NYMPHS AND IMAGOES OF FOUR NORTH AMERICAN SPECIES OF *PROCLOEON* BENGTSSON WITH DESCRIPTION OF A NEW SPECIES (EPHEMEROPTERA, BAETIDAE)

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Abstract

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Descriptions of *Procloeon rubropictum* (McD.), *P. quaesitum* (McD.), and *P. rufostrigatum* (McD.) are expanded to include features not previously published. A description of the nymph of *P. quaesitum* is given for the first time. *Procloeon irrubrum* sp.nov. is described from nymphs and female imagoes. From our interpretation of preliminary data, it is possible that *P. rufostrigatum* and *P. rubropictum* form one species group; *P. quaesitum* is included with *P. pennulatum* (Eaton) in another. *Procloeon irrubrum* does not fit either species group but shows some affinities to the *P. rufostrigatum* group. Some characters for separating the nymphs of *Procloeon* and *Centroptilum* are given.

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Résumé

Les descriptions de *Procloeon rubropictum* (McD.), de *P. quaesitum* (McD.) et de *P. rufostrigatum* (McD.) ont été complétées par addition de caractéristiques inédites. La description de la larve de *P. quaesitum* est présentée pour la première fois. *Procloeon irrubrum* sp.nov. est décrit ici après examen de larves et de femelles adultes. D'après l'analyse des données préliminaires, nous croyons que *P. rufostrigatum* et *P. rubropictum* constituent un groupe d'espèces et que *P. quaesitum* appartient à un autre groupe qui comprend aussi *P. pennulatum* (Eaton). *Procloeon irrubrum* ne correspond à aucun de ces deux groupes, mais comporte certaines affinités avec le groupe *P. rufostrigatum*. Les caractéristiques qui permettent de séparer les larves de *Procloeon* des larves de *Centroptilum* sont présentées.

[Traduit par la rédaction]

INTRODUCTION

Bengtsson (1914) proposed the genus name *Pseudocloeon* for *P. bifidum* (Bengtsson). The generic name was preoccupied and the genus was renamed *Procloeon* (Bengtsson 1915). The initial concept of *Procloeon* included adults that lacked hind wings. The group was regarded as distinct from *Cloeon* Leach in that nymphs of *Cloeon* have bilamellate gills but *Procloeon* nymphs have unilamellate gills (Gillies 1980). McCafferty and Waltz (1990) re-examined the genera *Cloeon, Procloeon, Centroptilum* Eaton, and *Pseudocentroptilum* Bogoescu. They transferred the majority of Nearctic species of *Cloeon* and *Centroptilum*, and the Holarctic species *Pseudocentroptilum pennulatum* (Eaton), to the genus *Procloeon*. As now understood, the genus *Procloeon* includes species both with and without hind wings as well as species with unilamellate or bilamellate gills.

North American species of *Procloeon* have not been re-examined to determine species relationships. Original descriptions usually were based on colour variations of a single life stage, with little structural information given. *Centroptilum infrequens* McDunnough was declared a junior synonym of the Palaearctic *Pseudocentroptilum pennulatum* (Eaton) by Lowen and Flannagan (1990) and then transferred to *Procloeon* by McCafferty and Waltz (1990).

This paper expands published descriptions of *Procloeon quaesitum* (McDunnough), *P. rufostrigatum* (McDunnough), and *P. rubropictum* (McDunnough). *Procloeon irrubrum* sp.nov. is described from nymphs and female imagoes. Relationships among these species are discussed and the status of the genus *Procloeon* is considered.

MATERIALS AND METHODS

Mature nymphs were collected in the field, transported to the lab, and reared singly in 1-L jars. The jars were half filled with the same water from which the nymphs were collected and contained a small stone for substrate, a few flakes of vegetable-based fish food, and a small block of styrofoam on which subimagoes could rest. The jars were aerated slowly and subimagoes were transferred to dry jars for their final moult. Imagoes were allowed to mature for 24 h so that colour would be fully developed before preservation.

Specimens were dehydrated through an alcohol series and cleared in cedarwood oil, then dissected and mounted on slides in Canada Balsam. Male genitalia were dissected prior to clearing and macerated in hot 10% KOH solution for 10 min. Genitalia were then passed through glacial acetic acid and cedarwood oil and mounted in Canada Balsam.

All type specimens are housed in the Canadian National Collection (CNC), Biosystematics Research Centre, Ottawa, Ont.

