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A RARE AND CRYPTIC ENDEMIC OF THE CENTRAL ROCKY MOUNTAINS, U.S.A: THE DISTRIBUTION OF THE ARAPAHOE SNOWFLY, *ARSAPNIA ARAPAHOE* (NELSON & KONDRATIEFF, 1988) (PLECOPTERA: CAPNIIDAE)

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The Arapahoe snowfly, *Arsapnia arapahoe* (Nelson & Kondratieff, 1988) (Plecoptera: Capniidae) is a candidate species warranted for listing under the Endangered Species Act. Prior to this study, *A. arapahoe* was known from only two tributaries of the Cache la Poudre River in Larimer County, Colorado: Young Gulch and Elkhorn Creek. The objectives of this study were to determine the distribution of this endemic stonefly, and to identify sympatric species as possible surrogate indicators of its occurrence. Eighty-four streams were sampled within the expected geographical range and emergence time-period from 2013 to 2017. Adults of *A. arapahoe* were discovered in 19 first-, second-, and fourth-order streams beyond the original type localities tributary to the Cache la Poudre River. The new and recently recorded localities were discovered in the Big Thompson River, St. Vrain River, Boulder Creek, and Upper South Platte River Watersheds. Two species, *A. decepta* (Banks, 1897) and *Capnia gracilaria* Claassen, 1924, always co-occurred with *A. arapahoe*, suggesting this species pair may serve as a surrogate indicator of suitable stream habitat for *A. arapahoe*. Suggestions for future investigation into the distribution, life-history, and habitat of *A. arapahoe* are presented to aid the conservation of this rare and endemic Colorado stonefly.

Keywords: Winter stonefly, *Arsapnia arapahoe* (Nelson & Kondratieff, 1988), rare species

INTRODUCTION

Stoneflies are indicators of environmental health, as they are often one of the first taxonomic groups of aquatic insects extirpated from streams where water quality and physical habitat have been degraded (Baumann 1979, Rosenberg & Resh 1993, Barbour et al. 1999). Species within the Capniidae are one of the most characteristic groups of winter emerging stoneflies throughout the Holarctic Region (Fochetti & Tierno de Figueroa 2008), and where studied, they possess high sensitivity to organic pollution (Hilsenhoff 1988) and other types of disturbance (e.g., Courtney and Clements 2002, Vieira et al. 2004). Most capniids have been extirpated from reaches where streams transition from mountains to plains along the northern Colorado Front Range of the Rocky Mountains, possibly due to water quality, siltation and subsequent loss of hyporheic connections, or low flows (Zuellig et al. 2012, Stoaks & Kondratieff 2014).

The Arapahoe snowfly, *Arsapnia arapahoe* (Nelson & Kondratieff, 1988) is a capniid species originally described from two male specimens collected from Elkhorn Creek (April 3, 1987; holotype) and Young Gulch (March 22, 1986; paratype) in Larimer County, Colorado. Recently, Baumann & Stark (2017) evaluated the variation of the male epiproct of this species throughout its range. The streams at these localities support a diverse array of regional aquatic insect taxa, including other stonefly species (Ward et al. 2002, Zuellig et al. 2006, Zuellig et al. 2012). They are both cool, first-order mountain tributaries of the Cache la Poudre River. Elevations range from 1,800 m to 2,300 m, and streambeds comprise a pebble, cobble, and bedrock substrate. Riparian vegetation includes cottonwood (*Populus deltoides* Bartr.), willow (*Salix alba* L.), and box elder (*Acer negundo* L.) (Nelson & Kondratieff 1988). Elkhorn Creek is mostly perennial in its lower reaches, but is subject to intermittency higher in the watershed. The upper stream reaches are surrounded by ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), steep slopes, and sparse riparian vegetation (Nelson & Kondratieff 1988). Young Gulch usually becomes intermittent in late summer/early fall, depending upon timing of

precipitation and subsequent groundwater recharge.

