SPECIES RICHNESS, DIVERSITY, AND ECOLOGY OF CHIRONOMIDAE (DIPTERA) IN FOUNTAIN CREEK: A COLORADO FRONT RANGE SANDY-BOTTOM WATERSHED

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ABSTRACT.—The primary purpose of this study was to assess the chironomid species diversity of a high-gradient sandy-bottom watershed along the Colorado Front Range. Adult male Chironomidae were collected concurrently in 2007 and 2008 from 14 sites in the Fountain Creek Watershed (FCW), south central Colorado, USA, using ultraviolet night lights and sweep netting methods. Species-level identifications resulted in 151 species including 24 new species from 65 genera and 6 subfamilies. Forty species are reported here as new Colorado records, and many North American range extensions were recorded. Some species had geographical ranges that included the Neotropical, Afrotropical or Oriental regions. Species from high elevations and northern latitudes were common. Individual species accounts include annotated North American distributions, associated water quality and sediment (particle size) analyses for each site, and ecological notes. Species richness calculations using Jaccard and Sørensen similarity indices indicated, with some exceptions, that sites in closest proximity shared the most common species. *Chironomus decorus* was the most commonly collected species in the FCW, occurring at 13 of 14 sites; the orthoclad *Cricotopus infuscatus* was collected at 12 of the sites. In 2007–2008, the FCW had a very diverse chironomid species assemblage. How species composition changes in the watershed will be influenced by urbanization, global warming, and increased base flows from water diversions.

RESUMEN.—El propósito principal de este estudio fue evaluar la diversidad de especies de quironómidos en un gradiente alto de fondo arenoso a lo largo del Colorado Front Range. Colectamos machos adultos de quironómidos, concurrentemente en 2007 y 2008, en 14 sitios de Fountain Creek Watershed (FCW), en el centro-sur de Colorado, Estados Unidos, utilizando luces ultravioleta nocturnas y con barrido de redes. La identificación a nivel de especies resultó en 151 especies, incluyendo 24 nuevas especies de 65 géneros y 6 subfamilias. Registramos cuarenta especies nuevas para Colorado y muchas extensiones de distribución en América del Norte. Algunas especies tuvieron rangos geográficos que incluyen la zona Neotropical, Afrotropical y regiones orientales. Las especies de altitudes elevadas y latitudes norteadas resultaron comunes. Realizamos descripciones individuales por especie, incluyendo distribuciones identificadas en América del Norte, calidad del agua asociada y análisis de sedimentos (tamaño de las partículas) para cada zona y notas ecológicas. Obtuvimos el cálculo de la riqueza de especies utilizando los índices de Jaccard y de Similitudes de Sørensen. Estos índices mostraron, con algunas excepciones, que las zonas más próximas compartían más especies. La especie más frecuentemente colectada en FCW fue *Chironomus decorus* la cual se encontró en 13 de las 14 zonas; el orthoclad *Cricotopus infuscatus* se colectó en 12 de los sitios. En 2007-2008 la FCW tenía un ensamble de especies de quironómidos muy diverso. El cambio en la composición de las especies en la cuenca se verá afectado por la urbanización, el calentamiento global y el aumento de los flujos base de las desviaciones de agua.

ACRONYMNS.—AR – Arkansas River, ARC – aquatic research center, BDL – below detectable limits, CPOM – coarse particulate organic matter, CSU – Colorado State University, D – dissolved, DMT – daily maximum temperature, DO – dissolved oxygen, EC – specific conductivity, EF – East Fork–Arkansas River, FPOM – fine particulate organic matter, FWC – Fountain Creek Watershed, ICP-MS – inductively coupled plasma mass spectrometry, LAR – Lower Arkansas River, LFC – Lower Fountain Creek, MC – Monument Creek, MPN – most probable number, NCBI – National Center for Biotechnology Information, SDS – Southern Delivery System, SFPE – surface floating pupal exuviae, T – total, UAR – Upper Arkansas River, UFC – Upper Fountain Creek, UM – University of Minnesota, UV – ultraviolet, WWTP – wastewater treatment plant.

NOTE.—The sites AR-1 through AR-20 and EF-1, 2 mentioned in this document are sites designated and surveyed in Ruse et al. 2000. See Appendix on page 252 for a map.

Chironomids exist on every continent, including Antarctica, and species can be found in lentic and lotic habitats with wide ranges of temperature, pH, salinity, oxygen levels, current

speeds, nutrients, depth, productivity, altitude, and latitude (Ferrington 2008). Voshell (2002) stated that chironomids may comprise at least half of the species in an aquatic community.

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Some freshwater investigators have attempted to correlate the ecological health of lotic or lentic systems by the chironomid species aggregations found in different aquatic habitats (Wilson 1980). In boreal ecosystems, Raunio et al. (2011) found that assemblages of chironomid species may respond differently to human impacts than other macrobenthic orders. In addition to mayflies, stoneflies, and caddisflies (EPT species), some species of aquatic plants, fish, and chironomids have been commonly used as bioindicators or sentinel species of impacts on their physicochemical environment (Sæther 1979, Rosenberg 1992, Ruse et al. 2000, Herrmann et al. 2012).

Chironomid species exhibit habitat preference based on environmental gradients such as conductivity, pH, maximum temperature and Zn toxicity (Ruse et al. 2000, Ruse 2006), and species richness varies along elevation (Hayford et al. 2014). In Italy, Rossaro (1991) concluded that water temperature was the most important environmental factor driving chironomid species distribution, followed by rate of flow, substrate quality, and canopy cover. Stevens et al. (1998) found that flow regulation factors such as temperature and turbidity affected the species composition of chironomid assemblages in the Colorado River of the Grand Canyon downstream of Glen Canyon Dam to Lake Mead. In 81 pristine alpine springs of northern Italy, Lencioni et al. (2011) identified 5 site clusters based on chironomid species assemblages defined by altitude, pH, percentage of cobble and stones, and hydrological regimes.

Chironomid assemblages, collected from high-gradient mountain tributaries transitioning to meandering sandy-bottom plains streams, have rarely been studied for their biodiversity at the species level. In this research, identifications were completed to the species level using adult males. All determinations were based on adult male dissections. No larval–adult associations were made during this study. Other adult species-level studies have been completed on segments of the main stem of the Arkansas River: the Upper Arkansas River (UAR) by Ruse et al. (2000) and the Lower Arkansas River (LAR) by Kleinert (2008) and Powell (2008). Zuellig et al. (2008) stated, “to date, no systematic survey of the Colorado aquatic insect fauna

has focused on plains streams.” After further literature review, it became apparent that there have been no species-level studies of chironomids in an entire watershed of a Colorado sandy-bottom stream. This research represented a systematic survey of the adult chironomid fauna identified to species in the Fountain Creek Watershed (FCW), a Front Range Colorado plains stream. Species-level studies of the entire Fountain Creek Watershed fill a major void in our understanding of chironomid community assemblages of sandy-bottomed streams in western United States.

Water quality throughout the FCW was extremely varied; with elevational changes come concomitant differences in thermal regimes, specific conductivity, sediments, cations, anions, nutrients, dissolved oxygen, current velocities, depth, and pH. This high degree of physicochemical variability in the FCW leads us to anticipate a correspondingly high diversity in the chironomid assemblages. Two research questions prompted us to complete this project: (1) what was the chironomid species richness in the FCW in 2007 and 2008, and (2) what environmental variables played a role in the distributions of chironomid species in the FCW? We hypothesized that some chironomid species’ distributions were limited primarily by elevation and substrate composition. The following specific aims were completed in attempting to answer our research questions: (1) concurrent collection of adult chironomids using 2 different collection methods (ultraviolet lights and sweep netting) at 14 sites within the FCW, and (2) collection of 3 surficial sediment samples and many water samples at each of 14 sites to assess varying physical substrates and water quality.

METHODS

Study Area and Sampling Sites

The FCW is located within the Arkansas River Basin, Colorado, and encompasses a total drainage area of 2409 km² (930 mi²). This Y-shaped watershed is bordered by Pikes Peak to the west, the Palmer Divide to the north, Chico Basin to the east, and the Arkansas River to the south. Upper Fountain Creek (UFC) and Monument Creek (MC) are perennial third-order streams and constitute the 2 branches of the Y-shaped watershed.

Fig. 1. Sampling sites in the Fountain Creek Watershed. Geographical landmarks, major highways, and vegetation patterns are indicated. Sites or stations are identified by color-coded dots: MC sites are green, UF sites red, and LF sites yellow.

Lower Fountain Creek (LFC) represents the stem of the Y as a fourth-order stream and flows south to its confluence with the Arkansas River at Pueblo. Monument Creek, the main tributary of Fountain Creek, drains 308 km² (119 mi²) while Upper Fountain Creek drains 614 km² (237 mi²). Watershed elevations range from 4301 m (14,110 ft) at Pikes Peak to 1415 m (4642 ft) at Pueblo (Edelmann et al. 2002). Monument and

Fountain Creeks flow through 8 urbanized communities within the watershed.

Sampling sites in the FCW included 4 sites in the UFC reach (UF-1–4), 5 sites in the MC reach (MC-1–5), and 5 sites in the LFC reach (LF-1–5) (Fig. 1). These sites were the same used by Herrmann et al. (2012). Specific site coordinates, descriptions, and elevations are cited in Table 1. The substrate in UFC consisted of boulders and cobble as well as sand

TABLE 1. Coordinates, elevation, and physical description for each Fountain Creek Watershed (FCW) site. LFC = Lower Fountain Creek, MC = Monument Creek, UFC = Upper Fountain Creek.

Site	Latitude	Longitude	Elevation (m)	Physical description of site location
UF-1	38.92691	-105.004	2334.77	UFC at Green Mountain Falls, CO
UF-2	38.85948	-104.920	1940.66	UFC at Manitou Springs, CO
UF-3	38.84629	-104.866	1859.89	UFC at 26th St., Colorado Springs, CO
UF-4	38.83015	-104.842	1818.44	UFC at 8th St., Colorado Springs, CO
MC-1	39.08271	-104.876	2097.22	MC at Mt. Herman Rd. near Monument, CO
MC-2	39.02415	-104.844	2031.80	MC at N Entrance, U.S.A.F.A., CO
MC-3	38.95424	-104.834	1942.80	MC at S Entrance, U.S.A.F.A., CO
MC-4	38.93322	-104.817	1924.20	MC at Woodmen Rd., Colorado Springs, CO
MC-5	38.84282	-104.828	1840.69	MC at Colorado College, Colorado Springs, CO
LF-1	38.81613	-104.822	1798.02	LFC at Nevada St., Colorado Springs, CO
LF-2	38.60245	-104.670	1634.95	LFC, S Fountain, CO
LF-3	38.42975	-104.598	1532.84	LFC at Piñon Bridge
LF-4	38.27893	-104.602	1432.86	LFC at Hwy. 50, Pueblo, CO
LF-5	38.25572	-104.591	1414.88	LFC upstream of confluence with Arkansas River, Pueblo, CO

and gravel. The substrate in Monument Creek (MC) contained some cobble and gravel and mainly deep coarse sand derived from easily eroded sandstone and mudstone of the Dawson Formation (von Guerard 1989b, Zuellig et al. 2008). While LFC was primarily a sandy-bottom stream consisting of varying degrees of sand, gravel, cobble, and some shale bedrock, it became braided as it flowed southward into a wide alluvial valley dominated by Pierre shale deposits (von Guerard 1989a).

Adult Chironomid Collection

Adult chironomids were collected in the summers of 2007 (1–7 September) and 2008 (10 July–1 August) from 14 sites within the Fountain Creek Watershed. Fine sweep nets and long-wave ultraviolet (UV) lights were used to collect adult chironomids; late afternoon and evening UV and net collections were made simultaneously at each site from 0.5 h before legal sunset to 1.5 h after sunset. Aerial swarm sweep netting collections were conducted using a Bioquip® 0.1-mm-mesh net, 28 cm in diameter by 60 cm in length. Netted specimens were placed into a labeled jar containing 75% ethanol. The UV collections were conducted concurrently with sweep netting by placing one UV lantern housing (Navy brand, No. 987 with General Electric® Lamp No. F6TS BLD, dimensions [L × W × H]: 27.5 × 7.5 × 7.5 cm) on an exposed shore location (a sand bar island or a rocky island) between 2 rectangular aluminum loaf pans (Kaiser No. 408-35, dimensions [L × W × H]: 20 × 10 × 5 cm) three-fourths

full of 75% ethanol (Helland 2015). Insects collected in the loaf pans were carefully poured into a labeled jar. The captured insects were later sorted specifically for male chironomid species and stored in jars of 100% ethanol that were appropriately labeled with date, location, and collection method.

Collections in 2007 were made at a later date in the summer than in 2008. Sampling 2 consecutive years ensured collection representation and continuity of as many subfamilies and species as possible for each particular site. The data showing the number of species collected at each site for 2007 and 2008 by each collection method are available in Helland (2015).

The varied microhabitats of the FCW ranged from torrential to sluggish lotic sites and ponded and backwater lentic locations. Evaporation rates were high and affect both standing and flowing surface waters of the FCW. From July through mid-September in the FCW, low rainfall, high temperatures, and gentle breezes contributed to high aridity, which tended to concentrate chironomids along the UFC, MC, and LFC corridors. Ambient humidity, controlled by temperature and wind, is a major factor in causing dessication of adult chironomids (Armitage 1995). Further, from 2002 to 2014 the FCW and southeastern Colorado were under severe to exceptional drought conditions. Mean daily base flows of Fountain Creek at Colorado Springs (LF-1) and Pueblo (LF-4) in July, August, and September were usually <3.96 m³/s, and have been as low as 1.8 m³/s (USGS 2015). The base flows of each reach or

corridor during September 2007 collections were at or slightly greater than historical (39–93 years) daily mean flows. During July and August 2008, base flows were only 10% to 25% of the historical mean daily flows. No other comparable permanent flowing waters with similar base flows occurred in the FCW; therefore, chironomid species were largely confined to the 3 reaches (UF, MC, and LF) of the watershed. It was always possible for some species as adults to fly or be carried by the wind to other sampling sites; however, we sweep-netted small to huge swarms of males in early evening when wind conditions were calm. The high protective west banks of our sites contributed to calmness. If winds from thunderstorms were imminent, no sweeps or UV light trapping occurred. Armitage (1995) summarized how wind generally inhibited swarming of males and influenced them to land. The prevailing winds in the Colorado Springs area were primarily from the north for 12 months of the year, with easterly breezes occurring secondarily in the summer (Newman 2015). In the Pueblo region, the prevailing winds were from the east-northeast in the summer and from the west-northwest in other seasons (Newman 2015). Aerial translocation of isolated males could have occurred between sites separated by a kilometer or less, but with the exception of sites LF-4 and LF-5 this would have been a rare event. There was no way to completely rule out some wind-driven translocations in our collections of adults; larvae or pupal exuviae, if included in our study, would also have shown some displacement due to downstream drift, particularly in a sandy-bottom stream with ever-shifting substrates such as in the FCW. We were confident our adult collections were representative of each of the reported sites with all their individual microhabitats.

Adult Dissection, Identification Procedures, and Voucher Specimen Deposition

Microdissections were performed on adult male specimens using modifications of slide mounting procedures described by Schlee (1966), Hansen and Cook (1976), and Pinder (1989). Each male specimen was placed in a drop of Euparal in the center of a glass slide. Each wing was removed and placed on the upper left portion of the center of the slide. One prothoracic, mesothoracic, and metathoracic leg including the trochanter was

removed from the thorax and placed in order directly below the wings. The antennae were also removed and aligned to the right of the mesothoracic leg. The head, thorax, and abdomen were placed in a 12% KOH macerating solution for 24–48 h depending on specimen darkness and size to “clear” the internal anatomy. After the clearing procedure, the KOH was rinsed from the specimen with 2 changes of water followed by 2 changes of absolute ethanol to effect dehydration. Another drop of Euparal was added to the slide to the right side of the wings, legs, and antennae. The thorax was removed and placed to the right of the wings, and the head capsule was placed to the right of the antennae. Lastly, the abdomen was placed dorsal side up with the male anatomy toward the inside of the slide to prevent possible damage to the male sex organs during cover-slipping. The Euparal was then thinned with absolute ethanol and the entire slide placed on a slide-drying table for a period of 2 weeks. After drying, another drop of Euparal was added to the dissected specimen, which was then cover-slipped using a 12-, 15-, or 18-mm-diameter round coverslip depending on specimen size. Completed slides were left to dry for 4 weeks before the identification process began. Identification of all chironomid males to species level was completed by Dr. James E. Sublette (late Professor Emeritus of Biology, CSU–Pueblo). After identification, all slides had a locality-collection data label placed to the left of the coverslip, and an identification label to the right of the coverslip as documented by Kleinert (2008) and Powell (2008).

All slides of adult chironomids from this and other Colorado projects in the SJH collection will be deposited as voucher specimens in The Dr. James E. and Mary F. Sublette Collection of Chironomidae at the University of Minnesota (UM). In addition all UV and sweep net collections from this FCW study will be deposited at the UM.

Calculation of Binary (Site) Coefficients of Species Richness

Similarity indices are commonly used to measure the likeness of species composition between 2 sites. Bruce (2002) used the Jaccard similarity coefficient of community to determine variations of chironomid community structure in spring and fall between sites in

the FCW. Bruce (2002) determined that similarity of community indices was greater for tributary sites than for sites located on the main stem. Von Guerard (1989a) used the Sørensen index to evaluate chironomid taxon similarity for 5 site-pairs in Monument and Fountain Creek.

We used the Jaccard similarity coefficient of community calculation to determine taxa similarity (species richness) between 2 sites:

$$J = a/(a + b + c),$$

where J = Jaccard similarity coefficient, a = the number of taxa common to both samples, b = the number of taxa present in sample b but not in sample a, c = the number of taxa present in sample a but not in sample b. J values were calculated for all binary site pairs in all 3 reaches of the watershed.

For comparative purposes we also used the Sørensen similarity coefficient (same as the index of similarity of Odum [1971]) to determine chironomid species similarity or richness between sites:

$$S = 2a/(2a + b + c),$$

where S = Sørensen similarity coefficient, a = the number of taxa common to both samples, b = the number of taxa present in sample b but not in sample a, c = the number of taxa present in sample a but not in sample b.

If all the same species of chironomids occurred at a pair of sites, both coefficients would have a value of 1. With fewer shared species, the coefficients trend to 0, where there would be no common species. Baselga (2012) discussed the relative behavior of the Jaccard and Sørensen families of binary indices and concluded that both coefficients are closely correlated by the following equation:

$$\beta_{\text{sor}} = 2\beta_{\text{jac}}/(1 + \beta_{\text{jac}}).$$

Water Quality Analyses

Physicochemical water quality measurements during spring and fall 2007 included temperature (°C), dissolved oxygen (DO), hydrogen ion concentration (pH), specific conductivity (EC), and total hardness. Minimum temperature data for some sites were extracted from Bossong (2001). On 13 March 2008 and 18 June 2008, we conducted 2

synoptic surveys of the entire FCW on each date. Seven limnological teams visited all 14 sites between 2:00 pm and 3:00 pm on each date. They collected field data for temperature, EC, pH, and DO, and also collected surface water samples. This sampling provided an instantaneous snapshot of physicochemical conditions throughout the watershed. Handheld Yellow Springs Instruments™ (YSI) were used for field determinations of EC and temperature (Model 30), DO (Model 55), and pH (Model 63). Water samples were placed on ice in coolers and immediately transported to the CSU–Pueblo Aquatic Research Center (ARC) where total hardness and total alkalinity titrations (mg/L CaCO₃) were completed. Total (T) and dissolved (D) water subsamples were generated using an Acrodisc® (0.45 µm porosity) and a 60 mL plastic syringe; these subsamples were acidified with Ultrex™ concentrated nitric acid and analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS), resulting in total and dissolved phosphorus concentrations expressed as µg/L. Within 2 h of water sampling, Colilert®-18/Quanti-Tray® (IDEXX methodology) protocols were begun to determine total coliform bacterial loads at each site, and the results reported as the most probable number per 100 mL (MPN/100 mL).

Thermal Classification of FCW sites

Bouchard (2007) studying *Diamesa mendo-tae* Muttkowski stressed the importance water temperature has on developmental rates of aquatic insects. Eggermont and Heiri (2012) reinforced the significance of the relationship between chironomid species assemblages and temperature, but realized the mechanism explaining this interaction is still not understood. With the use of USGS (2015) water quality data and data from Tables 2 and 3, we constructed a thermal classification for the 14 sites of the FCW (Edelmann 1990, Chafin 1996, Bossong 2001). Sites with an annual daily maximum temperature (DMT) <24 °C were called “cold” sites or stations; sites with a DMT in the range 24–30 °C were assigned “cool”; and stations with a DMT >30 °C were classified as “warm.” This classification scheme was intended for the Chironomidae only; it was not a strict scheme because land use and streamside vegetation such as trees, shrubs, and tall grasses may influence the effects of

TABLE 2. Mean concentrations for water quality parameters measured in the FCW, spring and fall 2007. DO (dissolved oxygen) is expressed as mg/L; temperature (Temp) as °C; EC (specific conductivity @ 25 °C) as µS/cm; and total hardness as mg/L CaCO₃. Each mean value in the table is an average of 3 separate samples obtained during two 10-day periods in spring and fall 2007: 28 March, 2 April, 7 April; 24 October, 29 October, 3 November.

Spring 2007						Fall 2007					
Site	DO	Temp	pH	EC	Total hardness	Site	DO	Temp	pH	EC	Total hardness
MC-1	10.9	4.2	7.4	129.3	39.9	MC-1	9.0	5.5	7.9	283.1	91.3
MC-2	11.0	3.9	7.5	190.0	67.1	MC-2	9.6	5.3	8.0	403.0	129.0
MC-3	11.3	4.1	7.2	194.7	75.1	MC-3	9.6	4.5	8.1	361.9	144.8
MC-4	11.5	4.1	7.5	242.6	89.3	MC-4	8.9	5.0	8.0	405.2	176.9
MC-5	11.7	4.8	7.4	301.5	136.0	MC-5	9.9	6.4	8.1	695.7	276.3
UF-1	12.0	4.6	7.2	197.8	99.6	UF-1	9.1	5.8	8.2	271.9	102.7
UF-2	12.0	4.9	7.2	218.9	101.6	UF-2	9.7	5.7	8.1	184.4	66.3
UF-3	12.2	5.7	7.6	255.2	121.6	UF-3	8.4	6.0	8.1	212.1	76.3
UF-4	12.3	6.6	7.6	340.2	146.6	UF-4	7.5	7.1	8.1	256.2	91.6
LF-1	12.1	7.7	7.5	286.9	147.3	LF-1	7.8	9.9	8.1	515.7	188.7
LF-2	10.8	9.6	7.5	691.6	203.2	LF-2	7.8	15.2	8.1	847.3	265.6
LF-3	10.2	10.6	7.6	854.2	251.4	LF-3	8.2	15.1	8.0	919.7	275.3
LF-4	9.4	11.3	7.7	923.1	296.3	LF-4	8.5	15.2	8.1	1092.3	350.9
LF-5	9.3	11.8	7.8	1024.0	297.8	LF-5	7.5	15.8	8.2	1098.0	357.7

TABLE 3. Water quality data for the Fountain Creek Watershed (FCW) from 2 synoptic sampling efforts on 13 March 2008 and 18 June 2008. Colilert® values are most probable numbers (MPN/100 mL) for total coliforms; dissolved phosphorus (Dis. P) and total phosphorus (Tot. P) as µg/L; temperature (Temp) as °C; specific conductivity (EC) as µS/cm; and total alkalinity (T. Alk.) as mg/L CaCO₃. BDL = below detectable limits.

13 March 2008										18 June 2008					
Site	Dis. P	Tot. P	Colilert	Temp	pH	EC	T. Alk.	Site	Dis. P	Tot. P	Colilert	Temp	pH	EC	T. Alk.
MMC-1	BDL	BDL	<1	6	7.9	296	66	MC-1	—	—	196.8	19	7.8	200	86
MMC-2	549	564	17.5	6	8.1	453	74	MC-2	—	—	159.7	19	8.0	526	89
MMC-3	746	793	36.4	8	8.1	449	73	MC-3	—	—	145.5	21	8.2	427	88
MMC-4	523	561	2.0	9	8.1	518	78	MC-4	—	—	65.7	22	8.3	484	86
MMC-5	314	337	9.4	10	8.3	742	110	MC-5	—	—	248.9	25	7.9	663	105
UF-1	1.16	3.98	5.2	5	8.3	362	72	UF-1	—	—	88.8	14	8.1	355	76
UF-2	BDL	BDL	1.0	5	8.2	273	50	UF-2	—	—	61.6	15	8.0	320	63
UF-3	BDL	BDL	65.0	6	8.0	341	81	UF-3	—	—	686.7	17	7.8	564	146
UF-4	BDL	1.64	10.9	8	7.4	412	83	UF-4	—	—	214.2	24	8.2	1130	154
LF-1	198	216	13.4	10	8.3	682	104	LF-1	—	—	1203.1	23	8.2	723	108
LF-2	640	680	12.2	11	8.3	1119	141	LF-2	—	—	127.4	29	8.5	1354	179
LF-3	618	716	14.8	12	8.3	1161	138	LF-3	—	—	325.5	28	8.5	1398	180
LF-4	619	690	7.4	12	8.3	1170	140	LF-4	—	—	298.7	30	8.5	1437	183
LF-5	—	—	—	—	—	—	—	LF-5	—	—	—	—	—	—	—

daytime thermal maxima. Knowing the thermal requirements of indicator chironomid species aided us in making these assignments. Sites MC-1, 2, UF-1, 2 are cold-water; stations MC-3, 4, 5, UF-3, 4, LF-1 are cool-water; and sites LF-2, 3, 4, 5 are warm-water.

Sediment Collection and Sieving

In addition to using temperature and lentic/lotic criteria as environmental gradients in which chironomid species may or may not survive, Rossaro (1991) concluded that substrate may be a third major separatory gradient. Since the sediment or substrate in Fountain Creek ranged from bedrock to cobble to gravel to sand, a wide variety of habitat preferences or niches were available to chironomids. Thus, characterization of a stream's substrate at varying sites can provide information on habitat availability. Bruce (2002) determined that "substrate particle size accounted for most of the variation in invertebrate community structure among sites in the Fountain Creek Basin [Watershed]." More specifically, the question is as follows: Did sediment particle size at each of our 14 sites impact chironomid species composition and diversity? Three sediment samples were collected in March 2012 along a bank-to-bank transect at each of the 14 sites. The samples were collected with polyethylene terephthalate (PETE) bottles measuring 122 mm in height by 64 mm in diameter with a total volume of 480 mL. The open mouth of the bottle was forced completely into the sediment filling the entire container. Oliver (1971) reported that 95% of chironomid larvae occur in the upper 100 mm of the sediment surface, and our substrate samples extended to a depth of 122 mm. These samples were placed in pans to dry for 14 d at 75 °C and later placed in labeled plastic freezer bags according to site and sample number. Each sample was sieved through 8 sieve size fractions, each sieve standardized according to the grain size classification system as described by Wentworth (1922). Stacked sieves ranged from small cobble (64–256 mm), very coarse gravel (32–63 mm), coarse gravel (16–31 mm), medium gravel (8–15 mm), fine gravel (4–7 mm), very fine gravel (2–3 mm), very coarse to fine sand (0.0625–1.9 mm), and silt and clay [silt-clay] (<0.0625 mm). Each dried sieve fraction was placed in a lightweight tared plastic dish and weighed to

0.01 g using a Denver Instrument XL-3100 balance. The weight of each sieve fraction was determined and fractions averaged. The fractional weights were converted to mean percentiles of the original total sample.

Distribution Abbreviations, Concentration Units, and Taxonomic Listings

We indicated Nearctic or North American distributions using the 2-letter abbreviation codes developed by the postal systems of Canada and the United States:

Canadian Provinces

Alberta	AB
British Columbia	BC
Manitoba	MB
New Brunswick	NB
Newfoundland & Labrador	NL
Northwest Territories	NT
Nova Scotia	NS
Nunavut	NU
Ontario	ON
Prince Edward Island	PE
Quebec	QC
Saskatchewan	SK
Yukon	YT

United States including District of Columbia

Alabama	AL
Alaska	AK
Arizona	AZ
Arkansas	AR
California	CA
Colorado	CO
Connecticut	CT
Delaware	DE
District of Columbia	DC
Florida	FL
Georgia	GA
Hawaii	HI
Idaho	ID
Illinois	IL
Indiana	IN
Iowa	IA
Kansas	KS
Kentucky	KY
Louisiana	LA
Maine	ME
Maryland	MD
Massachusetts	MA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO
Montana	MT
Nebraska	NE
Nevada	NV
New Hampshire	NH
New Jersey	NJ
New Mexico	NM
New York	NY
North Carolina	NC

North Dakota	ND
Ohio	OH
Oklahoma	OK
Oregon	OR
Pennsylvania	PA
Rhode Island	RI
South Carolina	SC
South Dakota	SD
Tennessee	TN
Texas	TX
Utah	UT
Vermont	VT
Virginia	VA
Washington	WA
West Virginia	WV
Wisconsin	WI
Wyoming	WY

Concentrations of selected water quality parameters were cited as mg/L, $\mu\text{g/L}$ or $\mu\text{S/cm}$, which are equivalent to $\text{mg} \cdot \text{L}^{-1}$, $\mu\text{g} \cdot \text{L}^{-1}$, or $\mu\text{S} \cdot \text{cm}^{-1}$, respectively. When physicochemical analyses were below detectable limits, BDL was indicated. When referring to concentrations of coliform bacteria, we used most probable number per 100 mL (MPN/100 mL). If not otherwise indicated in the text, elevations were understood to be meters above mean sea level or m amsl. Other acronyms are given on the lead page of this article.

