Plat. | *Orconectes* sp. (juveniles) | *Pimephales promelas, Lepomis macrochirus* |
| SPR06-13 (36) | Everitt Spring | Ozark Plat. | *O. neglectus* | *Cottus carolinae* |
| SPR06-14 (37) | Krause Spring | Ozark Plat. | *O. neglectus* | |
| SPR06-15 (38) | Cave Spring | Ozark Plat. | *O. neglectus* | *Cottus carolinae* |
| SPR06-16 (39) | Pumpkin Spring | Ozark Plat. | *O. neglectus* | |
| SPR06-17 (40) | Cave Spring | Ozark Plat. | | |
| SPR06-18 (41) | Cave Spring | Ozark Plat. | | |
| SPR03-300 | unnamed | High Plains | | |
| SPR03-301 | Chet Springs | High Plains | | |
| SPR03-302 | unnamed | High Plains | | |
| SPR03-303 | unnamed | High Plains | | |
| SPR03-304 | Flagg Springs | High Plains | *Orconectes* sp. (juveniles) | unidentified catfish |
| SPR03-305 | Desperado Spring | Arbuckle | *Orconectes* sp. (juveniles) | seen downstream |
| SPR03-306 | Pot Spring | Arbuckle | *Orconectes* sp. (juveniles) | |
| SPR03-307 | Wide Spring | Arbuckle | *Orconectes* sp. (juveniles) | |
| SPR03-308 | Deadman Spring | Arbuckle | | |

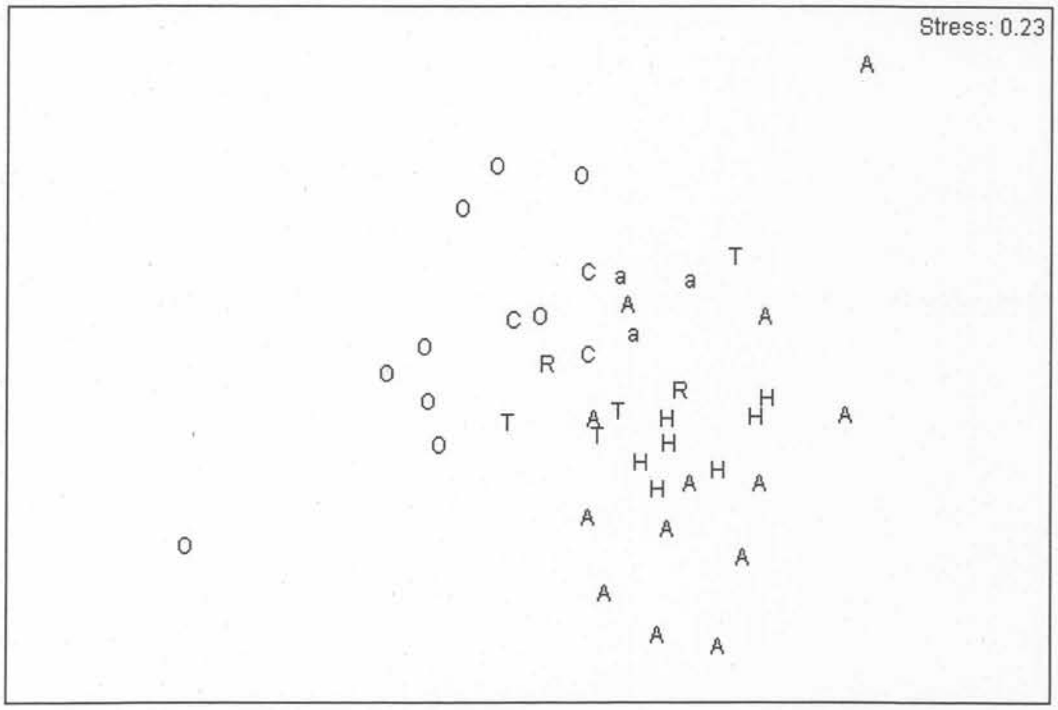


**Figure B.** Relative similarity of the invertebrate faunas of 41 springs surveyed in 2004-2006 as depicted using non-metric multi-dimensional scaling (PRIMER, Version 5; Primer-E Ltd, Plymouth Marine Laboratory, U.K.). Springs are by aquifer: A = Arbuckle-Simpson, O = Ozark, H = High Plains, C = Central Oklahoma, R = Rush Springs, T = Timbered Hills, a = alluvial springs.

**Table C.** Characteristic taxa of invertebrates in all 41 surveyed springs and in the springs associated with three aquifers (other aquifers had few sampled springs). Characteristic taxa occur in at least half of the springs.

| Common name | All springs (N = 41) | Arbuckle (N = 13) | Ozark (N = 9) | High Plains (N = 7) |
|---|---|---|---|---|
| flatworms | planarians | ▲ | ▲ | ▲ |
| aquatic worms | Naididae | | | ▲ |
| aquatic worms | Tubificidae | ▲ | ▲ | ▲ |
| a no-see-um larva | Ceratopogonidae | ▲ | | ▲ |
| midge larvae | Chironomidae | ▲ | ▲ | ▲ |
| a water strider | *Aquarius* | ▲ | | |
| broad-shouldered water strider | *Microvelia* | ▲ | ▲ | ▲ |
| damselfly nymph | *Argia* | ▲ | | ▲ |

| | | | | |
|---|---|---|---|---|
| scud | *Hyalella* | ▲ | | ▲ |
| a fingernail clam | Sphaeriidae | ▲ | | ▲ |
| pond snail | *Physa* | ▲ | ▲ | ▲ |
| a water scavenger beetle | | *Tropisternus* III | | |
| a marsh beetle | | *Limnichus* | | ▲ |
| a mosquito larva | | *Anopheles* | | |
| a mayfly nymph | | *Callibaetis* | | ▲ |
| a water strider | | *Trepobates* | | |
| ringed crayfish | | | *O. neglectus* | |
| an isopod | | | *Lirceus* | |
| a scud | | | *Gammarus* | |
| hydra | | | | *Hydra* |
| aquatic roundworms | | | | nematodes |
| a predaceous diving beetle | | | | *Hydroporus* II |
| a crawling water beetle | | | | *Peltodytes* |
| a water scavenger beetle | | | | *Berosus* |
| a water scavenger beetle | | | | *Enochrus* |
| a dixid midge | | | | *Dixella* |
| giant water bug | | | | *Belostoma/Abedus* |
| a dragonfly nymph | | | | *Aeschna* |
| a net-spinning caddisfly | | | | *Cheumatopsyche* |

**F. Significant deviations:**

- Springs surveys were conducted in under-surveyed portions of Oklahoma, in addition to surveys in the limestone areas. These included gypsum areas and the High Plains aquifer springs. Because we found only one flowing spring in Cimarron County, we sampled four springs located within a few miles of Oklahoma (other Cimarron County springs were dry or tapped and stored for stock tanks (with no release).

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# I. Appendices

## Appendix 1: Checklist of Taxa Inventoried in Caves During This Study

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### Adair County

**AD-12:** Araneae, Caecidotea sp., Caudata (larval), Corynorhinus townsendii ingens, Eurycea lucifuga, Gordiidae, Litocampa sp., Periomyotis subflavus, Plethodon albagula

**AD-13:** Araneae sp. no. 2, Ceuthophilus sp., Coleoptera, Collembola, Corynorhinus townsendii ingens, Diptera, Eurycea lucifuga, Gastropoda (terrestrial snail), Hemiptera, Hesperochernes sp., Ixodes sp., Lepidoptera, Macrocera nobilis, Meta americana, Neotoma floridana, Periomyotis subflavus, Porcellionides pruinosis, Scolopendromorpha, Siphonaptera, Trombidiidae

**AD-137:** Caecidotea ancyla, Caecidotea sp., Ceuthophilus gracilipes, Collembola, Collembola sp. no. 2, Cottus carolinae, Culicidae, Cylisticus convexus, Didelphis virginiana, Diplopoda sp. no. 2, Diplopoda sp. no. 3, Diptera, Dolomedes sp., Eurycea lucifuga, Gastropoda (slug), Heleomyzidae, Hymenoptera, Inflectarius inflectus, Isopoda (terrestrial), Mycetophilidae, Orconectes sp., Oxidus gracilis, Oxidus gracilis, Platynus sp., Plecoptera, Procyon lotor, Stygobromus ozarkensis, Trichoptera

**AD-14:** Acarina, Araneae, Araneae sp. no. 4, Archaeognatha, Caecidotea stiladactyla, Caudata (larval), Ceuthophilus gracilipes, Collembola, Collembola sp. no. 2, Corynorhinus townsendii ingens, Crosbyella sp., Culicidae, Diplopoda, Entomobryidae, Eurycea multiplicata griseogaster, Eurycea spelaea, Heleomyzidae, Hemiptera, Hyla sp., Inflectarius inflectus, Japygidae, Leiodidae, Linyphiidae, Lumbricidae, Lycosidae, Macrocera nobilis, Meta americana, Mycetophilidae, Myotis grisescens, Myotis septentrionalis, Neotoma floridana, Opiliones, Periomyotis subflavus, Plethodon albagula, Procyon lotor, Pseudosinella sp., Psocoptera, Ptomaphagus sp., Sayornis phoebe, Sayornis phoebe, Sciaridae, Scolopendromorpha, Stygobromus alabamensis, Thysanura, Tipulidae, Tomocerus sp.

**AD-161:** Periomyotis subflavus

**AD-17:** Araneae sp. no. 2, Araneae sp. no. 3, Ceuthophilus gracilipes, Collembola, Collembola sp. no. 2, Corynorhinus townsendii ingens, Culicidae, Eurycea lucifuga, Heleomyzidae, Isopoda (terrestrial), Leiodidae, Lepidoptera, Macrocera nobilis, Meta americana, Mycetophilidae, Myotis septentrionalis, Neotoma floridana, Oxidus gracilis, Periomyotis subflavus

**AD-18:** Araneae sp. no. 3, Araneae sp. no. 4, Carabidae, Ceuthophilus gracilipes, Corynorhinus townsendii ingens, Dolomedes sp., Eptesicus fuscus, Heleomyzidae, Meta americana, Mycetophilidae, Neotoma floridana, Periomyotis subflavus, Staphylinidae

**AD-19:** Acarina, Amphipoda (stygobitic), Araneae sp. no. 2, Araneae sp. no. 3, Caecidotea steevesi, Ceuthophilus gracilipes, Coleoptera, Collembola, Collembola sp. no. 2, Corynorhinus townsendii ingens, Didelphis virginiana, Diptera, Diptera sp. no. 2, Diptera sp. no. 3, Discus patulus, Heleomyzidae, Inflectarius inflectus, Leiodidae, Lepidoptera, Lumbricidae, Macrocera nobilis, Mesodon thyroidus, Meta americana, Myrmeleontidae, Neotoma floridana, Periomyotis subflavus, Plethodon albagula, Procyon lotor, Pseudoscorpiones, Psychodidae, Sayornis phoebe, Siphonaptera, Sphecidae, Staphylinidae, Thryothorus ludovicianus, Tipulidae, Zonitoides arboreus

**AD-220:** Amphipoda (stygobitic), Carabidae, Caudata (larval), Ceuthophilus sp., Collembola, Eurycea spelaea, Heleomyzidae, Leiodidae, Lirceus sp., Mycetophilidae, Myotis grisescens, Opiliones, Oxidus gracilis, Periomyotis subflavus, Plethodon albagula, Plethodon angusticlavius, Sayornis phoebe, Staphylinidae, Tipulidae

**AD-24:** Araneae sp. no. 2, Corynorhinus townsendii ingens, Gastropoda (terrestrial snail), Gastropoda (terrestrial snail) no. 2, Leiodidae, Macrocera nobilis, Meta americana, Oxidus gracilis, Periomyotis subflavus, Staphylinidae, Stygobromus onondagaensis

**AD-25:** Corynorhinus townsendii ingens, Meta americana, Periomyotis subflavus

**AD-29:** Acarina, Araneae sp. no. 2, Araneae sp. no. 3, Araneae sp. no. 4, Ceuthophilus gracilipes, Collembola, Collembola sp. no. 2, Corynorhinus townsendii ingens, Culicidae, Diptera sp. no. 2, Eurycea lucifuga, Formicidae, Isopoda (terrestrial), Leiodidae, Lumbricidae, Macrocera nobilis, Mesodon thyroidus, Mesomphix sp., Meta americana, Neotoma floridana, Oxidus gracilis, Periomyotis subflavus, Procyon lotor, Sayornis phoebe, Scolopendromorpha

**AD-41:** Corynorhinus townsendii ingens, Periomyotis subflavus

**AD-54:** Caecidotea simulator, Carabidae, Ceuthophilus gracilipes, Collembola, Collembola sp. no. 2, Corynorhinus townsendii ingens, Crosbyella sp., Isopoda (terrestrial), Macrocera nobilis, Meta americana, Mus musculus, Neotoma floridana, Opiliones, Patera perigrapta, Periomyotis subflavus, Procyon lotor, Stygobromus alabamensis

**AD-6:** Acarina, Araneae sp. no. 2, Cicurina sp., Collembola, Corynorhinus townsendii ingens, Hesperochernes sp., Leiodidae, Lepidoptera, Meta americana, Neotoma floridana, Oxidus gracilis, Psocoptera, Stygobromus sp.

