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First records of *Gulcamptus huronensis* Reid, 1996 (Copepoda, Harpacticoida, Canthocamptidae) from Lake Superior, with morphological notes on the male

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Abstract

Gulcamptus huronensis Reid, 1996 is a seldom-reported harpacticoid copepod known only from two female specimens, one collected from Lake Huron, Michigan, USA, the other from Nunatak Creek, Alaska, USA. Herein, we report a new distributional record for *G. huronensis* from the meiobenthos of Lake Superior, Michigan and Wisconsin, USA. A total of 12 specimens were collected from four localities across Lake Superior in August, 2018. Additionally, we provide information on the habitats where specimens of *G. huronensis* were recovered and morphological notes on the previously undescribed male of the species.

Keywords

Biological monitoring, Crustacea, Great Lakes, meiofauna

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Introduction

Part of the large, primarily freshwater harpacticoid copepod family Canthocamptidae (Boxshall and Halsey 2004), *Gulcamptus* Miura, 1969 is a small genus with only six species described from throughout most of the Holarctic realm (Wells 2007). Species of *Gulcamptus* have been reported from the Nearctic and eastern Palearctic regions (Fig. 1A). In the Palearctic region, three species of *Gulcamptus* are known from South Korea (Miura 1969) and Japan (Ishida and Kikuchi 1994; Ishida 1995). In the Nearctic region, three species are known from Canada (Flössner 1992) and the northern USA (Reid and Ishida 1996).

Collections of *Gulcamptus huronensis* Reid, 1996 have been reported from only two localities (Fig. 1A): a female specimen from Lake Huron, near Rogers City, Michigan, USA (Reid and Ishida 1996; Hudson et al. 1998) and a female specimen from Nunatak Creek, Glacier Bay National Park, Alaska, USA (Reid and Ishida 1996; Robertson and Milner 1999). However, there is no reported collection of the male of *G. huronensis*, and for this reason the morphology of males has remained unknown (Reid and Ishida 1996; Reid and Williamson 2010). *Gulcamptus huronensis* appears to be quite rare, as very few specimens have been reported (Reid