DESCRIPTIONS

PROCLOEON BENGTSSON

Procloeon Bengtsson 1915: 34.
McCafferty and Waltz 1990: 769–799.
Pseudocloeon Bengtsson 1914: 210–220 (not Klapálek, name preoccupied).
Centroptilum Eaton 1869: 131–132 (in part).
Cloeon Leach 1815: 57–172 (in part).
Pseudocentroptilum Bogoescu 1947: 602–604 (in part).
Keffermüller and Sowa 1984: 309–340 (in part).
Cloeoptilum Kazlauskas 1969: 337–338 (invalid name).

Type Species. *Procloeon bifidum* (Bengtsson 1912): by original designation.

Characteristics. Imago. Body length 3.0–10.0 mm. Male genital forceps with distal segment small, medial shelf-like extension of basal segment where it joins with segment I, posteriorly directed medial process between basal segments of forceps absent, penal plate with distal margin broadly rounded or truncated. Forewings with single marginal intercalaries, hind wings absent or, if present, with distinct costal process and distal margin broadly rounded or truncated.

Nymph. Apical segment of maxillary palp half or less as long as penultimate segment and partially fused to it, canines of left mandible fused for more than half of length, canines of right mandible fused or not, gills unilamellate or bilamellate, gills distinctly asymmetrical and lacking serrations, lateral spines on at least abdominal segments VIII and IX, longest lateral spine one-sixth to one-seventh length of segment IX.

Procloeon rufostrigatum (McDunnough)

Centroptilum rufostrigatum McDunnough 1924: 95–96.
Traver (in Needham, Traver, and Hsu 1935): 717 (male imago redescribed).
Burks 1953: 120 (description of female imago).
Centroptilum bistrigatum Daggy 1945: 389 (description of nymph).
Procloeon rufostrigatum (McDunnough); McCafferty and Waltz 1990: 769–799.

Imago. Lengths (mm): body 4.0–6.0, forewings 4.0–5.0, hind wings 0.7–0.9, width of hind wing one-fifth its length, cerci 6.0–8.5. Colouration: male adequately described by