**AD-7:** Acarina, Araneae sp. no. 2, Araneae sp. no. 3, Araneae sp. no. 4, Caudata (larval), Ceuthophilus sp., Cicurina sp., Collembola (troglobitic), Corynorhinus townsendii ingens, Crosbyella sp., Culicidae, Diplopoda (troglobitic), Diptera, Entomobryidae, Eptesicus fuscus, Eurycea longicauda melanopleura, Eurycea lucifuga, Heleomyzidae, Hesperochernes sp., Isopoda (terrestrial), Lirceus sp., Macrocera nobilis, Meta americana, Myotis grisescens, Narceus americanus, Oxidus gracilis, Periomyotis subflavus, Psychodidae, Rhagidiidae, Sciaridae, Staphylinidae, Staphylinidae sp. no. 2, Stygobromus alabamensis

**AD-85:** Ceuthophilus gracilipes, Collembola, Culicidae, Leiodidae, Meta americana, Periomyotis subflavus, Procyon lotor, Staphylinidae

**AD-86:** Araneae sp. no. 2, Araneae sp. no. 2, Cambala minor, Cathartes aura, Ceuthophilus gracilipes, Culicidae, Lepidoptera, Meta americana, Neotoma floridana, Oxidus gracilis, Patera perigrapta, Periomyotis subflavus, Platynus sp., Procyon lotor, Sayornis phoebe, Scolopendromorpha

**AD-87:** Cambala minor, Culicidae, Gastropoda (terrestrial snail) no. 2, Meta americana, Mus musculus, Neotoma floridana, Noctuidae, Patera perigrapta, Sphecidae

**Lost Turtle Cave:** Araneae sp. no. 3, Cambaridae, Carabidae, Ceuthophilus gracilipes, Chilopoda, Collembola, Diptera, Gastropoda (terrestrial snail), Lepidoptera, Linyphiidae, Lumbricidae, Macrocera nobilis, Meta americana, Neotoma floridana, Oxidus gracilis, Periomyotis subflavus, Procyon lotor, Procyon lotor, Pseudosinella sp., Sminthuridae, Staphylinidae, Testudines

## Cherokee County

**Cave Spring:** Caecidotea sp., Caudata (larval), Cottus carolinae, Crangonyx forbesi, Culicidae, Eurycea longicauda melanopleura, Eurycea lucifuga, Heleomyzidae, Micropterus dolomieu, Orconectes neglectus neglectus, Oxidus gracilis, Periomyotis subflavus, Rana palustris

**CZ-10:** Achaeranea tepidariorum, Araneae, Ceuthophilus gracilipes, Coccinellidae, Collembola, Eurycea lucifuga, Heleomyzidae, Litocampa sp., Psocoptera, Scutigera sp., Sphaeroceridae, Staphylinidae

**CZ-11:** Araneae sp. no. 2, Caecidotea simulator, Ceuthophilus sp., Coleoptera, Crosbyella sp., Eurycea lucifuga, Heleomyzidae, Isopoda (terrestrial), Leiodidae, Lepidoptera, Litocampa sp., Meta americana, Nicoletiidae gen. nov. sp. nov., Oxidus gracilis, Polydesmida, Psocoptera, Sphaeroceridae, Staphylinidae, Stygobromus sp., Trichoniscidae

**CZ-12:** Achaeranea tepidariorum, Ceuthophilus gracilipes, Cicurina sp., Coleoptera, Collembola, Crosbyella sp., Culicidae, Eurycea lucifuga, Formicidae, Isopoda (terrestrial), Leiobunum sp., Meta americana, Noctuidae, Oxidus gracilis, Pseudacris crucifer crucifer, Psocoptera, Sphaeroceridae, Staphylinidae, Tabanidae, Tomocerus sp., Trichoniscidae

**CZ-18:** Corynorhinus townsendii ingens, Periomyotis subflavus

**CZ-19:** Corynorhinus townsendii ingens, Periomyotis subflavus

**CZ-9**: Acarina sp. no. 2, Achaeranea tepidariorum, Araneae sp. no. 4, Caecidotea ancyla, Ceuthophilus gracilipes, Ceuthophilus sp., Coleoptera sp. no. 2, Corydalidae (larva), Dasypus novemcinctus, Dolomedes sp., Eurycea longicauda melanopleura, Eurycea lucifuga, Eurycea multiplicata griseogaster, Heleomyzidae, Isopoda (terrestrial), Leiobunum sp., Leiodidae, Lithobiidae, Lycosidae, Macrocera nobilis, Megapallifera ragsdalei, Muridae, Neotoma floridana, Onychiuridae, Platynus sp., Plethodon albagula, Polydesmida, Pseudoscorpiones, Rhagidiidae, Sphaeroceridae, Staphylinidae sp. no. 2, Stygobromus sp., Thysanura, Tipulidae, Tomocerus sp.

**Luck Spring:** Caecidotea sp., Crangonyx forbesi, Eurycea spelaea

## Comanche County

**Baker's Peak Cave:** Ceuthophilus sp.

**Baker's Spring:** Odonata (naiad), Procambarus simulans, Stygobromus alabamensis

**Black Bear Spring:** Culicidae, Elimia sp., Ephemeroptera (larva), Odonata (naiad), Orconectes sp.

**Bluff Shelter on Bat Cave Mountain:** Ceuthophilus sp., Pipistrellus hesperus

**Bonanza Mine:** Culicidae, Rana catesbeiana

**Panther Creek CCC Well:** Caecidotea sp., Ceuthophilus sp., Muridae, Stygobromus alabamensis

**Pennington Mine:** Ceuthophilus sp., Chilopoda, Coleoptera, Corynorhinus townsendii pallescens, Elimia sp., Gastropoda (terrestrial snail), Lumbricidae, Periomyotis subflavus, Staphylinidae

**Sugar Creek Spring:** Acris crepitans, Cambaridae, Elimia sp., Hyalella azteca, Odonata (naiad), Ostracoda
**Tarbone Spring:** Culicidae, Elimia sp., Odonata (naiad), Plecoptera, Rana catesbeiana
**Time O'Day Spring:** Hyalella azteca, Lepomis cyanellus, Odonata (naiad), Orconectes sp., Ostracoda
**Turtle Springs:** Culicidae, Gyrinidae, Orconectes sp., Plecoptera
**Unnamed spring on Wichita Mountains NWR:** Odonata (naiad), Ostracoda

## Delaware County

**Carroll's Grotto:** Caecidotea simulator, Cambarus subterraneus, Cottus carolinae, Culicidae, Inflectarius inflectus
**Cave near Brush Creek Bridge:** Amphipoda (stygobitic), Caecidotea stiladactyla, Ceuthophilus gracilipes, Culicidae, Eurycea spelaea, Lirceus sp., Rana palustris, Tricladida (stygobitic)
**DL-1:** Caecidotea stiladactyla, Caudata (larval), Culicidae, Eurycea spelaea, Heleomyzidae, Leiodidae, Macrocera nobilis, Meta americana, Mycetophilidae, Myotis grisescens, Periomyotis subflavus, Platynus sp., Procyon lotor, Rana palustris, Scoliopterix sp.
**DL-102:** Araneae sp. no. 2, Caecidotea sp., Campodeidae, Ceuthophilus sp., Ceuthophilus utahensis, Chironomidae, Cicurina sp., Diplopoda sp. no. 2, Dolomedes sp., Eurycea lucifuga, Eurycea spelaea, Formicidae, Gordiidae, Heleomyzidae, Leiobunum sp., Lepidoptera, Megapallifera ragsdalei, Mycetophilidae, Nicoletiidae gen. nov. sp. nov., Oxidus gracilis, Periomyotis subflavus, Plethodon albagula, Psocoptera, Staphylinidae, Tipulidae, Tomocerus sp.
**DL-104:** Caecidotea sp., Collembola, Dolomedes sp., Eurycea lucifuga, Eurycea spelaea, Leiodidae, Lumbricidae, Meta americana, Oxidus gracilis, Periomyotis subflavus, Platynus sp., Plethodon albagula, Procyon lotor, Turbellaria
**DL-105:** Collembola sp. no. 2, Eurycea lucifuga, Eurycea spelaea, Lycosidae, Myotis grisescens, Oxidus gracilis, Plethodon albagula, Rana catesbeiana, Rana palustris, Sayornis phoebe, Sciaridae, Sphaeroceridae, Staphylinidae, Tomocerus sp.
**DL-119:** Amblyopsis rosae, Cambarus tartarus
**DL-148:** Amblyopsis rosae, Caecidotea ancyla, Caecidotea mackini, Cambarus tartarus, Cambarus tartarus, Castor canadensis, Dolomedes sp., Dugesia sp., Eurycea lucifuga, Gerridae, Mycetophilidae, Oxidus gracilis, Rana palustris, Semotilus atromaculatus, Sphaeroceridae, Stygobromus sp., Tipula sp., Tipulidae
**DL-16:** Caecidotea sp., Cottus carolinae, Culicidae, Gastropoda (terrestrial snail), Periomyotis subflavus, Sayornis phoebe
**DL-19:** Caecidotea ancyla, Culicidae, Didelphis virginiana, Dolomedes sp., Eurycea longicauda melanopleura, Eurycea spelaea, Eurycea spelaea, Gastropoda (terrestrial snail), Lycosidae, Mycetophilidae, Nocomis biguttatus, Oxidus gracilis, Plethodon albagula, Rana catesbeiana, Rana palustris, Sphaeroceridae, Tipulidae
**DL-2:** Ceuthophilus gracilipes, Cicurina sp., Culicidae, Cyprinidae, Diplopoda (troglobitic), Diplopoda sp. no. 2, Dolomedes sp., Dytiscidae, Eurycea lucifuga, Ictaluridae, Neotoma floridana, Periomyotis subflavus, Platynus sp., Rana catesbeiana, Rana sphenocephala, Sciaridae, Staphylinidae
**DL-21:** Amblyopsis rosae, Ceuthophilus sp., Corynorhinus townsendii ingens, Cottus carolinae, Japygidae, Lepomis sp., Myotis grisescens, Orconectes sp., Orconectes sp., Periomyotis subflavus
**DL-22:** Ambloplites constellatus, Ceuthophilus sp., Cottus carolinae, Cyprinidae, Eurycea lucifuga, Orconectes neglectus neglectus
**DL-3:** Araneae sp. no. 3, Arrhopalites sp., Carabidae, Ceuthophilus gracilipes, Cicurina sp., Collembola sp. no. 2, Dolomedes sp., Formicidae, Gastropoda (terrestrial snail), Isopoda (terrestrial), Lepidoptera, Macrocera nobilis, Megapallifera ragsdalei, Meta americana, Periomyotis subflavus, Plethodon albagula, Procyon lotor, Pseudoscorpiones, Psocoptera, Salticidae, Sayornis phoebe, Scarabaeidae, Sphaeroceridae, Staphylinidae, Stygobromus sp., Tomocerus sp.
**DL-32:** Araneae sp. no. 2, Caecidotea sp., Cathartes aura, Ceuthophilus sp., Dolomedes sp., Heleomyzidae, Ixodidae, Litocampa sp., Megapallifera ragsdalei, Mycetophilidae, Neotoma floridana, Oxidus gracilis, Periomyotis subflavus, Plethodon albagula, Pseudacris crucifer crucifer, Rana catesbeiana, Rana palustris, Rhagidiidae, Sminthuridae, Sphaeroceridae, Staphylinidae, Stygobromus sp., Tipulidae, Tomocerus sp.
**DL-38:** Amblyopsis rosae, Cambarus subterraneus, Eptesicus fuscus, Eurycea spelaea, Heleomyzidae, Neotoma floridana, Periomyotis subflavus
**DL-39:** Culicidae, Eurycea lucifuga, Eurycea spelaea, Heleomyzidae, Macrocera nobilis, Mycetophilidae, Myotis grisescens, Myotis septentrionalis, Orconectes neglectus neglectus, Periomyotis subflavus, Procyon lotor, Rana palustris