The goal of this study was to determine the distribution of *A. arapahoe* in streams of the northern Front Range of Colorado and to ascertain whether the species was still present in Elkhorn Creek and Young Gulch in the Cache La Poudre watershed after severe fire in 2012 and flood disturbances in 2013. Specifically, the objectives were to (1) determine the distribution of *A. arapahoe* by sampling nearby streams deemed similar to the type localities, (2) characterize sympatric winter stonefly species that may serve as indicators of suitable habitat for the more rare Arapahoe snowfly, and (3) investigate annual variability in the presence/absence of *A. arapahoe* in Elkhorn Creek and Young Gulch.

MATERIALS AND METHODS

Sampling for adult winter stoneflies was conducted at 84 streams during late winter through early spring (January to May) from 2013 to 2017. Winter stoneflies were collected primarily using beating sheets in riparian vegetation, but were also collected via emergence traps, larval rearing, and by hand-picking from other substrate (e.g., on trees, snow, or exposed cobbles). The beating sheet is one of the most effective and efficient means for collecting adult winter stoneflies from streamside vegetation (DeWalt et al. 2015). All adult stoneflies were preserved in 80% ethanol and transported to the laboratory at Colorado State University for identification. All specimens reported in this paper were deposited in the C.P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, Colorado (CSUC). A supplementary data set is available in [comma separated values format](#).

RESULTS AND DISCUSSION

A total of 13 winter stonefly species and 26,170 individual specimens were collected from 84 streams between 2013 and 2017 (Table 1, Fig. 1). In 2013 and 2014, six localities with *A. arapahoe* males were discovered in Sheep Creek (Big Thompson), Central Gulch (Saint Vrain), and Bear Canyon Creek, Bummer's Gulch, Martin Gulch, and Tom