With the exception of the Chironominae, all subfamilies were not separated into tribes and each genus and species was listed alphabetically within the appropriate subfamily. The tribes Chironomini and Tanytarsini are listed separately and alphabetically under the Chironominae following Andersen et al. (2013).

RESULTS

Chironomid Subfamilies, Genera, Species, and New Species

This systematic study of 714 adult male chironomid specimens, 309 collected in 2007 and 405 collected in 2008, resulted in 151 total species (Table 4) from 65 genera and 6 subfamilies—Chironominae, Diamesinae, Orthocladiinae, Podonominae, Prodiamesinae, and Tanypodinae. Orthocladiinae and Chironominae were the dominant subfamilies at 43% and 42%, respectively, followed by Tanypodinae at 13%, Prodiamesinae at 1%, Podonominae at <1%, and Diamesinae at <1%. The number of genera and species recorded for each of the 3 reaches (MC, UF, and LF) and all 14 sites appear in Figs. 2 and 3, respectively. Further, 24 new-to-science

species were included in this total, representing 19 genera and 3 subfamilies—Chironominae, Orthocladiinae, and Tanypodinae (Table 5). New species were found at all sites except LF-3 (Fig. 4). The most new species were collected at sites MC-1 and MC-3, with a total of 16% each over 2 years; site MC-2 had 11% of the overall total of 24 species. The majority (54%) of new species were collected using the UV light method, while 17% were collected by sweep netting; both methods resulted in 29% of the total. In Table 5 we have included detailed notes generated by Dr. James E. Sublette (JES) for each new species.

The subfamily composition at each site fluctuated year to year with some subfamilies and species being present in one year but not the other. Representatives from Chironominae and Orthocladiinae were present in collections for both years at all sites. For collections at sites MC-1 and MC-2, the subfamily Tanypodinae was present only in 2008.

Effectiveness of Collection Methods

The species list from the UV light trap collections from 2 sites were compared to the species list generated by net sweeping vegetation. Surprisingly, the results of the 2 collection methods were totally different in composition with no duplications (Tables 6, 7). If the sweep netting or UV method had been used alone, many species would not have been represented. These data supported the need to use multiple methods when making simultaneous adult collections at the same location and time.

Similarity Coefficients and Species Richness

There was close agreement between the 2 indices for site pairs with and without many shared species (Table 8). For example, the highest Jaccard similarity values (0.33) were for site pairs LF-1/MC-5 and UF-3/MC-3; the highest Sørensen similarity values (0.50) were for the same binary site sets. Both indices were 0 for pairing LF-4/UF-2; these 2 stations shared no common species. In general, contiguous sites had higher index values than those more widely separated, but not always. The UF-3/MC-3 pairing value was somewhat of a surprise even though the elevations of the sites are not dissimilar. In the FCW it was difficult to compare our species-level richness data with other studies of lower taxonomic

TABLE 4. List of species collected from 14 sites in the Fountain Creek Watershed (FCW). 1 = present, 0 = absent.

Subfamily	Genus	Species	MC-1	MC-2	MC-3	MC-4	MC-5	UF-1	UF-2	UF-3	UF-4	LF-1	LF-2	LF-3	LF-4	LF-5
Chironominae	<i>Chironomus</i>	<i>atrella</i>	0	0	0	1	0	0	0	0	0	0	1	0	0	1
Chironominae	<i>Chironomus</i>	<i>decorus</i>	1	1	1	1	1	1	0	1	1	1	1	1	1	1
Chironominae	<i>Chironomus</i>	<i>dilatatus</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Chironominae	<i>Chironomus</i>	<i>maturus</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Chironominae	<i>Chironomus</i>	<i>staegeri</i>	1	0	1	0	0	0	0	0	0	0	0	0	0	1
Chironominae	<i>Chironomus</i>	<i>utahensis</i>	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Chironominae	<i>Chironomus</i>	<i>whitseti</i>	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Chironominae	<i>Chironomus</i>	n. sp. CO-5	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Chironominae	<i>Chironomus</i>	n. sp. CO-10	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Chironominae	<i>Chironomus</i>	n. sp.	1	0	0	0	0	0	0	1	1	0	0	0	0	0
Chironominae	<i>Cladopelma</i>	<i>edwardsi</i>	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Chironominae	<i>Cladopelma</i>	<i>viridulum</i>	0	1	1	0	0	0	0	0	0	1	0	0	0	1
Chironominae	<i>Cryptochironomus</i>	<i>digitatus</i>	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Cryptochironomus</i>	<i>fulvus</i>	0	1	1	0	0	0	0	0	0	0	0	0	0	1
Chironominae	<i>Cryptochironomus</i>	<i>parafultus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Cryptochironomus</i>	n. sp. 9	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chironominae	<i>Cryptotendipes</i>	<i>emorsus</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Chironominae	<i>Dicortendipes</i>	<i>crypticus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chironominae	<i>Dicortendipes</i>	<i>fumidus</i>	0	0	1	0	0	1	0	1	1	1	0	0	0	1
Chironominae	<i>Dicortendipes</i>	<i>modestus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Dicortendipes</i>	<i>nervosus</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Endochironomus</i>	<i>nigricans</i>	1	1	1	0	0	0	0	0	1	0	0	0	0	0
Chironominae	<i>Gillotia</i>	n. sp. CO-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chironominae	<i>Glyptotendipes</i>	<i>barbipes</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Chironominae	<i>Glyptotendipes</i>	<i>lobiferus</i>	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Chironominae	<i>Parachironomus</i>	<i>tenuicaudatus</i>	0	0	0	0	1	0	0	0	0	1	1	0	0	0
Chironominae	<i>Paracladopelma</i>	<i>doris</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Paracladopelma</i>	n. sp.	0	0	1	1	0	0	0	0	0	0	1	0	0	0
Chironominae	<i>Paracladopelma</i>	n. sp. CO-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chironominae	<i>Paratendipes</i>	<i>subaequalis</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Phaenopsectra</i>	<i>profusa</i>	1	1	1	0	0	0	1	1	1	0	1	1	0	0
Chironominae	<i>Polypedium</i>	<i>digitifer</i>	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Chironominae	<i>Polypedium</i>	<i>pedatum</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Chironominae	<i>Polypedium</i>	<i>flavum</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Polypedium</i>	<i>illinoense</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Chironominae	<i>Polypedium</i>	<i>laetum</i>	0	0	1	0	0	1	1	1	1	0	0	0	0	1
Chironominae	<i>Polypedium</i>	<i>obtusum</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Polypedium</i>	<i>prolixipartum</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0

TABLE 4. Continued.

Subfamily	Genus	Species	MC-1	MC-2	MC-3	MC-4	MC-5	UF-1	UF-2	UF-3	UF-4	LF-1	LF-2	LF-3	LF-4	LF-5
Chironominae	<i>Polypedium</i>	<i>scalaenum</i>	1	1	1	1	1	0	0	0	0	1	1	1	1	1
Chironominae	<i>Polypedium</i>	<i>simulans</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Polypedium</i>	<i>sulaceps</i>	0	1	0	1	1	0	0	0	0	0	0	0	0	0
Chironominae	<i>Polypedium</i>	n. sp. 14	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Chironominae	<i>Pseudochironomus</i>	<i>richardsoni</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Robackia</i>	<i>claviger</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Chironominae	<i>Saetheria</i>	<i>tylus</i>	0	1	1	1	1	0	0	1	1	1	1	1	1	1
Chironominae	<i>Saetheria</i>	n. sp. 1	0	0	1	1	1	0	0	0	1	1	1	0	0	0
Chironominae	<i>Stichtochironomus</i>	<i>annulicrus</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Chironominae	<i>Stichtochironomus</i>	<i>varius</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Xestochironomus</i>	<i>brunneus</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	1
Chironominae	<i>Cladotanytarsus</i>	<i>crusculus</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Chironominae	<i>Cladotanytarsus</i>	<i>fusiformis</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Cladotanytarsus</i>	<i>viridiventris</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Cladotanytarsus</i>	n. sp. 7	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Micropectra</i>	<i>logani</i>	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Chironominae	<i>Micropectra</i>	<i>nigripila</i>	0	1	1	0	1	0	0	1	0	0	0	1	1	0
Chironominae	<i>Micropectra</i>	<i>polita</i>	1	1	1	0	0	1	1	1	0	0	0	0	0	0
Chironominae	<i>Micropectra</i>	<i>recurvata</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Paratanytarsus</i>	n. sp. OH-3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Rheotanytarsus</i>	n. sp. 3	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Tanytarsus</i>	<i>acifer</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Chironominae	<i>Tanytarsus</i>	<i>hastatus</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Chironominae	<i>Tanytarsus</i>	<i>pallidicornis</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Chironominae	<i>Tanytarsus</i>	<i>pelsuei</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Diamesinae	<i>Diamesa</i>	<i>heteropus</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Orthocladinae	<i>Apometrocnemus</i>	<i>fontinalis</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Orthocladinae	<i>Brillia</i>	<i>flavifrons</i>	0	1	0	0	1	1	1	1	0	1	0	0	0	0
Orthocladinae	<i>Brillia</i>	<i>retifrons</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Orthocladinae	<i>Cardiocladius</i>	<i>obscurus</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Orthocladinae	<i>Chaetocladius</i>	<i>astis</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Orthocladinae	<i>Corynoneura</i>	<i>arctica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Orthocladinae	<i>Corynoneura</i>	<i>taris</i>	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Orthocladinae	<i>Cricotopus</i>	<i>annulator</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Orthocladinae	<i>Cricotopus</i>	<i>bicinctus</i>	1	1	0	1	0	0	0	0	0	1	1	1	1	1
Orthocladinae	<i>Cricotopus</i>	<i>blinni</i>	1	1	0	0	1	0	0	0	0	1	1	1	0	1
Orthocladinae	<i>Cricotopus</i>	<i>hermanni</i>	1	1	1	1	0	0	0	1	1	1	0	0	0	0
Orthocladinae	<i>Cricotopus</i>	<i>infuscatius</i>	1	1	1	1	1	1	0	0	1	1	1	1	1	1

TABLE 4. Continued.

Subfamily	Genus	Species	MC-1	MC-2	MC-3	MC-4	MC-5	UF-1	UF-2	UF-3	UF-4	LF-1	LF-2	LF-3	LF-4	LF-5
Orthocladinae	<i>Cricotopus</i>	<i>sylvestris</i>	0	1	1	0	0	0	0	0	0	1	0	1	0	0
Orthocladinae	<i>Cricotopus</i>	<i>trifascia</i>	0	1	1	1	1	0	0	1	1	1	1	1	1	1
Orthocladinae	<i>Cricotopus</i>	<i>trifasciatus</i>	0	0	0	0	1	0	0	1	1	0	1	0	0	0
Orthocladinae	<i>Cricotopus</i>	<i>varipes</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Diplocladius</i>	<i>cultriger</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Eudactylocadius</i>	<i>dubitatus</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Eudactylocadius</i>	<i>fuscimanus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Eukiefferiella</i>	<i>claripennis</i>	1	0	1	1	0	1	1	1	1	1	0	1	0	0
Orthocladinae	<i>Eukiefferiella</i>	<i>coeruleus</i>	1	1	1	1	1	0	0	0	1	1	1	1	0	1
Orthocladinae	<i>Eukiefferiella</i>	<i>gracei</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Eukiefferiella</i>	n. sp. 4	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Orthocladinae	<i>Eukiefferiella</i>	n. sp. 9	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Euorthocladus</i>	<i>reticola</i>	1	1	0	0	1	0	0	0	0	0	0	1	0	0
Orthocladinae	<i>Halocladus</i>	n. sp. CO-1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Orthocladinae	<i>Helentella</i>	<i>hirta</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Limnophyes</i>	<i>angelicae</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Limnophyes</i>	<i>asquanatus</i>	0	0	0	0	0	0	0	0	1	0	1	1	0	0
Orthocladinae	<i>Limnophyes</i>	<i>fumosus</i>	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Limnophyes</i>	<i>hastulatus</i>	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Orthocladinae	<i>Limnophyes</i>	<i>hudsoni</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Orthocladinae	<i>Limnophyes</i>	<i>margaretae</i>	0	1	1	1	1	0	0	1	0	0	1	0	1	0
Orthocladinae	<i>Limnophyes</i>	<i>minimus</i>	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Orthocladinae	<i>Limnophyes</i>	<i>natalensis</i>	1	0	1	0	0	1	1	1	0	0	1	0	0	0
Orthocladinae	<i>Limnophyes</i>	<i>recisus</i>	0	0	0	1	0	1	1	1	0	0	0	0	0	0
Orthocladinae	<i>Metriocnemus</i>	n. sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Orthocladinae	<i>Nanocladius</i>	<i>incomptus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Nanocladius</i>	<i>spinipennis</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Orthocladus</i>	<i>appersoni</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Orthocladus</i>	<i>dorens</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Orthocladinae	<i>Orthocladus</i>	<i>frigidus</i>	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Orthocladus</i>	<i>obumbratus</i>	1	1	0	1	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Parachaetocladus</i>	n. sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Paracletus</i>	<i>alpicola</i>	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Orthocladinae	<i>Parakiefferiella</i>	<i>subaterrina</i>	0	0	0	0	0	0	0	0	1	0	0	1	1	0
Orthocladinae	<i>Parametrioctenium</i>	<i>lundbecki</i>	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Orthocladinae	<i>Parametrioctenium</i>	n. sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Orthocladinae	<i>Paraphaenocladus</i>	<i>exagittans</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Orthocladinae	<i>Paraphaenocladus</i>	<i>impensans</i>	0	0	0	0	0	0	0	0	0	1	1	0	0	0

Fig. 2. Total number of species and genera collected from each watershed reach: MC = Monument Creek reach, UFC = Upper Fountain Creek reach, and LFC = Lower Fountain Creek reach.

Fig. 3. Total number of species and genera reported from each of 14 watershed stations: MC-1, 2, 3, 4, 5 = Monument Creek sites; UF-1, 2, 3, 4 = Upper Fountain Creek sites; and LF-1, 2, 3, 4, 5 = Lower Fountain Creek sites.

resolution (von Guerard 1989a, 1989b, Bruce 2002).

Sediment Characterization

Medium gravel, fine gravel, very fine gravel, and coarse to fine sand were the dominant components of the sediment samples collected at all 14 sites (Table 9). Small cobble was not reported at any site. Very coarse gravel was collected at 5 sites only: MC-3, UF-2, 4 and LF-1, 3. Coarse gravel was collected at all

sites except UF-4 and LF-5. Silt-clay was collected at all sites except LF-4.

TAXONOMIC ACCOUNTS

Family Chironomidae

Within the subfamily Chironominae of the Chironomidae, 12 species of the genus *Polypedilum*, 11 species of *Chironomus*, and 4 species each of *Cryptochironomus*, *Dicrotendipes*, *Cladotanytarsus*, and *Tanytarsus*

TABLE 5. List of new chironomid species from 2007 and 2008 sweep netting and UV light collections in the Fountain Creek Watershed (FCW).

Subfamily	Genus	Location
Chironominae	<i>Chironomus</i> n. sp. CO-5	LF-1
Chironominae	<i>Chironomus</i> n. sp. CO-10 [nr.blaylocki]	UF-3
Chironominae	<i>Chironomus</i> n. sp. [nr.quinnifukqut]	UF-3, 4, MC-1
Chironominae	<i>Cryptochironomus</i> n. sp. 9	LF-5
Chironominae	<i>Gillotia</i> n. sp. CO-1	LF-5
Chironominae	<i>Paracladopelma</i> n. sp. [nr.doris]	MC-3, 4, LF-2
Chironominae	<i>Paracladopelma</i> n. sp. CO-1	LF-5
Chironominae	<i>Polypedilum</i> n. sp. 14 [=herrmanni.ms]	LF-4
Chironominae	<i>Saetheria</i> n. sp. 1 [marki.ms.name]	MC-2, 3, 4, 5, UF-4, LF-1, 2
Orthoclaadiinae	<i>Eukiefferiella</i> n. sp. 9 [cuesta.ms.name]	MC-1, 3
Orthoclaadiinae	<i>Eukiefferiella</i> n. sp. 4 NM & CO	UF-1
Orthoclaadiinae	<i>Halocladus</i> n. sp. CO-1	LF-1
Orthoclaadiinae	<i>Metriocnemus</i> n. sp.	UF-1
Orthoclaadiinae	<i>Parachaetocladus</i> n. sp.	MC-3
Orthoclaadiinae	<i>Parametriocnemus</i> n. sp.	UF-3
Orthoclaadiinae	<i>Psectrocladius</i> n. sp. 8	MC-1, 4
Orthoclaadiinae	<i>Rheocricotopus</i> n. sp. 1 CFW-3 [hatchi.ms.name]	MC-3, UF-3
Orthoclaadiinae	<i>Saetheriella</i> n. sp. (marki.ms)	MC-2
Orthoclaadiinae	<i>Thienemanniella</i> n. sp. 8 [=herrmanni]	UF-2
Orthoclaadiinae	<i>Thienemanniella</i> n. sp.7 [luna.ms]	MC-3
Tanypodinae	<i>Conchapelopia</i> n. sp.	MC-4
Chironominae	<i>Cladotanytarsus</i> n. sp. 7	MC-1, 2
Chironominae	<i>Paratanytarsus</i> n. sp. OH-3	MC-1
Chironominae	<i>Rheotanytarsus</i> n. sp. 3 [fontanalis.ms]	MC-1, 2

occurred in the FCW; in the subfamily Orthoclaadiinae of the Chironomidae, 9 species of *Cricotopus*, 9 of *Limmophyes*, 6 of *Thienemanniella*, 5 of *Eukiefferiella*, and 4 of *Orthocladus* were present; and in the subfamily Tanypodinae of the Chironomidae, 4 species of *Ablabesmyia* and 4 of *Procladius* were identified. All other 51 genera were represented by 3 or fewer species. The subfamilies Diametinae, Podonominae, and Prodiamesinae of the Chironomidae were represented by only 1 or 2 species (Table 4).

A total of 21 species occurred in all 3 segments (UFC, MC, and LFC) of the FCW: 6 in the Chironominae, 12 in the Orthoclaadiinae, and 3 in the Tanypodinae. *Chironomus decorus* was present at 13 of 14 sites, being absent only at site UF-2 (Table 4). The number of species and genera for each of the 14 FCW sites and the 3 reaches (MC, UF, and LF) of the catchment are indicated in Figs. 2 and 3, respectively. Genera and species richness or robustness was greatest at site MC-1 (40 spp. in 25 gen.) and lowest at site UF-2 (12 spp. in 11 gen.). Sites MC-4 and MC-5 showed declines in both generic and species numbers apparently due to increased urbanization and channelization of the streambed. When the

3 reaches were compared, the MC sites had the greatest species richness and generic diversity (96 spp. in 45 gen.), followed by the LF sites (76 spp. in 41 gen.) and, lastly, the UF segment (53 spp. in 30 gen.).

Twenty-one species occurred at one or more MC and LFC sites but were absent from any UFC sites. Of the 21 species, 11 were in the Chironominae (distributed among 8 genera), 8 in the Orthoclaadiinae (6 genera), and 2 in the Tanypodinae (2 genera). *Polypedilum scalaenum* was uniquely present at all MC and LF sites but missing from all 4 UF sites. Conversely, *Polypedilum laetum* was present at all UF sites and MC-3 but absent from all other MC and LF sites.

Species that occurred only at the 3 extreme sites (UF-1, MC-1, and LF-5) showed some interesting distributions. At UF-1, the site with the greatest elevation (2335 m), 9 species in 9 genera were present, with the Orthoclaadiinae being dominant. At site MC-1, the site in the Monument Creek tributary with the highest elevation (2097 m), 17 species in 15 genera occurred, with the orthoclads again most common. In contrast, at LF-5, the site in the Lower Fountain reach with the lowest elevation (1415 m), 11 species in 11 genera were

Fig. 4. Percentage of new species collected at each of 14 sites.

TABLE 6. Variation of chironomid species reported for site LF-3 on 3 September 2007 for 2 collection methods: UV light and sweep netting.

LF-3 collected 3 September 2007	
Ultraviolet night lighting collection	Sweep net collection
<i>Ablabesmyia mallochi</i>	<i>Diamesa heteropus</i>
<i>Cricotopus bicinctus</i>	<i>Odontomesa ferringtoni</i>
<i>Cricotopus blinni</i>	<i>Eukiefferiella coerulescens</i>
<i>Cricotopus infuscatus</i>	<i>Euorthocladius rivicola</i>
<i>Corynoneura taris</i>	<i>Tvetnia paucunca</i>
<i>Cryptotendipes emorsus</i>	<i>Micropsectra logani</i>
<i>Eukiefferiella claripennis</i>	<i>Micropsectra nigripila</i>
<i>Parakiefferiella subaterrima</i>	
<i>Parametriocnemus lundbecki</i>	
<i>Phaenopsectra profusa</i>	
<i>Saetheria tylus</i>	
<i>Smittia aterrima</i>	
<i>Thienemanniella xena</i>	
<i>Xestochironomus brunneus</i>	

TABLE 7. Variation of chironomid species reported for site MC-5 on 6 September 2007 for 2 collection methods: UV light and sweep netting.

MC-5 collected 6 September 2007	
Ultraviolet night lighting collection	Sweep net collection
<i>Chironomus decorus</i>	<i>Saetheria tylus</i>
<i>Polypedilum scalaenum</i>	<i>Corynoneura arctica</i>
<i>Saetheria</i> n. sp. 1	<i>Cricotopus blinni</i>
<i>Stichtochironomus annulicrus</i>	<i>Eukiefferiella coerulescens</i>
<i>Cricotopus infuscatus</i>	<i>Euorthocladius rivicola</i>
<i>Cricotopus trifasciatus</i>	<i>Limnophyes margaretae</i>
<i>Ablabesmyia illinoensis</i>	<i>Thienemanniella xena</i>
<i>Conchapelopia pallens</i>	<i>Micropsectra logani</i>
	<i>Micropsectra nigripila</i>

brown or black.” The size of the larvae range from “small to very large” and the color may be red, white, or green (Pinder and Reiss 1983).

Tribe Chironomini

Genus *Chironomus* Meigen 1803

Cranston et al. (1989a) indicated that adults of the genus *Chironomus* are medium to very large in size and range in color from “green, pale gold-brown to dark brown or black” with legs often banded. In the diverse genus *Chironomus*, 3 new species and 8 documented species occurred in our FCW collections. The new species included *Chironomus* n. sp. CO-10 [nr. *blaylocki*], *Chironomus* n. sp. [nr. *quinifukqut*], and *Chironomus* n. sp. CO-5.

identified, with the Chironominae outnumbering all other subfamilies combined. Within the Lower Fountain reach, only 6 species occurred at multiple LF sites; species were distributed among 6 genera with the Chironominae being the most numerous subfamily.

Subfamily Chironominae

Cranston et al. (1989a) described the ranges in size, color, and patterning of the legs, wings, and abdomen of males of this large chironomid subfamily; adult size varies from “small to large and color from yellow-green to

TABLE 8. Matrix of the Jaccard similarity coefficient (above diagonal) and the Sørensen similarity coefficient (below diagonal) for binary comparisons of paired sites in the Fountain Creek Watershed (FCW). Values approaching 1 indicate the most shared species; values closest to 0 indicate the fewest shared species.

SITE	MC-1	MC-2	MC-3	MC-4	MC-5	UF-1	UF-2	UF-3	UF-4	LF-1	LF-2	LF-3	LF-4	LF-5
MC-1														
MC-2	0.43					0.09	0.08	0.17	0.14	0.15	0.16	0.16	0.09	0.14
MC-3	0.32	0.44				0.08	0.07	0.19	0.18	0.27	0.22	0.29	0.21	0.18
MC-4	0.25	0.37	0.30			0.16	0.11	0.33	0.25	0.29	0.21	0.19	0.21	0.21
MC-5	0.22	0.48	0.32	0.44		0.09	0.05	0.16	0.19	0.26	0.27	0.18	0.20	0.15
UF-1	0.17	0.15	0.28	0.16	0.19	0.10	0.06	0.21	0.20	0.33	0.32	0.32	0.20	0.15
UF-2	0.15	0.13	0.20	0.09	0.11	0.45	0.29	0.26	0.16	0.12	0.07	0.09	0.06	0.06
UF-3	0.25	0.32	0.50	0.27	0.35	0.41	0.44	0.28	0.12	0.05	0.06	0.08	0.00	0.02
UF-4	0.24	0.31	0.41	0.32	0.42	0.27	0.22	0.41	0.26	0.17	0.15	0.16	0.18	0.09
LF-1	0.26	0.42	0.45	0.41	0.50	0.21	0.10	0.36	0.42	0.26	0.21	0.29	0.13	0.12
LF-2	0.27	0.36	0.35	0.42	0.48	0.13	0.11	0.25	0.35	0.48	0.32	0.21	0.18	0.19
LF-3	0.29	0.45	0.32	0.30	0.49	0.17	0.15	0.32	0.44	0.35	0.40	0.25	0.19	0.24
LF-4	0.17	0.35	0.35	0.33	0.33	0.11	0.00	0.30	0.23	0.30	0.32	0.34	0.21	0.22
LF-5	0.29	0.30	0.34	0.26	0.25	0.15	0.05	0.17	0.21	0.40	0.39	0.36	0.33	0.20

Chironomus (Chironomus) atrella
(Townes) 1945

The Nearctic *C. atrella* occurs from BC, AB, SK, MB, MN, SD east to Prince Edward Island (PE), south and west to CO, NM, and CA (Townes 1945, Driver 1971, Oliver et al. 1990). It was present at MC-4 and LF-2 but absent from all of the colder UF sites; it is commonly collected throughout most of the Nearctic in sloughs, backwater in-stream pools, ponds, and lakes (Townes 1945, Driver 1971, Oliver et al. 1990). When water quality data for 2 Saskatchewan pond sites were compared to our data (Tables 2, 3), no extreme physicochemical differences were observed (Driver 1971); *C. atrella* appeared to tolerate conditions of pH 8.5 and specific conductivity as high as 2834 $\mu\text{S}/\text{cm}$.

Chironomus (Chironomus) decorus
Johannsen 1905

Chironomus decorus is distributed over most of the Nearctic (NT, BC to NB, south to FL, GA, TX, NM, AZ, CA) and is both lotic and lentic (Townes 1945, Oliver et al. 1990); Townes (1945) reported that this species "is the most abundant and widespread of our larger tendipedids." In CO, Townes (1945) documented it from Boulder, Fort Collins, Grand Lake, Hayden, and Mountain Home Reservoir near Fort Garland. In the UAR (Ruse et al. 2000) and LAR (Powell 2008), *C. decorus* was reported for exuviae and adults whose site elevations ranged from 1431 to 3042 m; very cold, cool, and warm thermal regimes occur throughout the elevational range, indicating this species is exceptionally eurythermic. In the FCW, *C. decorus* adult males were collected from 13 of 14 sites and were often collected in the thousands from swarms. It was the most numerous and widely distributed species in the watershed (Table 4). This species emerges from early spring to late fall, often in large swarms of males (Sublette personal communication). Sublette and Sublette (1979) and Sublette et al. (1998) found this species in "soft, muddy" sediments in all major river basins of New Mexico. Soft muddy silts and sands throughout the FCW (Table 9) supported *C. decorus*, often resulting in extensive male swarms on summer evenings. These swarms measured up to 400 m long, 20 m wide, and 10 m high on the lee side of bridges and attracted cliff swallows (*Petrochelidon*

TABLE 9. Mean percentage of fraction sizes for sediment at each site.