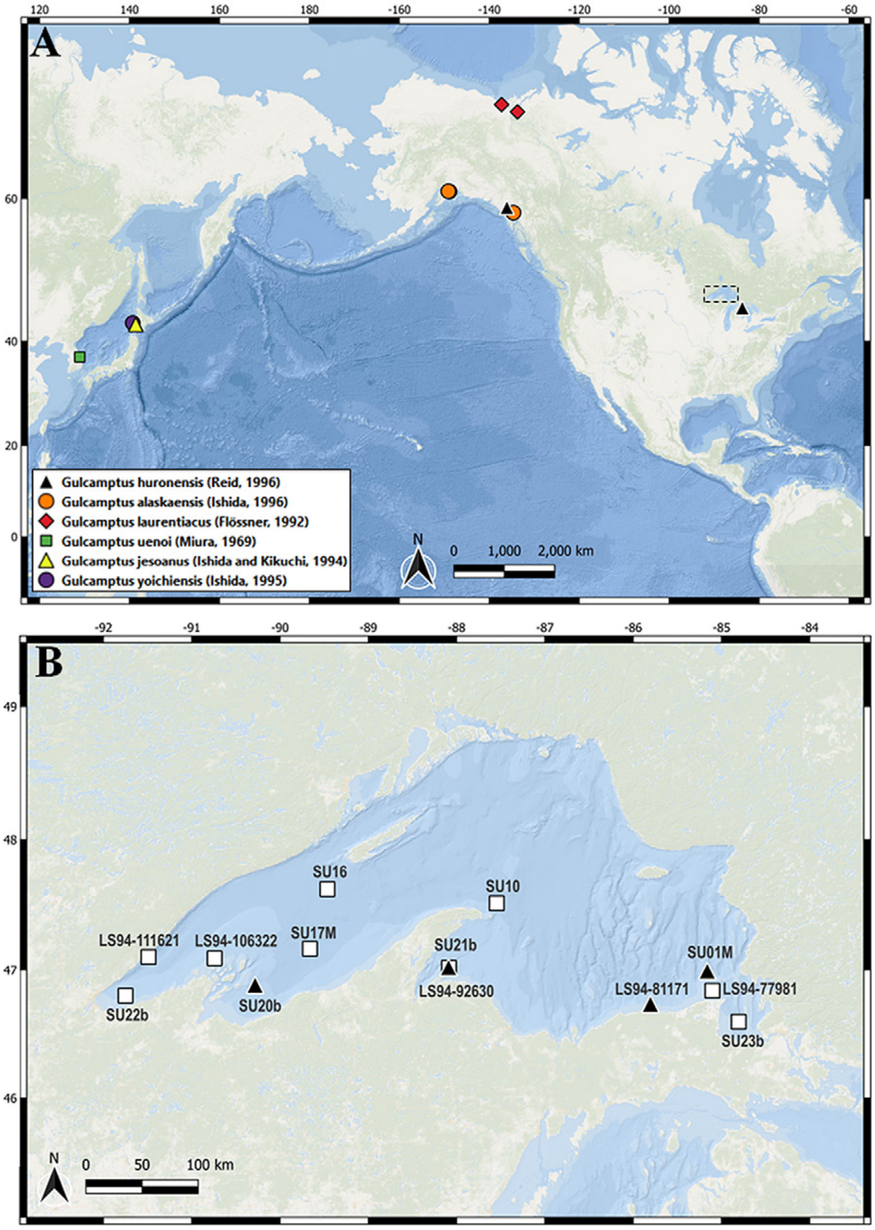

Figure 1. A. All localities where collections of *Gulcamptus* have been reported. Black triangles represent *G. huronensis* (Reid and Ishida 1996), orange circles represent *G. alaskaensis* (Reid and Ishida 1996), red diamonds represent *G. laurentiacus* (Flössner 1992), green squares represent *G. uenoi* (Miura 1969), yellow triangles represent *G. jesoanus* (Ishida and Kikuchi 1994), and purple circles represent *G. yoichiensis* (Ishida 1995). The dotted line delimits the study area of the present work. **B.** Lake Superior U.S. EPA monitoring stations where meiobenthic samples were collected in August of 2018. Black triangles indicate stations where *G. huronensis* was present, and white squares indicate stations where *G. huronensis* was absent.

and Ishida 1996; Hudson et al. 1998; Robertson and Milner 1999). In the present contribution we provide new records for *G. huronensis* from the meiobenthos of the southern shore of Lake Superior (Fig. 1B), collected in August 2018, with ecological notes together with morphological notes on males of the species.

Methods

Samples were obtained from 13 stations across Lake Superior, aboard the U.S. Environmental Protection Agency's (U.S. EPA) R/V *Lake Guardian* in August 2018. Benthic grab samples were collected with a 229 × 229 mm Ponar® grab sampler (0.0523 m^2 area) and a non-quantitative subsample was retained for analysis of meiofauna. Benthic grab samples were field-processed according to the following method. The contents of an entire Ponar grab were released into a plastic tray. A portion of the top sediment layer containing the organic floc was removed by hand, using a trowel, and placed into a 19-L bucket. If the substrate was coarse-grained sand, the contents of the subsample was rinsed directly into the bucket. Hose water sourced from the lake surface was used to fill the bucket approximately half full. The material was elutriated by stirring and the supernatant decanted through a 100 µm-mesh bucket sieve atop a separate 19-L bucket. This process was repeated several times until only large particles remained in the elutriation bucket. Material from the