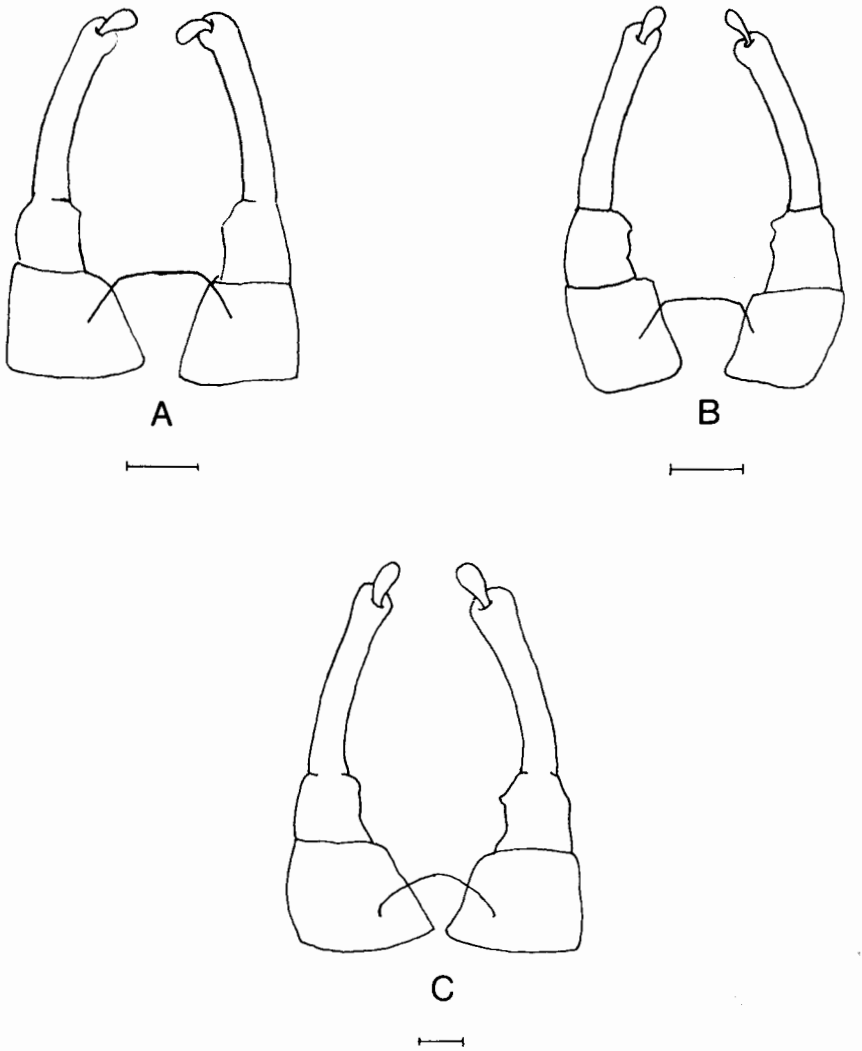

FIG. 1. Male genitalia of *Procloeon* Bengtsson: (A) *P. rufostrigatum* (McDunnough), (B) *P. rubropictum* (McDunnough), and (C) *P. quaesitum* (McDunnough). Scale line represents 0.1 mm.

McDunnough (1924) and Traver (in Needham et al. 1935) excepting that the forewings are shaded brown basally and the antennae are hyaline brown throughout. The lateral row of four minute red transverse dashes described by McDunnough (1924) occurs as one dash on each side of terga II through V and not four dashes on each tergum as stated by Traver (in Needham et al. 1935). Female colouration adequately described by Burks (1953) and Daggy (1945, as *C. bistrigatum*). Hind wings each with an erect costal process, anterior margins nearly straight, distal ends coming to rounded points. Male genitalia with posterior margin of penal plate truncated (Fig. 1A).

Nymph. Lengths (mm): body 4.5–5.8, antennae 1.4–1.8, median terminal filament 1.8–2.0, and cerci 1.7–2.0. Colour pattern as in Figure 2A. Mouthparts as in Figure 3. Colouration adequately described by Daggy (1945). All femora with short transverse arc of setae across dorsal surface at distal end, arc of setae lacking in tibae. Posterior tergal

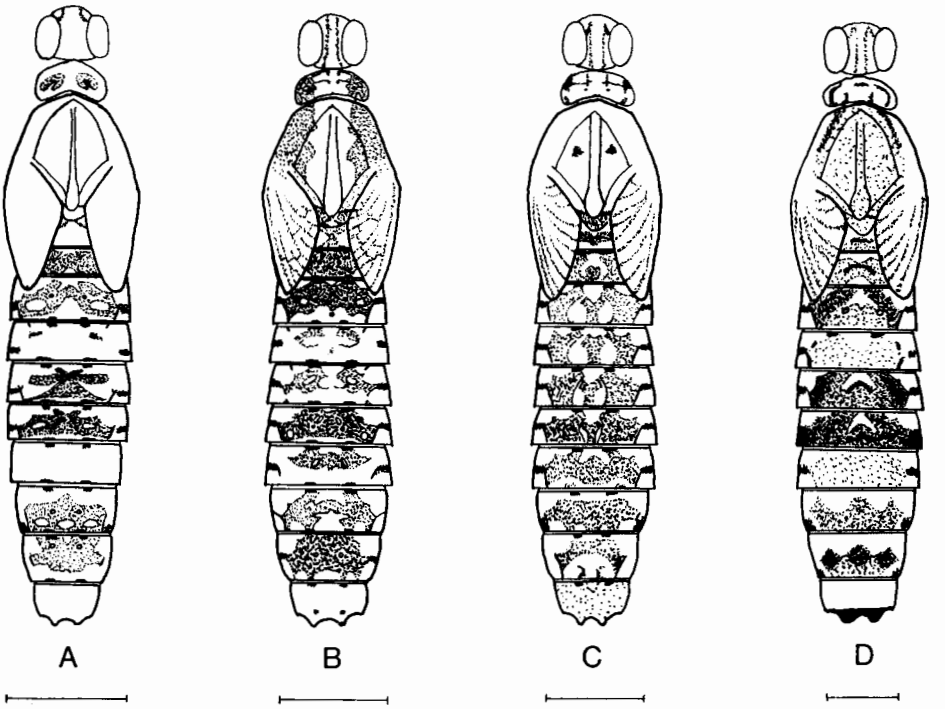

FIG. 2. Dorsal colour pattern of nymphs of *Procloeon* Bengtsson: (A) *P. rufostrigatum* (McDunnough), (B) *P. rubropictum* (McDunnough), (C) *P. irrubrum* sp.nov., and (D) *P. quaesitum* (McDunnough). Scale line represents 0.1 mm.

spines long and narrow, separated by shorter spines. Lateral spines only on terga VIII and IX, longest being one-sixth length of tergum IX (Table 1). Gills bilamellate on segment I only, tracheae weakly pigmented (Fig. 4A). Cerci and median terminal filament unmarked except for dark bands every fourth intersegmental membrane.