Site	Fraction size							
	Small cobble ^a	Very coarse gravel ^b	Coarse gravel ^c	Medium gravel ^d	Fine gravel ^e	Very fine gravel ^f	Coarse to fine sand ^g	Silt-clay ^h
MC-1	0	0	0.14	1.46	12.55	28.67	56.39	0.49
MC-2	0	0	2.87	10.62	17.14	23.39	45.72	0.25
MC-3	0	2.94	16.49	16.78	14.40	20.58	28.74	0.07
MC-4	0	0	2.17	4.40	13.31	29.39	50.63	0.09
MC-5	0	0	0.36	5.03	14.57	28.44	51.53	0.06
UF-1	0	0	1.12	7.01	12.40	16.85	62.39	0.23
UF-2	0	14.30	7.42	8.51	12.67	23.63	33.22	0.25
UF-3	0	0	7.27	13.29	16.31	15.34	47.58	0.21
UF-4	0	10.24	0	0.99	4.00	9.75	74.13	0.89
LF-1	0	2.25	3.43	10.96	21.18	27.42	34.68	0.08
LF-2	0	0	3.40	5.19	10.51	24.91	55.45	0.53
LF-3	0	5.14	6.68	10.53	14.83	18.30	43.79	0.74
LF-4	0	0	1.31	6.99	18.43	29.76	43.50	0
LF-5	0	0	0	2.43	9.29	24.11	64.14	0.04

^a64–256 mm^b32–63 mm^c16–31 mm^d8–15 mm^e4–7 mm^f2–3 mm^g0.0625–1.9 mm^h<0.0625 mm

pyrrhonota) and bats into feeding frenzies. Moore (1980) observed 2 emergences during a summer in Great Slave Lake, Canada. Floss et al. (2013) reported *C. decorus* from southern Brazil. The only site from which we did not collect *C. decorus* was UF-2, whose sediment had the highest percentage (14.3%) of very coarse gravel, even though coarse to fine sand was 33.22% and silt-clay 0.25%. Silt-clay material was recovered at all sites except LF-4, where 0% silt-clay was evident in 3 transect samples of the upper 12 cm of stream sediment; even with no recoverable silt-clay, *C. decorus* was present. Moore (1980) reported that gut contents of *C. decorus*, *Dicrotendipes nervosus*, and *Cryptochironomus digitatus* consisted almost entirely of detritus and sand grains at all stations. No water quality parameters in Tables 2 and 3 appeared to be uniquely different to explain its absence at site UF-2. Very low coliform bacterial counts (Colilert®) and below-detection-limit phosphorus concentrations may indicate this site was ultraoligotrophic. We may have just missed collecting this generalist, euryokous species at site UF-2.

Chironomus (Chironomus) dilutus
Shobanov, Kiknadze and Butler

Shobanov et al. (1999) reported that *C. dilutus* is genetically different from *C. tentans*, and renamed it with *C. pallidivittatus* as a synonym. Martin et al. (2002) found that *C. dilutus* and *C. pallidivittatus* could not be separated using a DNA barcode sequence, but could with a globin gene sequence. Apparently *C.*

dilutus occurs as 2 distinct races with the dividing line along the western borders of Wisconsin and Ontario (Martin 2015). Both races together show a northern Nearctic distribution; the western race has been reported from SK, MB, AB, BC, QC, MN, UT, SD, and WY (Martin 2015). Martin (2015) reported *C. dilutus* from “prairie sloughs, shallow eutrophic lakes and ponds, and sewage oxidation lagoons”; in the FCW it was collected only from site LF-2, a location characterized by many semipermanent backwater pools and water quality having high concentrations of dissolved and total phosphorus (640 and 680 µg/L, respectively) emanating from upstream sewage treatment plants and agricultural practices. These eutrophic conditions were consistent with Proulx et al. (2013) who cited *C. dilutus* thriving in eutrophic sewage-laden waters and waste from mining and smelting activities.

Chironomus (Chironomus) matorus
Johannsen 1908

Chironomus matorus occurred only at site UF-1, where elevation was highest and total alkalinity, total hardness, and bacterial counts from Colilert® were low (Tables 2, 3). Martin (2015) indicated this species could be found in “shallow pools, often temporary and often polluted”; there was no environmental evidence of site UF-1 being polluted from septic systems. Ruse et al. (2000) reported *C. matorus* from 5 sites in the upper Arkansas River including AR-1, a headwater location at 2944 m

elevation, where it was commonly collected. Proulx et al. (2013) reported a pH of 7.3 for one lake in Quebec; the range in our study was pH 7.2 to 8.2. Its Nearctic distribution ranges from NY to CA (Oliver et al. 1990), south to NM and LA, and north to AK, QC, ON, and MB (Martin 2015).

Chironomus staegeri Lundbeck 1898

Another *Chironomus* species, *C. staegeri*, is Palearctic (Oliver et al. 1990), occurs in Greenland, and is also widely collected in North America (Martin 2015) from lentic habitats and lotic pools; in the Nearctic region, it ranges from NT, BC, WA east to Labrador south to NC, SC and west to AL, NM, and CA (Sublette 1960, Sublette and Sublette 1979, Caldwell et al. 1997, Martin 2015). In the FCW, *C. staegeri* appeared to be eurythermal by its presence at sites MC-1 and MC-2 (cool regimes) and, at the other temperature extreme, site LF-5 (warm regime) (Tables 2, 3). Proulx et al. (2013) found *C. staegeri* in standing waters ranging from deep lakes to shallow pools where the pH varied from 5.9 to 8.0; at site LF-2 in the FCW, pH ranged from 7.2 to 8.5 (Tables 2, 3).

Chironomus (Chironomus) utahensis
Malloch 1915

Townes (1945) and Sublette and Sublette (1965) published province and state records of *C. utahensis* including AB, CA, CO, MN, NE, OR, and UT; Schaller and English (1976) reported this species from AZ; Sublette and Sublette (1979) and Martin et al. (1979) cited NM and SD records; Wülker et al. (1991) added records of MT, ND, and WI; Oliver et al. (1990) included reports from SK and MB. Eggleton (1931) observed larvae of *C. utahensis* associated with *C. staegeri* (= *C. fasciventris*) in a MI lake. The distribution records indicate this species is widely distributed in western North America. Townes (1945) first reported this species from Fort Collins, CO; in the Grand Canyon, AZ, Sublette et al. (1998) reported that this primarily lentic species could also occur in playa lakes and backwater lotic pools with “silty sand substrata.” In the FCW, silt-laden sand was found in backwaters, and *C. utahensis*, like *C. staegeri*, was collected at a cold upper MC site (MC-2) and a warm lower LF site (LF-4); interestingly, both species were not recorded at any of the 4 UF

sites (Table 4). Curry (1956) reported larvae of this species from a lake habitat with sediments being *gyttja*-like and containing marl.

Chironomus (Chironomus) whitseli
Sublette and Sublette 1974

Oliver et al. (1990) documented *C. whitseli* only from CA and NM; Martin (2015) cited 6 records from CA only. In the FCW, this species occurred in shallow, slow backwater areas of the lowest elevational site of the Upper Fountain Creek reach (UF-4), a site characterized by the highest percentages of sedimentary sand and silt-clay fractions of the 14 study sites (Table 9), and abundant FPOM. Site UF-4 was frequently altered by the dam-building efforts of beaver.

Genus *Cladopelma* Kieffer 1921

Two species of the genus *Cladopelma* were identified from the FCW: *C. edwardsi* and *C. viridula*. Epler (2001) indicated that the larvae of this genus live on or in substrates of lentic and lotic habitats.

Cladopelma edwardsi (Kruseman) 1933

Cladopelma edwardsi has Palaearctic and Nearctic distributions; in North America it ranges from BC to ON and NY south to GA, FL, AL, MS west to NV, AZ and CA (Oliver et al. 1990, Caldwell et al. 1997). In the FCW, *C. edwardsi* occurred at disparate sites UF-2 and LF-5, cool-water and warm-water sites, respectively (Table 4). In the Arkansas River Legacy Reach (cool to warm-water) immediately downstream of the Pueblo Reservoir dam (elevation 1444 m), Kleinert (2008) and Powell (2008) reported this species; Ruse et al. (2000) did not report it from the UAR.

Cladopelma viridulum (Linnaeus) 1767

Cladopelma viridulum is Holarctic in distribution. In the Nearctic region it ranges as far north as AK and NT south and east to SK, MN, NY south to GA, FL west to NM, CA (Sublette 1960, Beck and Beck 1964, Sublette and Sublette 1979, Oliver et al. 1990). Dutta et al. (1996) listed it from England, Finland, India, Japan, Sweden, and Thailand. In the FCW, this species occurred at 4 sites with variable thermal regimes: MC-2 (cold), MC-3 (cool), LF-1 (cool), and LF-5 (warm). Site LF-5 had the highest annual thermal regime within the watershed, and it had extensive growths

of the warm-climate common or cane reed (*Phragmites communis* Trin.) with its thick rhizomes coursing over and through predominantly sand and gravel sediment (Correll and Correll 1972). Simpson and Bode (1980) and Epler (2001) reported that the larvae of this genus may be restricted to unpolluted streams and rivers. In the west Palaearctic, Langton (1991) reported this species "from slow-flowing rivers and drains; ponds with through-flow." Ruse et al. (2000) reported *C. viridulum* from sites AR-7 (elevation 2771 m) and AR-11 (elevation 2338 m), cold-water stations of the UAR. In the Arkansas River Legacy Reach (cool to warm-water) immediately downstream of the Pueblo Reservoir dam (elevation 1444 m), Kleinert (2008) and Powell (2008) also reported this species.

Genus *Cryptochironomus* Kieffer 1918

One new species and 3 described species of *Cryptochironomus* occurred in the FCW. The larvae of this genus are primarily sedimentary and apparently prefer sandy bottoms, which are typical of the FCW (Epler 2001). None of the 3 described species were present in any of the UF sites.

Cryptochironomus digitatus (Malloch) 1915

Cryptochironomus digitatus is a Nearctic species favoring small creeks and streams and ranging from YK, NT, SK, ON, NF south to GA, FL west to NM and CA (Sublette 1960, Sublette and Sublette 1979, Oliver et al. 1990, Caldwell et al. 1997). At sites MC-2 and MC-3, *C. digitatus* and *C. fulvus* co-occurred. The former station is a cold-water habitat and the latter a cool-water biotope; both sites had high concentrations of dissolved and total phosphorus leading to elevated periphyton growth. Moore (1980) reported *C. digitatus* had June and August emergences. This species was not reported by Ruse et al. (2000) from the UAR or by Powell (2008) from the LAR.

Cryptochironomus fulvus Johannsen 1905

This Nearctic species ranges from MT, SK, MB to NB south to FL west to AL, NM and CA (Sublette 1960, Sublette and Sublette 1979, Oliver et al. 1990, Caldwell et al. 1997). Townes (1945) and Curry (1958) reported *C. fulvus* from lakes, ponds, and rivers. Ferrington et al. (2008) indicated that *Cryptochironomus* larvae occur in lentic and lotic microhabitats;

prey on protozoans, microcstraceans, other chironomids; and are piercers of oligochaetes. Epler (2001) stated Nearctic larvae of this genus "prefer sandy substrata"; Vallenduuk and Morozova (2005) reported European representatives also preferred a sandy sediment mixed with FPOM. Townes (1945) reported *C. fulvus* from CO at Hayden (elevation 1932 m) and Mount Rainier in WA at 5000 feet (1524 m) elevation, and stated adults were present during the entire growing season. Oliver (1971) described how the pupal stage of this species is not protected by a case but instead is free on the sediment surface; Roback (1957b) identified larvae of *C. fulvus* from 29 of a total of 70 sites in the Philadelphia, PA, region where the water's pH ranged from 4 to 5 at one location, 5 to 6 at none, 6 to 7 at 10, 7 to 8 at 15, and 8 to 9 at 3; in the 3 sites from the FCW, we observed a narrower pH range of 7.2 to 8.2. Both *C. fulvus* and *C. digitatus* are Nearctic species and co-occurred at sites MC-2 and MC-3; both sites were characterized by high concentrations of dissolved and total phosphorus leading to optimal growth of periphyton. The warm-water LF-5 site was also positive for *C. fulvus*. Ruse et al. (2000) reported *C. fulvus* from site AR-18 in the UAR, a station immediately upstream of Pueblo Reservoir, and Powell (2008) and Kleinert (2008) cited its presence in all 5 sites downstream of Pueblo Reservoir. Apparently this species was intolerant of the cold-water regimes or heavy metal pollution of the UAR.

Cryptochironomus parafulvus

Beck and Beck 1964

Beck and Beck (1964) described *C. parafulvus* from a single adult male reared from a larva; no female allotype or paratypes were reared. The holotype male came from Waddell's Mill Creek, Jackson County, FL; this creek was described as a small, calcareous stream. Caldwell et al. (1997) reported this species from GA. In the FCW, this species was collected only from site MC-1, a cold-water biotope with madicolous features and varying flow rates ranging from almost standing water pools to riffles over rocks (>30 cm). Total hardness of MC-1 indicated moderately hard water, but the site could not be considered a calcareous lotic habitat; dissolved oxygen concentrations were usually near or at saturation (Table 2).

Cryptochironomus n. sp.

One new species of *Cryptochironomus* occurred in the FCW—*Cryptochironomus* n. sp. 9 as designated by coauthor JES. This undescribed species was collected from site LF-5, the station with the highest maximum temperature in the FCW.

Genus *Cryptotendipes* Lenz 1941

One species of the genus *Cryptotendipes* was identified from the FCW material—*C. emorsus*. Epler (2001) indicated that larvae of this genus inhabit various standing and flowing waters and apparently tolerate organic enrichment.

Cryptotendipes emorsus (Townes) 1945

The distribution of Nearctic *C. emorsus* includes North America east of the Rocky Mountains north to MN, IA, OH, QC, NY, NJ and south to FL and AL (Townes 1945, Sæther 1977, Caldwell et al. 1997). This report is apparently a new record for CO. Dendy (1971) reported adults of this species emerging March through September from experimental ponds at Auburn University, AL. Beck (1977) cited its specific habitat as epibenthic, alkaliphilous, and eutrophic. In the FCW, this species was present only at site LF-3, a warm-water site with an elevated range of specific conductivity values (854–1398 $\mu\text{S}/\text{cm}$). Chironomid studies of the main stem of the Arkansas River from Pueblo to Climax, CO, did not result in any records of this species being present (Ruse et al. 2000, Powell 2008, Kleinert 2008).

Genus *Dicrotendipes* Kieffer 1913

Four species of the genus *Dicrotendipes* were identified from the FCW: *D. crypticus*, *fumidus*, *modestus*, and *nervosus*. In the southeastern U.S., Caldwell et al. (1997) found larvae of this genus in lotic and lentic waters that may be organically enriched, and also in some waters containing toxic wastes.

Dicrotendipes crypticus Epler 1987

The Nearctic species *D. crypticus* has been recorded from NM, CA, KS, and possibly Paraguay (Epler 1988, Spies and Reiss 1996). We collected adults of *D. crypticus* from site LF-5 (elevation 1415 m), which is characterized by a warm-water thermal regime and a constantly shifting sand-gravel substratum.

This species may be associated with warm to hot spring effluents as Epler (1987) cited for paratypes from Gallinas Creek at Hot Springs west of Las Vegas, NM; this species' range appears to include the Neotropical region of northern Mexico. Ruse et al. (2000) collected this species in the UAR from a cool-water location (AR-18) in the transition zone from mountains to plains east of Cañon City, CO.

Dicrotendipes fumidus (Johannsen) 1905

The Nearctic *D. fumidus* is widespread and common in southern Canada and the United States (WA, OR, MT, MN, ON, NL south to WV, NC, SC, FL west to AL, NM, UT, CA) (Townes 1945, Sublette and Sublette 1965, 1979, Epler 1987, Oliver et al. 1990, Caldwell et al. 1997) and occurred at 6 sites throughout the FCW (Table 4); 2 of these sites, UF-3 and UF-4, are impacted by heavy metals in the total and dissolved water fractions and sediments from the Gold Hill tailings pile (USEPA 1994). Caldwell et al. (1997) indicated that this species occurs in lakes, rivers, and streams in the southeastern U.S. Townes (1945) stated, "The species seems to breed most abundantly in streams and rivers." In NM streams, Epler (1987) collected larvae from *Myriophyllum* and algae covering rocks in slack or slow-flowing water. Ferrington et al. (2000) found the trichomycete fungus (*Smittium gravimetalum*) in the hindgut of *D. fumidus* occurring in a KS stream also heavily polluted by Pb, Zn, and Cd from a USEPA Superfund site. This species appears to tolerate thermal regimes from very cold (site UF-1) to warm (site LF-5). Ruse et al. (2000) recorded it from stations AR-12 and AR-13 (above and below Salida) and 2 stations immediately downstream of Pueblo Reservoir (AR-19 and AR-20); the former 2 sites are cold-water regimes, and the latter couplet warm-water. Kleinert (2008) and Powell (2008) also listed this common species from the LAR.

Dicrotendipes modestus (Say) 1823

The Holarctic *D. modestus* is widespread in eastern Canada, northeastern and southeastern U.S. (Oliver et al. 1990, Caldwell et al. 1997), and the scattered western states of MN, OR, WA, CA, and NM (Townes 1945, Sublette 1960, Sublette and Sublette 1979). In the states of AL, FL, GA, NC, SC, and TN, this species was found in lakes, rivers, and

streams (Caldwell et al. 1997). A high NCBI pollution tolerance value (9.2) was given to this species by Lenat (1993). In the FCW we collected it only from site MC-1, a cold-water station with riffles, side-pools, and runs at an elevation of 2097 m. In the UAR Ruse et al. (2000) found this species at site AR-18 with companion species *D. crypticus*. Townes (1945) noted that this species was collected in WA from the base of Mt. Rainer at elevation 1524 m, and from Yelm, WA, at elevation 108 m; in the northeast U.S. he indicated that it was “the most abundant green species,” and he collected adults in central NY from 8 May to 12 September (Townes 1945). Epler (1987) hypothesized *D. modestus* might replace *D. crypticus* in the U.S. desert Southwest.

Dicrotendipes nervosus (Staeger) 1839

Dicrotendipes nervosus is Holarctic in distribution, ranging in North America from AK, NT, BC, AB, east to NB south to FL, AL west to TX, NM, and CA (Townes 1945, Sublette and Sublette 1965, 1979, Bode 1983, Epler 1987, Oliver et al. 1990, Caldwell et al. 1997). Caldwell et al. (1997) observed this species inhabiting only lakes and other lentic waters; however, in NY waters Simpson and Bode (1980) found it a dominant species in rivers polluted by organic and toxic wastes. Records from pristine waters of Sequoia National Park, Lake Tahoe, and Mt. Rainer indicated this is an extremely tolerant and eurykous species (Townes 1945, Sublette 1960). Lenat (1993) assigned a very high NCBI tolerance value (10.0) to this species. In the FCW, *D. nervosus* occurred only at site MC-4, a site located immediately downstream of the Colorado Springs Phillips WWTP. No other CO records from the UAR or LAR were found. Epler (1988) examined larval material from Brazil that appeared to be this species or a member of the *D. nervosus* group.

Genus *Endochironomus* Kieffer 1918

Epler (2001) indicated the larvae of this genus often occur in nutrient-enriched standing and flowing waters. The only species of *Endochironomus* collected in the FCW was *E. nigricans*.

Endochironomus nigricans (Johannsen) 1905

The distribution of widespread, Nearctic *E. nigricans* extends from NT, BC east to NB

south to GA, FL west to OK, TX, CA, OR, WA (Townes 1945, Sublette 1960, Sublette and Sublette 1965, Oliver et al. 1990, Caldwell et al. 1997). In the FCW from an elevation perspective, this species occurred at the 3 uppermost MC sites and the lowest UF site. Caldwell et al. (1997) reported this widespread species from all southeastern states, occurring primarily in lakes but also slow-moving lotic habitats. Moorhead et al. (1998) found it in the playa lakes of the semiarid Southern High Plains of West TX, and indicated this species had drought-resistant life stages. Our water quality data indicated that it is eurythermal, euryhalinous, and alkaliophilous (Beck 1977). Grodhaus (1987) summarized its feeding habit as a miner of plant leaves and macrophytes, and possibly as a collector of algae and diatoms.

Genus *Gillotia* Kieffer 1921

Hudson et al. (1990) indicated that distribution records for this genus have been restricted to the Midwest. Little is known of the ecology of this genus except for the narrative provided by Ferrington et al. (2008); they described species in this genus as burrowers and collector-gatherers in sandy rivers. Epler (2001) stated that knowledge of the ecology of this genus is nonexistent; Wiederholm (1989) noted this genus as Nearctic, Afrotropical, and probably Neotropical.

Gillotia n. sp.

Only one new species of the genus *Gillotia* was collected; *G. n. sp.* CO-1 (as denoted by coauthor JES) occurred only at site LF-5 (Table 5), the location with highest water temperatures (Tables 2, 3).

Genus *Glyptotendipes* Kieffer 1913

The genus *Glyptotendipes* is lentic and lotic (Epler 2001, Ferrington et al. 2008). Two species were collected from the FCW: *G. barbipes* and *G. lobiferus*.

Glyptotendipes barbipes (Staeger) 1839

Oliver et al. (1990) indicated *G. barbipes* is Nearctic, Palaearctic, and Oriental in distribution; in North America it occurs from AK, BC to NB south to NJ, IL, NC, SC, GA and NM (Townes 1945, Sublette and Sublette 1965, 1979, Oliver et al. 1990, Caldwell et al. 1997). Sublette and Sublette (1979) reported this

species primarily from lentic habitats in NM; in the southeastern U.S., Caldwell et al. (1997) also indicated it occurring in lakes. In the FCW *G. barbipes* was collected only from site LF-2, a site located immediately downstream of the Colorado Springs Las Vegas WWTP where specific conductivity and dissolved and total phosphorus concentrations were very high (Table 2). These data supported the reports of Ali (1995) and Epler (2001) who noted that this species occurs in nutrient-rich waters such as sewage lagoons and ponds.

Glyptotendipes lobiferus (Say) 1823

Even though Oliver et al. (1990) cited Nearctic *G. lobiferus* as being widespread in North America (BC to QC south to NC, SC, GA, FL west to MS, TX, UT, and CA) (Townes 1945, Sublette 1960, Caldwell et al. 1997), there is some uncertainty about its distribution; Epler (2001) stated this species may be more northern and may not occur in the southeastern U.S. We collected *G. lobiferus* in the FCW from stations MC-1 and LF-2, the first being a cold-water site and the second a warm-water habitat. From Tables 2 and 3 it was evident this generalist species was eurythermic, eurytrophic, and alkaliphilous; the sand content for sites MC-1 and LF-2 exceeded 55% (Table 9), indicating this species was probably episabulic (Beck 1977).

Genus *Parachironomus* Lenz 1921

Epler (2001) stated the larvae of this genus occur in standing and flowing waters with conditions varying widely. One species of this genus (*P. tenuicaudatus*) was collected at 3 sites in the FCW.

Parachironomus tenuicaudatus
(Malloch) 1915

The North American distribution of the Holarctic *P. tenuicaudatus* extends from BC, SK to QC south to FL, AL, NM, CA (Townes 1945, Sublette 1960, Oliver et al. 1990, Caldwell et al. 1997). In the FCW it was collected at sites MC-5, LF-1, and LF-2, which were characterized by high dissolved oxygen and relatively high dissolved and total phosphorus concentrations (Tables 2, 3). Caldwell et al. (1997) found this species in lotic and lentic habitats of the southeastern U.S. Cranston et al. (1989a) reported this genus has a worldwide distribution excluding Antarctica. Epler

(2001) suggested larval identifications of this species be questioned. Moller Pillot (2009) indicated this species was not collected from acidic lotic or lentic habitats in the Netherlands.

Genus *Paracladopelma* Harnisch 1923

In addition to *P. doris*, 2 additional species of *Paracladopelma* collected in the FCW were new species. Epler (2001) indicated that the larvae of this genus occur in sandy lotic habitats and may also be in standing waters.

Paracladopelma doris (Townes) 1945

The Nearctic *P. doris* was collected only at MC-2, a cool-water site with moderately high phosphorus concentrations and 85% of the sediment being fine gravel and sand (Table 9). Cranston et al. (1989a) reported the larvae of this genus occurred in sandy sediments of streams and lakes. This species has a very restricted range. Townes (1945) and Oliver et al. (1990) cited it from OK, SD, and IA; the type locality was Gore, OK. Caldwell et al. (1997) and Epler (2001) reported this species from FL, SC, and NC. This CO record appears to be a westward extension of its range.

Paracladopelma n. spp.

Two new species of *Paracladopelma* were designated by coauthor JES as *P. n. sp.* and *P. n. sp. CO-1* (Table 5). In the FCW the former species occurred at sites MC-3, MC-4, and LF-2; the first 2 sites were cool-water stations and the third was a warm-water habitat.

Genus *Paratendipes* Kieffer 1911

The larvae of this genus are found in many different types of aquatic biotopes (Epler 2001). One species of this genus, *P. subaequalis*, was collected from the FCW.

Paratendipes subaequalis (Malloch) 1915

Oliver et al. (1990) reported this species as being Palearctic and Holarctic and widespread in North America. *Paratendipes subaequalis* was the only species of this genus; it was collected only at MC-2. Environmental conditions were the same as the co-occurring *Paracladopelma doris* (i.e., substratum with a high percentage of gravel and sand and a wide eurythermal [$>15^{\circ}\text{C}$] range). Epler (2001) reported the larvae of this genus occurring in a variety of habitats; Cranston et al. (1989a)

cited the immatures inhabiting “fine and sandy sediments” in lotic and lentic waters. Ruse et al. (2000) reported adults of this species at the cold-water site AR-6 in the UAR; this site was moderately impacted by heavy metals pollution in contrast to the sites immediately upstream.

Genus *Phaenopsectra* Kieffer 1921

Epler (2001) reported the larvae from lotic habitats. Larvae are drought resistant and can tolerate dessication. Hudson et al. (1990) indicated that some species may be semiterrestrial. One species of the genus, *P. profusa*, was collected in the FCW.

Phaenopsectra profusa (Townes) 1945

Phaenopsectra profusa was the singular species for this genus in the FCW at sites MC-2, 3, UF-2, 3, 4 and LF-2, 3; it was collected in all 3 reaches of the watershed ranging from cold to cool to warm thermal regimes. This lotic species has been reported from WA, MT, ID, CA, UT, NV, CO, and NM (Townes 1945, Sublette and Sublette 1965, 1979, Oliver et al. 1990). The male holotype came from Reno, NV (Townes 1945); many male and female paratypes came from Brainard Lake, Estes Park, Fort Collins, Grand Lake, and Hayden in CO. Beck (1977) described its environmental requirements as oligohalobous (waters <500 mg/L salt), oligoxyphilous (tolerant of low dissolved oxygen concentrations), metathermal (tolerant of temperatures 5 °C to 15 °C), and limnobiontic (lentic habitats). Grodhaus (1976) described some larvae of this and another species of *Phaenopsectra* as being drought resistant and emerging in the middle of a CA winter. In the UAR, Ruse et al. (2000) collected adults and exuviae of this eurythermal species from the headwaters at site EF-1 (3042 m elevation) near Leadville, CO, to site AR-20 below Pueblo Reservoir (1431 m elevation); however, it was absent from the reach most heavily polluted by heavy metals (AR-2 to AR-6).

Genus *Polypedilum* Kieffer 1912

Epler (2001) stated the larvae of *Polypedilum* occur in many different types of aquatic biotopes, ranging from unpolluted to severely impacted. Sæther and Oyewo (2008) indicated the larvae are found in all lentic and lotic sites “except at high latitude and altitude.” Hudson

et al. (1990) summarized by saying this taxon “is one of the most commonly seen genera in all aquatic habitats.” Epler (2001) stressed the need of using adult males to accurately identify species of the *P. halterale* group, which includes *P. digitifer*, *griseopunctatum*, *halterale*, and *simulans*. Boesel (1985) placed *P. digitifer* as a synonym under *P. halterale*; coauthor JES did not. Eleven species of *Polypedilum* were collected from the FCW: 1 new species and 10 others with some interesting distributions worldwide and regionally (Table 10). Global distributional data were compiled from Boesel (1985), Oliver et al. (1990), Maschwitz and Cook (2000), Sæther and Oyewo (2008).

Polypedilum laetum was the only species of this genus collected at site UF-4 from the FCW; *P. laetum* and *P. suliceps* were collected from some of the most metal-laden sites in the UAR (Ruse et al. 2000). The other 8 species were collected above and below the sites of extreme contamination.

Intragenetic species associations occurred at 9 of 14 sites in the FCW. Specific companion associations or co-occurrences of *Polypedilum* species are best understood using the presence-absence data in Table 4. The number of companion species by site were as follows: MC-2 (2), MC-3 (4), MC-4 (3), MC-5 (2), UF-1 (2), UF-3 (2), LF-3 (2), LF-4 (2) and LF-5 (3).

Polypedilum (Tripodura) digitifer Townes 1945

According to coauthor JES, this species should not be synonymized with *P. halterale*. The distribution in North America extends from SD to IL, MI, MD south to NC, SC, FL, AL west to TX, NM, and CA (Townes 1945, Sublette 1960, Sublette and Sublette 1965, 1979, Caldwell et al. 1997). In the southeastern U.S. it occurs primarily in lakes; however, Atchley et al. (1979) collected *P. digitifer* from 8 of 11 river stations in NM. In the FCW this species occurred at sites MC-3 and LF-4, cool-water and warm-water stations, respectively. In the UAR Ruse et al. (2000) reported *P. digitifer* from a very cold headwaters site (EF-1), a cool-water station upstream of Pueblo Reservoir (AR-18), and a warm-water location immediately downriver of Pueblo Reservoir (AR-19). Kleinert (2008) and Powell (2008) collected this species in the LAR.