**DL-41:** Araneae, Araneae sp. no. 2, Arrhopalites sp., Ceuthophilus gracilipes, Cicurina sp., Collembola sp. no. 2, Culicidae, Diptera sp. no. 3, Eurycea lucifuga, Formicidae, Gastropoda (terrestrial snail), Hesperochernes sp., Isopoda (terrestrial), Leiobunum sp., Lepidoptera, Lumbricidae, Megapallifera ragsdalei, Neotoma floridana, Oribatida, Oxidus gracilis, Periomyotis subflavus, Plethodon albagula, Procyon lotor, Psocoptera, Rhagidiidae, Sminthuridae, Staphylinidae, Staphylinidae sp. no. 2, Stygobromus sp., Tipulidae, Tomocerus sp., Trichoniscidae
**DL-51:** Arrhopalites sp., Caecidotea ancyla, Caecidotea stiladactyla, Eurycea longicauda melanopleura, Eurycea lucifuga, Heleomyzidae, Megapallifera ragsdalei, Oxidus gracilis, Plethodon albagula, Sphaeroceridae, Staphylinidae, Stygobromus sp., Tipulidae
**DL-59:** Acarina, Araneae sp. no. 2, Caecidotea stiladactyla, Caudata (larval), Ceuthophilus sp., Cicurina sp., Culicidae, Eurycea lucifuga, Eurycea spelaea, Gastropoda (terrestrial snail), Heleomyzidae, Isopoda (terrestrial), Leiobunum sp., Lepidoptera, Mycetophilidae, Onychiuridae, Oxidus gracilis, Periomyotis subflavus, Phoridae, Plethodon albagula, Psychodidae, Rana palustris, Sminthuridae, Sphaeroceridae, Staphylinidae, Staphylinidae sp. no. 2
**DL-64:** Cambarus sp. (stygobitic), Ceuthophilus sp., Cicurina sp., Culicidae, Dolomedes sp., Eurycea spelaea, Heleomyzidae, Inflectarius inflectus, Macrocera nobilis, Nematoda, Orconectes neglectus neglectus, Oxidus gracilis, Periomyotis subflavus, Platynus sp., Sayornis phoebe
**DL-74:** Amblyopsis rosae, Caecidotea antricola, Cambarus subterraneus, Culicidae, Eurycea lucifuga, Eurycea spelaea, Macrocera nobilis, Procyon lotor, Rana palustris, Rana sp., Sayornis phoebe, Stygobromus sp., Trichoceridae
**DL-79:** Araneae, Arrhopalites sp., Caecidotea stiladactyla, Cathartes aura, Cicurina sp., Collembola sp. no. 2, Eurycea lucifuga, Formicidae, Gastropoda (terrestrial snail), Heleomyzidae, Lumbricidae, Megapallifera ragsdalei, Meta americana, Mycetophilidae, Oribatida, Plethodon albagula, Pseudoscorpiones, Staphylinidae, Stygobromus sp., Tipulidae, Tricladida (stygobitic)
**DL-8:** Araneae, Caecidotea stiladactyla, Ceuthophilus gracilipes, Cicurina sp., Eptesicus fuscus, Gastropoda (terrestrial snail), Heleomyzidae, Isopoda (terrestrial), Leiobunum sp., Lithobiidae, Myotis grisescens, Noctuidae, Onychiuridae, Oxidus gracilis, Periomyotis subflavus, Plethodon albagula, Pseudoscorpiones, Psocoptera, Rhagidiidae, Sayornis phoebe, Sciaridae, Sminthuridae, Staphylinidae, Stygobromus onondagaensis, Tipulidae, Tomocerus sp., Trichoniscidae
**DL-91:** Cambarus subterraneus
**DL-92:** Acarina, Caecidotea stiladactyla, Collembola, Culicidae, Gambusia affinis, Macrocera nobilis, Mycetophilidae, Oxidus gracilis, Platynus sp., Stygobromus ozarkensis, Tipulidae
**DL-97:** Caecidotea ancyla, Diplopoda (troglobitic), Diptera, Heleomyzidae, Lumbricidae, Macrocera nobilis, Orthoptera, Oxidus gracilis, Periomyotis subflavus, Stygobromus sp.
**Krause Spring:** Dugesia sp., Eurycea spelaea
**Matthews et al. (1983) Spring # 12:** Gammarus minus
**Pitfall Cave:** Araneae, Caudata (larval), Eurycea lucifuga, Eurycea spelaea, Heleomyzidae, Litocampa sp., Neotoma floridana, Periomyotis subflavus, Platynus sp., Rana catesbeiana, Rana palustris, Rhagidiidae
**Spring on Bob Kelley's Land:** Amphipoda, Dugesia sp., Gambusia affinis, Lirceus sp.
**Unnamed cave on Dry Creek:** Cambaridae, Castor canadensis, Cottus carolinae, Culicidae, Eurycea longicauda melanopleura, Lepomis macrochirus, Oxidus gracilis, Platynus sp., Polydesmida, Rana clamitans melanota, Semotilus atromaculatus

## Ellis County

**Bowman Spring 1:** Hyalella azteca
**Dugger Spring 1:** Cambaridae, Hyalella azteca
**McCorkle Springs:** Gambusia affinis, Hyalella azteca
**OBS Spring # SPR05-05:** Cambaridae, Hyalella azteca
**OBS Spring # SPR05-06:** Gambusia affinis, Hyalella azteca
**Reininger Spring:** Gambusia affinis, Hyalella azteca
**Word Springs:** Hyalella azteca

## Greer County

**Jester Cave:** Ameiurus melas, Anthicidae, Araneae, Araneae sp. no. 2, Araneae sp. no. 3, Armadillidae, Cambaridae, Carabidae, Castor canadensis, Ceuthophilus sp., Chilopoda, Coleoptera, Coleoptera sp. no. 2, Collembola sp. no. 2, Corydalidae (larva), Corynorhinus townsendii pallescens, Culicidae, Deroceras laeve, Diplopoda, Diptera sp. no. 2, Dolomedes sp., Dytiscidae, Gerridae, Gerridae, Hirudinea, Isopoda (terrestrial), Leiodidae, Lepidoptera, Lumbricidae, Myotis velifer, Orconectes sp., Periomyotis subflavus, Phoridae, Physa virgata, Rana blairi, Rhagidiidae, Sayornis phoebe, Scaphinotus sp., Sphaeroceridae, Staphylinidae, Staphylinidae sp. no. 2, Tomocerus sp.

## Johnston County

**Big Spring:** Gammarus lacustris

**Deadman Spring:** Caecidotea sp.

**Inslee Spring:** Gammarus lacustris

**Martin Spring:** Allocrangonyx pellucidus, Caecidotea acuticarpa, Hyalella azteca

**Nelson Spring:** Amphipoda (stygobitic), Caecidotea sp., Gammarus lacustris, Gastropoda (aquatic snail), Hirudinea, Orconectes sp., Plecoptera, Turbellaria

**Rutherford Spring:** Caecidotea sp.

**Second spring upstream of Tishomingo National Fish Hatchery:** Allocrangonyx pellucidus, Amphipoda, Caecidotea acuticarpa, Orconectes sp.

**Spring # 2 on Bruno's Land:** Amphipoda, Caecidotea acuticarpa, Lirceus sp.

**Spring on Easterling's Land:** Amphipoda, Dugesia sp., Gambusia affinis, Gastropoda (aquatic snail), Percidae, Rana sphenocephala

**Springbox upstream of Tishomingo National Fish Hatchery:** Allocrangonyx pellucidus, Araneae sp. no. 2, Caecidotea acuticarpa, Loxosceles reclusa, Orconectes sp.

**Twin Vulture Cave:** Amphipoda, Caecidotea acuticarpa, Ceuthophilus sp., Coragyps atratus, Culicidae, Neotoma floridana

**Unnamed cave on Oliver Ranch:** Araneae, Araneae sp. no. 2, Araneae sp. no. 3, Carabidae, Ceuthophilus sp., Culicidae, Gastropoda (terrestrial snail), Neotoma floridana, Sphaeroceridae, Staphylinidae, Tomocerus sp.

**Washington Spring:** Amphipoda, Caecidotea sp., Gammarus sp., Plecoptera, Turbellaria

## Kiowa County County

Dietrich's Spring: Cambaridae, Coleoptera, Gastropoda (terrestrial snail), Hyalella azteca, Physidae, Trichoptera

Turtle Spring: Acarina, Cordulegaster sp., Cyprinidae, Gastropoda (aquatic snail), Hirudinea, Lepomis sp., Percidae

## Major County County

**Nescatunga Cave:** Ambystoma tigrinum, Corynorhinus townsendii pallescens, Stygobromus alabamensis

**Vickery Cave:** Tadarida brasiliensis

## Mayes County County

**MY-12:** Caecidotea sp., Caudata (larval), Causeyella sp., Ceuthophilus gracilipes, Dolomedes sp., Eurycea lucifuga, Eurycea spelaea, Heleomyzidae, Japygidae, Leiobunum sp., Onychiuridae, Plethodon albagula, Scarabaeidae, Sminthuridae, Sphaeroceridae

**Roadside Park Spring:** Crangonyx forbesi, Lirceus garmani

## Murray County County

**Blue Hole Spring:** Cyprinidae, Dytiscidae

**Crystal Cave:** Achaeranea tepidariorum, Araneae sp. no. 2, Ceuthophilus sp., Coccinellidae, Diplopoda (troglobitic), Isopoda (terrestrial), Lumbricidae, Trichoniscidae

**Cueva Cascavel:** Araneae, Ceuthophilus sp., Coleoptera, Collembola, Crotalus sp., Gastropoda (terrestrial snail), Lumbricidae

**Cueva Escorpion:** Centruroides vittatus

**Little Crystal Cave:** Achaeranea tepidariorum, Araneae, Araneae sp. no. 2, Ceuthophilus sp., Crosbyella sp., Gastropoda (terrestrial snail), Heleomyzidae, Leiobunum sp., Lumbricidae, Neotoma floridana, Rana sp., Scolopendromorpha, Squamata (Snake), Tomocerus sp., Trichoniscidae

**MU-2:** Allocrangonyx pellucidus, Araneae, Argiope aurantia, Caecidotea acuticarpa, Ceuthophilus sp., Collembola sp. no. 2, Collembola sp. no. 3, Leiobunum sp., Oxidus gracilis, Periomyotis subflavus, Platynus sp., Rhagidiidae, Scolopendromorpha, Tomocerus sp., Trigenotyla vaga

**Mystic Cave:** Allocrangonyx pellucidus, Caecidotea acuticarpa, Caecidotea acuticarpa, Cambaridae, Collembola, Diplopoda (troglobitic), Diptera, Gastropoda (terrestrial snail), Ictaluridae, Lepomis sp., Periomyotis subflavus, Platynus sp., Platynus sp., Procambarus simulans, Trichoniscidae

**Outlaw Cave:** Achaeranea tepidariorum, Araneae sp. no. 2, Crosbyella sp., Culicidae, Eptesicus fuscus, Isoptera, Opiliones

**Spring # 1 on Hickory Creek:** Allocrangonyx pellucidus, Caecidotea acuticarpa, Gastropoda (aquatic snail)
**Spring # 2 on Hickory Creek:** Allocrangonyx pellucidus, Caecidotea sp., Cambaridae
**Spring # 3 on Hickory Creek:** Allocrangonyx pellucidus, Caecidotea sp.
**Spring # 4 on Hickory Creek:** Allocrangonyx pellucidus, Caecidotea sp.
**Spring # 5 on Hickory Creek:** Allocrangonyx pellucidus, Caecidotea sp.
**Spring # 6 on Hickory Creek:** Allocrangonyx pellucidus, Caecidotea sp.
**Squeeze Box:** Araneae, Araneae sp. no. 2, Armadillidium sp., Ceuthophilus sp., Collembola, Gastropoda (terrestrial snail), Gastropoda (terrestrial snail) no. 2, Trombidiidae
**Wagon Wheel Cave:** Culicidae, Opiliones

## Ottawa County County

**OT-19:** Amblyopsis rosae, Amphipoda, Caecidotea sp., Chironomidae, Lirceus sp.
**Unnamed Cave:** Araneae, Araneae sp. no. 2, Caecidotea simulator, Ceuthophilus sp., Culicidae, Diplopoda (troglobitic), Isopoda (terrestrial), Macrocera nobilis, Neotoma floridana, Oxidus gracilis, Periomyotis subflavus, Sciaridae