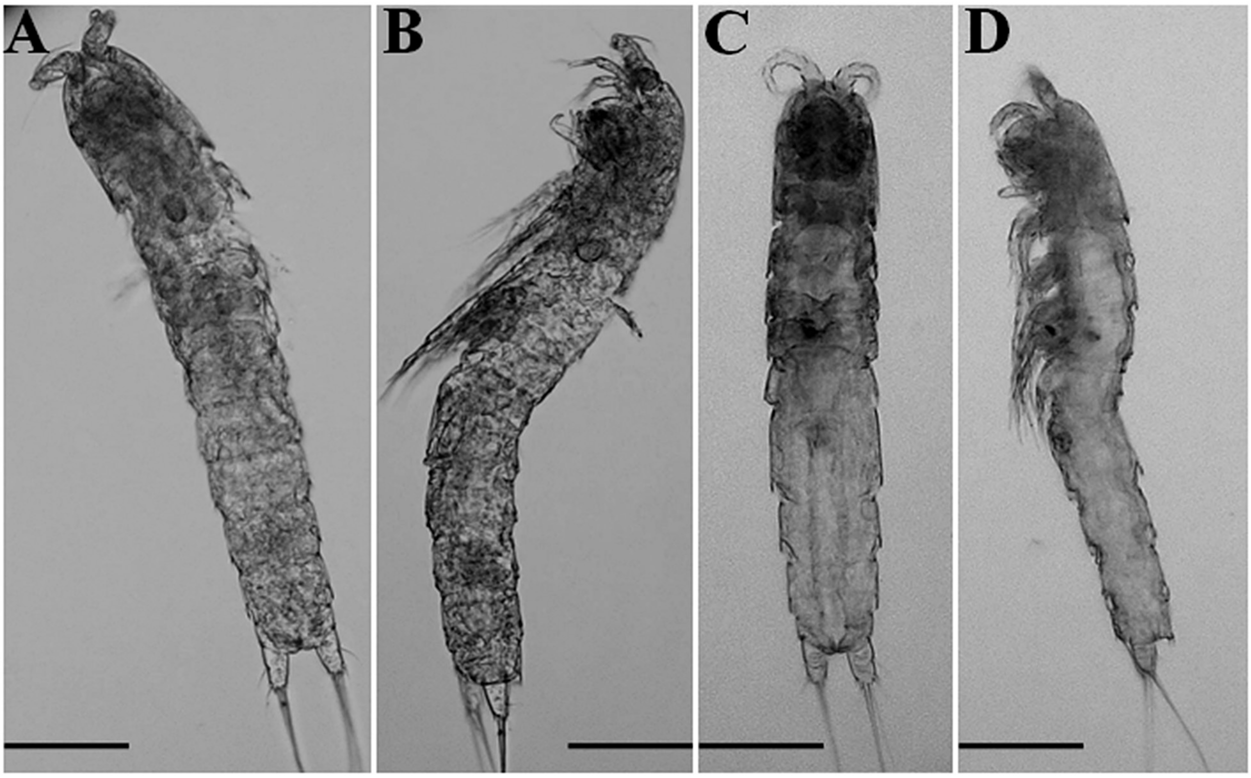

Figure 2. *Gulcamptus huronensis.* **A.** Male, collected from SU20b, in dorsal view. **B.** Male from SU20b, in lateral view. **C.** Female from LS94-81171, in dorsal view. **D.** Female from LS94-81171, in lateral view. Scale bars: A–D = 50 μm.

100 μm-mesh bucket sieve was rinsed, agitated by hand, and then washed into a 125-mL plastic sample bottle with deionized water. Finally, the sample was preserved with 95% non-denatured ethanol. Water temperature (°C) was recorded with a Sea-Bird conductivity, temperature, and depth (CTD) multiparameter sensor, 2 m above the lake bottom at each locality. Substrate composition was estimated based on appearance and consistency as percent clay, sand, and silt and noted on field sheets.

In the laboratory, samples were washed with deionized water and sorted from a four-compartment Petri dish under an Olympus SZX7 stereomicroscope. For dissection, specimens were transferred into a drop of glycerol on a 75 × 25 mm glass slide, dissected, and covered with a 22-mm round cover glass. Slides were initially sealed with nail polish and ultimately sealed with Permount™ for long term storage. Species were determined according to Hudson and Lesko (2003), Wells (2007), and Reid and Williamson (2010). Specimens were identified, measured, and imaged under an Olympus CX41 compound microscope fitted with a drawing tube and an Excelis™ HD microscope camera. The contrast and brightness of micro-photographic images was adjusted in Fiji ImageJ software (Schindelin et al. 2021) and an extended depth of field image (Fig. 3A) was obtained using the stitching plugin (Preibisch et al. 2009). Specimens were measured with a GTCO CalComp DrawingBoard VI™ digitizing tablet. All *Gulcamptus huronensis* specimens were assigned catalog numbers and deposited into the Smithsonian Institution, National Museum of Natural History, Washington, DC, USA.

Results

Gulcamptus huronensis Reid in Reid & Ishida, 1996

Gulcamptus huronensis was identified from four of 13 localities in southern Lake Superior in August of 2018 (Fig. 1B). This is a new distributional record for the species. A total of 12 specimens were collected, six males (Fig. 2A, B) and six females (Fig. 2C, D). Total male body length, measured from the anterior tip of the rostrum to the posterior end of the caudal ramus (excluding caudal setae) ranged from 0.38–0.51 mm. Total female body length ranged from 0.42–0.56 mm. No female specimens were observed with egg sacs or spermatophores attached to the genital aperture. The specimens of *G. huronensis* were recovered from depths ranging from 17.3–109.4 m, water temperatures from 3.8–8.5 °C, and from substrates comprised primarily of clay, sand, or silt. The species was collected at distances of 5–25 km offshore from the nearest coastline.