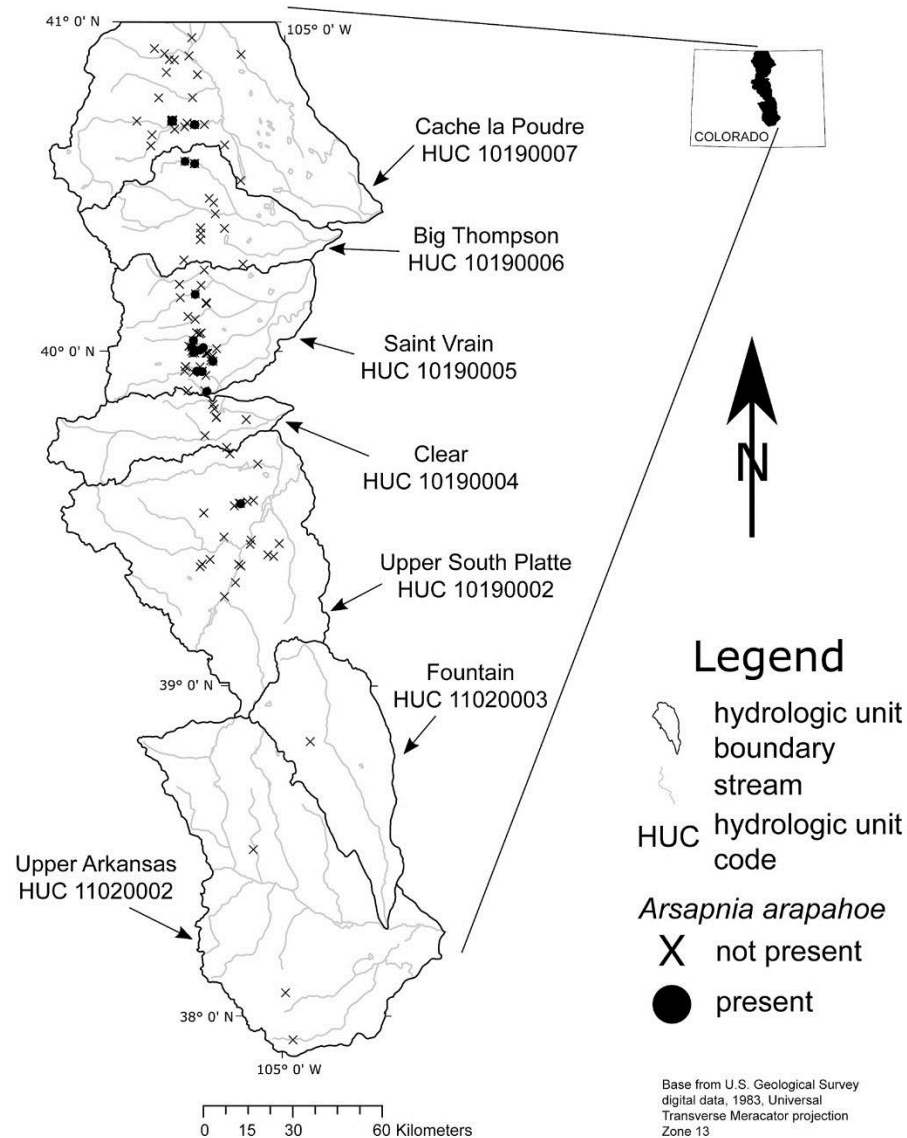


Fig. 1. Presence and absence of *Arsapnia arapahoe* from sampling conducted 2013 to 2017 in the Front Range of Colorado. Watersheds are United State Geological Survey Hierarchical Unit Code 8 (HUC8) scale watersheds.

Davis Gulch (Saint Vrain) as reported in Heinold et al. (2014). Herein, we report new localities of *A. arapahoe* from seven additional streams: Twin Cabin Gulch (Big Thompson), Boulder Creek (Saint Vrain), Coal Creek (Saint Vrain), Four Mile Creek (Saint

Vrain), Keystone Gulch (Saint Vrain), Lost Gulch (Saint Vrain), and Deer Creek (Upper South Platte, Table 1, Fig. 1). Of the 26,170 specimens, only 41 were *A. arapahoe* adult males, representing <0.01% of the total number collected. *Arsapnia arapahoe* was

confirmed from Elkhorn Creek in 2013, 2014, and 2015 and from Young Gulch, in 2016 (Table 1). Overall, *A. decepta* (Banks, 1897) (66%) and *C. gracilaria* (Claassen, 1924) (24%) made up nearly 90% of all adult stoneflies collected, while the remaining nine species combined accounted for less

than 10% of all capniids collected. At all streams where *A. arapahoe* was collected, *A. decepta* was also present and often the most abundant capniid with the exception of Elkhorn Creek and Tom Davis Gulch, where it was second to *C. gracilaria*.

Table 1. Streams sampled for adult winter stoneflies in the Big Thompson River, Cache la Poudre River, St. Vrain River, St. Charles River, Boulder Creeks, South Platte River, and Clear Creek watersheds, Colorado, USA. (X) denotes collection(s) made in each year. (a) denotes confirmed locality for *Arsapnia arapahoe*. Material collected in 2013 and 2014 are attributed to Heinold et al. 2014

Hydrologic unit code	Hydrologic unit code name	Stream name	2013	2014	2015	2016	2017	
10190007	Cache la Poudre River	Bennett Creek	X					
		Cedar Gulch		X				
		Dale Creek	X					
		Devil's Creek		X				
		Divide Creek		X				
		Elkhorn Creek	X ^a	X ^a	X ^a	X		
		Fish Creek	X					
		Hewlett Gulch		X				
		Little Beaver Creek	X					
		Lone Pine Creek	X					
		Poverty Gulch		X				
		Rabbit Creek	X					
		Rabbit Creek at North Fork						
		Cache la Poudre River	X	X				
		Rist Canyon Creek						X
		Sand Creek	X					
		Sevenmile Creek	X	X		X		
		Skin Gulch						X
		South Lone Pine Creek			X			
		Spring Creek			X			
		Trail Creek	X					
		Tributary to Meadow Creek			X			
		Young Gulch			X		X ^a	
10190006	Big Thompson	Buckhorn Creek	X				X	
		Cedar Creek		X				
		Cottonwood Creek		X				
		Dry Creek		X				
		Hell Canyon Creek				X		
		Little Thompson River	X	X				
		North Fork Little Thompson River				X		
		Quillan Gulch		X				
		Sheep Creek	X ^a	X		X		
		Twin Cabin Gulch				X	X ^a	
Unnamed Creek		X						