Specimens Examined. Holotype: male imago, Aweme, Manitoba, Canada, 30 September 1923, R.M. White (CNC). Paratypes: 10 male imagoes, same data (CNC); 2 male imagoes, same locale, 8 September 1923, N. Criddle (CNC); 1 male imago, Treesbank, Manitoba, 22 September 1923, R.M. White (CNC). Others: 8 nymphs, 29 male imagoes and subimagoes, 43 female imagoes and subimagoes from Manitoba, New Brunswick, and Ontario.

Distribution. This species is known in Canada from Manitoba, New Brunswick, Ontario, and Quebec and in the United States from Illinois, Kentucky, Maryland, Michigan, Minnesota, Pennsylvania, and Wisconsin.

Procloeon rubropictum (McDunnough)

Cloeon dubium; Clemens 1915: 126 not Walsh (misidentification of nymph).
Cloeon rubropicta McDunnough 1923: 43–44.
McDunnough 1925: 185–186 (in discussion of *C. simplex* and *C. insignificans*).
McDunnough 1930: 59 (rectifies Clemens 1915 error).
McDunnough 1931: 88 (in discussion of *C. triangulifer*).
Cloeon rubropictum McDunnough; Traver (in Needham, Traver, and Hsu 1935): 737 (redescription of male, emends gender of specific epithet).

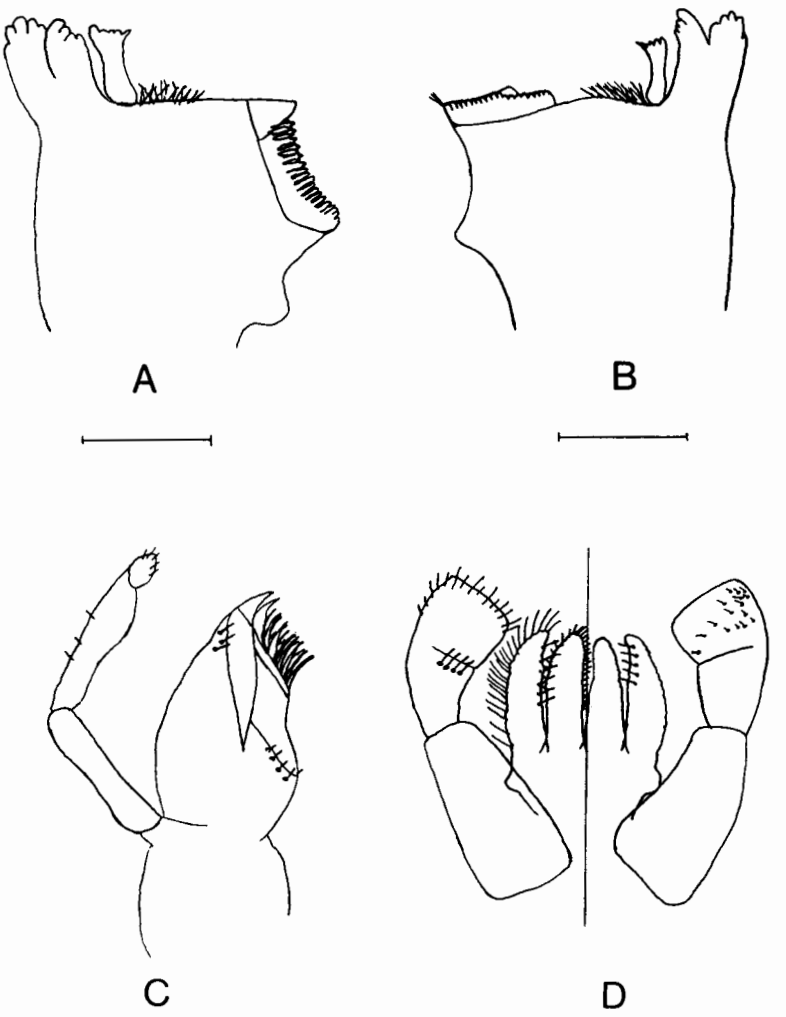

FIG. 3. Nymphal mouthparts of *Procloeon rufostrigatum* (McDunnough): (A) left mandible, (B) right mandible, (C) maxilla, and (D) labium. Scale line represents 0.2 mm.