## Pontotoc County

**Byrds Mill Spring:** Caecidotea acuticarpa
**Coal Creek Cave:** Allocrangonyx pellucidus, Caecidotea acuticarpa, Ceuthophilus sp., Culicidae, Diplopoda (troglobitic), Gastropoda (terrestrial snail), Gerridae, Lumbricidae, Orconectes sp., Sayornis phoebe
**Coffee Pot Spring:** Bezzia sp., Cambaridae, Cricotopus sp., Dixa sp., Larsia sp., Odontomyia sp., Pseudochironomus sp., Rheotanytarsus sp., Stenochironomus sp.
**Deadman's Spring:** Amphipoda (stygobitic), Caecidotea acuticarpa, Hyalella azteca

## Sequoyah County

**SQ-1:** Corynorhinus townsendii ingens

## Washita County

**Lady's Cave:** Ceuthophilus sp., Dolomedes sp., Isopoda (terrestrial), Platynus sp., Staphylinidae
**WA012:** Araneae, Carabidae, Ceuthophilus sp., Coleoptera, Culicidae, Diplopoda, Diptera sp. no. 2, Diptera sp. no. 3, Gerridae, Gryllidae, Insecta, Isopoda (terrestrial), Lumbricidae, Oxidus gracilis, Phoridae, Staphylinidae

## Woodward County

**J. Selman Cave System:** Acarina, Annelida, Araneae, Araneae sp. no. 2, Araneae sp. no. 3, Araneae sp. no. 4, Carabidae, Ceuthophilus sp., Coleoptera, Coleoptera sp. no. 2, Collembola, Deroceras laeve, Diplopoda, Diptera, Diptera sp. no. 2, Diptera sp. no. 3, Elimia sp., Hymenoptera, Insecta, Isopoda (terrestrial), Leiodidae, Lepidoptera, Oxidus gracilis, Phoridae, Physa sp., Platynus sp., Psephenidae, Staphylinidae, Staphylinidae sp. no. 2

## Appendix 2: Taxonomic Composition of 50 Surveyed Springs

**Appendix 2.** Taxonomic composition of 50 surveyed springs. 'x' = present. Site numbers are given in Table A. Summary statistics are the total number of sites where a taxon occurs ('sites') and the total number of taxa present at a site ('richness'). Modified richness excludes microcrustaceans and double counts of both larvae and pupae for a single taxon.

| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cnidaria | Hydroida | Hydridae | *Hydra* | x | | | | | | | | | | | | | | x | x | x | | x | x | | |
| Turbellaria | Tricladida | Dugesiidae | planarians | x | | | x | x | x | | x | | x | x | | | | | | x | x | x | x | x | x |
| Annelida | Hirudinea | Glossiphoniidae | *Batracobdella phalera* | | | | x | | | | | | | | | | | | | | | | | | |
| | | | *Deserobdella picta* | | x | | | | | | | | | | | | | | | | | | | | |
| | | | *Helobdella fusca* | | | | | | | | | | | | | | | | | | | x | | | |
| | | | *Helobdella stagnalis* | | | | | | | | | | | | | | | | | | | | x | | |
| | | | *Helobdella triserialis* | | | | x | | | | | | | | | | | | | | | | | | |
| | | | *Placobdella ornata* | x | | | | | | | | | | | | | | | | | | | | | |
| | | | *Placobdella papillifera* | | | | | | | | | | | | | | | | | | | | x | | |
| | | Eprobdellidae | *Erpobdella* nr. *punctata* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Mooreobdella fervida* | | | | | | | | | | | | | | | | | | | x | | | |
| | | | unidentified | | | | | | | | | | | | | | | | | x | | | | | |
| | Oligochaeta | Naididae | unidentified | x | x | | x | | | | | | | x | | x | x | | x | x | | x | x | | x |
| | | Tubificidae | *Brachiura sowerbyi* | | x | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | | x | | x | x | | x | | x | x | x | | x | x | x | x | x | | x | x | | x |
| | | Lumbriculidae | unidentified | | | | | | | | | | | | | | | | | | | | | | |
| | Polychaeta | Sabellidae | *Manayunkia speciosa* ? | | | | | | | | | | | | | | | | | | | | | | |
| Nematoda | | unidentified | unidentified | | | | x | | | | | | | x | | x | x | x | x | x | | x | x | | |
| Entognatha | Collembola | Isotomidae | unidentified | x | | | | x | | | | | | x | | | x | | | x | | | | | |
| Entognatha | | Poduridae | *Podura* | x | | | | | | | | | | | | x | | | | | | | | | |
| | | Sminthuridae | unidentified | | | | | | | | | | | | | | | | | x | x | | x | | |
| Insecta | Coleoptera | Dytiscidae | *Agabus* | | | | | | | | | x | | | | x | x | x | | | | x | | x | |
| | | | *Coptotomus* | | | | | | | | | | | | | | | | | x | | | | | |
| | | | *Hydaticus* | | | | | | | | | | | | | | x | | | | | | | | |
| | | | *Hydrobius* | | | | | | | | | | | | | x | | | | | | | | | |
| | | | *Hydroporus* I | | | | x | | x | | | x | x | | | | | | | | | | | | x |
| | | | *Hydroporus* II | | | x | x | | | | | x | | | | x | | | | | x | x | | x | x |
| | | | *Hydroporus* III | | | | x | x | | | | | | | | x | | | | | | | | | |
| | | | *Hydroporus larvae* | | | | | | | | | | | | | | | x | | | | | | | |
| | | | *Hydrovatus* | | | | | | | | | | | | | | | | | | | x | | x | x |

| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
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| | | | *Ilybius* | | | | | | | | | | | | | | | | | x | x | | | | |
| | | | *Laccophilus* | | | x | x | | | | x | | x | | | | | | | | | | | | |
| | | | *Liodessus* | x | | | | | | | | | x | | | | | | | x | | | x | x | |
| | | | *Liodessus* II | | | | | | | | | | | | | | | | | | | x | | | |
| | | | *Neoporus* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Oreodytes* | | | | | | | | | | | | | x | | x | | | | | | | |
| | | | *Uvarus* | | | | | | | | | | | | | x | x | | | | | | | | |
| | | | unid dytiscid | | | | | | | | | | | | | | | | | | | | | | |
| | | Elmidae | *Dubiraphia vittata* | | x | | | | | | | | | | | | | | | | | | | | |
| | | | *Microcylloepus pusillus* | | | | | | | | | | | | | | | | | | | x | | | |
| | | | *Optioservus* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Stenelmis* | | x | | | | | | | | | | | | | | | x | | | | | |
| | | | unid (too small) | | | | | | | | | | | | | | | | | | | | | | |
| | | Gyrinidae | *Dineutis* | | x | | | | | | | | | | | | | | | | | | | | |
| | | Haliplidae | *Haliplus* | | | | | | | | | | | | x | | | | | | | | x | | |
| | | | *Peltodytes* | x | x | x | x | | x | | | | | | | | | | | x | | x | | x | x |
| | | Helophoridae | *Helophorus* | | | | | | | | | x | x | | | | | | | | | | | | |
| | | Heteroceridae | unidentified | | | | | | | | | | | | | | | | | | | | | | |
| | | Hydrochidae | *Hydrochus* | x | | | | | | | | | | | | | | | | | | | | | |
| | | Hydrophilidae | *Berosus* | | | | x | | | | | | | | | | | | | x | x | x | x | | |
| | | | *Crenitulus* | x | | | x | x | | | | x | x | | x | | | | | | | | | | |
| | | | *Cymbiodyta* | | | | | | | | | x | | | | | | | | | | | | | |
| | | | *Enochrus* | x | | | | | | | | x | x | | | | | | | x | | x | | x | x |
| | | | *Hydrochara* | x | | | | | | | | | | | | | | | | | | | | | |
| | | | *Laccobius* | | | | | | | | | x | | | | | | | | | | | | | |
| | | | *Paracymus* | x | | | x | | | | | x | | | | | | | | | | x | | | x |
| | | | nr *Paracymus* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Phaenonotum* | | | | x | x | | | | | | | | | | | | | | | | | |
| | | | *Tropisternus* II | | | | | | | | | | | | | | | | | | x | | x | | x |
| | | | *Tropisternus* III | x | x | x | x | | x | | x | | x | | | | | | x | | | | x | | x |
| | | | *Tropisternus* (larvae) | | | | | x | | | | | | | | | | x | | | | | | | |
| | | Limnichidae | *Limnichus* | | | x | x | x | x | | x | x | | x | x | | | | x | x | x | x | | | |
| | | Noteridae | *Suphisellus* | | | | | | | | x | | | | | | | | | | | | | | |
| | | Psephenidae | *Ectopria nervosa* | | | | | | | | | | | | | | | | | | | | | | |
| | | Scirtidae | *Microcara* | | | | | | | | | | | | | | | | | | | | | | |
| | | unidentified | immature larvae | | | | | | | | | | | | | | | | | | | | | | |

| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
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| | Diptera | Ceratopogonidae | *Bezzia/Palpomyia* | x | | | | x | | | | x | | | x | x | | x | | | | x | x | x | |
| | | | *Dasyhelea* | | | | | | | | | | | | | | | | x | | | | x | | |
| | | | others | x | x | x | x | | x | x | x | | | | x | x | x | | | x | x | x | x | x | |
| | | Chironomidae | Orthocladinae | x | | | x | x | | | x | x | x | x | x | x | x | x | x | x | x | | x | x | |
| | | | Tanypodinae | x | x | x | x | | | | | x | x | x | x | x | x | x | x | x | x | | x | x | x |
| | | | Chironominae | x | x | x | x | x | x | x | | x | x | x | x | x | x | x | x | x | x | | x | x | x |
| | | | unid. small larvae | x | | x | | | | | x | | x | | x | | | | | | | | | | |
| | | | pupae | | | | x | | | | | | | | | | x | x | | | | | | | x |
| | | Culicidae | *Anopheles* | | x | x | | x | x | | x | | x | x | | x | | x | x | | | | x | | x |
| | | | *Culex* | | | | | | | | | | | | | | | x | x | | | | | | |
| | | | *Culiseta* | | | | | | | | | | | | | | | | | | | | | | |
| | | | pupae | | | | | | | | | | | | | | | x | x | x | | | | | |
| | | Dixidae | *Dixa* | | | | | | | | x | | | | | | | | | | | | | | |
| | | | *Dixella* | x | | | | x | | | | | x | x | | x | | | | x | | | x | x | x |
| | | | pupae | | | | | | | | | | | | | | | x | | x | x | | x | | |
| | | Empididae | *Chelifera* | | | | | | | | | | x | | | | | | | | | | | | |
| | | | *Hemerodromia* | x | | | x | | | | | | | | | | | | | | | | | | |
| | | Ephydridae | *Lemnaphila* | | | | | | | | | | | | | | | | | | | | | | x |
| | | | *Parydra* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Pelina* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Scatella* | | | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | | | | | x | | x | | | | | | | | | | | | | | | |
| | | Muscidae | unidentified | | | | | | | | | | | | | | | | | | | | | | |
| | | Psychodidae | *Pericoma/Telmatoscopus* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Psychoda* | x | | | | | | x | | | | | | | | | x | | | | x | x | |
| | | | pupa | | | | | | | | | | | | | | x | | | | | | | | |
| | | Ptychopteridae | *Ptychoptera* | | | | | | | | | | | | | | | | | | | | | x | |
| | | Sciomyzidae | *Sepedon/Sepedomenerus* | | | | | | | | | | | | | | | | | | | | | | |
| | | Simuliidae | *Simulium* | x | | | | | | | | | | | | | x | | | x | | | x | x | |
| | | Stratiomyidae | *Caloparyphus* | | | | | | | x | | x | | | | | | | | | | | | | |
| | | | *Euparyphus* | | | | | | | x | | | | | | | | | | | | | | | |
| | | | *Myxosargus* | | | | x | x | x | | x | | | x | | | | | | | | | | | |
| | | | *Nemotelus* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Odontomyia* (*Catatasina*) | | | | | | | x | | | | | | | | | | | | | | | |
| | | | *Odontomyia/Hedriodiscus* | x | | | | | | | | | | | | | | | x | | | | x | | x |
| | | | *Stratiomys* | | | | x | | | x | | | | | | | | | | | | | | x | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | unid | | | | | | | | | | | | | | | | | | | | | | |
| | | Tabanidae | *Chrysops* | | | x | x | | | | | | | | | | | | | x | x | | | | |
| | | Tipulidae | *Gonomyia* | | | | | | | x | | | | | | | | | | | | | | | |
| | | | *Holorusia* | | | | | | | | | | x | | | | | | | | | | | | |
| | | | *Limonia* | | | | | | | | | | | | | | | | x | | | | | | |
| | | | *Pseudolimnophila* | | | | | x | | | | | | | | | | | | | | | | | |
| | | | *Tipula* | x | x | | | | x | | x | x | | | | x | | x | x | | | | | | |
| | | | *Ulomorpha* | | | | | | | | | | | | | | | | | | | | | | x |
| | | | pupae/unidentified | | | | | | | | | | | | | | x | | | | x | | | | |
| | | unidentified | | | | | | | | | | | | | | | | | | | | | | | |
| | Ephemeroptera | Baetidae | *Baetis* | | | | | | | | | | x | | | | | | | | | | x | | |
| | | | *Callibaetis* | | | x | x | x | | | | x | x | x | x | x | | | x | x | x | | x | | x |
| | | Caenidae | *Caenis* | | | | | | | | | | | | x | | | | | | | | | | |
| | | Ephemerellidae | *Hexagenia* | x | | | | | | | | | | | | | | | | | | | | | |
| | | Heptageniidae | *Leucrocuta* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Stenacron* | | | | | | | | | | | | | | | | | | | | | | |
| | | Leptophlebiidae | *Paraleptophlebia* | | | | | | | | | | | | | x | | | | | | | | | |
| | Hemiptera | Belostomatidae | *Belostoma / Abedus* | x | | | | | | | | | | | | | | | | | x | | x | x | |
| | | Corixidae | *Hesperocorixa* | | | x | | | | | | | | | | | | | | | | | | | |
| | | | *Sigara* | x | | | | | x | | x | x | x | | | | | | | | | | | | |
| | | | *Trichocorixa* | | | | x | x | | | | | | | | | | | | | | | | | |
| | | | *unidentified* | | | | | | | | | | | | | | | x | | | | | | | |
| | | Gelastocoridae | *Gelastocoris* | | | | | | | | | | | | | | | | | | | | | | |
| | | Gerridae | *Aquarius* | x | x | x | x | x | x | | x | | x | x | | | | x | x | | x | | x | | |
| | | | *Gerris* | | x | | | | | | x | | | | x | x | | x | | | x | | | | |
| | | | *Limnoporus* | | | | | | | | | | | | | x | x | | | | | | | | |
| | | | *Trepobates* | | x | x | x | x | x | | x | | x | x | x | | | | | | | | | | |
| | | | *Rheumatobates* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Trepobates* | | | | | | | | | | | | | x | | | | | | | x | | |
| | | Hebridae | *Hebrus* | | | | | | | x | | x | | | | | | | | | | | | | |
| | | | *Merragata* | x | | | | | | | | | | | x | | | | | | | | x | | |
| | | Hydrometridae | *Hydrometra* | | | | | | | | | | | | | | | | | | | | x | | |
| | | Mesoveliidae | *Mesovelia* | x | | | | | | x | | | | | x | | | | | | | | x | | |
| | | Notonectidae | *Notonecta* | | | x | | | | | x | | | | | | | | | | | | | | |
| | | Pleidae | *Paraplea* | | | | | | | | | | | | x | | | | | | | | | | x |
| | | Veliidae | *Microvelia* | x | | x | x | x | x | | x | x | x | x | | x | x | x | x | x | x | x | x | x | x |

