

NATURAL HISTORY AND OBSERVATIONS

Plecoptera from the Crooked River, British Columbia

D.J. ERASMUS¹ and D.P.W. HUBER²

The Crooked River is the southernmost Arctic watershed stream in British Columbia (B.C.). It is the northwards-flowing outlet of Summit Lake, connecting a series of lakes before it enters Williston Reservoir and the Peace River. With its location in north-central B.C. and its south-to-north flow, the Crooked River is in the direct path of petroleum pipelines originating from northeastern B.C. and Alberta to the Pacific coast. One proposed pipeline, Coastal GasLink, is slated to cross the Crooked River (McCreary and Turner 2018). Currently, no pipelines cross the Crooked River, and so it is important to develop a species diversity baseline for future monitoring (Pauly 1995).

The EPT taxa richness index (Lenat 1988) — comprised of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) — is a monitoring tool for the rapid assessment of water quality (Barbour *et al.* 1999). Most often, it is compiled from larval data and generic-level identification, but it is also built from adult specimens where species-level identification is possible. A baseline accounting of the assemblage of EPTs in a river is thus useful for monitoring assemblage changes caused by anthropogenic or natural changes (DeWalt *et al.* 1999). The order Plecoptera is the most environmentally sensitive aquatic insect order to addition of organic pollutants (Baumann 1979; Klemm *et al.* 2002; Mandaville 2002) and monitoring shifts in species presence may be important for assessing the effects of future oil, gas or bitumen spills.

We have previously published surveys of Trichoptera and Ephemeroptera for this system (Erasmus *et al.* 2018; Huber *et al.* 2019), recovering at least 39 species of caddisflies and 40 species of mayflies. We have reported a total of 11 new provincial records for caddisflies and mayflies. This paper serves to complete the EPT checklist for the Crooked River, because no previous work reports on stoneflies from this or nearby systems.

Stonefly adults were sampled from May to August 2015 from eight locations (Table 1) using Malaise traps. Insects were captured into 95% ethanol, and the trap contents were emptied every seven to 10 days. Collected specimens were transferred to new 95% ethanol and stored at -20°C until sorting.

Stoneflies were sorted to morphospecies and identified to the lowest possible taxon using keys found in Stewart and Oswald (2006). Following sorting and morphological identification, 95 adult specimens were sent to the Canadian Centre for DNA Barcoding at the University of Guelph, Ontario. We obtained 92 useable sequences (>400 bp; <5 miscalls; no contamination detected). We identified species using the BOLD platform with MUSCLE sequence alignments and a Kimura-2-parameter distance model. The data set is available at dx.doi.org/10.5883/DS-CRPLE. Sequenced specimens, DNA, and sequence data were vouchered at the Centre for Biodiversity Genomics and on the Barcode of Life Database System at the University of Guelph.

A total of 3,421 adults were sampled, and based on our survey the Crooked River supports at least 19 stonefly species belonging to 14 genera and seven families (Table 2). Our initial morphology-based identification identified 13 species with a number of specimens we classified only to family level, but DNA barcoding allowed the identification of six more species. These data, combined with our previous efforts, result

¹ Biochemistry and Molecular Biology, 3333 University Way, University of Northern British Columbia, Prince George, British Columbia, Canada, V2N 4Z9; daniel.erasmus@unbc.ca

² Faculty of Environment, University of Northern British Columbia, 3333 University Way, Prince George, BC V2N 4Z9; huber@unbc.ca

in a total count of 96 mayfly, caddisfly, and stonefly species for the Crooked River (Erasmus *et al.* 2018; Huber *et al.* 2019).

Ephemeroptera, Plecoptera, and Trichoptera species richness is a key indicator of water quality (Kenney *et al.* 2009), and the number of EPT species from Crooked River compares favourably to other systems. Cordero *et al.* (2017) found 155 EPT species across many rivers and lakes throughout northern Canada. Other studies have shown 70 EPT species from eight rivers of the Lower Illinois River basin (DeWalt *et al.* 1999). Among these eight rivers, the highest EPT species count for a single river was 38 EPT species. A survey for EPTs in the area around Churchill, Manitoba, revealed 112 EPT species from several streams, ponds, and lakes (Zhou *et al.* 2009).

Our work provides a solid approximation for EPT species richness for the Crooked River, B.C. It serves as a baseline for future studies such as environmental assessments. It also provides a useful checklist for other systems in this rather under-surveyed region.

Table 1. Sampling Sites.