TABLE 10. Distribution of species of *Polypedilum* found in the Fountain Creek Watershed (FCW). Global distribution acronyms follow Oliver et al. (1990) and Maschwitz and Cook (2000): NE = Nearctic, HO = Holarctic, UAR = Upper Arkansas River, LAR = Lower Arkansas River, 1 = present, 0 = absent.

	<i>digitifer</i>	<i>flavum</i>	<i>illinoense</i>	<i>laetum</i>	<i>obtusum</i>	<i>pedatum</i>	<i>prolixipartum</i>	<i>scalaenum</i>	<i>simulans</i>	<i>sulaceps</i>
Global	NE	NE	NE	HO	NE	NE	NE	HO	NE	NE
UAR	1	0	1	1	0	1	0	1	0	1
LAR	1	0	0	1	1	0	0	1	0	1

Polypedilum (Uresipedilum) flavum
(Johannsen) 1905

In the past, Epler (2001) indicated this common lotic species in the Carolinas was called *P. convictum* because the adults are similar to *P. flavum* but the larvae are not; it may not be correct to synonymize them and consider either Holarctic. The Nearctic distribution for *P. flavum* extends from SK, MB, ON, QC, NY south to SC, FL, west to LA, MO, TX, AZ (Townes 1945, Oliver et al. 1990, Maschwitz and Cook 2000). This species has been reported from the neighboring states of KS and NE and possibly Germany (Maschwitz and Cook 2000). In NY Simpson and Bode (1980) reported this filter-feeding chironomid as common. In the FCW it occurred only in the cool-water station MC-3. This species has not been recorded from the UAR or LAR (Ruse et al. 2000, Kleinert 2008, Powell 2008).

Polypedilum (Polypedilum) illinoense
(Malloch) 1915

The Nearctic distribution of *P. illinoense* ranges from NT, ON, QC south to FL, west to AL, LA, TX, NM, and CA (Sublette and Sublette 1979, Oliver et al. 1990, Caldwell et al. 1997, Maschwitz and Cook 2000). Adults have been reported from lotic and lentic sites from the nearby or contiguous states of SD, NE, OK, NM, and TX (Sublette and Sublette 1979, Maschwitz and Cook 2000). In the Carolinas, larvae of this species were "common and ubiquitous" (Epler 2001). Larvae occurred in waters with high organic enrichment and reduced dissolved oxygen, such as those associated with paper pulp mills (Epler 2001). Simpson and Bode (1980) indicated this species is often a companion to *P. flavum*. In the FCW, *P. illinoense* and *P. scalaenum* appeared to be companion species. It appeared that both of these species were tolerant of both anthropogenic enrichment and heavy metal loads. Lenat's (1993) NCBI tolerance value for *P. illinoense* was 9.2 (on a scale of 0–10, with 10 being most pollution tolerant). In the FCW this species occurred at sites LF-3 and LF-5, both warm-water stations. In the Philadelphia area, Roback (1957a) identified larvae of *P. illinoense* from 36 of a total of 70 sites where the water's pH ranged from 4 to 5 at 1 location, 5 to 6 at 3, 6 to 7 at 12, 7 to 8 at 15, and 8 to 9 at 2; in the 2 sites from the FCW, the pH ranged from 7.6 to 8.5. In a

second set of regional water quality data from PA, Roback (1974) provided some ranges that could be compared to those of the FCW in CO (Tables 2, 3): pH, 3.0–8.8 and 7.6–8.5 (Roback and FCW, respectively); total alkalinity, 0–220 and 138–180 mg/L CaCO₃; total hardness, 6–2100 and 251–358 mg/L CaCO₃.

Polypedilum (Polypedilum) laetum
(Meigen) 1818

In North America, Holarctic *P. laetum* ranges from AB to QC south to FL, west to AL, CO, NM, NV, and CA (Townes 1945, Sublette and Sublette 1965, 1979, Oliver et al. 1990, Caldwell et al. 1997, Maschwitz and Cook 2000); in the Nearctic region it is primarily a larval resident of streams and rivers, but in the west Palearctic it is characteristic of “fast-flowing rivers” and eutrophic lakes (Sæther 1975a, Sublette and Sublette 1979, Langton 1991, Caldwell et al. 1997). Records from adjoining states include WY, NM, and UT (Sublette and Sublette 1979, Maschwitz and Cook 2000). In the FCW, *P. laetum* was found at station MC-3 and all 4 UF sites; these are either cold or cool locations. In the UAR, Ruse et al. (2000) cited its occurrence from sites AR-6 to AR-20, which range from very cold to warm thermal regimes with an elevational range of 1431 to 2795 m. For several sites in the LAR, Powell (2008) and Kleiner (2008) observed 3 species of *Polypedilum* co-occurring at the time of collection: *P. laetum*, *P. sulaceps* and *P. scalaenum*. Ruse et al. (2000) reported the same interspecific association at sites AR-13, AR-17, and AR-18 in the UAR.

Polypedilum (Uresipedilum) obtusum
Townes 1945

The Nearctic *P. obtusum* ranges from MN, IL, MI, ON, QC, south to NY (type locality), VA, SC, FL west to LA, AR, OK, CO, and NM and was “not commonly collected” (Townes 1945, Sublette 1957b, Iovino and Miner 1970, Sublette and Sublette 1979, Maschwitz and Cook 2000). Beck (1977) described the larval habitat of this species as acidophilous (pH around 7, but usually <7); oligohalobous (salt concentration <500 mg/L); oligo- to mesoxyphilous (low to moderate O₂ concentration); oligo- to mesothermal (water temperature range 0–30 °C) and limno- and rheobiontic (lentic and lotic habitats). In the FCW, *P.*

obtusum occurred only at station MC-2, a cold-water biotope with pH ranging from 7.5 to 8.1; dissolved oxygen 9.6–11.0 mg/L and total salt concentration <500 mg/L. Ruse et al. (2000) did not report this species from the UAR; however, Powell (2008) collected it from 4 of 5 stations within 4.5 km downstream of the Pueblo Reservoir dam, all warm-water sites. With the use of emergence traps, Iovino and Miner (1970) found emerging adults only in the month of July in an AK reservoir.

Polypedilum (Uresipedilum) pedatum
Townes 1945

The Nearctic *P. pedatum* ranges from BC, WA, OR, MT, MN, ON, QC, NS south to NY, VA, SC, LA west to MO, CA (Townes 1945, Sublette 1960, Sublette and Sublette 1965, Oliver et al. 1990, Caldwell et al. 1997, Maschwitz and Cook 2000). In the FCW this species was collected only from station UF-1, the site with the coldest thermal regime and pristine water (Tables 2, 3). Ruse et al. (2000) reported this species in the UAR at site AR-12, a cold-water location with minimal organic loading and nutrient enrichment. This lentic and lotic species appears to have a scattered and disjunct distribution within its range. Eggs and early instars can tolerate some dessication in dry tree-hole litter (Grodhaus and Rotramel 1980).

Polypedilum (Polypedilum) prolixipartum
Maschwitz 2000

Polypedilum prolixipartum is known from the type locality in WY and AK, CA, CO, NV and NM, essentially all records from cool or cold western North American lotic (creek) habitats (Maschwitz and Cook 2000). The collection of this recently described species at site UF-3 in the FCW extended its range to the south by hundreds of kilometers. Station UF-3 was a cold to cool location with water quality indicative of oligotrophic conditions (BDL concentrations of dissolved and total phosphorus) (Table 3). No records from the UAR or LAR were reported for this species.

Polypedilum (Tripodura) scalaenum
(Schränk) 1803

The range of Holarctic *P. scalaenum* in North America extends from ON to ME south to NC, SC, GA, FL west to AL, LA, NM, NV, CA (Townes 1945, Sublette 1960, Sublette and

Sublette 1979, Oliver et al. 1990, Caldwell et al. 1997). In the west Palearctic, Langton (1991) simply stated that this species occurs in rivers; in NM Sublette and Sublette (1979) found it abundant in 11 of 12 river systems. In the FCW this species occurred in 10 of the 14 study stations. All 5 MC sites and all 5 LF sites were positive; all of the UF stations were negative. Presently, we are unable to fully explain this watershed distribution. Roback (1974) provided water quality data for sites inhabited by *P. scalaenum* in the Philadelphia, PA, region that could be compared to those of the FCW in CO (Tables 2, 3): pH, 3.0–8.2 and 7.4–8.5 (Roback and FCW, respectively); total alkalinity, 0–206 and 66–183 mg/L CaCO₃; total hardness, 11–227 and 40–358 mg/L CaCO₃. Ruse et al. (2000) cited this species from 6 of 22 stations (EF-1, AR-13, 14, 16, 17, and 18 of the UAR; the elevational range for these sites was 1497–3042 m. In 1984 and 1985, Ruse et al. (2000) completed their study of the UAR; during the period 24 March 2006 to 25 August 2006, Powell (2008) completed her fieldwork on the LAR. At sites AR-13 and AR-17, Ruse et al. (2000) identified 3 species of *Polypedilum* (*P. laetum*, *P. sulaceps*, and *P. scalaenum*) co-occurring; at site AR-18 the following were companion species: *P. digitifer*, *laetum*, *illinoense*, *sulaceps*, and *scalaenum*. Powell (2008) collected *P. scalaenum* immediately above and below Pueblo Reservoir at sites AR-18 and AR-19; 5 species of this genus were companion species co-occurring at site AR-18 (*P. digitifer*, *laetum*, *parascalaenum*, *sulaceps*, and *scalaenum*). The NCBI pollution tolerance value of Lenat (1993) is 8.7. It appears that this species is tolerant of partially degraded waters, nutrient enrichment, and heavy metal loads.

Polypedilum (Tripodura) simulans
Townes 1945

The distributional range of Nearctic *P. simulans* extends from MT, MN, ON to ME south to VA, NC, SC, FL, AL west to OK, NM, CA (Townes 1945, Sublette 1960, Sublette and Sublette 1979, Oliver et al. 1990, Caldwell et al. 1997). Townes (1945) and Caldwell et al. (1997) reported this species from lentic biotopes; however, Sublette and Sublette (1979) documented it from the Sapello River in NM. In the FCW this species occurred only at site MC-4, a cool-water site. In the UAR and LAR

investigations, there were no records of this species (Ruse et al. 2000, Kleinert 2008, Powell 2008).

Polypedilum (Polypedilum) sulaceps
Townes 1945

Polypedilum (P.) sulaceps is a Nearctic species whose distribution extends from WA east to ID, WY, SD south to CO and NM west to CA (Townes 1945, Sublette 1960, Sublette and Sublette 1979, Oliver et al. 1990, Caldwell et al. 1997, Maschwitz and Cook 2000). A paucity of provincial and state records precludes a more continuous range for this species. Sublette and Sublette (1979) reported this species from 8 of 12 rivers in NM. The type locality is Riverdale, ID (Townes 1945); the elevation of Riverdale is 1389 m and the Bear River transects the community. Ruse et al. (2000) reported this species from the UAR at stations AR-8, 13, 17, and 18; Powell (2008) cited this species from site AR-18 also. For intrageneric associations, the reader is referred to the discussion of *P. scalaenum*.

Polypedilum n. sp

Coauthor JES designated a new species of *Polypedilum* as *P. n. sp.* 14 [herrmanni.ms] (Table 5). This new species was collected at site LF-4, a warm-water site with elevated specific conductivity (range 923–1437 µS/cm).

Genus *Robackia* Sæther 1977

One species of *Robackia* was recorded from the FCW—*R. claviger*. Epler (2001) indicated the larvae of this genus were inhabitants of sandy sediments of lotic environments.

Robackia claviger (Townes) 1945

The larvae of *R. claviger* prefer sandy substrates of rivers and streams and are widely distributed in North America from WA, SK, SD, MN, NE, IN, ME south to NC, SC, GA, FL west to MS, NM (Townes 1945, Sæther 1977, Oliver et al. 1990, Caldwell et al. 1997). Lenat (1993) generated an NCBI tolerance value of 2.4 for this species; such a low value indicates a preference for clean water. In the FCW, *R. claviger* was collected only at site LF-4, a warm-water location with 75% of the sediment fine gravel and sand, and little if any silt or clay. This species occurs at transition sites (AR17, 18) separating the UAR and LAR just

east of Cañon City, near Portland, CO (Ruse et al. 2000).

Genus *Saetheria* Jackson 1977

The genus *Saetheria* was represented by 2 species in the FCW: one new species and *S. tylus*. The larvae of this genus occur in sandy-gravel sediments in flowing waters (Epler 2001).

Saetheria tylus (Townes) 1945

The North American distribution of this Nearctic species ranges from YT, NT, WA, NE, IN, NC south to SC, GA, FL west to CO (Townes 1945, Oliver et al. 1990, Caldwell et al. 1997). Epler (2001) indicated it is the most commonly collected species of the genus. *Saetheria tylus* occurred at 11 of the 14 FCW sites; it was found in all 3 reaches of the watershed. This euryokous species appears to be thriving in the ever-shifting gravel and sand substrata of the FCW in spite of the elevational and temperature differences. In the UAR and LAR studies, this species was never found; we cannot explain why it is so common in the FCW and absent from the main stem Arkansas River between Leadville and Pueblo. The NCBI tolerance value is 8.1, suggesting this facultative species has a wide tolerance to a variety of pollutants (Lenat 1993). Ferrington et al. (2008) cited that the habitat preference for this species was sandy bottom of lotic and lentic waters.

Saetheria n. sp.

Coauthor JES designated a new species of *Saetheria* as *S. n. sp. 1* [marki.ms.name] (Table 5). This new species was collected from 7 of the 14 sites: MC-2, 3, 4, 5, UF-4, LF-1 and 2.

Genus *Stichtochironomus* Kieffer 1919

Two species of *Stichtochironomus* were found in the FCW: *S. annulicrus* and *S. varius*. In this genus the larvae usually inhabit sandy substrates of lotic and lentic waters (Cranston et al. 1989a).

Stichtochironomus annulicrus (Townes) 1945

The distribution of Nearctic *S. annulicrus* ranges from SD, ON, NY, TN to NC (Townes 1945, Sublette and Sublette 1965, Oliver et al. 1990, Caldwell et al. 1997). This species was recorded only at site MC-5, a cool-water

station with a total hardness range of 136–276 mg/L CaCO₃, and total alkalinity range of 105–110 mg/L CaCO₃. *Stichtochironomus annulicrus* was collected in the headwaters of the UAR at site AR-2 at 2905 m elevation (Ruse et al. 2000); this species appeared to be tolerant of cold thermal regimes.

Stichtochironomus varius (Townes) 1945

Townes (1945) and Oliver et al. (1990) cited its distribution as MN to NY, IA to OH, KS, CO, and NM. The type male of this species was collected from Six Mile Creek in Ithaca, NY; paratypes include 2 males from the University of Colorado, Boulder campus (Townes 1945). Nearctic *S. varius* was found only at site MC-1 in the FCW. Site MC-1 could be considered a cold-water location with BDL concentrations of total and dissolved phosphorus and a pH range of 7.4–7.9 (Tables 2, 3). In contrast to *S. annulicrus*, *S. varius* was never collected from the UAR, only from 5 of 6 LAR sites downstream of Pueblo Reservoir (Powell 2008). Companion species, *S. marmoreus* and *S. unguiculatus*, were reported from the LAR sites by Kleinert (2008) and Powell (2008) but were not collected in the FCW.

Genus *Xestochironomus*

Sublette and Wirth 1972

Only one species of the genus *Xestochironomus* was collected from the FCW—*X. brunneus*. Epler (2001) indicated the larvae of this genus are miners of dead, decaying woody materials in flowing waters.

Xestochironomus brunneus Borkent 1984

The Nearctic *X. brunneus* has a limited distribution in the southwestern United States and is known only from NM (Borkent 1984, Oliver et al. 1990), and now CO. This species was found in sites LF-2, LF-3, and LF-5—all nutrient-rich, warm-water sites with abundant woody material embedded in the sandy substrate. The woody debris is a mixture of rootstocks, living and dead roots, rhizomes, branches, trunks, and culms from common reed (*Phragmites communis*), salt cedar (*Tamarix gallica*), plains cottonwood (*Populus sargentii*) and willow (*Salix* spp.). Borkent (1984) described the type locality near Acme, NM, as consisting of larvae in “dead, submerged, trailing roots of *Tamarix* on the banks of the Pecos River.” Similar conditions exist in the LF sites

of the FCW. Cranston and Oliver (1988b) suspected species of the genus *Xestochironomus* might be obligate xylophages (miners and ingesters of immersed woody products). Sublette and Sasa (1994) indicated the genitalia of *X. brunneus* were identical to those of a Guatemalan species, *X. ankylis*.

Subfamily Chironominae

Tribe Pseudochironomini

Genus *Pseudochironomus* Malloch 1915

Only one species of the genus *Pseudochironomus* was found in the FCW—*P. richardsoni*. Larvae of this genus occur in sandy sediments of lotic and lentic habitats (Epler 2001).

Pseudochironomus richardsoni Malloch 1915

The Nearctic *P. richardsoni* is widespread in North America, occurring in lentic and lotic habitats from IL, ON east to NY south to SC, FL west to AL, CO, CA (Townes 1945, Sublette and Sublette 1965, Sæther 1977, Oliver et al. 1990, Caldwell et al. 1997), with adults emerging from March to October (Sæther 1977). Epler (2001) stated the larvae of this genus inhabit sandy sediments of streams and lakes. This species was collected from site MC-2 of the FCW; this station is a cold-water biotope with elevated total and dissolved phosphorus concentrations from treated wastewater (Table 3). This species was collected from cold- to cool-water sites AR-11, 16 and 18 in the UAR (Ruse et al. 2000).

Subfamily Chironominae

Tribe Tanytarsini

Genus *Cladotanytarsus* Kieffer 1921

Within the tribe Tanytarsini of the Chironominae, the genus *Cladotanytarsus* was represented by one new species and 3 described species in the FCW: *C. cruscus*, *C. fusiformis*, and *C. viridiventr*. Epler (2001) reported larvae of this genus occur in many lentic and lotic habitats.

Cladotanytarsus cruscus (Sæther) 1971

The distribution of Nearctic *C. cruscus* is limited to SD and NM, and possibly TX (Oliver et al. 1990). In the FCW this species occurred at sites LF-2 and LF-5, both warm-water sites with elevated specific conductivity values ranging from 692 to 1354 $\mu\text{S}/\text{cm}$. This species was not reported from the main stem

Arkansas River by Ruse et al. (2000), Kleinert (2008), or Powell (2008).

Cladotanytarsus fusiformis

Bilyj and Davies 1989

The distribution of Nearctic *C. fusiformis* is restricted to ON (Bilyj and Davies 1989). In the FCW, it was identified only from site MC-1, a cold-water site low in phosphorus (Tables 2, 3). No other confirmed records of this species could be found in CO or elsewhere.

Cladotanytarsus viridiventr

(Malloch) 1915

The distribution of *C. viridiventr* is widespread in the Nearctic from AK, NT, south to AB, ON, QC east to NY, NC, FL west to OH, MI, AL, CA (Sublette and Sublette 1965, Oliver et al. 1990). Epler (2001) stated this genus occurred in a wide variety of aquatic habitats, including hot springs and estuaries. This species was collected only at site MC-1 in the FCW, a location with >75% of the sediment being very fine gravel and sand, a cold temperature regime, low total hardness (<93.3 mg/L CaCO_3), and high CPOM and FPOM as a result of several beaver ponds. According to Ferrington et al. (2008), the modes of feeding for this genus are either collector-gatherers or collector-filterers; Berg (1995) reported that collector-gatherers “predominate where FPOM accumulates” in lakes and lotic sites where velocities are slow.

Cladotanytarsus n. sp.

Coauthor JES assigned a new species of this genus as *Cladotanytarsus* n. sp. 7 (Table 5). It was collected from site MC-1; this same station had a co-occurrence of companion species of the same genus that included *C. fusiformis* and *C. viridiventr*.

Genus *Micropsectra* Kieffer 1909

In the tribe Tanytarsini, 4 species of the genus *Micropsectra* were collected in the FCW: *M. logani*, *nigripila*, *polita*, and *recurvatus*. Epler (2001) reported the larvae occurred in many types of flowing and standing water, and in the Carolinas the larvae were “most abundant in mountain streams.”

Micropsectra logani (Johannsen) 1928

The distribution of Nearctic *M. logani* is greatly restricted to UT and NM in lotic

habitats (Sublette and Sublette 1979, Oliver et al. 1990). In the FCW, this species occurred at sites MC-5 and LF-3, cool-water and warm-water stations, respectively. The range in pH for both sites was 302–1398 $\mu\text{S}/\text{cm}$, and the range for total phosphorus 337–716 $\mu\text{g}/\text{L}$. Sublette and Sublette (1979) reported this species from the Sapello River, San Miguel County, NM. In the UAR, Ruse et al. (2000) reported this species from site AR-6, a very cold station that has been impacted by heavy metal discharges from the Leadville Drain, California Gulch, and Iowa Gulch. Both Kleinert (2008) and Powell (2008) cited *M. logani* from sites at the tailwaters (Juniper Bridge) site of Pueblo Reservoir and downstream 10 km.

Micropsectra nigripila (Johannsen) 1905

The Nearctic *M. nigripila* is distributed from WA, SK, MB, QC, IA, IL, OH, NY south to LA west to CO, UT, CA (Sublette and Sublette 1965, 1979, Oliver et al. 1990). In the FCW, *M. nigripila* was collected at 6 sites in all 3 reaches (MC-2, 3, 5, UF-3, LF-3, 4); these sites range thermally from cold to cool to warm. This species appeared to tolerate moderate heavy metal pollution at UF-3 and nutrient loading, with total phosphorus ranging from 680 to 716 $\mu\text{g}/\text{L}$ for sites LF-3 and LF-4. Ruse et al. (2000) listed *M. nigripila* from 11 of 22 sites in the UAR—some at the headwaters of the Arkansas River and others extending to below Pueblo Reservoir. As with *M. logani*, *M. nigripila* occurred at sites below Pueblo Reservoir dam; however, they were not companion species at any of the 5 sites (Kleinert 2008, Powell 2008). In a major chironomid survey of NM, Sublette and Sublette (1979) found this species in 8 of 12 river systems.

Micropsectra polita (Malloch) 1915

The distribution of Nearctic *M. polita* extends from OR, AB, SK, SD, QC, PA, MD, IL, NM, UT, AZ to CA (Sublette and Sublette 1965, 1979, Oliver et al. 1990); in the FCW it occurred in 6 sites (MC-1, 2, 3, UF-1, 2, 3) with none being warm-water locations. At sites MC-2, 3 and UF-3, *M. polita* and *M. nigripila* were companion species. Both *M. nigripila* and *M. polita* were collected from many sites in the UAR impacted by heavy metal discharges from mining activity (Ruse et al. 2000); they appear to be tolerant of heavy metals such

as Cu, Zn, Cd, and Pb. In the LAR, Kleinert (2008) collected both companion species in the Legacy Reach extending 10 km down river from the Pueblo Reservoir dam. Simpson and Bode (1980) found this species “only in clean waters of streams and moderate-sized rivers” in NY. Webb (1981) found the adults and larvae in a spring-fed seep in IL; the larvae were in fine sand in water 5–10 cm deep, females were swept from vegetation, and males were swept from swarms forming over vegetation along the edge of the seep.

Micropsectra recurvata (Goetghebuer) 1928

Holarctic *M. recurvatus* is distributed in North America from NC to SC (Oliver et al. 1990); it is found in “northern and montane lakes” in the west Palaearctic (Langton 1991). This species is also found in Greenland and Iceland (Fauna Europaea 2014). Caldwell et al. (1997) did not indicate in what types of aquatic habitats this species occurred in the Carolinas. In the FCW, *M. recurvatus* was found only at site MC-1, a cold-water location. Of the 4 species in the FCW, *M. recurvatus* was the only one absent in the UAR and LAR.

Genus *Paratanytarsus*

Thienemann and Bause 1913

In the genus *Paratanytarsus*, one new species was found in the FCW. Epler (2001) reported that the larvae of this genus inhabit a number of different aquatic biotopes, including estuarine conditions.

Paratanytarsus n. sp.

The new species of this genus was designated *P. n. sp.* OH-3 (Table 5) by coauthor JES. This tanytarsine was collected only from site MC-1, a cold-water site. Four species of *Paratanytarsus* were collected in the UAR (Ruse et al. 2000).

Genus *Rheotanytarsus*

Thienemann and Bause 1913

In the FCW we found a new species of the genus *Rheotanytarsus*. The larvae of this genus usually occur in brooks, creeks, small streams (rhithron habitats) and larger rivers (potamon biotopes) where they may be associated with macrophytes upon which they construct their tubes; some may inhabit shallow lentic sites in which wave action corresponds to flowing waters (Epler 2001, Epler et al. 2013).

Rheotanytarsus n. sp.

Coauthor JES assigned the new species of this genus with the following label: *R.* n. sp. 3 [fontanalis.ms] (Table 5). This unknown species was found at sites MC-1 and MC-2, both cold-water stations. One new species in the genus *Rheotanytarsus* was also reported from the UAR (Ruse et al. 2000). Sublette and Sublette (1979) reported 5 new species of this genus from many river systems of NM; they reported *R.* n. sp. 3 from the Rio Grande at Otowi Bridge (Atchley et al. 1979). Epler et al. (2013) reported via a personal communication with coauthor JES that nearly 30 species of this genus are known from North America.

Genus *Tanytarsus* Wulp 1874

The genus *Tanytarsus* in the Tanytarsini was represented by 4 species in the FCW: *T. acifer*, *hastatus*, *pallidicornis*, and *pelsuei*. None of these 4 species co-occurred at the same sites. In the UAR and LAR, 5 different additional described species and 7 undescribed species of *Tanytarsus* were cited by Ruse et al. (2000), Kleinert (2008) and Powell (2008). Tanytarsines are found in brackish waters, and varied lotic and lentic habitats (Epler 2001).

Tanytarsus acifer Ekrem,
Sublette and Sublette 2003

Nearctic *T. acifer* ranges from ON to NY south to FL, west to TX and SD; a previous record from CO was noted (Ekrem et al. 2003). The CO record for *T. acifer* from Ekrem et al. (2003) was from the LAR at the Highway 45 bridge crossing the Arkansas River in Pueblo, CO. In the FCW this species was collected only from site MC-3, a cool-water biotope. In the UAR Ruse et al. (2000) did not record this species; however, Kleinert (2008) reported it from the Legacy Reach immediately downstream of the Pueblo Reservoir dam.

Tanytarsus hastatus Sublette and Sasa 1994

The distribution of the tanytarsine *T. hastatus* is Nearctic and Neotropical inclusive of Central America: in South America from Brazil, Ecuador (Galapagos Islands – Isabela), Peru, and Venezuela; in Central America from Guatemala (holotype and allotype) and Panama; in North America from CA (Sublette

and Sasa 1994, Sanseverino 2006). In Brazil and CA male imagoes were collected from an artificial pond and an overflow pond, respectively (Sublette and Sasa 1994, Sanseverino 2006). Sanseverino (2006) stated that *T. hastatus* is the only described Neotropical tanytarsine species known; *T. hastatus* adults were collected from FWC site LF-2 (elevation 1635 m), a location with mean spring and fall 2007 temperatures of 9.6 °C and 15.2 °C, respectively. Site LF-2 is a warm-water site with many side-pools of standing water. This species was not found in the UAR or LAR by Ruse et al. (2000) or Powell (2008).

Tanytarsus pallidicornis Walker 1956

The Holarctic *T. pallidicornis* has a greatly restricted North American distribution that includes NM, and now CO (Sublette and Sublette 1979). In the FCW, this species occurred only at station LF-4, a warm-water site with maximum specific conductivity of 1398 µS/cm (Tables 2, 3) at 1433 m elevation. In the UAR Ruse et al. (2000) reported *T. pallidicornis* from station AR-12, a cold-water site at elevation 2143 m. No other CO records were found for this tanytarsine. Widespread global distributions characterize *T. hastatus* and *T. pallidicornis*. In the west Palaearctic, Langton (1991) reported that *T. pallidicornis* occurred in “stagnant and running water.”

Tanytarsus pelsuei Spies 1998

Tanytarsus pelsuei is a Nearctic species occurring in CO, TX, NM, and CA (Spies 1998). The CO record for *T. pelsuei* from Spies (1998) was the Navajo River near the NM–CO state line. In the FCW, this species was found only at site MC-4, a cool-water station with low coliform bacterial counts and total alkalinities (Table 3). The range in specific conductance reported by Spies (1998) for *T. pelsuei* in CA (385–1410 µS/cm) was greater than that for MC-4 in the FCW of CO (89–518 µS/cm). Spies (1998) indicated that in warmer environments emergence of *T. pelsuei* appears to occur throughout the year. *Tanytarsus pelsuei*, a nuisance species in the rice fields of CA, did co-occur at site MC-4 with *Cricotopus bicinctus*, but not *C. sylvestris* or *Parachironomus tenuicaudatus* as indicated by Spies (1998); Spies (2000) assigned *T. pelsuei*, *C. bicinctus*, and *C. sylvestris* a class 1 nuisance rating because of their ubiquitous nature and frequency of abundance.