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Hydrologic unit code	Hydrologic unit code name	Stream name	2013	2014	2015	2016	2017	
10190005	Saint Vrain	Bear Canyon Creek		X ^a	X ^a	X		
		Boulder Creek		X	X	X ^a		
		Bummer's Gulch	X	X ^a	X	X		
		Central Gulch	X ^a	X		X		
		Coal Creek			X		X ^a	
		Deadman Gulch		X				
		Forsythe Creek					X	
		Four Mile Canyon Creek					X	X
		Four Mile Creek				X ^a	X ^a	
		Geer Canyon Creek				X	X	
		Gregory Creek			X	X	X	
		Hawkin Gulch					X	
		James Creek		X				
		Keystone Gulch		X			X ^a	
		Lefthand Creek		X				
		Lost Gulch			X		X ^a	
		Martin Gulch			X ^a		X	
		North Saint Vrain Creek					X	
		Skunk Creek			X		X	
		South Beaver Creek						X
		South Boulder Creek			X			
		South Draw					X	
		South Saint Vrain Creek					X	
		Tom Davis Gulch				X ^a	X ^a	
		Tributary to Bummer's Gulch			X			
		Unnamed Creek			X			
Winiger Gulch					X			
10190004	Clear	Van Biber Creek		X		X	X	
		Guy Gulch					X	
		Lena Gulch					X	
		Ralston Creek					X	
10190002	Upper South Platte	Bear Creek				X	X	
		Brush Creek		X				
		Buffalo Creek				X		
		Deer Creek					X ^a	
		Indian Creek					X	
		Jarre Creek					X	
		Kennedy Gulch		X			X	
		Morrison Creek				X		
		Mount Vernon Creek					X	
		Pine Creek					X	
		Shinglemill Creek				X		
		South Deer Creek					X	
		South Platte River					X	
		Stevens Gulch					X	
Sugar Creek					X			
Tributary to Bear Gulch		X						

Hydrologic unit code	Hydrologic unit code name	Stream name	2013	2014	2015	2016	2017
11020003	Fountain	Bear Creek			X		
11020002	Upper Arkansas	Eightmile Creek		X			
		Greenhorn Creek	X	X			
		South Creek		X			

Arsapnia arapahoe males collected from these streams, and at the Elkhorn Creek type locality, were found in substantially lower numbers compared to other co-occurring capniids. Throughout the collections reported herein, several winter stonefly species, *A. decepta*, *C. gracilaria*, *Capnura wanica* (Frison, 1944), *Capnia confusa* (Claassen, 1936), *Paracapnia angulata* (Hanson, 1961), and *Utacapnia logana* (Nebeker and Gaufin, 1965), consistently co-occurred with *A. arapahoe*, as did the nemourid *Zapada cinctipes* (Banks, 1897). These species are all common in western North America, including Colorado (Baumann et al. 1977, Kondratieff & Baumann 2002). *Capnia coloradensis* (Claassen, 1937), *Eucapnopsis brevicauda* (Claassen, 1924), *Isocapnia vedderensis* (Ricker, 1943), *Mesocapnia frisoni* (Baumann & Gaufin, 1970), and *Prostoia besametsa* (Ricker, 1952) were collected infrequently. Where adult males of *A. arapahoe* were present, *A. decepta* and *C. gracilaria* were collected in the greatest abundance. *Arsapnia arapahoe* is closely related to *A. decepta* (Nelson & Baumann 1989) as discussed by Heinold et al. (2014) and appears to always be sympatric with this more common *Arsapnia* species. As such, *A. decepta* and *C. gracilaria* may potentially be used as indicators for identifying appropriate aquatic habitats and the presence of *A. arapahoe*. However, consideration of *A. decepta* as a surrogate indicator for the presence of *A. arapahoe* should be further examined within the context of recently reported variation in epiprocts of *A. decepta* (Baumann & Stark 2017).