Site name	Coordinates	Description
CR2	54.484 °N, -122.721 °W	Tail out section at the end of a slow-moving run and directly upstream from a bridge crossing with a dirt road
CR2B	54.484 °N, -122.721 °W	Slow moving run with foliage up to the high-water mark.
CR3	54.643 °N, -122.743 °W	Riffle section, with foliage to the high-water mark. 70 m from paved highway
CR4	54.388 °N, -122.633 °W	Riffles and pools, with foliage to the high-water mark. 15 m from railway line and 40 m from paved highway
CR5	54.478 °N, -122.719 °W	Riffles and runs with water supplied by Livingston Springs.
CR6	54.328 °N, -122.669 °W	Outflow at Summit lake and directly downstream from a bridge crossing with a dirt road
CR100BR	54.446 °N, -122.653 °W	Riffle, run, and pool section, and up- and downstream from a bridge crossing with a dirt road. Foliage to the high-water mark.
CR108	54.458 °N, -122.722 °W	Riffle and pool sections, with foliage to the high-water mark. 30 m from a dirt road.

Table 2. Plecoptera collected from the Crooked River, British Columbia

Family ^a	Genus ^a	Species ^a	Specimen ID ^b	BIN ^c	Collection site ^d
Capniidae	Capnia	coloradensis Claassen, 1937	P5-CR108 and 1 other	BOLD:A AM4443	CR108
Capniidae	Capnia	confusa Claassen, 1936	P87-CR108 and 6 others	BOLD:A AC4234	CR108
Capniidae	Utacapnia	columbiana (Claassen, 1936)	P1-CR108	BOLD:A AD2173	CR108
Chloroperlidae	Alloperla	severa (Hagen, 1861)	P67-CR108 and 4 others	BOLD:A AC5215	CR108
Chloroperlidae	Haploperla	brevis (Banks, 1895)	P48-CR3 and 3 others	BOLD:A AA6398	CR3
Chloroperlidae	Sweltsa	coloradensis (Banks, 1898)	P18-CR108 and 7 others	BOLD:A AF3559	CR108, CR2B, CR4
Chloroperlidae	Triznaka	signata (Banks, 1895)	P71-CR2B and 2 others	BOLD:A AD7836	CR108, CR2B
Leuctridae	Paraleuctra	vershina Gaufin and Ricker, 1974	P37-CR108 and 2 others	BOLD:A DM0482	CR108
Nemouridae	Malenka	californica (Claassen, 1923)	P66-CR108 and 13 others	BOLD:A AQ2350	CR108, CR4
Nemouridae	Podmosta	decepta (Frison, 1942)	P55-CR4	BOLD:A CG2351	CR4
Nemouridae	Podmosta	delicatula (Claassen, 1923)	P90-CR2B and 14 others	BOLD:A CS1790	CR108, CR2B, CR3, CR4
Nemouridae	Zapada	cinctipes (Banks, 1897)	P80-CR4 and 5 others	BOLD:A CB0726	CR108, CR4
Nemouridae	Zapada	frigida (Claassen, 1923)	P54-CR4	BOLD:A CC1688	CR4
Perlidae	Hesperoperla	pacifica (Banks, 1900)	P40-CR108 and 1 other	BOLD:A AK5931	CR108, CR4
Perlodidae	Isoperla	fulva Claassen, 1937	P59-CR4 and 10 others	BOLD:A AC2488	CR108, CR4, CR2B
Perlodidae	Isoperla	sobria (Hagen, 1874)	P58-CR108 and 2 others	BOLD:A AL8080	CR108, CR4

Table 2. continued

Family ^a	Genus ^a	Species ^a	Specimen ID ^b	BIN ^c	Collection site ^d
Perlodidae	Isoperla	transmarina (Newman, 1838)	P22-CR3 and 3 others	BOLD:AAA 9661	CR108, CR3
Perlodidae	Skwala	americana (Klapalek, 1912)	P39-CR108	BOLD:AAC 6148	CR108
Pteronarcyidae	Pteronarcys	californica Newport, 1848	P41-CR108	BOLD:AAM 2598	CR108

^a Determined using morphological keys and BOLD database

^b Specimen identification. Complete data set available at BOLD dataset CRPLE

^c Barcode Index number

^d CR2: 54.484 °N, -122.721 °W; CR2B: 54.484 °N, -122.721 °W; CR3: 54.643 °N, -122.743 °W; CR4: 54.388 °N, -122.633 °W; CR5: 54.478 °N, -122.719 °W; CR6: 54.328 °N, -122.669 °W; CR100BR: 54.446 °N, -122.653 °W; CR108: 54.458 °N, -122.722 °W

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