Subfamily Diamesinae

Oliver (1989) reported that the adult males of species in this subfamily range from small to large and are usually dark brown or black; the larvae vary from small to large and may be white, yellow-brown, brown, or red-yellow in color (Oliver 1983).

Genus *Diamesa* Meigen 1835

The larvae of the genus *Diamesa* are usually found in cold and cool waters of lotic habitats often emerging in the middle of winter as described by Herrmann et al. (1987). Epler (2001) reported the larvae of some diamesines may occur in lakes. The imagoes of a few species exhibit different levels of brachyptery. In the FCW only one species of this genus, *D. heteropus*, was collected.

Diamesa heteropus (Coquillett) 1905

Oliver (1989) reported that Diamesinae adults range from small to large and that larvae of *Diamesa* are cool to cold-adapted and emergent in winter. *Diamesa heteropus* was recorded only at site UF-3 (elevation 1860 m); Herrmann et al. (1987) found this diamesine at elevations of 1444 and 1431 m in the Arkansas River, and Sublette and Sublette (1979) reported it from most river systems of New Mexico below 2000 m. We expected to find this species at more LF sites since it is widely distributed in CO (Herrmann et al. 1987, Sublette et al. 1998, Ruse et al. 2000), NE (Hansen and Cook 1976), NM (Sublette and Sublette 1979), AZ (Sublette et al. 1998), and WA (Coquillett 1905, Sublette 1966). Sublette et al. (1998) stated that *D. heteropus* was the most widely distributed species of the genus in western North America, and usually occurred in cool to cold streams with cobble-gravel-sand substrata; site UF-3 conformed to his habitat description.

Subfamily Orthocladiinae

Many diverse species of orthoclads were collected from the FCW in this study. Cranston et al. (1989b) stated the male imagines of this subfamily ranged in size from small to large, and in body color from "brown to black, sometimes yellowish or whitish and occasionally greenish" with the tibiae often bearing light rings or bands. Clements (1994) found orthoclads in the UAR were numerous and

represented a major portion of the macroinvertebrate community at sites downriver from heavy metal discharges such as the Leadville Drainage Tunnel and California Gulch; unfortunately the chironomids in this study were identified only to tribe. In the Orthocladiinae parthenogenesis is common in terrestrial species but rare in aquatic forms (Moller Pillot 2014).

Genus *Apometriocnemus* Sæther 1985

In the genus *Apometriocnemus* only one species was found in the FCW—*A. fontinalis*; Sæther (1984) found *A. fontinalis* in a spring, and Cranston and Oliver (1988a) collected *A. beringensis* from 2 lentic locations of Trout Lake, YT. Apparently this genus occurs in standing and flowing waters.

Apometriocnemus fontinalis Sæther 1985

The distribution of *A. fontinalis* was limited to TN (type locality: a spring 19.3 km SE of Gatlinburg) until now (Sæther 1984). This species was collected from only one site in the FCW, UF-1, the location with the coldest thermal regime. At UF-1, surface sediment is 79% sand and very fine gravel and 20% fine to coarse gravel.

Genus *Brillia* Kieffer 1913

Two species of the genus *Brillia* of the Orthocladiinae occurred in the FCW: *B. flavifrons* and *B. retifinis*. Epler (2001) described *Brillia* species occurring in rheocrenes, streams, rivers, and shorelines of lakes; he also indicated this genus is nearly always associated with woody plant products, including leaves.

Brillia flavifrons (Johannsen) 1905

Species *B. flavifrons* is widely distributed in the Nearctic; it ranges over most of southern Canada and the United States (BC to NB south to NC, SC, GA, FL west to LA and NM) (Sublette and Sublette 1979, Oliver and Roussel 1983, Oliver et al. 1990, Caldwell et al. 1997). In the FCW *B. flavifrons* occurred in all 3 reaches (sites MC-2, 5, UF-1, 2, 3, LF-1); these stations range from cold- to cool- to warm-water thermal regimes. Oliver and Roussel (1983) described how *B. flavifrons* mined "decomposing deciduous wood," and how *B. retifinis* fed on individual "allochthonous leaves" or "leaf packets" in the water. Cranston

and Oliver (1988b) were uncertain whether this species was a miner of submerged wood or a dietary consumer of woody materials. Sublette and Sublette (1979) collected this species from 3 river systems in NM. Ruse et al. (2000) reported *B. flavifrons* from the uppermost 6 sites in the headwaters of the UAR; it was absent downstream from the Leadville area to Pueblo. In New York, Simpson and Bode (1980) found *B. flavifrons* in “clean headwater reaches,” and tolerant of unspecified toxic wastes.

Brillia retifinis Sæther 1969

Brillia retifinis is widespread across western North America; it occurs from AK, BC, MN and south to CA and east to CO (Sæther 1969, Oliver et al. 1990). The type locality was “a small mountain stream” in BC (Sæther 1969). In the FCW, *B. retifinis* was collected only at site UF-3, which is characterized by many cottonwood trees lining the banks. Leaf fall and branchlet fall from the plains and narrowleaf cottonwood trees (*Populus sargentii* and *P. angustifolia*) are major sources of allochthonous woody organic material for shredder and miner species of *Brillia* in the FCW. Ferrington et al. (2008) indicated that species of this genus are shredder-detritivores. Richardson (2001) reported that *B. retifinis* had a minimum of 3 generations a year in a cold second-order stream in British Columbia.

Genus *Cardiocladius* Kieffer 1912

The orthoclad genus *Cardiocladius* is represented by one species in the FWC—*C. obscurus*. The larvae of this genus chiefly occur in swiftly flowing streams and may tolerate toxic pollutants (Hudson et al. 1990)

Cardiocladius obscurus (Johannsen) 1903

Nearctic *C. obscurus* is distributed from ON, QC, PA, NY south to NC, SC, GA, FL west to MS, WY, UT (Oliver et al. 1990, Caldwell et al. 1997). In the FCW this species occurred at sites LF-1 and LF-5. Site LF-1 received a heavy metal load from Gold Hill sediments at site UF-4, and a phosphorus and bacterial load from MC-5 (Tables 2, 3) at the confluence of the UF and MC reaches upstream about 1 km. Site LF-5 was a warm-water station with elevated specific conductivity (1170–1437 $\mu\text{S}/\text{cm}$) and a shallow braided channel with 88% of substrate fine

gravel and sand. Neither Ruse et al. (2000), Powell (2008) nor Kleinert (2008) reported this species from the UAR or LAR.

Genus *Corynoneura* Winnertz 1846

Adult males of this genus are small (<4 mm) (Epler 2001) with wing length 0.7–1.3 mm and occurring in many types of permanent waters (Cranston et al. 1989b). Two species of *Corynoneura* were identified from the FCW: *C. artica* and *C. taris*.

Corynoneura artica Kieffer 1923

Corynoneura artica is Holarctic occurring in NT of Canada, PA in the U.S., west and east Palaearctic, and northern China (Oliver et al. 1990, Fu et al. 2009). Surprisingly, in the FCW *C. artica* was found only at warm-water site LF-5. This species usually occurs in very cold thermal regimes; for example, Ilyashuk et al. (2011) found *C. artica* highly abundant in the upper littoral of an oligotrophic Austrian alpine lake (2796 m elevation) where the total phosphorus was <5 $\mu\text{g}/\text{L}$, maximum specific conductivity 31 $\mu\text{S}/\text{cm}$, and pH 6.1. Values of the aforementioned parameters were considerably different than those for site LF-5 (Tables 2, 3). Langton (1991) reported *C. artica* from “montane and northern pools and lakes” in the west Palaearctic. In rock pools along the south-facing shore of Isle Royale, MI, within northwestern Lake Superior, *C. artica* emerged from both the “splash zones” and the “lichen zones,” but preferentially from the former zone (Egan and Ferrington 2015).

Corynoneura taris Roback 1957

The Nearctic range of *C. taris* covers much of the U.S. east of the Mississippi River OH, NY, NJ, south to FL, GA, NC, SC, MI, and TX (Oliver et al. 1990); it was collected from UF-4 and LF-3 in the FCW. In the original description of this species Roback (1957b) stated all specimens (holotype male, allotype female, and 3 paratypes) were collected from 4 lotic sites: 3 streams and 1 run; the water quality in these sites had total hardness >200 mg/L CaCO_3 and pH >8.0. For the 2 sites in the FCW, the total hardness range was 147–275, and the pH range 7.4–8.5. Roback (1974) indicated one additional site with pH 7.6, total alkalinity 111 mg/L CaCO_3 , and total hardness 149 mg/L CaCO_3 . After comparing the Nearctic *C. taris* with the Palaearctic *C. lobata*, Epler

TABLE 11. Distribution of species of *Cricotopus* found in the Fountain Creek Watershed (FCW). Global distribution letters follow Oliver et al. (1990): NE = Nearctic, HO = Holarctic, PA = Palaearctic, NT = Neotropical, AF = Afrotropical, USA = United States of America, UAR = Upper Arkansas River, LAR = Lower Arkansas River, GC-AZ = Grand Canyon Arizona. 1 = present, 0 = absent.

	<i>annulator</i>		<i>bicinctus</i>		<i>blinni</i>	<i>hermanni</i>	<i>infuscatus</i>	<i>sylvestris</i>	<i>trifascia</i>	<i>trifasciatus</i>	<i>varipes</i>
Global	HO	HO, NT, AF	HO, NT, AF	USA	USA	USA	NE	HO	HO	HO	NE
UAR	1	1	1	1	1	1	1	1	1	1	0
LAR	1	1	1	1	1	1	1	0	1	0	0
GC-AZ	1	0	0	1	1	1	1	0	1	0	0

(2001) concluded the 2 species were synonymous and *C. lobata* takes priority.

Genus *Cricotopus* Wulp 1874

Hirvenoja (1973) published a major revision on the genus *Cricotopus* of the western Palearctic; he included distributional and ecological data for most species. We have no comparable comprehensive work for Nearctic species of this genus. Nine species of *Cricotopus* were recorded for the FCW (Table 11). Five of the 9 are Holarctic, 2 are Nearctic, 2 are endemic to regions within the USA, and one is not only Holarctic but Neotropical and Afrotropical, namely, *C. bicinctus* (Simpson et al. 1983). Three species were not found at any of the UF sites: *C. bicinctus*, *C. blinni*, and *C. sylvestris*. Seven *Cricotopus* species were collected from site LF-1; 6 from MC-2, and 5 at LF-2, LF-3, and LF-5 (Table 4); the streambed of site LF-1 has some large boulder blocks (>2 m) of shale embedded in the sand and gravel matrix, providing prime sites for periphyton and algal growth (i.e., many microhabitats for various species of *Cricotopus*). In an ON stream, Salem Creek, LeSage and Harrison (1980b) intensively studied the biology and ecology of 15 species of *Cricotopus* occurring on a hard marl-covered creek bed; 6 of 9 of the FCW species of this genus were also included in their work; it was very interesting to compare the differences between the constantly shifting sand and gravel sediment of the FCW with the “very hard substrate covered by marl deposits” of Salem Creek.

Cricotopus (Cricotopus) annulator Goetghebuer 1927

Cricotopus annulator is a Holarctic orthoclad whose Nearctic distribution extends from ON to NL (Labrador) south to SC west to AZ, CA (Sublette and Sublette 1971, LeSage and Harrison 1980a, Caldwell et al. 1997, Sublette et al. 1998). Sublette et al. (1998) indicated this species occurs in a variety of lotic habitats, from spring runs to large rivers; Caldwell et al. (1997) found it in lentic biotopes as well. This species was found only at site LF-5, the station with the warmest thermal regime. In the Italian Alps Lencioni et al. (2011) found this species showing a substrate preference for bryophytes. We expected *C. annulator* to be more common in the FCW since it was found in a wide variety of flowing waters from

rheocrenes to fast, large rivers, and within a wide range of sand-gravel sediment mixtures. The only positive *C. annulator* site in the FCW (LF-5, elevation 1415 m) is at an elevation lower than that of the lowest site in the UAR study (AR-18, elevation 1497 m; Ruse et al. 2000), where this species occurred in large numbers to 2743 m elevation. In the LAR, Powell (2008) reported *C. annulator* from the same AR-18 site, and Kleinert (2008) recorded it from site AR-19 below Pueblo Reservoir dam.

Cricotopus (Cricotopus) bicinctus
(Meigen) 1818

In North America, the cosmopolitan Holarctic *C. bicinctus* (Spies 2000) (Table 11) occurs from SK, ON east to NB south to NY, NC, SC, GA, FL west to AL, NM, CA (LeSage and Harrison 1980a, Simpson and Bode 1980, Mason and Lehmkühl 1983, Oliver et al. 1990, Caldwell et al. 1997). Sublette and Sublette (1979) reported this species from 17 river systems in NM. In the FCW, *C. bicinctus* was found at 8 stations (MC-1, 2, 4, LF-1–5), having occurred in a wide variety of thermal and treated wastewater conditions. LeSage and Harrison (1980a) and Epler (2001) stated that *C. bicinctus* may be the commonest species in the genus *Cricotopus* and in the U.S. Spies (2000) gave this species the highest nuisance rating (1) possible. In Ohio, Boesel (1983) indicated there were apparently 3 or more generations each year for *C. bicinctus*.

Cricotopus (Cricotopus) blinni
Sublette 1998

Ruse et al. (2000) collected paratypes of *C. blinni* from 6 sites in the UAR; Sublette et al. (1998) reported records from CA, CO, NM, and AZ, a relatively restricted distribution. In the FCW this species was found at 8 sites (MC-1, 2, 4, LF-1–5); it appears this orthoclad tolerates a wide range of thermal conditions and organic enrichment. Sublette et al. (1998) found this species widespread in the “cold, swift Colorado River corridor” of the Grand Canyon where imagines were sweep-netted or light-trapped from July to February. We collected paratypes of *C. blinni* from 6 sites in the UAR (Ruse et al. 2000).

Cricotopus (Cricotopus) herrmanni
Sublette 1998

Sublette et al. (1998) cited the Nearctic (U.S.) distribution as CA, AZ, CO, and NM,

similar to *C. blinni*. The holotype of *C. herrmanni* was collected from the UAR at Cañon City, CO. In the FCW, *C. herrmanni* occurred at 7 sites (MC-1, 2, 3, 4, UF-3, 4, LF-1), all stations classified as thermally cold or cool. This species appears to prefer cold-water streams and rivers with sand-gravel beds. Sublette et al. (1998) first reported *C. herrmanni* as a new species from CO, CA, NM, and AZ in their paper on the chironomids of the Colorado River in the Grand Canyon, which is devoid of severe organic pollution and toxic metals sources. In the UAR this species was collected from 13 of 22 sites over most of the 220 km from Leadville to Pueblo, CO (Ruse et al. 2000). The UAR and FCW have stream segments that were impacted by sediments containing elevated concentrations of Cu, Zn, Pb, Cd, and As. Site UF-4 in the FCW was impacted by these metals; however, until recently, sites EF-2, AR-3–7 in the UAR were severely impacted by heavy metals pollution from the Leadville Drain, the Yak Tunnel’s California Gulch and Iowa Gulch (LaBounty et al. 1975). No adult males, only pupal exuviae of *C. herrmanni*, were collected by Ruse et al. (2000) from the aforementioned UAR sites; but males were collected from sites UF-3 and UF-4 in the FCW. The level of acute or chronic toxicity at these 2 UF sites was low enough for this species to tolerate the extant conditions.

Cricotopus (Cricotopus) infuscatus
(Malloch) 1915

The Nearctic distribution of *C. infuscatus* ranges from ON, SD, IL, OH, PA west to NM, AZ (Sublette and Sublette 1971, Oliver et al. 1990, Sublette et al. 1998). In the FCW, this species occurred at 12 of 14 sites (MC-1–5, UF-1, 4, LF-1–5), more than any other species of the genus and second to *C. decorus* in watershed distribution (Table 4). Occurrences at these stations appear to indicate that this species is an exceptionally euryokous generalist. Epler (2001) and Simpson and Bode (1980) stated *C. bicinctus* and *C. infuscatus* are tolerant of a variety of water pollutants. On the NCBI, it was assigned a high tolerance value of 9.0 (Lenat 1993). Spies (2000) placed *C. infuscatus* in the highest class (1) for being a nuisance species. Ruse et al. (2000) found this species at 7 cold-, cool- and warm-water sites (AR-8, 9, 16–20) in the UAR. Powell (2008) reported *C. infuscatus* from all 6 stations in her LAR investigation.

Cricotopus (Isocladius) sylvestris
(Fabricius) 1794

The Nearctic distribution of Holarctic *C. sylvestris* extends from AK, NT, KS, ON, IL, OH, PA, NY, CT, NJ south to NC, SC, FL west to AL, NM, CA (Sublette and Sublette 1979, LeSage and Harrison 1980a, Simpson and Bode 1980, Boesel 1983, Oliver et al. 1990, Caldwell et al. 1997). In the FCW, this species was recorded from sites MC-2, 3, LF-1, 3, cold-, cool- and warm-water locations. Menzie (1981) found the larvae living on the aquatic macrophyte *Myriophyllum spicatum* in the Hudson River estuary; Boesel (1983) reported that the larvae were associated with damage to pond-lilies, were nuisances in CA rice fields, and occurred in *Spirogyra* masses. Simpson and Bode (1980) reported *C. sylvestris* from highly turbid, slow to moderately flowing rivers and streams in NY. Sublette and Sublette (1979) recorded this widespread orthoclad in NM from streams, rivers, irrigation ditches and springs. In England Mundie (1957) indicated that *C. sylvestris* was multi-voltine with 3 generations per year. In NY, Simpson et al. (1983) found *C. sylvestris* and *C. trifasciatus* occurring together in samples; only in site LF-1 was this co-occurrence observed in the FCW. Ruse et al. (2000) collected *C. sylvestris* from cold-water sites AR-6, 8, 9, 11, 13 in the UAR. Neither Kleinert (2008) nor Powell (2008) reported this species from the LAR.

Cricotopus (Cricotopus) trifascia
Edwards 1929

The North American distribution of *C. trifascia* ranges from SK, ON, OH, PA, NY south to NC, FL west to NM, AZ, CA (Sublette and Sublette 1979, LeSage and Harrison 1980a, Simpson and Bode 1980, Boesel 1983, Oliver et al. 1990, Caldwell et al. 1997, Sublette et al. 1998). In the FCW, *C. trifascia* occurred in 11 of 14 sites, in all 3 reaches, and in all temperature regimes—cold, cool, and warm. In NY Simpson and Bode (1980) found the distribution of this species “patchy,” and usually found it in “rapidly flowing waters” from first-order streams to the Niagara River; they concluded it was probably saproxenous (Beck 1977). In NM, Sublette and Sublette (1979) collected it from the turbid Rio Grande, Navajo River and San Juan River. Spies (2000) placed this species in nuisance class 3, where it was at

most infrequent and never abundant. In the UAR Ruse et al. (2000) reported *C. trifasciatus* from 2 cool-water stations immediately above and 2 warm-water sites just below Pueblo Reservoir. Kleinert (2008) and Powell (2008) identified this species from all 5 sites 10 km below Pueblo Reservoir in the Legacy Reach.

Cricotopus (Isocladius) trifasciatus
(Meigen) 1813

The North American distribution of *C. trifasciatus* includes BC, ID, IL, ON, OH east to NY south to MO, NC, SC, FL west to NM, and now CO (Sublette and Sublette 1965, Boesel 1983, Oliver et al. 1990). In the FCW, it was collected from 5 sites (MC-5, UF-3, 4, LF-1, 2), all either cool-water or warm-water locations. This species was present at site UF-4, a station impacted by heavy metals in the streambed sediments from the Gold Hill ore smelter tailings pile. In the UAR, Ruse et al. (2000) reported *C. trifasciatus* from one site, AR-5, a location heavily polluted by Iowa Gulch mining discharges. This species appeared tolerant of heavy metals in solution, suspended matter, and sediments.

Cricotopus (Cricotopus) varipes
Coquillett 1902

Nearctic *C. varipes* is distributed from NT, WA, ON, NY, CT, MD south to NC, SC, GA, FL west to CO (Oliver et al. 1990, Caldwell et al. 1997). In the FCW it was collected only at station MC-1, a cold-water site. LeSage and Harrison (1980a, 1980b) reported *C. varipes* from a stream in southern Ontario that was described as alkaline and well oxygenated but having hard sediment encrusted with marl; the surface water of site MC-1 was certainly alkaline and well oxygenated (Tables 2, 3), but 85% of the streambed was soft sand and very fine gravel (Table 9) with no marl. Lenat (1993) published a high NCBI pollution tolerance value of 8.1 for this species. Of the 6 species of *Cricotopus* that Sublette et al. (1998) reported from the Grand Canyon, *C. varipes* was not one of them; Ruse et al. (2000) did not report it from the UAR, and neither Kleinert (2008) nor Powell (2008) reported it from the LAR.

Genus *Diplocladius* Kieffer 1908

In the FCW the genus *Diplocladius* was represented by one species—*D. cultriger*. Epler (2001) reported that the larvae of this

genus are mostly found in lotic habitats such as springs and cool streams.

Diplocladius cultriger Kieffer 1908

Only one species of *Diplocladius* occurred in the FCW—*D. cultriger*. This Holarctic orthoclad is the only species in the genus and ranges throughout the eastern United States (OH, PA, NY, CT, NC, SC, GA, AL, NE) (Sublette and Sublette 1965, Oliver et al. 1990, Caldwell et al. 1997, Epler 2001). Recently Hayford et al. (2014) reported this orthoclad from the Kuskokim River watershed of western AK. The larvae are primarily found in cold streams and springs in the winter but may also occur in lentic habitats (Hudson et al. 1990, Langton 1991). In the FCW we found this species only at MC-2, a cold-water site at 2032 m elevation near the north entrance of the Air Force Academy. In the Italian Prealps and Alps, Lencioni et al. (2011) found this species only in bryophytes of rheohelocrenes (springs with seeping stream and muddy substrate but without pools). In the UAR, Ruse et al. (2000) found this bryophilous species only at 4 headwater sites (AR-2, 3, 4, and 6), locations with sediments contaminated with heavy metals but not the most severely polluted.

Genus *Eudactylocladius* Thienemann 1935

Sublette and Sublette (1979) and Sublette et al. (1998) proposed and discussed different generic positions for 2 species of orthoclads: *Orthocladus* (E.) *dubitus* Johannsen to *E. dubitus* (Johannsen) and *Orthocladus* (E.) *fuscimanus* (Kieffer) to *E. fuscimanus* (Kieffer). On the basis of adult male genitalia, Sublette et al. (1998) believed the genus *Eudactylocladius* could “be separated from the closely related [genus] *Orthocladus*”; in this report we retained the former genus when referring to *dubitus* and *fuscimanus*. We found these 2 species in the FCW study. Both of these species were commonly collected from hygropetric or madicolous biotopes (Cranston 1984, 1998, Sublette et al. 1998).

Eudactylocladius dubitus (Johannsen) 1942

Eudactylocladius dubitus has a Nearctic distribution extending from AK, BC, WA, OR, AB, MB, ON, ME south to NY, PA to OH south to NC, GA, FL then west to CO, NM, and CA (Cranston 1998, Sublette et al. 1998, Epler 2001). In the FCW, *E. dubitus* was

collected only at site MC-4, a habitat with algae-covered rocks (>30 cm) in riffle areas over which a thin film (<2 mm) of water continuously flows, particularly along the stream margins. Sublette et al. (1998) suggested *E. dubitus* is likely a madicolous species. This species was reported from sites AR-2 and AR-5 in the UAR by Ruse et al. (2000). Heavy metals pollution is moderate at AR-2 but severe at AR-5 below Iowa Gulch; at both sites many seeps and springs with algae and bryophytes provide madicolous conditions. Kleinert (2008) and Powell (2008) did not collect this species from the warm-water locations in the LAR.

Eudactylocladius fuscimanus (Kieffer) 1908

Eudactylocladius fuscimanus appears to be primarily Palearctic in distribution, with no published records from the Nearctic region (Cranston 1984, 1998, Oliver et al. 1990, Caldwell et al. 1997, Hamerlík et al. 2010). In the FCW this species was identified only at site MC-1, a station with thin films of water coursing over algae-covered rocks (20–30 cm). Cranston (1984) first reported the madicole *E. fuscimanus* from filter beds of sewage plants and from hygropetric seeps near seacoasts above high tide line; Pinder (1995) stated that *E. fuscimanus* is an obligate madicole; Hamerlík et al. (2010) first documented this species from 4 fountains in Denmark. In these specialized hygropetric biotopes *E. fuscimanus* was often associated with *Limnophyes minimus* (Cranston 1984); even though both species occurred in the FCW, they were never collected together. No Colorado records of *E. fuscimanus* from the UAR or LAR have been reported.

Genus *Eukiefferiella* Thienemann 1926

Five species of *Eukiefferiella* were collected from the FCW: 2 new species designated by coauthor JES (*E. n. sp. 9* [cuesta.ns.name] and *E. n. sp. 4 NM & CO*), and *E. claripennis*, *E. coerulescens*, and *E. graciei*.

Eukiefferiella claripennis (Lundbeck) 1898

The global distribution of *E. claripennis* is Holarctic, including HI, and widespread in the Nearctic (Oliver et al. 1990, Sublette et al. 1998): NT, BC, AB, MB, MN, MI, PA, NY south to NC, SC west to NM, CO, ID and WA

(Sublette and Sublette 1979, Bode 1983, Oliver et al. 1990). Langton (1991) indicated this species occurs in “streams and occasionally lakes in the north” of the west Palearctic. In NY Bode (1983) reported it as common and widespread in large, warm rivers to cold, high-elevation streams. In Iceland springs, Hannesdóttir et al. (2012) followed its development and concluded that eurythermal *E. claripennis* was univoltine at mean water temperatures of 5.3 °C and 5.4 °C, and bivoltine at a mean temperature of 13.5 °C. In the FCW, 9 of 14 sites were positive collections for *E. claripennis*. Of all 14 sites, site UF-4 in the FCW had the highest concentrations of dissolved and total heavy metals in the surface water (USEPA 1994); *E. claripennis* occurred at this site. In the zinc-polluted River Nent of England, Armitage and Blackburn (1985) found *E. claripennis* a relatively tolerant species; in a report by Wilson (1988) comparing chironomid exuvial samples from the polluted River Nent and the East and West Allen tributaries, this species was dominant in the Allen sites but not in the Nent locations. Calcium concentrations were lower in the Nent and apparently impacted the species assemblages. In the LAR and UAR, both *E. claripennis* and *E. coerulescens* were commonly collected (Ruse et al. 2000, Kleinert 2008, Powell 2008). In the UAR Ruse et al. (2000) collected adults and exuviae of *E. claripennis* from 21 of 22 sites, which included the most heavily impacted heavy metals sites of EF-2 (immediately downstream of Leadville Drain), AR-3 (immediately below California Gulch), and AR-5 (just beyond Iowa Gulch); the only exceptional site (EF-1) was at the headwaters of the East Fork of the Arkansas River with a very cold thermal regime and an elevation of 3042 m. From the available literature (Bode 1983) and from our data, we concluded *E. claripennis* is extremely tolerant of organic enrichment and toxic metal pollutants. In acid-stressed first-order streams in the Adirondacks of NY, Simpson (1983) and Simpson et al. (1985) indicated *E. claripennis* was acidobiontic (larvae living at pH <5.5).

Eukiefferiella coerulescens (Kieffer) 1926

The Holarctic *E. coerulescens* is distributed in North America in the following provinces and states: AB, MB, NY, SC, NM, CO, and AZ (Bode 1983, Caldwell et al. 1997, Sublette et

al. 1998). Sublette et al. (1998) stated that *E. coerulescens* “is probably more widely distributed in the Nearctic region than records indicate.” This species was considered a member of the madicolous assemblage by Oliver and Sinclair (1989). Langton (1991) described this species occurring in “northern and montane lakes and streams” in the western Palearctic. In the FCW this species was present in 10 of 14 total sites, in all MC stations, and in all 3 reaches of the watershed; it occurred at site UF-4—the most polluted location for heavy metals from the Gold Hill tailings pile (USEPA 1994). It appears to be tolerant of a wide range of temperature, treated wastewater, and toxic metals, very similar to *E. claripennis*. In the UAR, Ruse et al. (2000) reported this species from 15 of 22 sites that included very cold to warm thermal regimes and toxic metals. In the LAR Powell (2008) collected adults of both *E. coerulescens* and *E. claripennis* at the same 2 sites immediately above and below Pueblo Reservoir.