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| | | | *Platyvelia* | x | x | | x | | | | | | | | | | | | | | | | | x | |
| | | | *Rhagovelia* | | x | | | | x | | x | | | | | | | | | x | | | | | |
| | Lepidoptera | Pyralidae | *Paraponyx* | x | | | | | | | | | | | | | | | | | | | | | |
| | | | *Mun./Syn./Neocat.* | | | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | x | | | | | | | | | | | | | | | | | | | | x | |
| | Megaloptera | Sialidae | *Sialis* | | | | | | | | | | | | x | | | | | | | | | | |
| | Odonata | Aeshnidae | *Aeshna* | | | | x | x | | | | | | x | | | | x | | x | | x | x | | x |
| | | | *Anax* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Boyeria* | | | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | | | | | | | | | | | | | | | | | | | | | | |
| | | Calopterygidae | *Calopteryx* | | | | x | | | | | | | | | | | | | x | | | | | |
| | | | *Hetaerina* | x | | | | | | | | | | | | | | | | x | | x | | | |
| | | Coenagrionidae | *Argia* | x | x | | x | x | | x | x | x | x | x | | | x | x | x | x | x | x | x | x | x |
| | | | *Coenagrion/Enallagma* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Enallagma* | | | x | | | | | | | | | x | | | | | | | | | | |
| | | | Enallagma/Ishnura | x | | x | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | | | | | x | | | | | | | | | | | | | | | | | |
| | | Corduliidae | *Epitheca* (*Epicordulia*) | | | | | | | | | | | | x | | | | | | | | | | |
| | | | *Didymops transversa* | | | | | | | | | | | | x | | | | | | | | | | |
| | | | *Somatochlora* | | | | x | | | | | | | | | | | | | | | | | | |
| | | Gomphidae | *Erpetogomphus* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Gomphus* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Progomphus* | | | | | | | | | | | | | | | | | x | | | | | |
| | | Lestidae | *Archilestes* | | | x | | | | | x | x | x | | | | | | | | | x | | | |
| | | Libellulidae | *Dythemis* | | x | | | | | | | | | | | | | | | | | | | | |
| | | | *Erythemis* | x | | | | | | | x | | | | x | | | | | | x | | x | | |
| | | | *Erythrodiplex* | | | | | | | | | | | | | | | | | | | | | x | |
| | | | *Libellula* | | | | | | | | | | | | | | | x | | | | | | | |
| | | | *Perithemis* | | | | | | | | | | | | | | | | | | | | | | |
| | | | *Plathemis* | | | | | | | | | | | | | | | | | | | x | | | |
| | | | *Sympetrum* | | | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | | | | | | | | | | | | x | | | | | | | | | | |
| | Orthoptera | Tetrigidae | unidentified | | | | | | | | | x | | | | | | | | | | | | | |
| | Trichoptera | Helicopsychidae | *Helicopsyche* | x | | | x | | | | | | x | | | | | | | | | | | | |
| | | Hydropsychidae | *Cheumatopsyche* | | | | | | | | | | | | | | x | | | x | | x | x | | |
| | | | *Diplectrona* | | | | | | | | | | | | | | | | | | | | | | |

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| | | | unidentified juveniles | | | | | | | | | | | | | | | | | | | | | | |
| | | Hydroptilidae | *Hydroptila* | x | | | x | | | | | x | | | | | | | | | | | x | | |
| | | | *Ochrotrichia* | | | | | | | | | | | | | | | | x | x | | | x | | |
| | | | *Oxyethira* | x | | | | | | | | | | | | | | | | | | | x | | |
| | | | pupa | | | | | | | | | | | | | | | | | | | | | | |
| | | Lepidostomatidae | *Lepidostoma* | | | | | | | | | | | | | | | | | | | | | | |
| | | Leptoceridae | *Nectopsyche* | | | | x | | | | | | | | | | | | | x | | | | | |
| | | Limnephidae | *Pycnopsyche* | | x | | | | | | | | | | | | | | | | | | | | |
| | | Molannidae | *Molanna* | | | | | | | | | | | | | | | | | | | | | | |
| | | Philopotamidae | *Chimarra* | | | | | | | | | | | | | | | x | | | | | | | |
| | | | *Wormaldia* | | | | | | | | | | | | | | | x | | | | | | | |
| | | Polycentropidae | *Polycentropus* | | | | | | | | | | | | | | | | | | | | | | |
| | | Psychomyidae | *Psychomyia* | | | | | | | | | | | | | | | | | | | | | | |
| | | unidentified | pupae | | | | | | | | | | | | | | | | | | | | | | |
| Crustacea | Amphipoda | | cave amphipod | | | | | | | | | | | | | | | | | | | | | | |
| | | Crangonyctidae | Crangonyx forbesi | | | | | | | | | | | | | | | | | | | | | | |
| | | Gammaridae | *Gammarus* | | | | | | | | | | | | | | | | | | | | | | |
| | | Talitridae | *Hyalella azteca* | x | x | x | x | x | x | | x | | x | | x | | | | | x | x | x | x | x | x |
| | Isopoda | Asellidae | *Lirceus hoppinae* | | | | | | | | | | | | | | | x | x | | | | | | |
| | | | *Caecidotea* | | | | | | x | | | | | | | | | | | | | | | | |
| | | | *Caecidotea acuticarpa* | | | | | | | | | | | | | | | | | | | | | | |
| | Ostracoda | | type A | | | | | | | | | | | | | | | | | x | x | x | x | x | x |
| | | | type B | | | | | x | | | | | | | x | | | x | | | | | x | | |
| | | | type C | | | | | | | | | | | x | | x | | | | x | | | | x | |
| | | | type D | | | | | | | | | | | | | | | | | | | x | x | | |
| | | | type E | | | | | | | | | | | | | | | | | | | | | x | x |
| | | | type F | | | | | | | x | | | | | | | | | x | x | x | x | | x | |
| | | | type G | | | | | | | | | | | | | | | | | | | | | | |
| | | | type H | | | | | | | | | | | | | | | | | | | | | | |
| | | | type I | | | | | | | | | | | | | | | | | | | | | | |
| | | | type J | | | | | | | | | | | | | | | | | | | | | | |
| | | | type K | | | | | | | x | | | | | | | | | | | | | | | |
| | | | type L | | | | | | | | | | | | | | | | | | | | | | |
| | | | type M | | | | | | | | | | | | | | | | | | | | | | |
| | Decapoda | | *Orconectes nais* | | | | x | | | | | | | | | | | | | | | | | | |
| | | | *Orconectes neglectus* | | | | | | | | | | | | | | | | | | | | | | |

| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *O. palmeri longimanus* | | | | | | | | x | | x | | | x | | | | | | | | | |
| | | | *Orconectes virilis* | x | x | | | | | | | | | | | | | | | | | | | | |
| | | | *Orconectes* sp. | | | | | x | | | | | | x | | | | | | | | | | | |
| | | | *Procambarus simulans* | | | x | | | | | | | | | | x | | x | x | x | | | | | |
| | Copepoda | Cyclopoida | copepod | x | | x | x | x | | | | | x | x | x | x | | x | | x | | x | x | | |
| | | Harpacticoida | copepod | x | | x | | x | x | | x | x | x | | | x | x | | x | x | x | x | x | | |
| | Cladocera | | unidentified | | | | | | | | | | | | | | | x | | | | | | | |
| | Acari | | misc. mites | | | x | x | x | | x | | x | x | | | x | | x | | | | x | x | | x |
| Bivalvia | | Sphaeriidae | unidentified | x | | x | x | | x | | x | | | x | x | | | | | x | x | x | x | x | x |
| Gastropoda | | Ancylidae | *Ferrissia* | x | | x | | | | | | | | | | | | | | | | | | | |
| | | Hydrobiidae | unidentified | | x | | | | | | | | | | | | | | | | | | | | |
| | | Lymnaeidae | *Fossaria* | x | x | x | | | x | | | | | | | | | | | x | x | | | x | |
| | | Physidae | *Physa* | x | x | x | x | | | | | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | | Planorbidae | *Gyraulus* | | | | x | | | | | | | | | | | x | | | | | | | |
| | | | *Helisoma* | x | | x | | | | | | | | | | | | | | x | x | | | | x |
| | | | *Menetus* | x | | | | | | | | | | | | | | | | | | | | | |
| | | | *Planorbula* | | | | x | x | | | | | | | | | | | | | | | | | |
| | | | *Promenetus* | | | | | | | | | | | | | | | | x | | | | | | |
| | | Pleuroceridae | *Elimia* | | | | | | | | | | | | | | | | | | | | | | |
| | | Pomatiopsidae | *Pomatiopsis* | | | | | | | | | | | | | | | | | | | | | | |
| | | | **richness** | 53 | 27 | 30 | 47 | 31 | 20 | 16 | 26 | 28 | 32 | 23 | 27 | 31 | 21 | 34 | 28 | 47 | 29 | 35 | 50 | 31 | 31 |
| | | | **richness (modified)** | 51 | 27 | 27 | 45 | 28 | 19 | 13 | 25 | 26 | 29 | 21 | 24 | 27 | 20 | 30 | 26 | 42 | 26 | 29 | 44 | 27 | 28 |

**Appendix 2.** Taxonomic composition of 50 surveyed springs. 'x' = present. Site numbers are given in Table A. Summary statistics are the total number of sites where a taxon occurs ('sites') and the total number of taxa present at a site ('richness'). Modified richness excludes microcrustaceans and double counts of both larvae and pupae for a single taxon.

| | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 300 | 301 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cnidaria | Hydroida | Hydridae | *Hydra* | x | | x | x | x | x | | x | | | | | x | | x | | x | | | | x |
| Turbellaria | Tricladida | Dugesiidae | planarians | x | | | | | x | x | x | | | x | x | x | x | x | | x | | x | | |
| Annelida | Hirudinea | Glossiphoniidae | *Batracobdella phalera* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Deserobdella picta* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Helobdella fusca* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Helobdella stagnalis* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Helobdella triserialis* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Placobdella ornata* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Placobdella papillifera* | | | | | | | | | | | | | | | | | | | | | |
| | | Eprobdellidae | *Erpobdella* nr. *punctata* | | | | | | | | | | | | x | | | | | | x | | | |
| | | | *Mooreobdella fervida* | x | | | | | | | | | | | x | | | | | | | | | |
| | | | unidentified | | | | | | | | | | | | | | | | | | | | | |
| | Oligochaeta | Naididae | unidentified | | x | x | x | x | x | | x | x | x | | | x | x | | | x | x | | | |
| | | Tubificidae | *Brachiura sowerbyi* | | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | x | x | x | x | x | | x | x | x | x | | x | | x | x | x | x | x | x | | |
| | | Lumbriculidae | unidentified | | | | | | | | | | | | x | | | | | | | | | |
| | Polychaeta | Sabellidae | *Manayunkia speciosa*? | | | | | | | | | | | | | | | x | | | | | | |
| Nematoda | | unidentified | unidentified | x | | | x | | | x | | | x | | | | | x | x | | x | | | |
| Entognatha | Collembola | Isotomidae | unidentified | x | | x | x | | x | | | x | | | | x | x | | | x | | | | |
| Entognatha | | Poduridae | *Podura* | | | | | x | x | | | | | | | | x | | x | | | | | |
| | | Sminthuridae | unidentified | | | | | | | | | | | | | | | | | | | | | |
| Insecta | Coleoptera | Dytiscidae | *Agabus* | x | x | x | | | | | | | | | | | | | | | | | x | |
| | | | *Coptotomus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Hydaticus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Hydrobius* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Hydroporus* I | | | | | | | | | | | | | | | | | | | | | |
| | | | *Hydroporus* II | | | | | | | | | | | | | | | | | | | | | |
| | | | *Hydroporus* III | | x | x | | | | x | | | | | | | | | | | | | | |
| | | | *Hydroporus larvae* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Hydrovatus* | | | | | | | | | | | | | | | | | | | | | |

| | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 300 | 301 |
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| | | | *Ilybius* | | | | | | | | | | | | | | | | | | | | | x |
| | | | *Laccophilus* | x | | | | | | | | x | | | | | | | | | | | | |
| | | | *Liodessus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Liodessus* II | | | | | | | | | | | | | | | | | | | | | |
| | | | *Neoporus* | | | | | | x | | | | | | | | | | | | | | | |
| | | | *Oreodytes* | | | x | | x | x | x | | | | | | | | x | | | | | | |
| | | | *Uvarus* | | | | | | | | | | | | | | | | | | | | | |
| | | | unid dytiscid | | | | | x | | | | | | | | | | | | x | | | | |
| | | Elmidae | *Dubiraphia vittata* | x | x | x | | | | | | | | | | | | | | | | | | |
| | | | *Microcylloepus pusillus* | | | x | | | x | | | | | | | x | | | | | | | | |
| | | | *Optioservus* | | | | | | | | | | | | | x | | | | | | | | |
| | | | *Stenelmis* | | | x | | | x | | | | | | | x | | | | | | | | |
| | | | unid (too small) | | x | | | | | | | | | | | x | | | | | | | | |
| | | Gyrinidae | *Dineutis* | | | | | | | | | | | | | | | | | | | | | |
| | | Haliplidae | *Haliplus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Peltodytes* | x | x | | | x | | x | x | x | | | | | | | | | | | | |
| | | Helophoridae | *Helophorus* | | | | | | | | | | | | | | | | | | | | | |
| | | Heteroceridae | unidentified | | | | | | | | | | | | | | | | | | | | | |
| | | Hydrochidae | *Hydrochus* | | | | | | | | | | | | | | | | | | | | | |
| | | Hydrophilidae | *Berosus* | x | x | | | x | | | | | | | | | | | | | | | | |
| | | | *Crenitulus* | | | | | | | | | | | | x | | | | | | | | | |
| | | | *Cymbiodyta* | | | | x | x | | | | | | | | | | | | | | | | |
| | | | *Enochrus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Hydrochara* | | | | | | | | | | | | | | x | | | | | | | |
| | | | *Laccobius* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Paracymus* | | | | | x | | | | | | | | | | | | | | | | |
| | | | nr *Paracymus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Phaenonotum* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Tropisternus* II | | | | | | | | | x | | | | | | | | | | | | |
| | | | *Tropisternus* III | x | | | x | | | | | | | | | | | | | | | | x | x |
| | | | *Tropisternus* (larvae) | | | | | x | x | | | | | | x | | | | | | | | x | x |
| | | Limnichidae | *Limnichus* | x | | | | | x | | | | | | | | | | | | | | | |
| | | Noteridae | *Suphisellus* | | | | | | | | | | | | | | | | | | | | | |
| | | Psephenidae | *Ectopria nervosa* | | | | | | | | | | | | | | | x | | | | | | |
| | | Scirtidae | *Microcara* | | | | | | | | | | | | | | | | | | | | | |
| | | unidentified | immature larvae | | | | | | | | | | | | | | x | | | | | | | |

| | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 300 | 301 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diptera | Ceratopogonidae | *Bezzia/Palpomyia* | | x | x | x | x | x | | | x | x | | | | | x | x | | | | | |
| | | | *Dasyhelea* | | | | | | x | | | | x | | | | | | | | | | | |
| | | | others | x | x | x | x | | x | | x | x | x | | x | x | | | | | | | | |
| | | Chironomidae | Orthocladinae | x | x | x | x | x | x | | x | x | x | | x | x | x | | x | x | x | | x | x |
| | | | Tanypodinae | x | x | x | | x | x | x | x | x | x | x | | x | x | x | x | x | x | x | | x |
| | | | Chironominae | x | x | x | x | x | x | x | x | x | x | | x | x | x | x | x | x | x | x | x | x |
| | | | unid. small larvae | | x | | | | | | | | | | | x | x | | | | | x | | |
| | | | pupae | x | x | x | x | x | x | x | x | x | x | | | x | x | | x | | x | x | | x |
| | | Culicidae | *Anopheles* | | | | | | | | | | | | | | | | | x | | | | |
| | | | *Culex* | | | | | x | | | | x | | | | | | | | | | | | |
| | | | *Culiseta* | | | | | | | | | | | | | | | | | | | | x | x |
| | | | pupae | | | | | | | | | | x | | | | | | | | | | | |
| | | Dixidae | *Dixa* | | | | | | | | | | | | | | | | | x | | x | | |
| | | | *Dixella* | | | | | | x | | | | | | | | | | | | | | | |
| | | | pupae | | | | | | | | | | | | | | | | | | | | | |
| | | Empididae | *Chelifera* | | | | | | | | | | | | | x | x | x | | | | x | | |
| | | | *Hemerodromia* | | | | | | | | | | | | x | x | | | | x | | | | |
| | | Ephydridae | *Lemnaphila* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Parydra* | | | | | | | | | | | | | | x | | | | | | | |
| | | | *Pelina* | | | | | | | | | x | | | | | | | | | | | | |
| | | | *Scatella* | | | | | | | | | | | | x | | | | | | | | | |
| | | | unidentified | | | | | | | | | | | | | | | | | | | | | |
| | | Muscidae | unidentified | | | | | | | | | | x | | x | | | | | | | | | |
| | | Psychodidae | *Pericoma/Telmatoscopus* | | | | x | | | | | | x | | | | x | | | | | | | |
| | | | *Psychoda* | | | | | | | | | | x | | | | | | | x | | | | |
| | | | pupa | | | | | | x | | | | x | | | | | | | | | | | |
| | | Ptychopteridae | *Ptychoptera* | | | | | | | | | | | | | | | | | | | | | |
| | | Sciomyzidae | *Sepedon/Sepedomenerus* | x | | x | | | | | | x | | | | | | | | | | | | |
| | | Simuliidae | *Simulium* | | x | | | | x | | | | | | | x | | | | | | | x | |
| | | Stratiomyidae | *Caloparyphus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Euparyphus* | | | | | | x | | | | | | | | | | | x | | | | |
| | | | *Myxosargus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Nemotelus* | | | | | | | | | x | x | | | | | | | | | | | |
| | | | *Odontomyia* (*Catatasina*) | | | | | | | | | | | | | | | | | | | | | |
| | | | *Odontomyia/Hedriodiscus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Stratiomys* | | | | | | | | x | x | | | | | | | | | | | | |

| | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 300 | 301 |
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| | | | unid | | | | | | | | | | | | | | | x | | | | | | |
| | | Tabanidae | *Chrysops* | x | | | | | | | | | x | | | | | | | | | | | |
| | | Tipulidae | *Gonomyia* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Holorusia* | | | | | | | | | | x | | | | | | | | | | | |
| | | | *Limonia* | | | | | | | | | | | | | | | | | x | | | | |
| | | | *Pseudolimnophila* | | | | | | | | x | x | x | | | | | | | | | | | |
| | | | *Tipula* | | | x | | | | | | | x | | | | | | | | | | | |
| | | | *Ulomorpha* | x | | | | | | | | | | | | | | | | | | | | |
| | | | pupae/unidentified | x | | | | | | | | | x | | | | | | x | | | x | | |
| | | unidentified | | | | | | | | | | | x | | | | | | | | | | | |
| | Ephemeroptera | Baetidae | *Baetis* | | x | x | | | x | | | | | x | | x | x | x | | | | | | |
| | | | *Callibaetis* | x | x | | x | x | x | x | | x | | | | | | | | | | | x | x |
| | | Caenidae | *Caenis* | | x | x | | | | | | | | | | | | | | | | | | |
| | | Ephemerellidae | *Hexagenia* | | | | | | | | | | | | | | | | | | | | | |
| | | Heptageniidae | *Leucrocuta* | | | | | | | | | | | | | | x | | | | | | | |
| | | | *Stenacron* | | | | | | | | x | | | x | | x | | | | | | | | |
| | | Leptophlebiidae | *Paraleptophlebia* | | | | | | | | | | | | | | | | | | | | | |
| | Hemiptera | Belostomatidae | *Belostoma / Abedus* | x | | | | | | | | x | | | | | | | | | | | | |
| | | Corixidae | *Hesperocorixa* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Sigara* | | | | | | x | | | | | | | | x | | | | | x | | |
| | | | *Trichocorixa* | x | | | | | | | | | | | | | | | | | | | | |
| | | | *unidentified* | | | | | | | | | | | | | | | | | | | | x | |
| | | Gelastocoridae | *Gelastocoris* | | | | | | | | | x | | | | | | | | | | | | |
| | | Gerridae | *Aquarius* | x | x | | x | | x | | x | | x | x | | | x | | | | | | | x |
| | | | *Gerris* | x | | x | x | | | x | | | | x | | | x | x | | | | x | | |
| | | | *Limnoporus* | | | | | x | | | | | | | | x | | | | | | | | |
| | | | *Trepobates* | | x | | | | | | | | | | | | | | | | | | | |
| | | | *Rheumatobates* | x | | x | | | | | | | | | | | | | | | | | | |
| | | | *Trepobates* | x | | | | | | | | | | | | | | | | | | | | |
| | | Hebridae | *Hebrus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Merragata* | | | | | | | | | | | | | | | | | | | | | |
| | | Hydrometridae | *Hydrometra* | | | | | | | | | | | | | | | | | | | | | |
| | | Mesoveliidae | *Mesovelia* | | | | | | | | | | | | | | | | | | | | | |
| | | Notonectidae | *Notonecta* | | | | | | | | | | | | | | | | | | | | x | x |
| | | Pleidae | *Paraplea* | | | | | | | | | | | | | | | | | | | | | |
| | | Veliidae | *Microvelia* | x | | x | | | x | x | x | | x | | x | x | x | x | | x | x | x | | |

| | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 300 | 301 |
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| | | | *Platyvelia* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Rhagovelia* | | x | | | | | | | | | | | | | | | | | | | |
| | Lepidoptera | Pyralidae | *Paraponyx* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Mun./Syn./Neocat.* | | | | | | | | | x | | | | | | | | | | | | |
| | | | unidentified | x | | | | | | | | | | | | | | | | | | | | |
| | Megaloptera | Sialidae | *Sialis* | x | x | x | | | | | | | | | | | | x | | | | | | |
| | Odonata | Aeshnidae | *Aeshna* | x | | | | | | x | | | | | | x | | | | | | | | |
| | | | *Anax* | | | | | | | | | | | | | | | | | | | | | x |
| | | | *Boyeria* | | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | | | | | | | | | | | | | | | | | | | | | |
| | | Calopterygidae | *Calopteryx* | x | x | x | x | | | | | | | | | | | | | | | | | |
| | | | *Hetaerina* | x | | | | | | | | | | | | | | | | | | | | |
| | | Coenagrionidae | *Argia* | x | x | x | x | x | x | x | x | | | | | x | | x | | x | | | | x |
| | | | *Coenagrion/Enallagma* | | | | | | x | | | | | | | | | | | | | | | x |
| | | | *Enallagma* | | | | | | | | | | | | | | | | | | | | | |
| | | | Enallagma/Ishnura | | | | | | | | | | | | | | | | | | | | | |
| | | | unidentified | | | | | | | x | | | | | | | | | | | | | | |
| | | Corduliidae | *Epitheca* (*Epicordulia*) | | | | | | | | | | | | | | | | | | | | | |
| | | | *Didymops transversa* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Somatochlora* | | | | | | | | x | | | | | | | | | | | | | |
| | | Gomphidae | *Erpetogomphus* | x | | | | | | | | | | | | | | | | | | | | |
| | | | *Gomphus* | x | | | | | | | | | | | | | | | | | | | | |
| | | | *Progomphus* | | | | | | | | | | | | | | | | | | | | | |
| | | Lestidae | *Archilestes* | | | x | x | | | x | x | | | | | | | | | | | | | |
| | | Libellulidae | *Dythemis* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Erythemis* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Erythrodiplex* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Libellula* | | | | | | | | | | | | | | | | | | | | | x |
| | | | *Perithemis* | | | | | | x | | | | | | | | | | | | | | | |
| | | | *Plathemis* | x | | | | | | | | | | | | | | | | | | | | |
| | | | *Sympetrum* | | | | | | | | | x | | | | | | | | | | | | |
| | | | unidentified | | | | | | | | | | | | | | | | | | | | | |
| | Orthoptera | Tetrigidae | unidentified | | | | | x | | | | | | | | | | | | | | | | |
| | Trichoptera | Helicopsychidae | *Helicopsyche* | | | | | | | | | | | | | x | x | | | | | | | |
| | | Hydropsychidae | *Cheumatopsyche* | x | x | x | | | | | | | | | | | x | | | | | | | |
| | | | *Diplectrona* | | | | | | | | | | | x | | x | | x | | | | | | |

| | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 300 | 301 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | unidentified juveniles | | | x | | | x | | | | | | | x | | | | | | | | |
| | | Hydroptilidae | *Hydroptila* | x | x | | | | | | x | x | | | | | x | | | | | x | | |
| | | | *Ochrotrichia* | | x | x | | | | | | | | | | x | | | | | | | | |
| | | | *Oxyethira* | | | | | | | | | | | | | x | x | | | | | | | |
| | | | pupa | x | | | | | | | x | | | | | | | | | | | | | |
| | | Lepidostomatidae | *Lepidostoma* | | | | | | | | | | | | | | | x | | | | | | |
| | | Leptoceridae | *Nectopsyche* | | | | | | | | | | | | | | | | | | | | | |
| | | Limnephidae | *Pycnopsyche* | | | | | | | | | | | | | | | | | | | | | |
| | | Molannidae | *Molanna* | | | | | | | | | | | | | | | x | | | | | | |
| | | Philopotamidae | *Chimarra* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Wormaldia* | | | | | | | | | | | | | | | | | | | | | |
| | | Polycentropidae | *Polycentropus* | | | | | | | x | | | | x | | x | | | | | | x | | |
| | | Psychomyidae | *Psychomyia* | | | | | | | | | | | | | | x | | | | | | | |
| | | unidentified | pupae | | | | | | | | | | | | | x | x | | | | | | | |
| Crustacea | Amphipoda | | cave amphipod | | | | | | | | | | x | | | | | | | | | | | |
| | | Crangonyctidae | Crangonyx forbesi | | | | | | | | | | | | x | | | | | | | | | |
| | | Gammaridae | *Gammarus* | | | x | | | | | | | | x | | x | x | | | | x | x | | |
| | | Talitridae | *Hyalella azteca* | x | x | | | x | x | | x | | x | | | | | | | | | | | |
| | Isopoda | Asellidae | *Lirceus hoppinae* | | | | | | | | | | x | | x | x | x | | x | x | x | x | | |
| | | | *Caecidotea* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Caecidotea acuticarpa* | | | | | | | | | | | | | | | | | | | | | |
| | Ostracoda | | type A | x | | | | | x | | | | | | | | | | | | | | x | x |
| | | | type B | | | | | | | | | | | | | | | | | | | | | |
| | | | type C | | | | | | | | | | | | | | | | | | | | | |
| | | | type D | | | | | | | | | | | | | | | | | | | | | |
| | | | type E | | | | | | | x | | | | | | | x | | | | | | | |
| | | | type F | x | | | x | x | | x | x | | | | | x | | | x | | | | x | |
| | | | type G | | | | x | x | | | | | | | | | | | | | | | | x |
| | | | type H | | | | | | | | | | x | | | x | | | | | | | | |
| | | | type I | | | | x | | x | | | | | | | x | | | | x | | | | |
| | | | type J | | | | | x | | | | | | | | x | x | | | | | x | | |
| | | | type K | | | | | | | | | | | | | | | | | | | | | |
| | | | type L | | | | | | | | | | | | | | | | | | | | x | |
| | | | type M | | | | | | | | | | | | | | | | | | | | | |
| | Decapoda | | *Orconectes nais* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Orconectes neglectus* | | | | | | | | | | | x | | | x | x | x | x | | | | |

| | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 300 | 301 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *O. palmeri longimanus* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Orconectes virilis* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Orconectes* sp. | x | x | | | | | | x | | | | | x | x | x | | | | | | |
| | | | *Procambarus simulans* | | | x | | x | | x | | | | | | | | | | | | | | |
| | Copepoda | Cyclopoida | copepod | x | x | x | x | x | x | x | x | x | x | | x | | | | | x | | x | x | x |
| | | Harpacticoida | copepod | x | | x | x | | x | | x | | x | | x | x | x | | x | x | | x | | |
| | Cladocera | | unidentified | | | | x | | | x | x | x | | | | | | | | | x | | x | x |
| | Acari | | misc. mites | x | x | | x | x | x | x | x | | x | | x | x | x | x | x | x | | x | x | x |
| Bivalvia | | Sphaeriidae | unidentified | x | | x | | | x | | x | x | x | | x | | | x | x | x | | | | |
| Gastropoda | | Ancylidae | *Ferrissia* | | | | | | | x | | | | | | | | | | | x | | | |
| | | Hydrobiidae | unidentified | | | | | | | | | | | | | | | | | | | | | |
| | | Lymnaeidae | *Fossaria* | | | | | | | | | | | | | | | | | | | | | |
| | | Physidae | *Physa* | x | x | x | x | x | x | x | x | x | x | | x | x | x | | | x | | x | x | x |
| | | Planorbidae | *Gyraulus* | | | | | | | | | | | | | | | | | x | | | | |
| | | | *Helisoma* | | | | | | | | x | | | | | | | | | | | | | |
| | | | *Menetus* | | | | | | | | | | | | | | | | | | | | x | |
| | | | *Planorbula* | | | | | | | | | | | | | | | | | | | | | |
| | | | *Promenetus* | | | | | | | | | | | | | | | | | | | | | |
| | | Pleuroceridae | *Elimia* | | | | | | | | | | | | | x | | | | | | | | |
| | | Pomatiopsidae | *Pomatiopsis* | | | | | | | | | | | | | | | | | | | | | |
| | | | **richness** | 51 | 33 | 36 | 27 | 29 | 39 | 25 | 30 | 28 | 33 | 10 | 21 | 41 | 36 | 24 | 15 | 26 | 13 | 21 | 18 | 22 |
| | | | **richness (modified)** | 46 | 31 | 34 | 20 | 24 | 34 | 20 | 25 | 26 | 29 | 10 | 18 | 34 | 31 | 23 | 12 | 22 | 12 | 17 | 12 | 16 |

**Appendix 2.** Taxonomic composition of 50 surveyed springs. 'x' = present. Site numbers are given in Table A. Summary statistics are the total number of sites where a taxon occurs ('sites') and the total number of taxa present at a site ('richness'). Modified richness excludes microcrustaceans and double counts of both larvae and pupae for a single taxon.

| | | | | 302 | 303 | 304 | 305 | 306 | 307 | 308 | sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cnidaria | Hydroida | Hydridae | *Hydra* | | | | | | | | 16 |
| Turbellaria | Tricladida | Dugesiidae | planarians | x | | x | | x | x | x | 29 |
| Annelida | Hirudinea | Glossiphoniidae | *Batracobdella phalera* | | | | | | | | 1 |
| | | | *Deserobdella picta* | | | | | | | | 1 |
| | | | *Helobdella fusca* | | | | | | | | 1 |
| | | | *Helobdella stagnalis* | | | | | | | | 1 |
| | | | *Helobdella triserialis* | | | | | | | | 1 |
| | | | *Placobdella ornata* | | | | | | | | 1 |
| | | | *Placobdella papillifera* | | | | | | | | 1 |
| | | Eprobdellidae | *Erpobdella* nr. *punctata* | | | | | | | | 2 |
| | | | *Mooreobdella fervida* | | | | | | | | 3 |
| | | | unidentified | | | | | | | | 1 |
| | Oligochaeta | Naididae | unidentified | | x | x | | | x | | 26 |
| | | Tubificidae | *Brachiura sowerbyi* | | | | | | | | 1 |
| | | | unidentified | | | | | | | | 31 |
| | | Lumbriculidae | unidentified | | | | x | | | | 2 |
| | Polychaeta | Sabellidae | *Manayunkia speciosa* ? | | | | | | | | 1 |
| Nematoda | | unidentified | unidentified | x | | | | | | | 17 |
| Entognatha | Collembola | Isotomidae | unidentified | | | | x | | x | | 15 |
| Entognatha | | Poduridae | *Podura* | | | | | | | | 6 |
| | | Sminthuridae | unidentified | | | | | | | | 3 |
| Insecta | Coleoptera | Dytiscidae | *Agabus* | x | | x | | | | | 12 |
| | | | *Coptotomus* | | | | | | | | 1 |
| | | | *Hydaticus* | | | | | | | | 1 |
| | | | *Hydrobius* | | | | | | | x | 2 |
| | | | *Hydroporus* I | | | | | | | | 5 |
| | | | *Hydroporus* II | | | | | | | | 8 |
| | | | *Hydroporus* III | | | | | | | | 6 |
| | | | *Hydroporus larvae* | | | | | x | | | 2 |
| | | | *Hydrovatus* | | | | | | | | 3 |

| | | | | 302 | 303 | 304 | 305 | 306 | 307 | 308 | sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Ilybius* | | | | | | | | 3 |
| | | | *Laccophilus* | x | | | | | | | 7 |
| | | | *Liodessus* | | | | | | | | 5 |
| | | | *Liodessus* II | | | | | | | | 1 |
| | | | *Neoporus* | | | x | | | | | 2 |
| | | | *Oreodytes* | | | | | | | | 7 |
| | | | *Uvarus* | | | | | | | | 2 |
| | | | unid dytiscid | | | | | x | | | 3 |
| | | Elmidae | *Dubiraphia vittata* | | | | | x | | | 5 |
| | | | *Microcylloepus pusillus* | | | | | | | | 4 |
| | | | *Optioservus* | | | | | | | | 1 |
| | | | *Stenelmis* | | | | | | | | 5 |
| | | | unid (too small) | | | | | | | | 2 |
| | | Gyrinidae | *Dineutis* | | | | | | | | 1 |
| | | Haliplidae | *Haliplus* | | | x | | | | | 3 |
| | | | *Peltodytes* | | | | | x | x | | 17 |
| | | Helophoridae | *Helophorus* | | | | | | | | 2 |
| | | Heteroceridae | unidentified | | | x | | | | | 1 |
| | | Hydrochidae | *Hydrochus* | | | x | | | | | 2 |
| | | Hydrophilidae | *Berosus* | | | x | | | | | 9 |
| | | | *Crenitulus* | | | | | x | | | 8 |
| | | | *Cymbiodyta* | | | | | | | | 3 |
| | | | *Enochrus* | | | | | | | | 7 |
| | | | *Hydrochara* | | | | | | | | 2 |
| | | | *Laccobius* | | | | | | | | 1 |
| | | | *Paracymus* | | | | | | | | 6 |
| | | | nr *Paracymus* | | | | | x | | | 1 |
| | | | *Phaenonotum* | | | | | | | | 2 |
| | | | *Tropisternus* II | | x | x | | | | | 5 |
| | | | *Tropisternus* III | x | | | | x | | | 16 |
| | | | *Tropisternus* (larvae) | x | | x | | x | x | | 11 |
| | | Limnichidae | *Limnichus* | | | | | x | x | | 16 |
| | | Noteridae | *Suphisellus* | | | | | | | | 1 |
| | | Psephenidae | *Ectopria nervosa* | | | | | | | | 1 |
| | | Scirtidae | *Microcara* | | | | | | x | x | 2 |
| | | unidentified | immature larvae | | | | | | | | 1 |