New records. USA – **Michigan** • U.S. EPA monitoring station SU01M; 46.9932, −085.1613; 92.2 m depth; 22.VIII.2018; J.K. Connolly leg.; Ponar grab, substrate 70% sand and 30% silt, water temperature 3.9 °C; USNM 1661625, 1 ♂ • U.S. EPA monitoring station LS94-81171; 46.7361, −085.8052; 17.3 m depth; 23.VIII.2018; J.K. Connolly leg.; Ponar grab, substrate 100% sand, water temperature 8.5 °C; USNM 166126; USNM 166127; USNM 166128, 1 ♂, 4 ♀ • U.S. EPA monitoring station LS94-92630; 47.0212, −088.0913; 50.0 m depth; 23.VIII.2018; J.K. Connolly leg.; Ponar grab, substrate

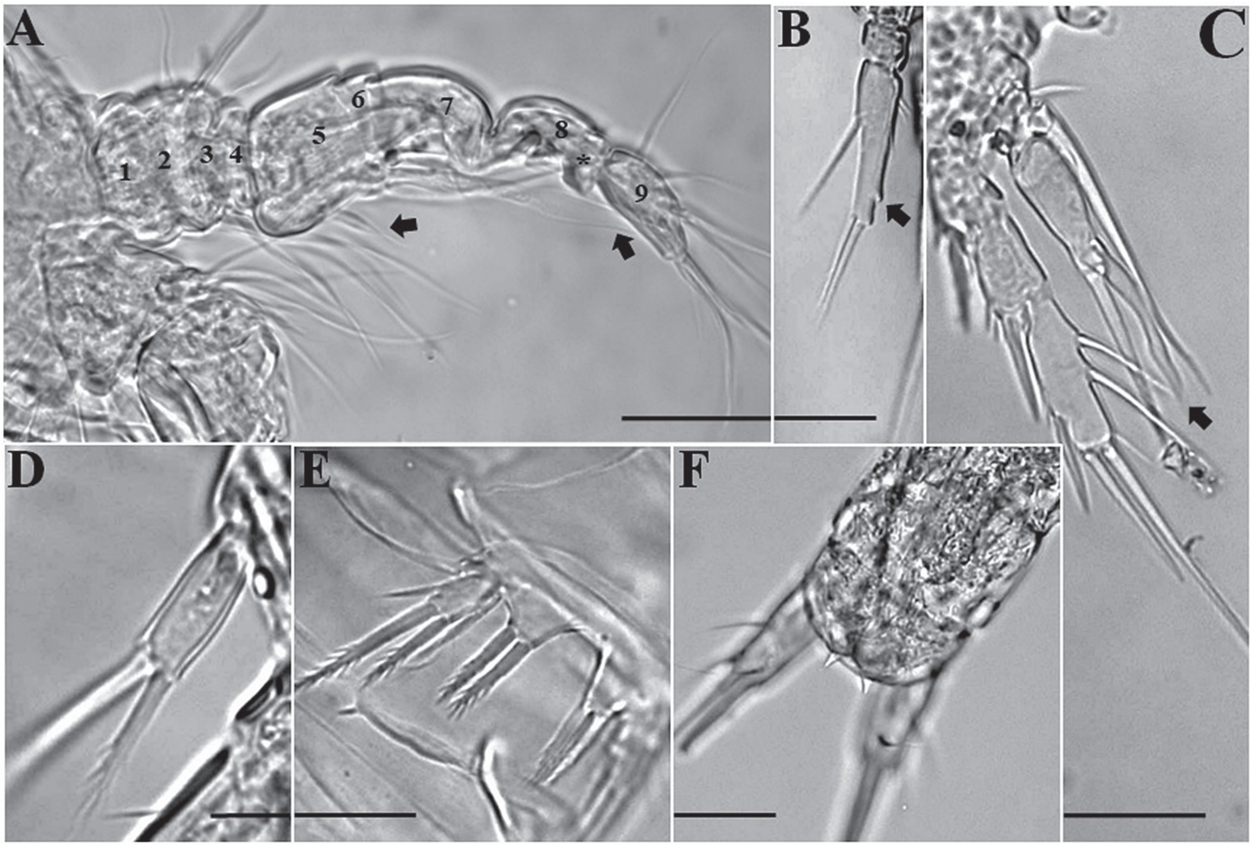

Figure 3. Male specimens of *Gulcamptus huronensis*. **A.** A1 annotated with segment number, asterisk represents incomplete segmentation at the distal end of segment 8, with long aesthetasc and short modified seta on segment 5 arrowed, specimen collected from SU01M. **B.** P2 endopod with indentation arrowed, specimen from SU20b. **C.** P3 with inner apical spine of endopod arrowed, specimen from SU20b. **D.** P4 endopod of specimen from LS94-81171. **E.** P5 of specimen from SU20b. **F.** Anal operculum of specimen from SU20b. Scale bars: A, C = 20 μm; B, E = 15 μm; D, F = 25 μm.

80% silt, 15% sand, and 5% clay, water temperature 4.7 °C; USNM 166129, 1 ♀ • **Wisconsin** • U.S. EPA monitoring station SU20b; 46.8836, −090.2827; 109.4 m depth; 24.VIII.2018; J.K. Connolly leg.; Ponar grab, substrate 80% clay and 20% sand, water temperature 3.8 °C; USNM 166130; USNM 166131, 4 ♂, 1 ♀.

Identification. The genus *Gulcamptus* is differentiated (Reid and Williamson 2010) from other North American genera in the family Canthocamptidae in part by the two-segmented leg 1 (P1) endopod and the lack of an inner seta on exopodite 2 of P2–P4. *Gulcamptus* can be distinguished from the morphologically similar genus *Moraria* (Scott and Scott 1893) by the two inner setae on exopodite 3 of P3 and the reduced inner apical seta on the exopodite 3 of P2–P4 (Reid and Williamson 2010). An additional morphological character used to distinguish *Gulcamptus* are the large conspicuous teeth of the anal operculum (Hudson and Lesko 2003). Finally, *G. huronensis* differs from its congeners in the presence of a single-segmented P4 endopod (Reid and Ishida 1996).