Burks 1953: (redescription of male and female).
Procloeon rubropictum (McDunnough); McCafferty and Waltz 1990: 769–799.

Imago. Lengths (mm): male body 3.6–5.2, female body 4.4–5.3, forewings 3.6–5.4, forewings of female always longer than body length, hind wings absent, cerci 6.7–9.1. Colouration: adequately described by McDunnough (1923, 1925, and 1931), Traver (in Needham et al. 1935), and Burks (1953). The red striations found on the abdominal terga are in similar location as, but brighter than, those found on *P. rufostrigatum*. Male genitalia with posterior margin of penal plate truncate as in Figure 1B (see also McDunnough 1925, pl. 4, fig. 13).

Nymph. Lengths (mm): body 5.1–6.3, antenna 1.6–2.2, median terminal filament 1.8–2.5, and cerci 1.9–2.4. Colour pattern as in Figure 2B (see also Clemens 1915). Mouthparts as in Figure 5. All femora with short transverse arc of setae across dorsal surface of

Table 1. Number of lateral spines on the left side of abdominal segments I–IX of nymphs of five Manitoba species of *Procloeon* Bengtsson (Ephemeroptera: Baetidae)

Abdominal segment	Species				
	rubropictum	*rufostrigatum*	*irrubrum*	*quaesitum*	*pennulatum*
I	0	0	0	0	0
II	0	0	0–4	0–2	0
III	0–2	0	0–4	0–2	0
IV	1–4	0	0–7	2–4	0
V	1–5	0	3–8	4–5	0
VI	1–5	0	3–8	6–8	0
VII	3–7	0	6–11	8–10	0
VIII	3–9	3–5	7–11	8–10	2–5
IX	6–9	4–7	7–11	11–14	5–7

distal ends. All tibiae with short longitudinal row of setae along dorsal surface of proximal ends, row curves transversely near femora. All tarsi with short longitudinal row of setae along dorsal surface of proximal end. Live specimens with emerald green median spot on abdominal tergum I, quickly fading to light brown in preserved specimens. Posterior abdominal tergal spines long and narrow, separated by shorter spines. Lateral abdominal tergal spines absent on segments I and II, on some specimens absent from segments I–III (Table 1); longest lateral spines one-seventh length of tergum IX. Gills bilamellate on