During this study, two major ecological disturbances occurred in the Cache la Poudre River watershed. In 2012, the High Park Fire burned nearly 35,209 hectares (Wohl 2013), which included the Young Gulch Watershed. The fire deposited ash

and post-fire monsoonal thunderstorms scoured sediments throughout much of Young Gulch. Severe flooding in September 2013 altered alluvial deposits, scoured streamside vegetation, and redistributed coarse woody material in streams across the northern Colorado Front Range, including both Young Gulch and Elkhorn Creek. Despite loss of streamside vegetation and severe flood impacts to the streambed and alluvium, several capniid species including *A. arapahoe* were detected in Elkhorn Creek in 2013. Capniids and other stoneflies were not found in Young Gulch in 2013; however, *A. decepta* and *C. gracilaria* adults were collected in Young Gulch in 2014, and three adult male *A. arapahoe* were collected in Young Gulch in 2016. The presence of *A. arapahoe* and other capniids following severe fire and flood suggests tolerance of periodic, severe natural disturbances and perhaps an evolutionarily adaptation to such disturbances.

Conservation of the rare Arapahoe snowfly will require an improved understanding of distribution, life-histories, and habitat requirements. The importance of variables such as bed substrate coarseness, degree of connection to the hyporheic zone, food preference, preferred riparian vegetation and microclimate, availability of detrital materials for larvae, and thermal characteristics of the streams where they occur will provide especially valuable information for species management. In summary, the Arapahoe snowfly is shown here to be spatially rare in distribution, and numerically rare as compared to other capniids. Further investigation of this species is warranted to aid resource managers in designing suitable protection and conservation measures for this rare Colorado endemic stonefly. This study provides another example of the

importance of headwater and intermittent streams to the maintenance of diversity of stoneflies.

***Arsapnia arapahoe* (Nelson & Kondratieff, 1988)**

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:465451>

Arsapnia arapahoe (Nelson & Kondratieff) in Nelson & Kondratieff, 1988: 77. Holotype ♂, United States National Museum, Elkhorn Creek, Larimer County, Colorado, United States of America.

Material Examined: New Records, COLORADO – Larimer County, Elkhorn Creek, CO-14 W - 21 miles from United States Highway 287 North, 14-III-2015, N 40°41'52" W -105°26'26", B. Heinold, C. Verdone, 1♂; Young Gulch, CO-14 W - 13 miles from United States Highway 287 North, 12-II-2016, N 40°41'18", W -105°20'50", C. Verdone, Y. Lapotre, 2♂; Young Gulch, Colorado Highway 14 West - 13 miles from United States Highway 287 North, 17-II-2016, N 40°41'18", W -105°20'50", Y. Lapotre, 1♂; Twin Cabin Gulch, Buckhorn Road 44H, 10-III-2017, 40°34'40", -105°23'13", C. Verdone, 1♂; **Boulder County**, Bear Canyon Creek, Bear Canyon Trail, South of the National Center for Atmospheric Research, 30-I-2015, N 39°58'31", W -105°16'54.1200", C. Verdone, 1♂; Boulder Creek, Boulder Canyon Drive above Jones Hole, 6-III-2016, N 40°00'52", W -105°18'40", C. Verdone, 1♂; Fourmile Creek, Link Trail Crossing, 9-II-2016, N 40°02'09", W -105°21'02", C. Verdone, 2♂; Fourmile Creek, Link Trail Crossing, 25-II-2016, N 40°41'21", W -105°21'01", Y. Lapotre, 1♂; Keystone Gulch, United States Forest Service land East of Magnolia Road., 4-IV-2016, N 39°59'58", W -105°20'59", Y. Lapotre, 1♂; Lost Gulch, Chapman Drive Trailhead, 29-III-2016, N 40°00'26", W -105°19'28", Y. Lapotre, 1♂; Tom Davis Gulch, Walker Ranch above confluence with South Boulder Creek, 4-III-2016, N 39°56'34", W -105°20'11", Y. Lapotre, 2♂; **Jefferson County**, Coal Creek, Colorado State Highway 72, Jefferson County Open Space, 2-III-2017, N 39°52'55", W -105°17'47", C. Verdone, 1♂; Deer Creek, Deer Creek Canyon Road, Jefferson County Open Space, 30-III-2017, 39°32'35", -105°9'42", C. Verdone, A. Massaro, 1♂;