In general, the body of *G. huronensis* is slender and vermiform (Fig. 2A–D). The morphology of male *G. huronensis* largely agrees with the description of females provided by Reid and Ishida (1996), with a few exceptions. The male antennule (A1) is geniculate with nine segments of differing size and shape, with segments 5, 7, 8, and 9 fairly elongate (Fig. 3A). Incomplete pseudo-segmentation is present at the distal end of A1 segment 8 (Fig. 3A). Setation is present on A1 segments 2, 3, 4, 5, 7, 8, and 9. A single long aesthetasc and a short modified seta are present on A1 segment 5 (Fig. 3A). Additionally, a single short, thin aesthetasc is present at the distal terminus of A1 segment 9. The P1 and P2 exopod of male *G. huronensis* is as described in females (Reid and Ishida 1996). The two-segmented P2 endopod (Fig. 3B) is sexually dimorphic, with endopodite 2 armed as in females (one outer seta and two apical setae) but with the segment shape slightly modified, with a small indentation on the inner surface. P3 exopod as in females (Reid and Ishida 1996). Sexually dimorphic P3 endopod three-segmented (Fig. 3C). P3 endopod with endopodite 1 thin and bearing a short inner seta, endopodite 2 modified with a long unornamented inner spine extending twice the length of the endopod. P3 endopodite 3 elongate with a long outer apical spine (longer then endopodite 3) which bears minute spinules on the distal third and a long inner apical spine (longer then endopodite 3) which is wide at the proximal margin, thins at the midpoint, expands in the distal third forming a small bump, before thinning at the distal terminus which is armed with minute spinules. P4 as described in females (Reid and Ishida 1996), with single-segmented endopod (Fig. 3D). Urosome five-segmented (Fig. 2A, B) and P5 sexually dimorphic. P5 exopodite (Fig. 3E) armed with four elements: a minute outer seta, a long outer apical spine, a short inner apical spine, and an inner seta. P5 endopodal lobe somewhat expanded and armed with two stout spines nearly equal in length (Fig. 3E). Of the specimens collected in Lake Superior, all males bear two teeth on the anal operculum (Fig. 3F) and females bear two or three teeth on the anal operculum.