Eukiefferiella gracei (Edwards) 1929

Holarctic *E. gracei* is commonly collected in the western Palearctic but there are few Nearctic records (WA, CO, ID, MT, MI, NY, NC) (Bode 1983). In the FCW we collected this species from only one site (MC-1); this station has a cold-water regime with about 40% of the substrate gravel (Table 9). Pinder (1980) found that the larvae were the dominant gravel species in May of an English chalk stream. We concluded that *E. gracei* is apparently less tolerant of elevated temperatures, and occurs where FPOM plus inorganic detritus are optimal, heavy metals loads minimal, and wastewater discharges little or none. Bode (1983) found larvae of *E. gracei* in North Boulder Creek, CO, which is a swift, clean cold-water stream at 3300–3800 m elevation. Lenat’s (1993) North Carolina biotic index (NCBI) included a tolerance value for *E. gracei* of 2.7—indicating this species is restricted to clean, unpolluted waters. In the UAR and LAR Ruse et al. (2000) and Powell (2008) did not report this species.

Eukiefferiella n. spp.

Two new species of *Eukiefferiella* were identified in the FCW; *E. n. sp. 4* NM & CO was recorded from site UF-1, a cold-water location at elevation 2335 m, and *E. n. sp. 9*

[cuesta.ms.name] from stations MC-1 and MC-3, the former a cold-water biotope at 2097 m elevation and the latter a cool-water site at 1943 m (Table 5).

Genus *Halocladius* Hirvenoja 1973

Hirvenoja (1973) proposed the genus *Halocladius* gen. n. and used *Chironomus varians* as the type species. Cranston et al. (1983) described larvae as medium sized and occurring in coastal brackish or inland saline waters. Cranston et al. (1989a) reported that adults are small to medium in size with wings reaching 3.0 mm in length. The only species of this genus found in the FCW was a new species.

Halocladius n. sp.

The genus *Halocladius* was represented by one new species and designated by JES as *H. n. sp. CO-1*. This species occurred only at site LF-1. We have no other records of this genus from the UAR, the LAR, NM, and the region. Ferrington et al. (2008) cited this genus as occurring in *Fucus* of beach zones of the marine habitat along the northeast coast of North America. Pinder (1995) stated *Halocladius* species tolerate a wide range of salinities. Taşdemir (2010) discussed the distributions of the 7 species known for this small genus.

Genus *Heleniella* Gowin 1943

The larvae of the genus *Heleniella* are usually small (<4.5 mm length) and are “cold, stenothermic rheophiles” (Cranston et al. 1983). In the FCW this genus was represented by only one species—*H. hirta*.

Heleniella hirta Sæther 1969

The global distribution of *H. hirta* is Nearctic with Canadian records from ON, QC (Sæther 1969), and NS (Cranston and Oliver 1988a), plus U.S. records from NC, GA (Hudson et al. 1990), and MI (UMMZ 2011; Pat Hudson personal communication). In the FCW this species was collected only at site MC-1, a cold-water station. No other Colorado records are known from the UAR and LAR. The holotype male was collected from a stream in QC and the allotype female from a stream in ON (Sæther 1969). Hudson et al. (1990) found larvae of this species in low-order streams of GA and NC.

Genus *Limnophyes* Eaton 1875

Within the genus *Limnophyes* we identified 9 species: *L. angelicae*, *asquamatus*, *fumosus*, *hastulatus*, *immucronatus*, *margaretæ*, *minimus*, *natalensis*, and *recisus*. The global, UAR, LAR, and Grand Canyon distributions are cited in Table 12; it is evident that species of this genus were not readily collected from the Arkansas River upstream of its confluence with Fountain Creek or from Arizona's Grand Canyon. Three species of *Limnophyes* were reported only between sites AR-2 and AR-14 of the UAR by Ruse et al. (2000). Two species, *L. minimus* and *L. natalensis*, are nearly worldwide in distribution with the exception of the Australasian Realm for both, and the Neotropical Realm for the latter. There is some uncertainty about *L. immucronatus* occurring in the Palearctic. Three species are clearly Holarctic, and 4 others Nearctic.

Two species occurred in all 3 reaches of the FCW: *L. margaretæ* and *L. natalensis*. *Limnophyes asquamatus* and *L. minimus* were collected only from UF and LF sites; *L. hastulatus* and *L. recisus* only from UF and MC sites; *L. angelicae* and *L. fumosus* only from MC sites; and *L. immucronatus* only from one site (UF-3).

Limnophyes angelicae Sæther 1990

This Palearctic species of *Limnophyes* appeared to be new to North America and Colorado. Przhiboro and Sæther (2007) described the Russian habitat of a small oligotrophic lake from which Przhiboro collected the larvae of *L. angelicae* and *L. natalensis*. The former species was collected at site 1 with sand-gravel-pebble sediment covered by fragments of sedge, leaves, and tree bark and supporting a small growth of *Carex rostrata*; the latter species was recorded at site 2 composed of sand covered with detritus and coexisting with a few clusters of *Phragmites australis*. In the Sylva River of the Middle Ural Mountains of Russia, *L. angelicae* exhibited a summer-only emergence phenology (Krasheninikov 2012). In the FCW, *L. angelicae* occurred only at site MC-1 in July, August, and early September—a site where a cold-water temperature profile and BDL phosphorus concentrations existed (Tables 2, 3).

Limnophyes asquamatus Andersen 1937

A northern Holarctic distribution describes the distributional range of *L. asquamatus*. In

TABLE 12. Distribution of species of *Limnophyes* found in the Fountain Creek Watershed (FCW). Global distribution letters follow Oliver et al. (1990): NE = Nearctic, HO = Holarctic, PA = Palearctic, NT = Neotropical, AF = Afrotropical, AU = Australasian, COS = Cosmopolitan, USA = United States of America; UAR = Upper Arkansas River, LAR = Lower Arkansas River; GC-AZ = Grand Canyon Arizona; 1 = present, 0 = absent. An underlined faunal realm indicates no records found.

	<i>angelicae</i>	<i>asquamatus</i>	<i>fumosus</i>	<i>hashulatus</i>	<i>immucronatus</i>	<i>margaretae</i>	<i>minimus</i>	<i>natalensis</i>	<i>recisus</i>
	HO	HO	NE	NE	NE, PA?	NO	COS (AU)	COS (AU & NT)	NE
Global									
UAR	0	1	0	1	0	0	0	1	0
LAR	0	0	0	0	0	0	0	0	0
GC-AZ	0	0	0	0	0	0	0	0	0

the Nearctic, Sæther (1990) reported it as far south as WV, and concluded this species of *Limnophyes* lives primarily in small lotic habitats and is truly aquatic. Caldwell et al. (1997) reported it from the southeastern U.S. (SC and GA), while Oliver and Dillon (1997) listed it from northern sites in AK, BC, the Yukon Arctic Slope, Greenland, Queen Elizabeth Islands, South Arctic Islands, and west of Hudson Bay. In the Italian Alps, Lencioni et al. (2011) collected this bryophilous species from hygropetric biotopes. We collected *L. asquamatus* from sites UF-4, LF-2, and LF-3, sites largely devoid of any visible bryophytes associated within the stream or on stream banks. Langton (1991) reported collecting larvae of this species from “moss on damp soil.” Dettinger-Klemm (2003) found *L. asquamatus* to be an opportunistic dweller of temporary pools in the Lahnberge mountain range of Germany; all larval instars were drought tolerant aestivators and could suspend growth when water disappeared, then later resume development once the pool refilled; the larvae would form silk-lined tubes when water dried completely and substrate moisture levels prevented additional development. This species reproduces both sexually and parthenogenically, leading Dettinger-Klemm (2003) to propose this species occurs as 1 sexual and 2 parthenogenetic ecotypes; from this temporary pool study he concluded *L. asquamatus* could complete terrestrial eclosion. At sites LF-2 and LF-3 in the FCW, many temporary pools are subjected to the same filling and drying cycles along the highly braided streambed. Phenological data for *L. asquamatus* from the Middle Ural Mountains of Russia indicated 2 distinct emergence periods, one in May and another in July (Krashennikov 2012).

Limnophyes fumosus (Johannsen) 1905

Pinder (1995) described *L. fumosus* as an obligate madicolous species. The Nearctic distribution includes eastern Canada and eastern USA (ON to NY, south to GA) (Sublette and Sublette 1965, Cranston and Oliver 1988a, Oliver et al. 1990). In the FCW this species occurred at sites MC-4 and MC-5 within the city limits of Colorado Springs; both sites have concrete levees for banks with willow, cottonwood trees, and scant *Typha latifolia* anchoring the streambed. Cranston and Oliver (1988a) cited a hygropetric seep as the source

of this species in ON; Hudson et al. (1990) indicated that its habitat in GA and SC was streams (≤ 12 m wide); Sæther (1990) reported this species from a “trickle” in SC.

Limnophyes hastulatus Sæther 1975

Limnophyes hastulatus is another Nearctic species occurring from BC to ON, south to SD and MN (Sæther 1975b, 1990, Cranston and Oliver 1988a, Oliver et al. 1990). Sæther (1975b) documented the holotype and paratypes from creeks, a spring pool and springs in SD and MN. Ruse et al. (2000) reported adults of this species from site AR-2 in the UAR; AR-2 at 2905 m elevation is characterized by a very cold (maximum temperature 14.2 °C) thermal regime and large cobble streambed. In the FCW, it was collected from sites MC-3 (1943 m elevation) and UF-4 (1818 m elevation); the former site receives runoff from the Air Force Academy and the latter receives heavy metal contributions from Gold Hill, a huge remnant tailings pile from gold ore processing.

Limnophyes hudsoni Sæther 1975
[= *L. immucronatus* Sæther 1969]

Limnophyes hudsoni is a junior synonym used by the coauthor JES for *L. immucronatus*; we used the former name in this publication. The distribution of this Nearctic species extends from YT, NT, BC east to NS, south to NM, NE, and SC (Sæther 1969, 1975b, Cranston and Oliver 1988a, Oliver et al. 1990); Oliver et al. (1990) questioned records of this species from the Palearctic. Sæther (1975b) reported the holotype male of *L. hudsoni* from the Missouri River in NE, the allotype female from Beaver Creek near Yankton, SD, and paratype males from a “small artesian fed creek” of the Missouri River bottomlands in NE. Sæther (1969) cited the collection of the holotype male of *L. immucronatus* from a dock at Marion Lake, BC. In the FCW, this species was recorded only at site UF-3, a location where large amounts of leaf fall from willow and cottonwood trees occurred.

Limnophyes margaretae Sæther 1975

The holotype male and a paratype male of *L. margaretae* were collected from the Lake Winnipeg area, MB, Canada (Sæther 1975b); the latter male was collected from a creek. This Holarctic species has been reported from Sweden, eastern Russia, and now Finland

(Fauna Europaea 2014, Paasivirta 2014) in the Palearctic; in the Nearctic it has been listed only from MB. In the FCW, *L. margaretae* was collected from 7 sites in all 3 segments of the FCW (Table 4); this species appears to tolerate cold- to cool-water thermal regimes with elevated concentrations of total and dissolved phosphorus and elevated coliform bacterial counts.

Limnophyes minimus (Meigen) 1818

Limnophyes minimus is a cosmopolitan species except for Australasia (Fauna Europaea 2014). In North America, *L. minimus* ranges from the Yukon Arctic North Slope, NT, BC, MB, ID, ON, NS south to FL, AL, and CO (Sublette and Sublette 1965, Oliver et al. 1990, Sæther 1990, Caldwell et al. 1997, Oliver and Dillon 1997); in the west Palearctic, larvae have been reported from seeps, damp rocks and soil, moss, dead leaves, margins of streams, and lakes (Langton 1991). Cranston (1984) reported that this chironomid was one of 3 species that were abundant on the percolating filter beds of sewage treatment facilities in the United Kingdom; *L. minimus* along with *Metriocnemus hygroperitis* and *Orthocladius fuscimanus* were considered hygroperitic species consuming the bacterial film on the filters. In the FCW this species occurred at 2 contiguous sites, UF-4 and LF-1, each with some disparate water quality and sediment characteristics, particularly for Colilert® coliform MPN's, total phosphate, and substrate sand-gravel percentages (Tables 2, 3, 10). This species is a facultative parthenogenetic species (Sæther 1990). In Russia, Krasheninnikov (2012) reported the adult emergence phenology as spring to summer.

Limnophyes natalensis (Kieffer) 1914

The nearly cosmopolitan *L. natalensis* has been reported from many aquatic habitats including springs, a semipermanent pool in a quarry, moss (*Sphagnum*) by a trickle, streams, rivers, and seeps (Sæther 1990, Langton 1991). In North America it ranges from MB, NS, SD, WI east to SC west to NM (Sæther 1975b, Sublette and Sublette 1979, Sæther 1990, Caldwell et al. 1997). Krasheninnikov (2012) reported this species emerging spring to autumn from the Sylva River in Middle Urals, Russia. In the FCW sites MC-1, 3, UF-4, and LF-1 provided widely varying microhabitats

for *L. natalensis*; willows, 2 species of cottonwood trees, tamarisk, and common or cane reed (*Phragmites communis*) were predominant bankside plants in different stream reaches.

Limnophyes recisus Sæther 1975

Limnophyes recisus has a restricted Nearctic distribution; it occurs from SD, south to NM and NE (Sæther 1975b, Sublette and Sublette 1979, Sæther 1990). The holotype male was collected from a "small artesian fed creek" near Niobrara, NE; paratype males were found in a creek and spring near Springfield, SD (Sæther 1975b). Sublette and Sublette (1979) reported males from the Rio Grande near Ildefonso Pueblo, NM, and the Navajo River near Edith, CO; Sæther (1990) examined more paratypes from SD. In the FCW this species was found at the 3 uppermost UF sites and MC-4; in 3 of the 4 sites, the fine to coarse sand exceeded 45%, with site UF-2 being the exception at 33% (Table 9); rank growths of willows and cottonwood trees compose the bankside vegetation for all 4 sites. Sublette and Sublette (1979) collected adults in NM from mid-July to early October during 1974 and 1976.

Genus *Metriocnemus* Wulp 1874

Cranston et al. (1983) and Epler (2001) indicated that the larvae of this genus are found in bryophytes and many types of lotic and lentic habitats including sewage treatment beds, tree holes, damp soil, lakes, and madiculous or hydropetric locations. For the FCW we found only one new species from this genus—*Metriocnemus* n. sp.

Metriocnemus n. sp.

One new species of *Metriocnemus* was collected in the FCW; coauthor JES designated this species *M.* n. sp. (Table 5). This species was collected only from site UF-1, the site with the greatest elevation (2335 m) of the 14 sites.

Genus *Nanocladius* Kieffer 1913

Larvae of this genus occur in lentic and lotic habitats as free-living, phoretic, or parasitic species (Cranston et al. 1983, Epler 2001). Two free-living Nearctic species of *Nanocladius* were found in the FCW: *N. incomptus* and *N. spiniplenus*.

Nanocladius (Nanocladius) incomptus
Sæther 1977

Sæther (1977) described *N. incomptus* from reservoir and lake sites; this species ranges from ON to NC, SC and GA (Oliver et al. 1990, Caldwell et al. 1997). Sæther (1977) felt the larvae of this species were primarily lentic inhabitants; he also reported that the emergence phenology of *N. incomptus* from Keowee Reservoir in SC included 2 intervals, February to April and October. Hudson et al. (1990) reported collecting this species from lakes and streams in the southeastern U.S. In the FCW it was identified only from site MC-1, a stream segment characterized by a cold-water thermal regime, low total hardness and alkalinity, and low phosphorus nutrient loads (Tables 2, 3). After examining many stonefly and mayfly immatures in the FCW, we have concluded that *N. incomptus* is a free-living, nonphoretic chironomid.

Nanocladius (Nanocladius) spiniplenus
Sæther 1977

Nanocladius spiniplenus was described by Sæther (1977) from a holotype female collected from a creek in ON, paratype exuvia from SC, and 6 males and a female from SC and NB. Oliver et al. (1990) reported it from SK, ON, OH, NC, and SC; additionally, Caldwell et al. (1997) cited it from NC, GA, FL, and AL. Sæther (1977) stated this species was likely a rheophile with 2 adult flight periods. Site MC-3 was the only location from which *N. spiniplenus* was recorded; this cool-water site has elevated phosphorus loads, elevated Colilert® (coliform) MPN's, and a pH range of 7.2 to 8.2 (Tables 2, 3). Dosdall et al. (1986) indicated *N. spiniplenus* is a phoretic species with the larvae often being transported by the stonefly *Pteronarcys dorsata* (Say) in Canada. DeWalt and Olive (1988) studied the occurrence of chironomids upstream and downstream of a glacial silt deposit that periodically releases a milky suspended load into an OH stream for 5 km; *N. spiniplenus* tolerated upstream conditions but was absent at the downstream site, which was 4 km below the silt deposit. In NY Simpson and Bode (1980) described this species as apparently rheophilous, occurring in clean lotic habitats and not tolerant of excessive organic enrichment or toxic wastes.

Genus *Orthocladius* Wulp 1874

Five species of *Orthocladius* were collected in the FCW: *O. appersoni*, *dorenius*, *frigidus*, *obumbratus*, and *rivicola*; 4 species, *O. appersoni*, *frigidus*, *obumbratus*, and *rivicola*, occurred at site MC-1 (a cold-water thermal regime); 3 species, *O. frigidus*, *O. obumbratus*, and *O. rivicola* co-occurred at site MC-2 (a cold- to cool-water regime). Epler (2001) indicated that finding multiple species at a site could be expected for this genus. Hudson et al. (1990) and Epler (2001) indicated that the species of this genus are primarily lotic (streams and rivers) but may occur in other habitats.

Distributional and ecological notes for 3 of 4 FCW species of *Orthocladius* were cited by Sponis (1977); *O. appersoni* appears to be in cool to cold streams at high latitudes (AK and YT) and montane elevations (CA, MT, and CO). Sponis (1977) stated *O. dorensis* and *O. obumbratus* are often found together; however, in FCW the former occurred at a warmer-water site (LF-1) and the latter at cooler sites (MC-1, 2, 4) (Tables 2, 3). Sponis (1987) re-described *O. frigidus* and provided updated distributional and ecological data; this species occurs in algal and moss masses of lotic habitats in mountainous and northern locations of the Nearctic, Palearctic, and Oriental eco-regions. In the FCW, *O. frigidus* co-occurred with *O. obumbratus* at sites MC-1, 2. Sæther (2004) proposed placing *O. frigidus* back into the genus *Euorthocladius*.

Orthocladius (Orthocladius) appersoni
Sponis 1977

Oliver et al. (1990) described the Nearctic distribution of *O. appersoni* ranging from AK and YT, south to NY, CO, MT, and CA. In the UAR Ruse et al. (2000) reported this species from only site AR-15, a cold-water location. Sponis (1977) examined a male collected from the Lake Fork of the Gunnison River in Hinsdale County, CO; the approximate elevation of this general location is ≥ 2744 m. The Lake Fork at this elevation is a cold-water regime. Ruse et al. (2000) found *O. appersoni* in the UAR only at cold-water site AR-15 near Parkdale, CO (elevation 1746 m). This species was not reported from the LAR by Kleinert (2008) or Powell (2008), and Sublette et al. (1998) did not report it from the Colorado River's Grand Canyon.

Orthocladius (Orthocladius) dorenius
(Roback) 1957

Orthocladius dorenius is a Nearctic orthoclad ranging from YT and NT east to ON, NB south to NY, SC west to CO, OR and NM (Roback 1957b, Sponis 1977, Sublette and Sublette 1979, Oliver et al. 1990); eastern and western North American streams and rivers support this species (Sponis 1977). Egan and Ferrington (2015) reported this orthoclad from splash zone pools on the shore of Lake Superior (Isle Royale National Park). In the FCW we collected it only from site LF-1, a cool-water location with moderate total hardness and total alkalinity. In the UAR Ruse et al. (2000) reported it from AR-1, a reach with a very cold-thermal regime and with moderate heavy metals contamination. We have not yet collected this species from the LAR. Roback's (1957b) type locality was Wissahickon Creek, Philadelphia, PA; the creek had slow flow, murky water, sand and mud substrate, and some rocks near the banks.

Orthocladius (Orthocladius) frigidus
Zetterstedt 1838

The Holarctic species *O. frigidus* occurs in "northern and mountainous" North America from CA to NM and CO in the west, and MN, PA, southeast U.S. (NC, SC, GA), and Greenland in the east (Sponis 1987, Caldwell et al. 1997, Sublette et al. 1998, Epler 2001, Anderson and Ferrington 2013). In the west Palearctic, Langton (1991) stated the larvae occur in "montane streams and lakes," and occur "on stones at the water surface." In reporting notes on the biology of *O. frigidus*, Sponis (1987) summarized contributions by several European authors; the larvae are free-living or produce mud tubes, live in bryophytes and algal masses in lotic habitats, and have been classified as rheophilic hemitenotherms. Adult emergence patterns varied by location, February to November, January to May, and April to May (Sponis 1987). In MN Anderson and Ferrington (2013) reported this species as a winter-emerging chironomid. Lindegaard and Mortensen (1988) determined that this species is multivoltine and may produce 4 or more generations per year. Sublette et al. (1998) complemented the biological material of Sponis (1987) with a detailed review of the ecology that included Palearctic and Nearctic publications. Armitage and

Blackburn (1985) reported this species could tolerate intermediate concentrations of zinc (0.77–1.68 mg/L) in an English river system; Wilson (1988) studied the same River Nent watershed and concluded metal pollution was not the only parameter influencing chironomid distribution. In the FCW this species occurred at cold-water sites MC-1 and MC-2; both sites have cobble >30 cm forming riffle zones where filamentous algae are common. Sublette et al. (1998) concluded the reason they collected only one larva from the Grand Canyon was due to the scouring action of the Colorado River macerating algal growths on the gravel substrate. In the UAR Ruse et al. (2000) collected this species frequently from 15 of 22 very cold- and moderately cold-regime sites; adults did not occur at site AR-3 downstream of California Gulch but did occur in large numbers at site EF-2 below the Leadville Drain and in lesser numbers at site AR-5 downriver of Iowa Gulch—all 3 sites heavily impacted by heavy metals including Zn. Pupal exuviae were collected at site AR-3. No adults were recorded below site AR-15 (elevation 1746 m) in the UAR (Ruse et al. 2000).

Orthocladius (Orthocladius) obumbratus
Johannsen 1905

A fourth orthoclad species collected in the FCW was *O. obumbratus*, a widespread Nearctic representative with a distribution extending from AK, NT, AB east to MB, NB, NY, MA south to AL, GA, AR west to TX, CO, NM, AZ, and CA (Sublette and Sublette 1965, Sponis 1977, Oliver et al. 1990, Caldwell et al. 1997). It occurred at 3 sites in the FCW: MC-1, 2, and 4, all cold- or cool-water sites. In the UAR Ruse et al. (2000) collected adults and exuviae in 2 separated reaches: sites AR-2, 4, 6, and 7, and sites AR-16, 19, and 20. Why this species was not recorded from the headwater sites (EF-1, 2, and AR-1) or from a continuous cluster of sites (AR-8–15) midway in the UAR is unknown. In the LAR, Kleinert (2008) and Powell (2008) recorded this species from 3 sites below Pueblo Reservoir and upriver of the confluence of the Arkansas River and Fountain Creek. Interestingly, this species was not collected from any UF or LF sites in the FCW. Apparently this species is tolerant of lotic cold-water and cool-water habitats and is a rheophilous eurythermophile.

Simpson and Bode (1980) considered this species saproxenous. The NCBI tolerance value is 8.8, indicating it is not greatly sensitive to organic wastes (Lenat 1993).

Orthocladius (Euorthocladius) rivicola
Kieffer 1911

Euorthocladius rivicola is the species name assigned to *Orthocladius rivicola* by our co-author JES; we will use the genus name *Euorthocladius* in this report. Globally, this Holarctic species is widely distributed in the Nearctic from NT, SK, NC, SC, TN, GA west to Grand Canyon, AZ (Oliver et al. 1990, Caldwell et al. 1997, Sublette et al. 1998). This species was collected from sites MC-1, MC-2, MC-5, and LF-3 in the FCW. It appeared from our data that this species was less tolerant of heavy metal pollutants and more tolerant of organic enrichment. However, in our UAR study (Ruse et al. 2000), we collected adult males and exuviae from all 22 sites, some being heavily polluted with metals and others impacted by wastewater discharges. Powell (2008) reported this eurythermal generalist species from the LAR upstream of Pueblo Reservoir.

Genus *Parachaetocladius* Wülker 1959

Immatures of the genus *Parachaetocladius* are usually collected from springs and spring-fed streams (rheocrenes and helocrenes) (Cranston et al. 1983, Epler 2001). In the FCW, one new species was identified.

Parachaetocladius n. sp.

A new species of the genus *Parachaetocladius* was collected at site MC-3. Coauthor JES referred to this new species as *P. n. sp.* (Table 5). Epler (2001) and Hudson et al. (1990) noted larvae of this genus occurred in streams, rivers, springs, and seeps. Larvae of this genus were frequently found in sediments of sand and gravel (Hudson et al. 1990); from Table 9 it was evident for site MC-3 that coarse to fine sand composed 29% of the surficial substrate material, and very fine to coarse gravel composed 77%. Medium and coarse gravel percentages were highest at site MC-3.

Genus *Paracladius* Hirvenoja 1973

The larvae of this genus may reach 9 mm in length and occur in many different standing

and flowing waters, including springs of the northern Holarctic (Cranston et al. 1983, Cranston 2014). Only one species of this genus was found in the FCW (*P. alpicola*).

Paracladius alpicola (Zetterstedt) 1850

Paracladius alpicola is a widespread Holarctic species occurring in northern and montane lakes in the east and west Palearctic and Near East (Hirvenoja 1973, Langton 1991, Egan 2014, Fauna Europaea 2014); in North America it has been reported in Canada only from NT and NL (Labrador), and in the United States from MI and new to CO. This species was unexpected in the FCW at site UF-4 because of the high level of urbanization and toxic metals; however, the site does support a reproducing population of brown trout (*Salmo trutta*). In the UAR we collected this species from 2 cold-water sites—AR-7 and AR-11, both downstream from the most polluted heavy metals zone (Ruse et al. 2000). This species was not recorded in the LAR by Kleinert (2008) or Powell (2008).

Genus *Parakiefferiella* Thienemann 1936

Larvae of this genus are usually collected from lentic habitats but may also occur in lotic biotopes (Cranston et al. 1983, Epler 2001). We encountered only one species from this genus in the FCW—*P. subaterrima*.

Parakiefferiella subaterrima (Malloch) 1915

Parakiefferiella subaterrima is widespread in North America (Nearctic) and occurs from NT east to QC south to IL, CO, NM, AZ, UT, and CA (Oliver et al. 1990, Sublette et al. 1998). In the FCW, this species was collected at sites UF-4, LF-3, and LF-4; the first location has a cool-water regime, while the other 2 have warm-water conditions. Ruse et al. (2000) found this orthoclad in the UAR study at only 2 disparate sites—the most distant from each other—at EF-1 (3042 m elevation) and AR-20 (1431 m elevation); the EF-1 site has a very cold headwater temperature regime, carries no heavy metal load and receives no anthropogenic pollution; the AR-20 site has a mixed cool- to warm-water regime because of the multilevel hypolimnetic discharge (tailwater) from the Pueblo Reservoir dam. Additionally, the AR-20 site carries an extremely low heavy metal load and shows no evidence of organic pollution. Sublette et al. (1998)

reported this species from the Colorado River, Grand Canyon National Park at 732 m elevation. Both Kleinert (2008) and Powell (2008) collected *P. subaterrima* at 4 sites (elevation range 1427–1439 m) within 8.15 km downstream of the Pueblo Reservoir dam in 2004 and 2006. It appears this species is an obligate rheophilous eurythermophile.

Genus *Parametriocnemus* Goetghebuer 1932

Parametriocnemus larvae occur in cool to cold lotic habitats such as springs, streams, and rivers (Cranston et al. 1983, Epler 2001). In this genus, one described species (*P. lundbecki*) and one new species were observed in the FCW.

Parametriocnemus lundbecki
(Johannsen) 1905

Another widespread lotic Nearctic orthoclad, *P. lundbecki*, ranges from AB to QC south to CA, AZ, NM, TX, AL, and FL (Sublette and Sublette 1979, Oliver et al. 1990, Caldwell et al. 1997). In the FCW it was collected from sites MC-5 and LF-3, the former a cool-water site and the latter a warm-water station with sand composing >43% of the substrate (Table 9) and total phosphorus indicating moderate anthropogenic enrichment (Table 3). Sublette and Sublette (1979) reported this species from cool- to cold-water streams in northern and western NM. In the UAR we collected exuviae of this species from 13 of 22 sites and adults from 9 of 22 locations ranging in elevation from 2969 to 1431 m (Ruse et al. 2000); Kleinert (2008) recorded this species at an elevation of 1427 m in the LAR. Sublette and Sublette (1979) collected adults from 7 sites of NM in all months except January and May. In New York Simpson and Bode (1980) concluded this species apparently favored clean water because it was absent downstream of wastewater plant discharges. The NCBI tolerance value of 3.7 is indicative of an obligate clean water species (Lenat 1993). Simpson (1983) and Simpson et al. (1985) indicated *P. lundbecki* was acidophilic (larvae living at pH 5.5–7.0) in acid-stressed NY streams.

Parametriocnemus n. sp.