| | | | | 302 | 303 | 304 | 305 | 306 | 307 | 308 | sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diptera | Ceratopogonidae | *Bezzia/Palpomyia* | x | | | | | | | 19 |
| | | | *Dasyhelea* | | | | | | | | 4 |
| | | | others | | x | | | | | | 26 |
| | | Chironomidae | Orthocladinae | | | x | x | x | | | 36 |
| | | | Tanypodinae | x | | | x | x | | | 38 |
| | | | Chironominae | x | x | x | x | x | x | | 46 |
| | | | unid. small larvae | | | | | | | | 9 |
| | | | pupae | | | | | | | | 20 |
| | | Culicidae | *Anopheles* | | | | | x | x | | 15 |
| | | | *Culex* | | | | | | | x | 5 |
| | | | *Culiseta* | x | | | | | | | 3 |
| | | | pupae | x | | | | | | | 5 |
| | | Dixidae | *Dixa* | | | | x | | | | 4 |
| | | | *Dixella* | x | | | | | x | | 12 |
| | | | pupae | | | | | | | | 4 |
| | | Empididae | *Chelifera* | | | | | | | | 5 |
| | | | *Hemerodromia* | | | | | | | | 5 |
| | | Ephydridae | *Lemnaphila* | | | | | | | | 1 |
| | | | *Parydra* | | | | | | | | 1 |
| | | | *Pelina* | | | | | | | | 1 |
| | | | *Scatella* | | | | | | | | 1 |
| | | | unidentified | | | | | | | | 2 |
| | | Muscidae | unidentified | | | | | | | | 2 |
| | | Psychodidae | *Pericoma/Telmatoscopus* | | | | | | | | 3 |
| | | | *Psychoda* | | | | | | | | 7 |
| | | | pupa | | | | | | | | 3 |
| | | Ptychopteridae | *Ptychoptera* | | | | | | | | 1 |
| | | Sciomyzidae | *Sepedon/Sepedomenerus* | | | | | | | | 3 |
| | | Simuliidae | *Simulium* | | | | | | | | 9 |
| | | Stratiomyidae | *Caloparyphus* | | | | | | | | 2 |
| | | | *Euparyphus* | | | | | | | | 3 |
| | | | *Myxosargus* | | | | | | | | 5 |
| | | | *Nemotelus* | | | | | | | | 2 |
| | | | *Odontomyia* (*Catatasina*) | | | | | | | | 1 |
| | | | *Odontomyia/Hedriodiscus* | | | | | | | | 4 |
| | | | *Stratiomys* | x | | | | | | | 6 |

| | | | | 302 | 303 | 304 | 305 | 306 | 307 | 308 | sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | unid | | | | | | | | 1 |
| | | Tabanidae | *Chrysops* | | | | | | | | 6 |
| | | Tipulidae | *Gonomyia* | | | | | | | | 1 |
| | | | *Holorusia* | x | | | | x | | | 4 |
| | | | *Limonia* | | | | | | | | 2 |
| | | | *Pseudolimnophila* | | | | | | | | 4 |
| | | | *Tipula* | | | | | | | | 10 |
| | | | *Ulomorpha* | | | | | | | | 2 |
| | | | pupae/unidentified | | | | | | | | 6 |
| | | unidentified | | | | | | | | | 1 |
| | Ephemeroptera | Baetidae | *Baetis* | | | | | | | | 9 |
| | | | *Callibaetis* | x | | x | | | | x | 25 |
| | | Caenidae | *Caenis* | x | | | | | | x | 5 |
| | | Ephemerellidae | *Hexagenia* | | | | | | | | 1 |
| | | Heptageniidae | *Leucrocuta* | | | | | | | | 1 |
| | | | *Stenacron* | | | | | | | | 3 |
| | | Leptophlebiidae | *Paraleptophlebia* | | | | | | | | 1 |
| | Hemiptera | Belostomatidae | *Belostoma / Abedus* | | | | | | | | 6 |
| | | Corixidae | *Hesperocorixa* | | | | | | | | 1 |
| | | | *Sigara* | | | x | x | x | | | 11 |
| | | | *Trichocorixa* | | | | | | | | 3 |
| | | | *unidentified* | | | | | | | | 2 |
| | | Gelastocoridae | *Gelastocoris* | | | | | | | | 1 |
| | | Gerridae | *Aquarius* | x | | | x | x | x | | 26 |
| | | | *Gerris* | | | x | | | | | 15 |
| | | | *Limnoporus* | | | | | | | | 4 |
| | | | *Trepobates* | | | | | | | | 10 |
| | | | *Rheumatobates* | | | | | | | x | 2 |
| | | | *Trepobates* | | | | | | | x | 4 |
| | | Hebridae | *Hebrus* | | | | | | | | 2 |
| | | | *Merragata* | | | | | | | | 3 |
| | | Hydrometridae | *Hydrometra* | | | | | | | | 1 |
| | | Mesoveliidae | *Mesovelia* | | | | | | | x | 5 |
| | | Notonectidae | *Notonecta* | x | x | x | x | x | | | 8 |
| | | Pleidae | *Paraplea* | | | | | | | | 2 |
| | | Veliidae | *Microvelia* | | x | x | | | x | | 35 |

| | | | | 302 | 303 | 304 | 305 | 306 | 307 | 308 | sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Platyvelia* | | | | | | | | 4 |
| | | | *Rhagovelia* | | | | | | | | 5 |
| | Lepidoptera | Pyralidae | *Paraponyx* | | | | | | | | 1 |
| | | | *Mun./Syn./Neocat.* | | | | | | | | 1 |
| | | | unidentified | | | | | | | | 3 |
| | Megaloptera | Sialidae | *Sialis* | | | | | | | | 5 |
| | Odonata | Aeshnidae | *Aeshna* | | | | | | | | 11 |
| | | | *Anax* | | | | | | | | 1 |
| | | | *Boyeria* | | | | | | x | | 1 |
| | | | unidentified | | | x | | | | | 1 |
| | | Calopterygidae | *Calopteryx* | | | | | | | | 6 |
| | | | *Hetaerina* | | | | | | | | 4 |
| | | Coenagrionidae | *Argia* | | | | x | x | | x | 33 |
| | | | *Coenagrion/Enallagma* | | | | | | | x | 3 |
| | | | *Enallagma* | | | x | | | | | 3 |
| | | | Enallagma/Ishnura | | | | | | | | 2 |
| | | | unidentified | | | | | | | | 2 |
| | | Corduliidae | *Epitheca (Epicordulia)* | | | | | | | | 1 |
| | | | *Didymops transversa* | | | | | | | | 1 |
| | | | *Somatochlora* | | | | | | | | 2 |
| | | Gomphidae | *Erpetogomphus* | | | | | | | | 1 |
| | | | *Gomphus* | | | | | | | | 1 |
| | | | *Progomphus* | | | | | | | | 1 |
| | | Lestidae | *Archilestes* | | | | | x | | | 10 |
| | | Libellulidae | *Dythemis* | | | | | | | | 1 |
| | | | *Erythemis* | | | | | | | x | 6 |
| | | | *Erythrodiplex* | | | | | | | | 1 |
| | | | *Libellula* | x | x | | | | | | 4 |
| | | | *Perithemis* | | | | | | | x | 2 |
| | | | *Plathemis* | | | | | | | | 2 |
| | | | *Sympetrum* | | | | | | | | 1 |
| | | | unidentified | | | | | | | | 1 |
| | Orthoptera | Tetrigidae | unidentified | | | | | x | | | 3 |
| | Trichoptera | Helicopsychidae | *Helicopsyche* | | | | | x | | | 6 |
| | | Hydropsychidae | *Cheumatopsyche* | | | | | | | | 8 |
| | | | *Diplectrona* | | | | | | | | 3 |

| | | | | 302 | 303 | 304 | 305 | 306 | 307 | 308 | sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | unidentified juveniles | | | | | | | | 3 |
| | | Hydroptilidae | *Hydroptila* | | | | | | x | | 11 |
| | | | *Ochrotrichia* | | | | | | | | 6 |
| | | | *Oxyethira* | | | | | | | | 4 |
| | | | pupa | | | | | | | | 2 |
| | | Lepidostomatidae | *Lepidostoma* | | | | | | | | 1 |
| | | Leptoceridae | *Nectopsyche* | | | | | | | | 2 |
| | | Limnephidae | *Pycnopsyche* | | | | | | | | 1 |
| | | Molannidae | *Molanna* | | | | | | | | 1 |
| | | Philopotamidae | *Chimarra* | | | | | | | | 1 |
| | | | *Wormaldia* | | | | | | | | 1 |
| | | Polycentropidae | *Polycentropus* | | | | | | | | 4 |
| | | Psychomyidae | *Psychomyia* | | | | | | | | 1 |
| | | unidentified | pupae | | | | | | | | 2 |
| Crustacea | Amphipoda | | cave amphipod | | | | | | | | 1 |
| | | Crangonyctidae | Crangonyx forbesi | | | | | | | | 1 |
| | | Gammaridae | *Gammarus* | | | | | | | | 6 |
| | | Talitridae | *Hyalella azteca* | | | | x | | x | x | 24 |
| | Isopoda | Asellidae | *Lirceus hoppinae* | | | | | | | | 10 |
| | | | *Caecidotea* | | | | | | | | 1 |
| | | | *Caecidotea acuticarpa* | | | | | | | x | 1 |
| | Ostracoda | | type A | | | | | | x | | 11 |
| | | | type B | | | | x | | | | 5 |
| | | | type C | x | | | | | | | 5 |
| | | | type D | x | | | | | | | 3 |
| | | | type E | | | | | | | | 4 |
| | | | type F | x | x | x | | x | x | | 19 |
| | | | type G | | | | | | | | 3 |
| | | | type H | | | | | | | | 2 |
| | | | type I | | | | x | | | | 5 |
| | | | type J | | | | | | | x | 5 |
| | | | type K | | | | | | | | 1 |
| | | | type L | | | | | | | | 1 |
| | | | type M | x | | | | | | | 1 |
| | Decapoda | | *Orconectes nais* | | | | | | | | 1 |
| | | | *Orconectes neglectus* | | | | | | | | 5 |

| | | | | 302 | 303 | 304 | 305 | 306 | 307 | 308 | sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *O. palmeri longimanus* | | | | | | | | 3 |
| | | | *Orconectes virilis* | | | | | | | | 2 |
| | | | *Orconectes* sp. | | | | x | x | x | | 11 |
| | | | *Procambarus simulans* | | | | | | | | 8 |
| | Copepoda | Cyclopoida | copepod | | x | x | x | | x | x | 32 |
| | | Harpacticoida | copepod | x | | | | | x | | 28 |
| | Cladocera | | unidentified | x | | x | | | | x | 11 |
| | Acari | | misc. mites | | | | | | x | x | 30 |
| Bivalvia | | Sphaeriidae | unidentified | | x | | | x | x | | 26 |
| Gastropoda | | Ancylidae | *Ferrissia* | | | | | | | | 4 |
| | | Hydrobiidae | unidentified | | | | | | | | 1 |
| | | Lymnaeidae | *Fossaria* | | | | | | | | 7 |
| | | Physidae | *Physa* | x | x | x | | x | x | x | 41 |
| | | Planorbidae | *Gyraulus* | | | | | | | | 3 |
| | | | *Helisoma* | | | | | | x | | 7 |
| | | | *Menetus* | | | | | | | | 2 |
| | | | *Planorbula* | | | x | | | | | 3 |
| | | | *Promenetus* | | | | | | | | 1 |
| | | Pleuroceridae | *Elimia* | | | | | | | | 1 |
| | | Pomatiopsidae | *Pomatiopsis* | | | | x | | | | |
| | | | **richness** | 26 | 11 | 24 | 16 | 26 | 24 | 20 | |
| | | | **richness (modified)** | 19 | 9 | 21 | 13 | 25 | 19 | 16 | |