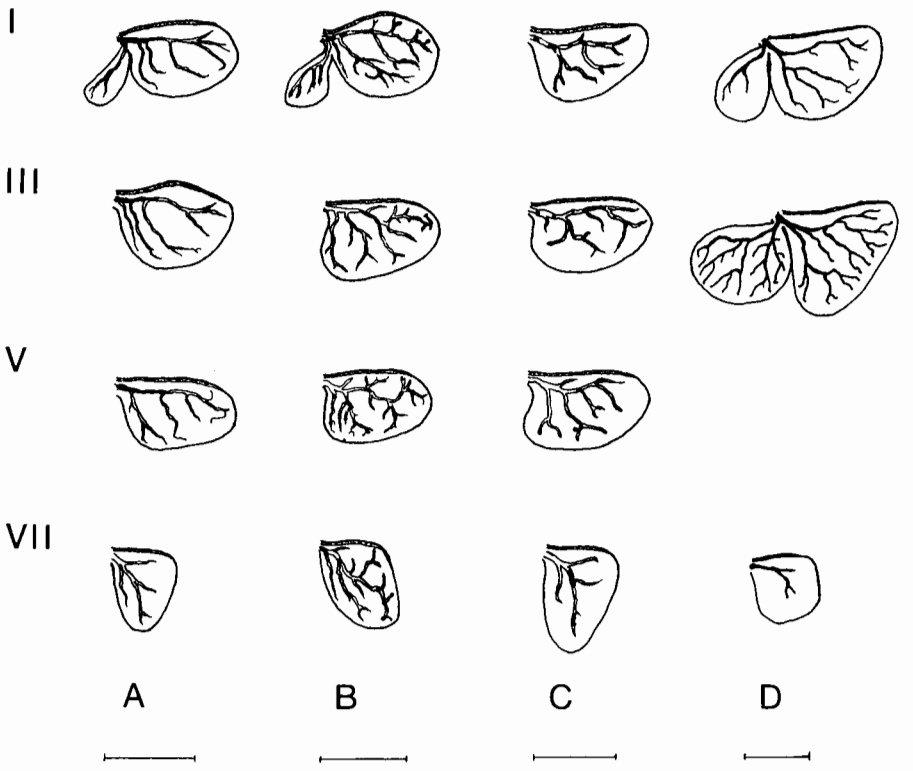

FIG. 4. Nymphal gills from abdominal segments I, III, V, and VII of four Manitoba species of *Procloeon* Bengtsson: (A) *P. rufostrigatum* (McDunnough), (B) *P. rubropictum* (McDunnough), (C) *P. irrubrum* sp.nov., and (D) *P. quaesitum* (McDunnough). Scale line represents 0.5 mm.

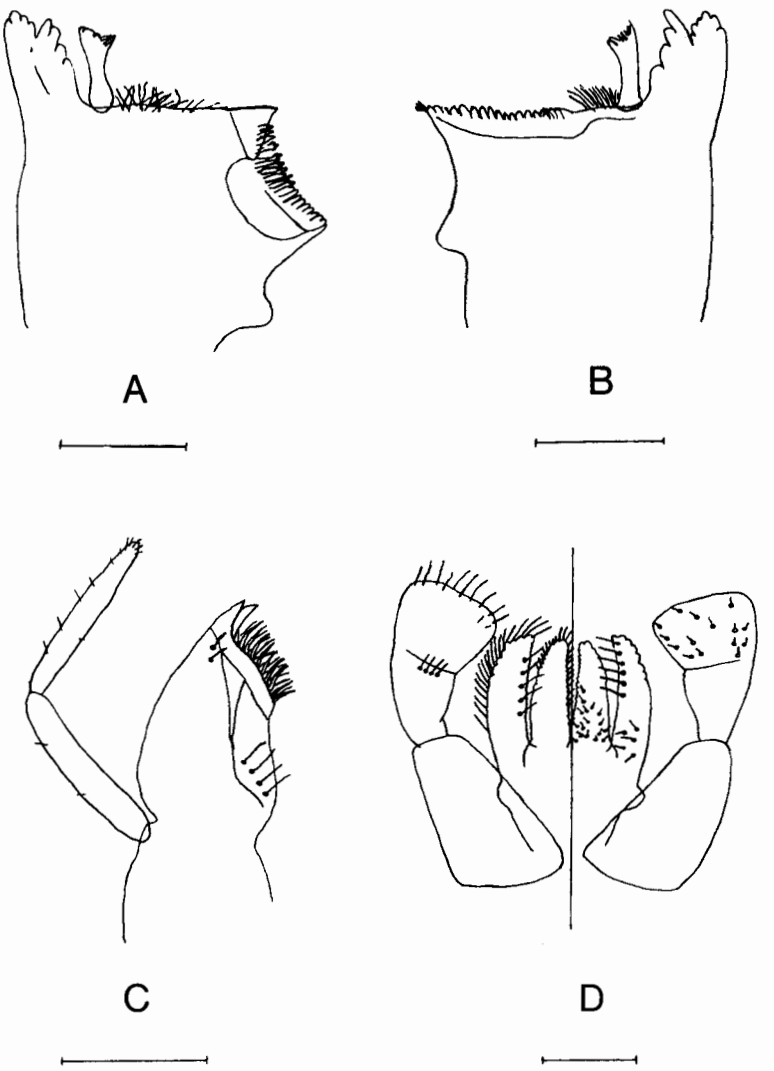

FIG. 5. Nymphal mouthparts of *Procloeon rubropictum* (McDunnough): (A) left mandible, (B) right mandible, (C) maxilla, and (D) labium. Scale line represents 0.2 mm.

segment I only, tracheae black in isolated sections (Fig. 4B). Median terminal filament and cerci with dark rings every fourth intersegmental membrane and a band of brown segments two-thirds distad.