Discussion

Our collections of *Gulcamptus huronensis* represent the first records of the species from Lake Superior and the first collections of male specimens. The easternmost collection of *G. huronensis* from Lake Superior (SU01M) came from 207 km northwest of the most eastern and southern collection of the species reported from Lake Huron (Fig. 1A) (Reid and Ishida 1996; Hudson et al. 1998). The westernmost collection of *G. huronensis* from Lake Superior (SU20b) came from 3,270 km southeast of the most northern and western collection of the species, from Nunatak Creek (Fig. 1A) (Reid and Ishida 1996; Robertson and Milner 1999). The northernmost record of the genus worldwide was reported for *Gulcamptus laurentiacus* (Flössner, 1992) from Yukon Territory, Canada (68.9333, −137.2500), and the southernmost record for *Gulcamptus uenoi* (Miura, 1969) from Yong'yeongul Cave, South Korea (37.2088, 128.9420) (Fig. 1A). Given that members of the genus have only been collected between these latitudes, we might expect that the population of *G. huronensis* in Lake Superior is toward the southern limit of its range.

Species of the genus *Gulcamptus* have been collected from a variety of habitats, including caves (Miura 1969), wet mosses (Flössner 1992; Ishida and Kikuchi 1994; Reid and Ishida 1996), snowmelt-fed streams (Ishida 1995; Reid and Ishida 1996; Robertson and Milner 1999), bogs (Reid and Ishida 1996), marshes (Reid and Ishida 1996), and lakebeds (Reid and Ishida 1996; Hudson et al. 1998). Uniquely, *G. huronensis* is the only species of the genus that has been recovered from the bottom sediments of lakes (Reid and Ishida 1996; Hudson et al. 1998). Hudson and Lesko (2003) speculated that the collection of *G. huronensis* from Lake Huron may have been the result of an introduction from an adjacent stream. However, observations from Lake Superior indicate that the species inhabits lake bottoms with some consistency (Fig. 1B). In Lake Superior, *G. huronensis* was collected from substrates comprised primarily of sand at two locations, clay at one site, and silt at one site, with a small proportion of sand present at both the clay and the silt sites. Reid and Ishida (1996) reported that the Lake Huron collection of *G. huronensis* also came from a sandy substrate. These observations may indicate that *G. huronensis* prefers sandy bottoms. *Gulcamptus huronensis* did not display a strong depth preference, nor was it depth-limited in Lake Superior, as the species occurred at both shallow (17.3 m) and deep (109.4 m) sites. *Gulcamptus huronensis* may be the only lake-dwelling species of *Gulcamptus*. However, the collection of *G. huronensis* from Nunatak Creek implies that streams are likewise a suitable habitat for the species.

The morphology of *G. huronensis* males was previously unknown and is described here for the first time. In general, the morphology of males agrees with that described for females of the species (Reid and Ishida 1996). The A1 of male *G. huronensis* bears a short thin aesthetasc on the terminal segment of A1 which is likewise reported in males of *Gulcamptus jesoanus* (Ishida & Kikuchi, 1994) and *Gulcamptus alaskaensis* (Ishida, 1996). The indentation on the inner surface of the P2 endopodite 2 (Fig. 3B) is a sexually dimorphic character and has been observed in all species of *Gulcamptus* (Miura 1969; Flössner 1992; Ishida and Kikuchi 1994; Ishida 1995; Reid and Ishida 1996). The P2 endopodite 2 of *G. huronensis* is similar in appearance to that of *G. alaskaensis* (Ishida 1996) but armed with longer apical setae. The inner apical spine of the P3 endopod of *G. huronensis* (Fig. 3C) has a distinctive shape, which is notably dissimilar from males of other North American *Gulcamptus* species (Flössner 1992; Reid and Ishida 1996). The P3 endopod inner apical spine of *G. huronensis* is more slender then that of *G. laurentiacus* (Flössner 1992) and more robust than that of *G. alaskaensis* (Reid and Ishida 1996). The P3 inner apical spine of *G. huronensis* (Fig. 3C) is wide at the base, tapers at the midpoint, expands in the distal third forming a small bump, and is relatively curved throughout; this spine is most similar in form to that of the South Korean cave-dweller *G. uenoi* (Miura 1969). The single-segmented P4 endopod (Fig. 3D) of *G. huronensis* is unique in the genus (Miura 1969; Ishida and Kikuchi 1994; Ishida 1995; Reid and Williamson 2010). The P5 (Fig. 3E) of male *G. huronensis* is most similar to *G. alaskaensis*, with a somewhat expanded endopodal lobe armed with two stout spines. However, the spines of the P5 endopodal lobe of male *G. huronensis* differs from those of *G. alaskaensis* (Reid and Ishida 1996) by being nearly equal in length. The number of teeth on the anal operculum of *G. huronensis* (Fig. 3F) may be a sexually dimorphic character, as observed in *Gulcamptus yoichiensis* (Ishida, 1995). However, this morphological character is subject to variability, as Reid and Ishida (1996) reported that female *G. huronensis* bear three teeth on the anal operculum, and we observed female specimens from Lake Superior with two or three teeth at this location.