A new species of *Parametriocnemus* was recorded from site UF-3, a cool-water location upstream of the Gold Hill tailings pile but

impacted by the dust containing toxic metals blown off the deposit by strong swirling winds. Coauthor JES designated this new species as *P. n. sp.* (Table 5).

Genus *Paraphaenocladius* Thienemann 1924

Three species of the genus *Paraphaenocladius* were identified from the FCW: *P. exagitans*, *P. impensus*, and *P. innasus*. Epler (2001) stated larvae of this genus are found in a wide variety of habitats that include lotic and lentic habitats, and semiterrestrial or semiaquatic locales such as “moss lined banks of streams and springs, moist soil in seeps, periphyton at the margin of water bodies.”

Paraphaenocladius exagitans (Johannsen) 1905

Sæther and Wang (1995) split *P. exagitans* into 3 subspecies: *P. exagitans* s. str. [*sensu stricto*], *P. exagitans longipes* and *P. exagitans monticola*. The Nearctic distribution of the nominal subspecies *P. exagitans* s. str. extends from SD to WI to NY to NH south to CA, AZ, CO, NM, KS, IL, OH, and SC (Oliver et al. 1990, Caldwell et al. 1997, Sublette et al. 1998); this species has also been collected in China and Japan where the immatures were collected from moist soil along rivers, streams, seeps, and springs (Sæther and Wang 1995). The subspecies *P. exagitans longipes* occurs in Costa Rica, Trinidad, Tobago, and St. Vincent; *P. exagitans monticola* ranges from Austria, Germany, Norway, and Japan (Sæther and Wang 1995). Larvae of this species appear to live in a variety of semiterrestrial, semiaquatic, and truly aquatic locations (Sublette et al. 1998). In the FCW, *P. exagitans* was present at MC-4 and UF-3, both cool-water sites, at 1942 m and 1860 m, respectively; the sand content for the sediment at both sites exceeded 47% (Table 9). Adults in the UAR were collected from only site AR-11 (2338 m elevation). One male was reported by Sublette et al. (1998) from the Colorado River at an elevation of 876 m. Sæther and Wang (1995) cited one record from Qiuxiang Tibet at 3300 m elevation. No collections of this species were recorded from the LAR by Kleinert (2008) or Powell (2008).

Paraphaenocladius impensus (Walker) 1956

Paraphaenocladius impensus has been revised into 3 subspecies by Sæther and Wang

(1995): *P. impensus* s. str., *P. impensus contractus*, and *P. impensus albusalatus*. Subspecies *P. impensus* s. str. is Holarctic occurring in England, Germany, Iceland, Greenland, Canada and U.S. (Sæther and Wang 1995); in North America it has been reported from YT, MB, ON, and MN (Oliver et al. 1990, Oliver and Dillon 1997). The distribution of *P. impensus contractus* includes China, Japan, Turkey, Algeria, and Austria; *P. impensus albusalatus* ranges from India to Saudi Arabia (Sæther and Wang 1995). Langton (1991) described the larvae living in “streams, ditches, drains and lakes [and] in wet moss by a stream.” Fittkau and Reiss (1978) documented it from a variety of wet habitats including springs on the north slope of the Yukon near Mackenzie Bay. Sendstad et al. (1977) found the larvae of this species in 2 semiterrestrial/semiaquatic sites—one fairly wet moss tundra site (mosses between clumps of alpine hairgrass) and one very wet *Deschampsia* site (primarily alpine hairgrass). Baranov (2011) reported this species as a new record from Ukraine located in a city park spring whose permanent temperature is 9 °C. In the FCW, it was recorded from LF-1 and LF-2, the former a cool-water location and the latter a warm-water station.

Paraphaenocladius innasus Sæther and Wang 1995

The Nearctic distribution of *P. innasus* is restricted to SD, SC, KS, NM, CA, and now CO (Sæther and Wang 1995, Caldwell et al. 1997). The holotype male was reared from littoral algae and debris of a small pond at Gavins Point National Fish Hatchery, Yankton, SD (Sæther and Wang 1995). Other investigators cited collecting this species from creeks and rivers. We collected this species in the FCW from sites MC-3 and LF-1, both cool-water lotic locations; water quality was similar at both sites (Tables 2, 3). In the UAR Ruse et al. (2000) recorded adults of 4 species—*P. exagitans*, *pseudirritus nearcticus*, *nasthecus*, and *tonsuratus*—but did not report any *P. innasus*; this species was not reported by Kleinert (2008) or Powell (2008) from the LAR sites.

Genus *Paratrachocladius* Santos Abreu 1918

Larvae of this genus are recorded from cool waters that may be lotic (particularly springs), lentic or brackish (Epler 2001, Cranston et al.

1983). One species of this genus was identified from the FCW—*P. rufiventris*.

Paratrichocladius rufiventris (Meigen) 1830

The orthoclad *P. rufiventris* ranges from the Palearctic to the Nearctic. In North America it has been reported from ON (Oliver et al. 1990), NC (Epler 2001), OH, and SC (Caldwell et al. 1997). Epler (2001) reported that the larvae occur in a variety of aquatic habitats, even brackish conditions; in the west Palearctic, Langton (1991) cited larvae from lotic and lentic locations. In the FCW, we found adults at sites MC-4 and UF-4, cool-water locations heavily impacted by urbanization and the latter site also by heavy metals. Ruse et al. (2000) registered adults from sites AR-13 and AR-14 in the UAR; these are clean cold-water sites between Salida and Cañon City.

Genus *Psectrocladius* Kieffer 1926

The larvae of this genus are medium to large (<11 mm length) and are described as eurytopic, inhabiting lotic, lentic, and acidic waters worldwide (Cranston et al. 1983, Epler 2001). Only one new species of this genus was encountered in the FCW.

Psectrocladius n. sp.

One new species of *Psectrocladius* was collected at sites MC-1 and MC-4; the former a cold-water site and the latter a cool-water site. Coauthor JES designated this species *P. n. sp. 8* (Table 5). Epler (2001) reported the occurrence of the genus in lotic and lentic waters, where acidic conditions are preferred.

Genus *Pseudosmittia* Goetghebuer 1932

The larvae of *Pseudosmittia* may occur in terrestrial or semiterrestrial biotopes, edges of marshes, ponds, and streams, as well as rivers and streams (Epler 2001). Only the species *P. forcipata* was found in the FCW.

Pseudosmittia forcipata Goetghebuer 1921

Pseudosmittia forcipata is Holarctic in distribution, with North American records including ON, NB, NS, VT (Cranston and Oliver 1988a), AL, FL, GA, NC, SC (Caldwell et al. 1997), and NM (Sublette and Sublette 1979). The larvae of this genus occur in lotic and lentic habitats that include marshes and edges

of ponds and streams in terrestrial and semiterrestrial locations (Epler 2001). We recorded this species from sites MC-4 (cool-water) and LF-4 (warm-water) in the FCW; substrates of both locations had sand and fine gravel greater than 73% (Table 9). In the UAR, Ruse et al. (2000) collected adults at sites AR-4, 8, 10, 11, and 14, primarily clean cold-water habitats; however, we did not record any exuviae for this species. One explanation is that the adults were collected for 17 consecutive months (May 1984–September 1985) from all 22 stations, but the exuviae were collected for only 3 consecutive months (July–September 1985) at all 22 locations; possibly no adult emergences occurred during the exuvial collection period. Our data suggested summer emergence may not have been occurring for *P. forcipata* in cold waters of its elevational range in CO. Another explanation is the larvae may have developed in semiterrestrial habitats along the UAR.

Genus *Rheocricotopus*

Thienemann and Harnisch 1932

The immatures of this genus are rheophilic, medium size (<6.5 mm length) larvae usually found in rivers and streams, and seldom in the littoral of ponds and lakes (Cranston et al. 1983, Epler 2001). One new species of this genus was collected in the FCW.

Rheocricotopus n. sp.

In the genus *Rheocricotopus*, one new species was recorded for the FCW; coauthor JES assigned the name *R. n. sp. 1* [hatchi.ms] (Table 5). Ruse et al. (2000) found the same undescribed species [designated *R. n. sp. 1* (nr. *chalybeatus*)] from 6 clean-water sites (EF-1, AR-2, 6, 8, 9, 11) in the UAR. Larvae of this species appeared to be lotic on the basis of where we collected the adults. Caldwell et al. (1997) indicated that larvae of most species in this genus from the southeastern U.S. were found in streams and springs. In the FCW this unknown species was recorded from sites MC-3, UF-1, and UF-3.

Genus *Saetheriella* Halvorsen 1982

Cranston et al. (1989b) indicated that adults of this genus are small with a wing length of 0.9 mm; little is known about the larval preferences of this species. Immatures may be terrestrial or semiaquatic (Hudson et al. 1990).

Only one species is known from a spring 19.3 km SE of Gatlinburg, TN, in the U.S. (Halvorsen 1982). Only one new species of this genus was identified from the FCW.

Saetheriella n. sp.

A new species in the genus *Saetheriella* was acquired from site MC-2 in the FCW. It was assigned the working name *S. n. sp.* [marking] (Table 5) by author JES.

Genus *Smittia* Holmgren 1869

Two species of *Smittia* were recorded from the FCW: *S. atterima* and *S. polaris*—the former from sites in all 3 watershed segments, the latter only from site UF-1. Epler (2001) considered this genus terrestrial, but frequently the larvae are aquatic.

Smittia atterima (Meigen) 1818

The distribution of *S. atterima* ranges from the Palearctic to Greenland and North America (AK, YK, ON, south to FL, MS, and NM) (Sublette and Sublette 1979, Oliver et al. 1990, Oliver and Dillon 1997). In the FCW, *S. atterima* was collected from one cold-water site (MC-2), one cool-water station (UF-4), and one warm-water location (LF-3). In the UAR, Ruse et al. (2000) recorded adults from stations AR-9 and AR-12—both clean cold-water river sites with many isolated, shallow (<15 cm depth), marshy semiterrestrial pools of a permanent nature fed by river groundwater. Kleinert (2008) and Powell (2008) reported this species from site AR-20, which is 8.15 km downstream of Pueblo Reservoir dam.

Smittia polaris (Kieffer) 1926

Oliver and Dillon (1997) indicated *S. polaris* was recorded at all of their north slope Yukon sites; they suggested it was most likely widespread above the Arctic Circle of North America. The current Nearctic distribution includes YT, NT, CO, and Ellesmere Island (Sæther et al. 1984, Oliver and Dillon 1997, Ruse et al. 2000). In the FCW this species occurred at MC-1, a cold-water site with many isolated, small shallow pools along the banks of the stream. Ruse et al. (2000) found adults at site AR-8 (clean-water, cold station), which has many bankside pools similar to those at site MC-1 in the FCW.

Genus *Thienemanniella* Kieffer 1911

Cranston et al. (1983) reported the larvae of this genus as being small, reaching 3 mm in length. Five species of the genus *Thienemanniella* were present in the FCW: *T. boltoni*, *elana*, *xena*, n. sp. 7, and n. sp. 8. Members of this genus may be found in lotic and lentic habitats with clean or organically enriched waters (Epler 2001).

Thienemanniella boltoni
Hestenes and Sæther 2000

The Nearctic distribution of *T. boltoni* is restricted to OH and NC (Epler 2001); in NC and OH it appeared to be restricted to “springs and small spring-fed streams” (Hestenes and Sæther 2000), even though the holotype male was reared from a larva of the Scioto River, Franklin County, OH. In the FCW, this species occurred at the site with the highest maximum temperature—site LF-5; this station is characterized by abundant cottonwood trees, common reed (*Phragmites*), and *Tamarix*. This species was not collected by us from the UAR or LAR (Ruse et al. 2000, Kleinert 2008, Powell 2008).

Thienemanniella elana (Roback) 1957

Corynoneura elana Roback 1957 has been revised to *T. elana* (Roback 1957a, Da Silva and Gelhaus 2010). The holotype male was collected from Lemon's Grove, 3 miles south of Kamas, Summit County, UT; there was no description of the type locality (Roback 1957b). From maps of the Kamas area it appears the type locality was site 4 on the Upper Provo River at an elevation of about 1997 m. In the FCW, we collected it from 2 sites, MC-4 (1942 m elevation) and LF-3 (1533 m elevation)—the former a cool-water station and the latter a warm-water location. It was not found in the UAR or LAR studies (Ruse et al. 2000, Kleinert 2008, Powell 2008).

Thienemanniella xena (Roback) 1957

Thienemanniella xena is a widespread Palearctic species ranging in North America from AK, ON, MN, AB, SD, IL, NY south to FL, and in Asia from Far East Russia south through China (Oliver et al. 1990, Fu et al. 2010). Epler (2001) indicated this species was “the most common and abundant species” of *Thienemanniella* in the southeastern U.S. In all but 3 New York river systems Simpson and

Bode (1980) found this species common in their larval collections. Roback (1957b) described the PA type locality as a stream tributary of the Upper Wissahickon with a depth <30 cm, a sluggish flow, and rank aquatic vegetation. It appeared to Roback (1957b) that larvae fed mainly on diatoms. Roback (1974) cited water quality data from one site where *T. xena* occurred as pH 7.3, alkalinity 39 mg/L CaCO₃, total hardness 66 mg/L CaCO₃, and dissolved oxygen 8 ppm. In the FCW, *T. xena* occurred at 5 sites: MC-1, 2, 5, UF-3 and LF-3 where the pH, total hardness, total alkalinity, and dissolved oxygen trended higher than Roback's (1974) data. In China, Fu et al. (2010) reported an elevation range for collection sites of 400–2400 m; the range for the 5 sites in FCW was 1533–2097 m. The 5 sites included cold-, cool-, and warm-water stations in all 3 segments of the watershed. Hestenes and Sæther (2000) concluded the larvae were probably inhabiting streams around Lake Winnipeg. Interestingly, in the UAR Ruse et al. (2000) reported adults of *T. xena* from only one site, AR-18, a transitional location between cool- and cold-water sites upstream and warm-water sites below Pueblo Reservoir. This species was not collected from warm-water sites below the Pueblo Dam by Kleinert (2008) or Powell (2008).

Thienemanniella n. spp.

One new species of the genus *Thienemanniella* was assigned the working name *T. n. sp.* 7 [luna.ms] (Table 5) by coauthor JES. This new species occurred at site MC-3, a cool-water location.

A second new species of *Thienemanniella* was identified with the name *T. n. sp.* [= *herrmanni*] (Table 5) by coauthor JES. In the FCW this new species was collected from only site UF-2—a cold-water station.

Genus *Tvetenia* Kieffer 1922

Two species of the genus *Tvetenia* were collected and identified from the FCW: *T. paucunca* and *T. vitracies*. Epler (2001) stated that larvae of this genus are found in lotic habitats.

Tvetenia paucunca (Sæther) 1969

Tvetenia paucunca is a Nearctic orthoclad ranging from YK, NT, AB, MB, ON south to GA and FL (Oliver et al. 1990, Caldwell et al. 1997, Epler 2001). In the FCW, we collected

it from sites MC-5, UF-1, 2, 3, 4, and LF-3—locations in all 3 reaches that feature cold-, cool-, and warm-water conditions. In the UAR Ruse et al. (2000) reported some interesting distributions for the exuvial and adult collections; exuviae were gathered from 13 of 22 sites that ranged from AR-1 (2944 m elevation) to AR-17 (1535 m elevation), while the adult collections were confined to the uppermost 4 sites: EF-1 (3042 m elevation) to AR-2 (2905 m elevation). At sites AR-1, 2, and 3 Ruse et al. (2000) indicated the pupal exuviae of this species constituted 20.0% to 39.9% of the total, whereas all other downstream sites were only 0.1% to 4.9%; adults were 0.1% to 9.9% for EF-1, EF-2, AR-1, and AR-2. To explain this difference between adult and exuvial occurrences we suspect that exuviae drift far downstream to site AR-17 before sinking, fragmenting, or decomposing. Kavanaugh et al. (2014) cautioned exuvial researchers to consider environmental conditions when interpreting presence and relative abundance at collection sites. The UAR is a cold, oligotrophic, low-nutrient, high-gradient, high-velocity lotic system; exuviae could float from Leadville to Pueblo Reservoir in as few as 40 h. In the LAR, *T. paucunca* was absent. This species is very abundant in some of the coldest year-round stream conditions in North America, yet it apparently tolerates warming downstream to the Portland, CO, site (AR-17) if the pupal exuvial data of Ruse et al. (2000) were indicative of *T. paucunca* larvae, pupae, and adults existing at that site. Epler (2001) noted how this species was more abundant in the mountains of NC and SC, and *T. vitracies* was more common in the coastal plain.

Tvetenia vitracies (Sæther) 1969

The second species of *Tvetenia* found in the FCW was *T. vitracies*, a Nearctic orthoclad whose distribution extends from SK to ON south to SC, CO, NM, AZ, and CA (Sublette et al. 1998). We collected this species in the FCW from site UF-1—the coldest station of the 14 studied. In the UAR we recorded exuviae from AR-9, 12, 14, 15, 16, 17, 18, and 20 and adults from AR-1, 9, 14, 16, and 18; with the exception of sites AR-1 and AR-20, there was a high level of concurrence with the 2 collection methods. Site AR-1 has a very cold temperature regime, AR-20 a temperate warm regime. Most of the concurrent sites (AR-9,

14, 16, and 18) are cold to cool regimes. Interestingly, in the 2 LAR studies (Kleinert 2008, Powell 2008), this species was also found downstream of Pueblo Dam in the tailwater reach. Stevens et al. (1998) reported this species as one of 5 abundant orthoclad species of the Colorado River in Grand Canyon; they considered the Colorado River today a “cold-stenothermic stream”; the sample-weighted relative abundance of *T. vitracies* varied from 0.015 to 0.042 to 0.032 for clear water, variably turbid, and usually turbid reaches, respectively.

Subfamily Podonominae

Brundin (1989) described the size and color ranges of male imagoes of this subfamily as small (<4 mm) to medium, and dark brown to black, respectively.

Tribe Podomini

Genus *Parochlus* Enderlein 1912

Parochlus kiefferi is the only species of this genus known from North America (Richards and Rogers 2006); it was collected in the FCW. Epler (2001) indicated podonomid larvae are uncommon and usually associated with bryophytes in cold streams and springs.

Parochlus kiefferi (Garrett) 1925

This Holarctic species in North America ranges from AK to NB, south to NY, CA, CO, and NM (Sæther 1969, Oliver et al. 1990). Hayford (2012) recently reported *P. kiefferi* from Squaw Creek, a low-elevation stream in northwest NE. Similar to *D. heteropus* in the FCW, *P. kiefferi* was present only at a single UF site, namely UF-1, a cold-water brown trout mountain stream at 2335 m elevation influenced by snowmelt and runoff from the Pikes Peak massif. Sæther and Andersen (2013) indicated larvae of this species occurred in “cool springs and running waters, preferably small ones.” By contrast in Italy Lencioni et al. (2007) recorded *P. kiefferi* from glacial ponds in the floodplain of a stream at 2455 m elevation. Ruse et al. (2000) reported this species from 3 of the 4 highest-elevation sites (EF-1, EF-2, and AR-2), which are characterized by very cold headwater conditions in the UAR.

Subfamily Prodiamesinae

Male imagines of the Prodiamesinae are medium to large in size and brown to black in

color (Sæther 1989). Only 2 species of Prodiamesinae were identified from the FCW: *Odontomesa ferringtoni* and *Prodiamesa olivacea*.

Genus *Odontomesa* Pagast 1947

Sæther (1989) stated that the larvae of this genus usually inhabit “sandy, lightly silted sediments of slow flowing waters and the littoral zone of lakes.” In the FCW only *O. ferringtoni* was found.

Odontomesa ferringtoni Sæther 1985

Odontomesa ferringtoni occurred only at site LF-3, a warm-water station where the substrate is 62% very fine gravel and sand and is constantly shifting course through erosional and depositional activity (Table 9). The distribution of *O. ferringtoni* is restricted to CO (Oliver et al. 1990, Ruse et al. 2000) and OH (Bolton 1992). Caldwell et al. (1997) reported the habitats of *Prodiamesa* and *Odontomesa* were similar, both moderately pollution tolerant in “sandy, lightly silted sediments of slow-flowing water.” These conditions occurred at most sites in the FCW.

Genus *Prodiamesa* Kieffer 1906

The larval immatures of the genus *Prodiamesa* occur in lotic and lentic biotopes similar to the genus *Odontomesa* (Sæther 1989). *Prodiamesa olivacea* was the only species of this genus collected from the FCW.

Prodiamesa olivacea (Meigen) 1818

The Holarctic *P. olivacea* is widespread in lotic and lentic biotopes of the Nearctic region and Europe, and was recorded earlier in Colorado by Coquillett (1902), Sublette and Sublette (1965), and Ruse et al. (2000). In the FCW it was collected only at sites UF-2 and UF-3, the former a cold-water station and the latter a cool-water location. In a Danish lowland stream, Lindegaard and Mortensen (1988) recorded the bivoltine emergence phenology of this species. The North Carolina Biotic Index (NCBI) pollution tolerance value for *P. olivacea* was 7.9 (scale 0–10, 10 most tolerant; Lenat 1993).

Subfamily Tanypodinae

Murray and Fittkau (1989) pointed out the size range of adult tanypods as small to large, with wing length reaching 7.5 mm; larvae of most species are free-living carnivores

occurring in all types of standing and flowing aquatic biotopes, including wet semiaquatic and semiterrestrial sites.

Genus *Ablabesmyia* Johannsen 1905

Four species of *Ablabesmyia* were identified from the FCW: *A. illinoensis*, *mallochi*, *monilis*, and *pulchripennis*. Vallenduuk and Moller Pillot (2007) stated that "all species of *Ablabesmyia* [larvae] occur more often in larger stagnant water bodies"; however, they also indicated the larvae were more abundant in medium-sized streams than in larger rivers. Sæther (2011) stated the larvae occur in many different types of flowing and standing waters such as ponds, lakes, bog pools, streams, and rivers. Vallenduuk and Moller Pillot (2007) reported these predaceous tanypods feeding on other chironomids, oligochaetes, cladocerans, dead prey, algae, and detritus.

Ablabesmyia illinoensis (Malloch) 1915

The Nearctic *A. illinoensis* ranges from NT, AB, SK, MB, ON, QC, NB south to ME, MA, NJ, NY, VA, WV, MI, IL, IA, WI, KS, ID, CO, and NM (Roback 1971, 1985, Oliver et al. 1990, Sæther 2011). Epler (2001) doubted it occurs in the southeast U.S. Sublette and Sublette (1979) reported this species from both lotic and lentic ecosystems in NM; Roback (1971, 1985) cited it predominantly from ponds, lakes, and swamps. In the FCW it occurred only at site MC-5, a cool-water site. In the UAR Ruse et al. (2000) reported this species from stations AR-18 and AR-19; these sites are immediately upstream and downstream of Pueblo Reservoir, and are considered cool-water locations. Roback (1985) provided environmental data for this species that can be compared directly with the water quality data for the FCW from Tables 2 and 3: total hardness, 20 and 206 mg/L CaCO₃ (Roback mean and FCW mean, respectively); total alkalinity, 8 and 108 mg/L CaCO₃; specific conductance, 70 and 522 µS/cm; elevation, 1270 and 1841 m. Water quality at the FCW MC-5 site is more mineralized than at Roback's locations. Direct comparisons for pH and temperature were not possible because empirical data from Roback (1985) were not available.

Ablabesmyia mallochi (Walley) 1925

Ablabesmyia mallochi is a Nearctic tanypod with numerous collection records from

throughout most of Canada and the United States (NT, BC, AL, ON, QC south to NY, VA, NC, SC, GA, FL west to AL, TX, NM, CA) (Sublette 1964, Roback 1971, 1985, Beck 1977, Caldwell et al. 1997, Epler 2001, Sæther 2011). Sublette and Sublette (1979) reported this species from many streams, rivers, lakes, and hot springs from NM. In the FCW, this species occurred at sites MC-3, LF-3, and LF-5, the first being a cool-water station and the 2 LF locations warm-water zones. In the UAR and LAR, we recorded this euryokous species from sites AR-18 and AR-19, above and below Pueblo Reservoir, both cool-water segments (Ruse et al. 2000, Kleinert 2008, Powell 2008). Roback (1985) split the larvae of this species into 2 varieties because of a disparity in the length of the longest dark claw on the posterior parapod. We combined Roback's (1985) environmental data for the 2 varieties to make comparisons with the FCW water quality data for sites MC-3, LF-3, and LF-5 from Tables 2 and 3: total hardness, 56 and 234 mg/L CaCO₃ (Roback mean and FCW mean, respectively); total alkalinity, 45 and 120 mg/L CaCO₃; specific conductance, 114 and 789 µS/cm; elevation, 158 and 1630 m. The first 3 parameters indicate that aquatic conditions in the FCW are more mineralized, and there is a large disparity in site elevations. Direct comparisons for pH and temperature were not possible because empirical data from Roback (1985) were not available. Simpson and Bode (1980) concluded that this species is facultative, occurring in "clean, swiftly flowing streams... organically enriched, sluggish rivers... and where toxic chemicals were present."

Ablabesmyia monilis (Linnaeus) 1758

The Holarctic chironomid *A. monilis* ranges from North America to Europe and Asia as well as the Oriental region (Roback 1971, 1985, Sublette and Sublette 1973, Oliver et al. 1990, Sæther 2011); records from states contiguous to CO include AZ, NM, UT, KS, and WY. Two CO records, Mountain Home Reservoir (Costilla Co.) and Beaver Meadows, are lentic habitats; however, Sublette and Sublette (1979) collected this species from rivers and ponds in NM. Roback (1971, 1985) cited records from creeks, rivers, reservoirs, lakes, and ponds. In the west Palearctic, Langton (1991) indicated it was found in stagnant water. In the FCW this species was collected only from

site LF-2, a warm-water location receiving wastewater effluent from several upstream towns and cities. Roback (1985) provided environmental data for this species that can be compared directly with the water quality data for the FCW in Tables 2 and 3: total hardness, 90 and 234 mg/L CaCO₃ (Roback mean and FCW mean, respectively); total alkalinity, 51 and 160 mg/L CaCO₃; specific conductance, 140 and 1003 µS/cm; elevation, 1599 and 1635 m. The water at the FCW LF-2 site was more mineralized than at Roback's locations, but the mean elevations were essentially the same. Direct comparisons for pH and temperature were not possible because empirical data from Roback (1985) were not available. This species was not collected in the UAR or LAR by Ruse et al. (2000), Kleinert (2008), or Powell (2008).

Ablabesmyia pulchripennis (Lundbeck) 1898

Ablabesmyia pulchripennis is a Nearctic species with a North American distribution extending from NT, BC, AB, NB and QC south to SD, KS, CO, WY, WA and DC; it also occurs in Greenland (Roback 1971, 1985, Oliver et al. 1990, Sæther 2011). Roback (1971, 1985) cited this species from Yellowstone Lake, Yellowstone National Park, WY, and Timber Creek Camp [Campground], Rocky Mountain National Park, CO. The latter site is located along the headwaters of the Colorado River at 2713 m elevation immediately downriver of the confluence of Timber Creek and the Colorado River. We collected this species from site MC-4 in the FCW; this site had a pH range of 7.5 to 8.3 (Tables 2, 3) and a high total percentage (80%) for sand and fine gravel content (Table 9). It was not reported from the UAR by Ruse et al. (2000) or from the LAR by Kleinert (2008) or Powell (2008).

Genus *Coelotanypus* Kieffer 1913

In the genus *Coelotanypus* larvae are medium to large size immatures inhabiting lakes and low velocity backwaters of rivers and streams (Fittkau and Roback 1983). In the FCW, only *C. concinnus* was collected and identified.

Coelotanypus concinnus (Coquillett) 1895

Coelotanypus concinnus is a Nearctic species reported from lentic and lotic ecosystems in NE, IL, IA, IN, PA, KS, MD, MI, MO, OH, TN, VA south to FL west to LA, MS, TX, and

NM (Roback 1971, Oliver et al. 1990, Epler 2001). The larvae of this genus prefer sediments of swamps, marshes, ponds, lakes, and low-velocity rivers and streams (Epler 2001). In the FCW, this species was found at only one site, LF-5; this stream location is characterized by warm water, high specific conductivities (>1450 µS/cm), a braided stream course, a constantly shifting streambed and 86% of the substrate being sand and fine gravel (Table 9). This species was not reported from the UAR (Ruse et al. 2000) or the LAR (Kleinert 2008, Powell 2008). In the southeastern U.S., Epler (2001) reported this species from "extremely eutrophic water bodies."

Genus *Conchapelopia* Fittkau 1957

Three species of *Conchapelopia* were collected from the FCW: *C. pallens*, *C. telema*, and one new species. Ferrington et al. (2008) described larvae of this genus as widespread predaceous sprawlers inhabiting lotic erosional and lentic littoral freshwaters in North America. Epler (2001) found larvae of this genus in aquatic sites with pH ranging from 5.1 to 8.0, specific conductivity 0 to 400 µS/cm, total hardness 0 to 250+ mg/L CaCO₃, total alkalinity 0 to 200 mg/L CaCO₃, and temperature 9 °C to 28 °C.