Records from Heinold et al. 2014: Larimer County, Elkhorn Creek, Colorado Highway 14 West - 21 miles from United States Highway 287 North, 8-III-2013, N 40°41'52" W -105°26'26", T.P. Belcher, 3♂; Elkhorn Creek, Colorado Highway 14 West - 21 miles from United States Highway 287 North, 21-III-2013, N 40°41'52" W -105°26'26", T.P. Belcher, 1♂; Elkhorn Creek, Colorado Highway 14 West - 21 miles from United States Highway 287 North 28-III-2013, N 40°41'52" W -105°26'26", T.P. Belcher, 1♂; Elkhorn Creek, Colorado 14 West - 21 miles from United States Highway 287 North, 8-IV-2013, N 40°41'52" W -105°26'26", T.P. Belcher, 1♂; Elkhorn Creek, Colorado Highway 14 West - 21 miles from United States Highway 287 North, 11-IV-2013, N 40°41'52" W -105°26'26", T.P. Belcher, 1♂; Elkhorn Creek, Colorado Highway 14 West - 21 miles from United States Highway 287 North, 20-IV-2013, N 40°41'52" W -105°26'26", T.P. Belcher, 1♂; Elkhorn Creek, CO-14 W - 21 miles from U.S. 287 N, 21-III-2014, N 40°41'52" W -105°26'26", T.P. Belcher, 1♂; Elkhorn Creek, Colorado Highway 14 West - 21 miles from United States Highway 287 North, 9-IV-2014, N 40°41'52" W -105°26'26", T.P. Belcher, 1♂; Sheep Creek, Buckhorn Road, 30-III-2013, N 40°34'14", W -105°20'53", B. Heinold, 1♂; Sheep Creek, Buckhorn Road, 31-III-2013, N 40°34'14", W -105°20'53", B. Heinold, 1♂; Sheep Creek, Buckhorn Road, 1-IV-2013, N 40°34'14", W -105°20'53", C. Verdone, 2♂; Sheep Creek, Buckhorn Road, 21-IV-2013, N 40°34'14", W -105°20'53", T.P. Belcher, 1♂; **Boulder County**, Bear Canyon Creek, Bear Canyon Creek Trail, 16-II-2014, N 39°58'22", W -105°16'22", C. Verdone, 1♂; Bummer's Gulch, Sugarloaf Road/Millionaire Road, 28-II-2014, N 40°00'58", W -105°21'26", C. Verdone & D. Fuller, 1♂; Central Gulch, Highway 7 (South St. Vrain Dr.), 26-IV-2013, N 40°10'31", W -105°20'38", C. Verdone, 2♂; Martin Gulch, Walker Ranch Loop, 27-II-2014, N 39°56'30", W -105°18'54", C. Verdone & D. Fuller, 4♂; Tom Davis Gulch, Walker Ranch Park, 14-III-2014, N 39°56'34", W -105°20'10", C. Verdone & D. Fuller, 1♂.

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