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Authors' Contributions

Conceptualization: LGR, JMW. Formal analysis: JKC. Methodology: JKC, JMW. Resources: JKC, JMW, LGR. Visualization: JKC. Writing – original draft: JKC. Writing – review and editing: LGR, JMW, JWR.

References

Boxshall GA, Halsey SH (2004) An introduction to copepod diversity. The Ray Society, United Kingdom, London, UK, 421 pp.

Flössner D (1992) A new genus and new species of freshwater Canthocamptidae (Copepoda: Harpacticoida) from wet mosses of Canada. Hydrobiologia 234: 7–14. https://doi.org/10.1007/bf00010774

Hudson PL, Reid JW, Lesko LT, Selgeby JH (1998) Cyclopoid and harpacticoid copepods of the Laurentian Great Lakes. Ohio Biological Survey Bulletin 12: 1–50.

Hudson PL, Lesko LT (2003) Free-living and parasitic copepods of the Laurentian Great Lakes: keys and details on individual species. Great Lakes Science Center, Ann Arbor, USA. http://www.glsc.usgs.gov/greatlakescopepods/. Accessed on: 2021-08-11

Ishida T, Kikuchi Y (1994) *Gulcamptus jesoanus*, a new harpacticoid copepod (Crustacea) from Hokkaido, northern Japan. Proceedings of the Japan Society of Systematic Zoology 51: 12–17.

Ishida T (1995) *Maraenobiotus veris* and *Gulcamptus yoichiensis* new harpacticoid copepods (Crustacea) from northern Japan. Proceedings of the Japan Society of Systematic Zoology 53: 40–45.

Miura Y (1969) Results of the speleological survey in South Korea 1966 XIV. Subterranean harpacticoid copepods of South Korea. Bulletin of the National Science Museum, Tokyo, Series A, Zoology 12: 241–254.

Preibisch S, Saalfeld S, Tomancak P (2009) Globally optimal stitching of tiled 3D microscopic image acquisitions. Bioinformatics 25: 1463–1465. https://doi.org/10.1093/bioinformatics/btp184

Reid JW, Ishida T (1996) Two new species of *Gulcamptus* (Crustacea: Copepoda: Harpacticoida) from North America. Japanese Journal of Limnology 57: 133–144. https://doi.org/10.3739/rikusui.57.133

Reid JW, Williamson CE (2010) Copepoda. In: Thorp JH, Covich AP (Eds.) Ecology and Classification of North American freshwater invertebrates. 3rd edition. Academic Press, London, UK, 829–899

Robertson AL, Milner AM (1999) Meiobenthic arthropod communities in new streams in Glacier Bay National Park, Alaska. Hydrobiologia 397: 197–209. https://doi.org/10.1023/a:1003782323718

Schindelin J, Arganda-Carreras I, Frise E, Kaynig V, Longair M, Pietzsch T, Preibisch S, Rueden C, Saalfeld S, Schmid B, Tinevez JY, White DJ, Hartenstein V, Eliceiri K, Tomancak P, Cardona A (2012) Fiji: an open-source platform for biological-image analysis. Nature Methods 9: 676–682. https://doi.org/10.1038/nmeth.2019

Scott T, Scott A (1893) On some new or rare Scottish Entomostraca. Annals and Magazine of Natural History (Series 6) 11: 210–215. https://doi.org/10.1080/00222939308677499

Wells JBJ (2007) An annotated checklist and keys to the species of Copepoda Harpacticoida (Crustacea). Zootaxa 1568: 1–872. https://doi.org/10.11646/zootaxa.1568.1.1