Conchapelopia pallens (Coquillett) 1902

Conchapelopia pallens was recorded from sites MC-2, 4, 5 and LF-1, 2; MC-2 is a cold-water station; MC-4, MC-5, and LF-1 cool-water; and LF-2 warm-water. This tany-pod did not occur in the UF reach of the FCW. This species is a new record for CO. Oliver et al. (1990) reported this Nearctic species from AK to QC south to FL, CA; Sublette and Sublette (1979) recorded the synonym *Conchapelopia goniodes* (Bilyi 1985) from NM, and Caldwell et al. (1997) cited additional occurrences in lakes, streams, and rivers of GA, NC, and SC. Data from Tables 2 and 3 show that the range of pH for all 5 sites was 7.4 to 8.5; specific conductivity 190 to 1354 µS/cm; total hardness 67 to 276 mg/L CaCO₃; total alkalinity 74 to 179 mg/L CaCO₃; and temperature 4 °C to 29 °C.

Conchapelopia telema Roback 1971

The Nearctic lotic *C. telema* is distributed from NT and AB to ON, MT, NY, IL, south to KS, NC (Roback 1971, Oliver et al. 1990,

Caldwell et al. 1997). Mason and Lehmkuhl (1983, 1985) reported this species from the Saskatchewan River and discussed the effects of a large hydroelectric development on the chironomid community. In the FCW this species occurred only at site MC-4. In the UAR and LAR, *C. telema* was not reported by Ruse et al. (2000), Kleinert (2008), or Powell (2008). Roback (1981) cited supporting water quality and ecological data for this species that can be compared with the FCW data: total alkalinity, 159 and 82 mg/L CaCO₃ (Roback mean and FCW site MC-4 mean, respectively); total hardness, 216 and 133 mg/L CaCO₃; specific conductivity, 303 and 412 µS/cm; elevation, 177 and 1924 m. Five species of this genus were cited from NC by Caldwell et al. (1997), including *C. pallens* and *C. telema*; Epler (2001) noted the larvae of this genus occurring in habitats with pH ranging from 5.1 to 8.0 with most values <7.0, and specific conductivities ranging from 0 [?] to 400 µS/cm. Site MC-4 was characterized by sand and fine gravel composing 80% of the substrate (Table 9), pH ranging from 7.5 to 8.3, and specific conductivity ranging from 243 to 518 µS/cm (Tables 2, 3).

Conchapelopia n. sp.

A new species of *Conchapelopia* was found at site MC-4, a companion species to both *C. pallens* and *C. telema*. Coauthor JES designated this new species as *C. n. sp.* (Table 5). Site MC-4 was in a moderately swiftly flowing reach with pool-riffle-run zones bordered by willow on each bank.

Genus *Larsia* Fittkau 1962

Small larvae (<5 mm length) of the genus *Larsia* inhabit lotic sites (hot and cold springs, slowly moving reaches of streams and rivers and ditches) and lentic waters (marshes, small pools and the littoral of lakes and ponds) (Fittkau and Roback 1983, Epler 2001). The only species collected from the FCW was *L. lyra*.

Larsia lyra (Sublette) 1964

Larsia lyra is a Nearctic tanypod with a very restricted western United States distribution: CA, KS, NM, and now CO (Oliver et al. 1990). Ferrington et al. (2008) indicated that *Larsia* species were sprawler predators inhabiting lotic erosional and lentic littoral

waters. Sublette (1964) described the type locality of a male as Wheeler's Springs, Ventura County, CA; the type specimen was collected with a light trap. Paratypes were recorded from other springs in Inyo County, CA. This species was collected in the FCW only from site MC-1, a cold-water station with alternating pools and riffles, including some small beaver dam ponds. Epler (2001) reported larvae of this genus occurring in marshes, ponds, lake littoral zones, slower reaches of streams and rivers, and even hot springs.

Genus *Procladius* Skuse 1889

Four species of the genus *Procladius* were identified from the FCW: *P. bellus*, *culiciformis*, *freemani*, and *sublettei*. Epler (2001) reported that the larvae live in the sediments of lakes, ponds, bogs, and slow and slack waters of rivers and streams.

Procladius (Psilotanypus) bellus
(Loew) 1866

The widespread Nearctic distribution of *P. bellus* extends from NT and BC to ON south to FL, GA, LA, TX, NM, AZ, and CA (Roback 1971, 1980, Caldwell et al. 1997). Caldwell et al. (1997) reported larvae of this species inhabiting lakes, rivers, and streams. In the FCW, this species occurred at 6 of 14 sites, including all 3 reaches of the watershed (MC-1, 3; UF-3; LF-1, 4, 5). These 6 sites range from cold- to cool- to warm-water conditions (Tables 2, 3). Sublette et al. (1998) collected one adult of *P. bellus* near the Colorado River (Grand Canyon) inlet to Lake Mead. Ruse et al. (2000) reported this species from sites AR-16, 18, and 19—all locations between Cañon City and Pueblo, CO, with cold- and cool-water thermal regimes; Kleinert (2008) and Powell (2008) cited its occurrence upriver and downriver of Pueblo Reservoir; similar to the reports of Ruse et al. (2000).

Procladius (Holotanypus) culiciformis
(Linnaeus) 1767

Roback (1971), Danks (1980), and Oliver et al. (1990) indicated that Palearctic *P. culiciformis* ranges in North America from NT, BC, WI, MI, ON south to FL west to KS, AZ, NV, and CA. In the FCW it occurred only at site UF-4, the cool-water site most heavily impacted by toxic metals from the 170-acre Gold Hill tailings pile (USEPA 1994, Dames and

Moore 1999). In the UAR Ruse et al. (2000) reported it from stations AR-11, 18, and 19; the first site is a cold-water location near Buena Vista, but the latter 2 are cool-water sites located immediately upstream and downstream of Pueblo Reservoir. In the LAR the distribution of this species coincided exactly with that of *P. bellus*; there was a strong correlation with the site records of Ruse et al. (2000) and those of Kleinert (2008) and Powell (2008).

Procladius (Holotanypus) freemani
Sublette 1964

The North American distribution of widespread Nearctic *P. freemani* extends from AK, NT, BC, SK, ON, QC south to GA, FL west to NM, UT, AZ, and CA (Roback 1971, 1980, Oliver et al. 1990, Caldwell et al. 1997). Ali (1995) and Caldwell et al. (1997) reported this species predominantly from lentic habitats; however, it has been documented from lotic sites by Sublette and Sublette (1979) and Roback (1980). In the FCW this species was collected from 5 stations: MC-3, 4, 5, UF-3, and LF-1—all cool-water locations. In the UAR, Ruse et al. (2000) reported it from a cold-water site (AR-6) and a cool-water station (AR-18); in the LAR, Kleinert (2008) and Powell (2008) collected this species above and below Pueblo Reservoir. Roback (1980) provided physicochemical water quality data for *P. freemani* that can be compared to the FCW data for the 5 sites: total hardness, 39.7 and 144.8 mg/L CaCO₃ (Roback mean and FCW mean, respectively); total alkalinity, 22.8 and 97.9 mg/L CaCO₃; specific conductivity, 88.7 and 407.8 µS/cm; elevation, 87.4 and 1873 m.

Procladius (Holotanypus) sublettei
Roback 1971

The widespread Nearctic *P. sublettei* has a North American distribution ranging from NT, SK, ON, QC, NB south to FL west to AL, TX, NM, CA (Roback 1971, Sublette and Sublette 1979). Caldwell et al. (1997) reported larvae of *P. sublettei* inhabiting lakes, streams, and rivers. In the FCW this species was collected from 3 stations each in a different reach—MC-3, UF-3, and LF-4; the first 2 are cool-water sites and the last is a warm-water location. Powell (2008) reported this species from site AR-18 of the LAR. Roback (1980) generated physicochemical water quality data for

P. sublettei that can be compared to the FCW data for the 3 sites: total hardness, 68.9 and 177.5 mg/L CaCO₃ (Roback mean and FCW mean, respectively); total alkalinity, 39.3 and 118.5 mg/L CaCO₃; specific conductivity, 143.6 and 597.6 µS/cm; elevation, 224.5 and 1745 m. Simpson and Bode (1980) cited this species from streams and rivers of NY where it inhabits “pristine headwaters” and conversely severely “polluted lowland rivers”; because of its euryokous nature, it appeared to lack indicator species status.

Genus *Tanypus* Meigen 1803

Three species of the genus *Tanypus* were collected from the FCW: *T. neopunctipennis*, *T. punctipennis*, and *T. stellatus*. Epler (2001) noted the larvae of this genus living in soft bottoms of ponds, marshes, and lakes, as well as slow backwaters and side pools of lotic habitats; Caldwell et al. (1997) reported these 3 species from lotic and lentic habitats from southeastern U.S.

Tanypus (Apelopia) neopunctipennis
Sublette 1964

Tanypus neopunctipennis is a Nearctic and Neotropical species that is widespread in the U.S. east of the Rocky Mountains, south of the Great Lakes, throughout the Southeast extending west to the Southwest (NT, NE, OK, IA, MO, IL, TN, NC, SC, GA, FL, AL, LA, TX, NM, AZ, CA) (Roback 1971, Sublette 1964, Sublette and Sublette 1979, Oliver et al. 1990); it extends into southern Mexico and to the Bahamas (Roback 1971, Oliver et al. 1990, Caldwell et al. 1997). Recently Téllez and González (2012) reported this species from the Cuban archipelago. Caldwell et al. (1997) and Epler (2001) indicated that this species occurs in springs, streams, rivers, and lakes. In the FCW, *T. neopunctipennis* occurred at only one cool-water site, LF-1; this location had the highest coliform (Colilert®) bacterial count (MPN 1203) of any of the 14 study sites. Sublette and Sublette (1979) reported this species from NM, and in CO, Ruse et al. (2000) reported it from site AR-18 of the UAR. Roback (1975) spent 4 years (1970–1973) May to June collecting immatures of this and other species and water quality data from 145 stations along the U.S. east coast from ME to FL; for *T. neopunctipennis*, comparative mean limnological values were as follows: total

hardness, 153 and 168 mg/L CaCO₃ (Roback mean and FCW mean, respectively); total alkalinity, 133 and 106 mg/L CaCO₃; specific conductivity, 330 and 702 µS/cm.

Tanypus (Tanypus) punctipennis
Meigen 1818

The North American distribution of the Holarctic and Oriental *T. punctipennis* includes BC, SK, MN, ON, QC south to FL, GA, AL, NV, and CA (Roback 1971, 1976, Oliver et al. 1990, Caldwell et al. 1997). In the southeastern U.S., this species has been reported from lakes, rivers, and streams (Caldwell et al. 1997); of 8 total sites, Roback (1976) reported 5 lotic stations including the Potomac River and 3 lentic locations such as Lake Erie and a sewage lagoon in NE. Roback (1976) observed this species tolerating a wide range of ecological conditions ranging from “clean, clear slightly brown” stream water to turbid large-river water. In the FCW, this species occurred only at site LF-5—a warm-water location characterized by rank growths of *Phragmites*, *Salix* spp., and *Tamarix* sp. Roback (1976) provided water quality data for this species that can be compared to the FCW data: total hardness, 54.4 and 327.8 mg/L CaCO₃ (Roback mean and FCW mean, respectively); total alkalinity, 34.9 and 161.5 mg/L CaCO₃ (total alkalinity concentrations for site LF-4 were used; water quality data were nearly the same for the closely spaced sites of LF-4 and LF-5); specific conductivity, 110.3 and 1061 µS/cm. Kleinert (2008) and Powell (2008) collected this species downstream of Pueblo Reservoir; however, Ruse et al. (2000) did not report it from the UAR.

Tanypus (Tanypus) stellatus Coquillett 1902

The Nearctic *T. stellatus* is widely distributed in Canada and the U.S.; it occurs from AB, SD, MN, ON, NY south to SC, FL west to AL, LA, TX, NM, AZ, and CA (Roback 1971, 1976, Sublette and Sublette 1979, Caldwell et al. 1997). Pamplin et al. (2006) reported this species from Americana Reservoir, São Paulo, Brazil. Caldwell et al. (1997) observed this species in lakes and streams in the southeastern U.S.; while Roback (1976) reported this species from rivers, canals, creeks, lakes, and sloughs. In the FCW, *T. stellatus* was collected only from site MC-3, a cool-water location on the south boundary of the U.S. Air Force

Academy; this site had the highest total and dissolved phosphorus concentrations of all 14 stations, and the second highest coliform bacteria (Colilert®) count (MPN 36.4) in the mid-March data set (Table 3). Sublette (1957a) and Roback (1976) noted this species was collected at depths of 14 m and 16 m from Lake Texoma (OK, TX) and Kentucky Lake (TN), respectively; they concluded that *T. stellatus* was the only chironomid species inhabiting the profundal zone. To the contrary, Roback (1976) found it in 7.5- to 10.0-cm depths in a side-pool of a Florida spring. Ruse et al. (2000) listed this species from only one site (AR-18) in the UAR; the adult was collected from a station immediately upriver of Pueblo Reservoir, the only impoundment on the main stem of the Arkansas River from its headwaters to Pueblo, CO. Neither Kleinert (2008) nor Powell (2008) collected it from the LAR.

Genus *Telopelopia* Roback 1971

The medium size (<8 mm length) larvae of *Telopelopia* are commonly found in rivers and streams, but may also occur in lentic biotopes (Sublette and Sublette 1979, Fittkau and Roback 1983). Only the common North American species *T. okoboji* was encountered in the FCW.

Telopelopia okoboji (Walley) 1928

Only one Nearctic species of the genus *Telopelopia* is currently known from North America—*T. okoboji*. This species has a restricted range from MB, MN, KS, IA, OH, MD, VA, TX, and NM (Roback 1971, Sublette and Sublette 1979, Davis 1980, Roback 1981, Oliver et al. 1990). The larvae are usually collected from rivers and permanent streams but may occur in standing waters too (Epler 2001). In the FCW, this species occurred in the 2 closely spaced warm-water sites (LF-4 and LF-5) with the greatest specific conductivity values. Similar conditions were reported by Sublette and Sublette (1979) for NM rivers such as the Pecos, Canadian, Rio Grande, and San Juan. High specific conductivities, temperatures, and total alkalinities were present in the lower Pecos River in TX where *T. okoboji* occurred at only one of 4 sites (identification made by coauthor JES); that station had a specific conductivity range of about 4000 to 14,000 µS/cm (Davis 1980). In contrast, the range of specific conductivities for

LF-4 and LF-5 was 923–1437 $\mu\text{S}/\text{cm}$. In the UAR, Ruse et al. (2000) reported this species from one warm-water site (AR-18) just upstream of Pueblo Reservoir. No records of *T. okoboji* from the LAR were cited by Kleinert (2008) or Powell (2008).

Genus *Thienemannimyia* Fittkau 1957

Fittkau and Roback (1983) reported that the medium size (<10 mm length) larvae of this genus are “polyoxybiontic, largely cold-stenothermic, and in temperate regions rheophilic”; the immatures prefer “sandy-muddy” sediments in streams. The only species of this genus found in the FCW was *T. barberi*.

Thienemannimyia barberi (Coquillett) 1902

Only one species of the genus *Thienemannimyia* was identified from the FCW—*T. barberi*. The larvae of this genus have been collected from creeks, streams, and rivers (Epler 2001). This species is a western U.S. tanypod; it occurs from WA and OR to NV, UT, CO and KS, south to CA and NM (Roback 1971, Roback and Ferrington 1983, Anderson and Anderson 1995, Furnish et al. 2002). One of 2 species of *Thienemannimyia* from Costa Rica may be conspecific with *T. barberi* (Cranston and Epler 2013). In the FCW, we collected adults from site LF-3 only, a warm-water station with the greatest silt-clay content (0.74%) of all 14 sites. Two OR studies found this species in different habitats. Anderson and Anderson (1995) documented this species from 7 springs in semiarid rangelands of OR. Furnish et al. (2002) reported larvae from Borax Lake, “a natural, geothermally-heated” 10-ha lake near Fields, OR; at 30 m depth the maximum temperature was 118 °C, while the mean surface temperature was 30 °C; heavy metals (As, Cd, Ce, Cu, Pb, and Hg) were high; *T. barberi* larvae were the most numerous and widely distributed chironomid in the lake. Sublette (1964) reported one male from Mono Lake in CA, which is 2.5 times more saline than the oceans, very alkaline at pH 10, endorheic, about 760,000 years old, and at an elevation of about 1932 m. Ruse et al. (2000) did not cite this species in the UAR. Roback and Ferrington (1983) collected larvae and pupae from Cheyenne Creek in Prowers County, CO, near the CO–KS border; they also collected adults with lights from the CO–KS border east to Barton County, KS. Water

quality data from USGS for Coolidge, KS, were cited by Roback and Ferrington (1983); ranges for total hardness were 560–1800 and 251–275 mg/L CaCO_3 (USGS and FCW, respectively); total alkalinity 8–240 and 138–180 mg/L CaCO_3 ; specific conductivity 1050–5140 and 854–1398 $\mu\text{S}/\text{cm}$; pH 7.9–8.4 and 7.6–8.5; temperature 0.0–27.5 and 0.0–28.0 °C; elevation 1022 and 1533 m. This species appeared to be an indicator species of sandy-bottom streams and rivers of the Great Plains in western KS and eastern CO.

DISCUSSION

In responding to our first research question about the chironomid species richness in the FCW, we could say that richness is unexpectedly high. The FCW was rich in total number of species (151), number of genera (65), number of subfamilies (6) and number of new species (24). The species diversity was distributed throughout all 14 sites of the watershed, with total number of species ranging from 12 at site UF-2 to 40 at site MC-1. For the 3 reaches or segments of the Y-shaped FCW, the MC reach recorded 96 species in 45 genera, the UF reach 53 species in 30 genera, and the LF reach 76 species in 41 genera. New species were reported from 13 of 14 sites, with one recorded from 7 sites, 2 from 3 sites, and 5 from 2 sites. Forty species were documented as new distribution records for Colorado. Range expansions or extensions of many species in North America or the Holarctic region were a secondary outcome of this study, particularly for species with restricted or disjunct distributions.

By comparison, in the 475-km reach of the Colorado River through Glen and Grand Canyons, Sublette et al. (1998) found a depauperate chironomid fauna consisting of 38 species dominated by orthoclads, 23 genera and 4 subfamilies. By contrast, in approximately 149 km of stream distance of the FCW, we identified 151 species, 65 genera, and 6 subfamilies with the rank order of species richness being Orthocladinae, Chironominae, Tanypodinae, Prodiamesinae, Podonominae, and Diamesinae. At 22 stations along a 259-km segment of the main stem of the Arkansas River in CO, Ruse et al. (2000) reported a total of 127 species from pupal exuviae and 200 species from adult collections; the Arkansas River sites

represented primarily very cold and cold thermal regimes, whereas the FCW study included cold-, cool-, and warm-water sites.

Among the 151 total species from the FCW, many had biogeographic distributions that include the Neotropical region: species included *T. hastatus*, *C. sylvestris*, *T. neopunctipennis*, *D. crypticus*, *T. stellatus*, *P. scalae-num*, and possibly *C. decorus*; several species had distributions that include the Afrotropical region: species were *C. bicinctus*, *L. minimus*, and *L. natalensis*; 6 species appeared to have ranges that include the Oriental region: species included *H. viridulus*, *T. punctipennis*, *C. sylvestris*, *A. monilis*, *C. fulvus*, and *E. clari-pennis* (Sublette and Sublette 1973, Epler 1988, Sublette and Sasa 1994, Dutta et al. 1996, Spies and Reiss 1996, Sæther and Ekrem 2003, Pamplin et al. 2006, Sanseverino 2006, Vinogradova and Riss 2007, Anderson et al. 2014). The biogeographic distribution of several other species need additional study before their ranges are included in the Neotropics, Afrotropics, or Orient. For example, the status of the vicariance biogeographic explanations for *P. kiefferi* is a study area needing greater resolution (Cranston 1995).

In addressing our second research question about what environmental variables play a role in the distributions of chironomid species in the FCW, we had to separate physicochemical parameters for discussion purposes; however, many factors interacted to impact a species' presence or absence. The FCW was unique in having many diverse microhabitats, all affected in time by the sand-gravel nature of its bedload, elevational gradient, temperature, water quality, and human activities. All of these internal and external factors impacted its invertebrate communities and, importantly, the nonbiting midges or chironomids. This relatively small watershed or catchment had a very diverse chironomid fauna in 2007 and 2008 that could be partially explained by variable temperature regimes, water qualities, elevations, varying microhabitats, and stream order. To Minshall et al. (1985), species richness was a function of stream size and order; midorder streams had higher diversities than headwater or high order streams and rivers. Minshall et al. (1985) studied the Salmon River, ID, and concluded there was "reduced environmental variability" in the lower- and higher-order lotic habitats. Coffman (1989)

suggested maximal species richness occurs in habitats with the highest array of environmental variability; he also concluded that third-order lowland streams usually showed maximal habitat diversity. In the FCW, reaches MC and UF were largely third order and segment LF fourth order. Oliver (1971) best summarized the complex interactions between chironomid larvae and diverse environmental parameters when he said, "The reasons for the distribution of the larvae of a species must be found in a combination of factors, rather than in one factor such as concentration of oxygen or the temperature of the water."

Water temperature may act as an environmental selective factor for some species. For example, the 2 "cold-water specialist" orthoclads, *O. frigidus* and *S. polaris*, were collected only from cold-water sites in MC, whereas many "warm-water specialist" species of the 2 tribes Chironomini and Tanytarsini of the subfamily Chironominae occurred only in the warm-water sites of LF-2, 3, 4, and 5 (Table 4). Species such as *C. decorus*, *S. tytus*, *C. infuscatus*, and others could be considered "generalists" because they occurred in cold-, cool-, and warm-water sites. Not only were there cold- and cool-water sites at higher elevations, but warm-water sites also occurred at lower elevations. In cool- and cold-water habitats of the Yukon Arctic North Slope and the Colorado River in the Grand Canyon, the number of species of subfamily Orthocla-diinae was greater than the number of species for the subfamilies Chironominae and Tany-podinae (Oliver and Dillon 1997, Sublette et al. 1998); in warm-water regions, the number of species of Chironominae and Tany-podinae was greater. Elgmork and Sæther (1965) found that 99.6% of the chironomids in the high-elevation (3800 m) North Boulder Creek, CO, were Orthocla-diinae. Additionally, orthoclad larvae occurred in a wide variety of lotic and lentic habitats, as well as terrestrial and semiterrestrial biotopes. The FCW had 21 species that occurred in all 3 reaches, with 12 being Orthocla-diinae, 6 Chironominae, and 3 Tany-podinae, resulting in only 57.1% being orthoclads.

In addition to the impact of different thermal regimes, chironomids had to adapt to a sand-dominated sediment at all 14 sites of the FCW. In many streams and rivers there is abundant detritus mixing with sedimentary silts

and clays forming a quasi-stable sediment; however, in the FCW the high percentage of sands and gravels contributes to an ever-changing stream course and bed. As sands and gravels of Pikes Peak granite tumble downstream, they grind against each other with a scouring molariform action that releases fragmented macrophytes, algae, bacteria, and other members of the aufwuchs in the form of CPOM and FPOM for consumption by various chironomids. The mechanism is similar to a rock tumbler of geologists. The 3 reaches of the FCW are all shallow in depth so photosynthetic bacteria, algae, and a few macrophytes grow on the sand-gravel substrate and often give a green color to the streambed. When flow rises, the sediment starts to move and abrade. Many of the chironomid species inhabiting this sandy-bottom watershed must adapt to an ever-shifting substrate during low and high flows. The work of LeSage and Harrison (1980a, 1980b, 1980c) is the only comparable species-level study to include a sediment characterization analysis; they reported that coarse to fine sand never exceeded 22% for 14 of 15 marl-encrusted sites; their range was 2.5%–36.3% and the mean was 12.3 (SD 8.4). In contrast, the range for the FCW was 28.7%–74.1% and the mean was 49.4 (SD 12.6). Interestingly, these 2 very different substrate types, sand (FCW) versus marl, supported 9 and 15 species of *Cricotopus*, respectively.

It is noteworthy to cite how the substrate of site UF-2 at Soda Springs Park in Manitou Springs was physically impacted by commercial buildings along this segment of UFC. The flowing water of site UF-2 cascades downstream in contact with the concrete foundations of commercial buildings along the east and south banks through Manitou Springs below Soda Springs Park. The second floors of these cantilevered buildings extend over the streambed causing shade on the water and substrate during most daytime hours. This physical human impact was apparently one major contributor to site UF-2 having the lowest number of species and genera of any of the 14 sites.

Temperature and substrate are physical environmental factors that may interact with dissolved and suspended components in the water. Nutrients, particularly total phosphorus, may affect the trophic dynamics of lotic

environments. Sæther (1979) discussed how selected species of chironomids could be used to locate exact sources of organic pollution; he also stated how they are used to indicate a transition from oligotrophy to eutrophy. Total phosphorus concentrations indirectly affect primary production by algae and bacteria. In the FCW, phosphorus concentrations often become more than 30× greater under storm-flow conditions than they are during base (normal) flows. Also, phosphorus concentrations may increase as much as 80% below WWTPs downstream of site LF-1 (Mau et al. 2007, AF CURE 2014). Total phosphorus data in Table 3 reflect base flow conditions.

In addition to the discharge of elevated phosphorus loads by WWTPs, other human activities may also discharge toxic heavy metals and metalloids. The UAR from 1859 to 2000 was severely impacted by mining activities and mine drainage, and the release of heavy metals (As, Cd, Cu, Mn, Pb, Fe, and Zn) and acidified water from the Leadville Drain and California Gulch. Ruse et al. (2000) reported how some species could tolerate a cocktail of toxic metals while others were intolerant. In the FCW site UF-4 was also impacted by gold ore processing and smelting; this site literally flows only a few meters from the base of Gold Hill, a large smelter tailings pile. The north side of Gold Hill Mesa “drains directly to Fountain Creek” (von Guerard 1989b). Toxic heavy metals (As, Cd, Cu, Pb, Hg, and Zn) in the Gold Hill tailings pile in Colorado Springs were continually eroded and discharged into site UF-4 only a few meters away (USEPA 1994, Dames and Moore 1999). During episodes of heavy precipitation, runoff from Gold Hill carried a sedimentary load into UFC resulting in major gully formation on the tailings pile. Eighteen species occurred at site UF-3 (2.17 km upstream of UF-4) that were absent at site UF-4 (Table 4); the species present at UF-3 but absent at UF-4 included 3 new species each of the genera *Chironomus*, *Parametriocnemus*, and *Rheocricotopus*, 4 *Limnophyes* species, 3 *Procladius* species, 2 *Micropsectra* species, 2 *Brillia* species, and 1 species each of *Polypedilum*, *Paraphaenocladius*, *Thienemanniella*, and *Prodiamesa*.

Future research on the chironomids in the FCW should focus on developing an illustrated atlas of the pupal exuviae associated with adult males. The surface floating pupal exuviae (SFPE) method (Wilson 1980, Ferrington

et al. 1991, Bouchard 2007, Kavanaugh et al. 2014), along with pharate adults providing adult males associated with their individual exuvae, could be applied to more sites and more seasons with less effort. Data from this report have provided a strong baseline for chironomid species diversity in the FCW during the summer months of 2007–2008. Greater species diversity using SFPE would be an expected outcome because winter-emerging species would be included, as well as late spring and early fall emergers. During 2016–2018, a water pipeline called the Southern Delivery System (SDS) will begin carrying about 96 million gallons of imported (western slope transmountain diversion) water per day from the Arkansas River at Pueblo Reservoir to Colorado Springs. Wright Water Engineers, Inc. (Denver, CO) has estimated that for every acre foot (1233.48 m³) of imported water per year delivered to Colorado Springs by SDS, ~0.85 acre feet (1040.46 m³) will flow into the FCW as “new water” added to historical base flows. The natural question follows: what effects will increased SDS return flows and runoff have on the species diversity of the Chironomidae and other trophic levels such as fish in the FCW? A rapid assessment protocol for monitoring emerging chironomid species assemblages during all seasons at more sites should be implemented as soon as possible using an SFPE atlas. Such an atlas would be a desirable tool for evaluating future watershed changes and impacts ranging from increased sediment transport to altered water quality resulting from the SDS and other urbanization projects.

CONCLUSIONS

The major aquatic insect taxon in the FCW, the Chironomidae, was species diverse and showed extensive species richness from cold-water reaches to cool-water segments to warm-water sections; the Y-shaped watershed exhibited exceptionally high environmental heterogeneity resulting from varied elevation, bedload composition, water quality, microbiological content, degree of urbanization, stream-side vegetation, and geological landforms. With 151 total species from 6 subfamilies and 65 genera, the chironomids of the FCW included species with very restricted distributions to others that were cosmopolitan,

Neotropical, Afrotropical, or Oriental. Many species were tolerant or intolerant of toxic heavy metals, wastewater discharges or thermal regimes; some species often shared the same microhabitat with companion species either intergeneric or intrageneric.

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