Specimens Examined. Holotype: male imago, Ottawa, Ontario, Canada, 19 August 1922, J. McDunnough (CNC). Allotype: female imago, same locale, 14 June 1920, J. McDunnough (CNC). Paratypes: 12 female imagoes, same locale, 9, 11, 14 June 1920 and 16, 19, 22 August 1922, J. McDunnough (CNC); 2 male and 1 female imagoes, Norway Point, Lake of Bays, Ontario, 14 July 1920 and 01 July 1922, J. McDunnough (CNC). Others: 221 nymphs and exuviae, 18 male imagoes and subimagoes, and 25 female imagoes and subimagoes from Manitoba, Ontario, and Quebec.

Distribution. This species is known in Canada from Manitoba, Ontario, and Quebec and in the United States from New York south to Florida and west to Illinois.

Procloeon irrubrum sp.nov.

Female Imago. Lengths (mm): body 4.5–6.0, cerci 7.0–8.5, forewings 4.5–6.0, hind wings 0.8–1.0, width of hind wings one-fifth of length. Colouration: head tan. Antennae brown distally, scape and pedicel olive-tan. Eyes with greenish sheen in life, black when preserved. Thorax tan with alabaster white markings dorsally and laterally. Prosternum opaque white becoming hyaline laterally. Mesosternum semi-hyaline white. Metasternum tan. Abdominal terga I–VIII semi-hyaline tan to chestnut brown. Terga IX and X alabaster white to opaque tan with hyaline median and sublateral stripes. Sterna semi-hyaline to tan. Broken black spiracular line with purple-black tracheal veins present. Cerci semi-hyaline. Hind wings as in *P. rufostrigatum*, i.e. with erect costal process, nearly straight anterior margin, and distal margin coming to a rounded point.

Nymph. Lengths (mm): body 5.5–6.8, antennae 1.5–2.0, median terminal filament 1.9–2.3 and subequal to cerci. Colour pattern as in Figure 2C. Mouthparts as in Figure 6. Pore-like spots in medial dorsal position between eyes. Paired subdorsal pore-like spots on pronotum. Legs light tan with small dark brown spot near distal ends of femora. All femora with distinct arc of long setae near distal and along dorsal margins. All tibiae with distinct proximal arc of long setae mostly along dorsal margins but bending slightly across edge. Claws two-thirds length of associated tarsi. Wing pads with dark markings resembling veins. Abdomen with posterior tergal spines very long and narrow, unevenly spaced and interspersed with many smaller spines. Paired mid-dorsal pore-like spots on tergum VI. Lateral abdominal spines absent from segment I, on some specimens absent from segments I–IV (Table 1). Longest lateral spines one-seventh length of tergum IX. Sterna VII–IX with wide black-brown bars along anterior margins. Sterna I–IX with lateral, subposterior brown patches. Gills unilamellate, tracheae black in isolated sections (Fig. 4C). Median terminal filament and cerci unmarked except for dark bands every fourth intersegmental membrane.

Specimens Examined. Holotype: female imago with associated nymphal and subimaginal exuviae, Ochre River, downstream from town of Ochre River, Manitoba, Canada, caught 09 August 1988, emerged 14 August 1988, R.G. Lowen (CNC). Paratypes: 5 nymphs, same data but died in captivity, R.G. Lowen (CNC); 1 nymph, same locale, 14 July 1986, R.G. Lowen (CNC); 2 nymphs, same locale, 24 September 1986, R.G. Lowen (CNC). Others: 2 female imagoes with associated exuviae, 10 nymphs, 10 unassociated nymphal exuviae, from the Ochre, North Pine, and Bird Rivers, Manitoba.

Etymology. From the Latin "ir" meaning not or without and "rubros" meaning red. Refers to the lack of red markings common in imagoes of the other species in this genus.

Distribution. Known only from Manitoba, Canada.

Female imagoes are distinguished from other species of this genus by their small size and lack of red colouration. Nymphs are easily identified by unilamellate gills with irregular marked tracheae and the broad brown-black band on the anterior margin of sterna VII–IX. The male is unknown. The possibility exists that this species is parthenogenic or the male is described as a species of *Centroptilum* sensu lato. The nymph appears to be similar to that of *Centroptilum ozburni* McDunnough, as described by Traver (in Needham et al. 1935) except that species is reported to have bilamellate gills.

Procloeon quaesitum (McDunnough)

Centroptilum quaesitum McDunnough 1931: 87.

Burks 1953: 120–121 (redescription of male imago).

Procloeon quaesitum (McDunnough); McCafferty and Waltz 1990: 769–799.

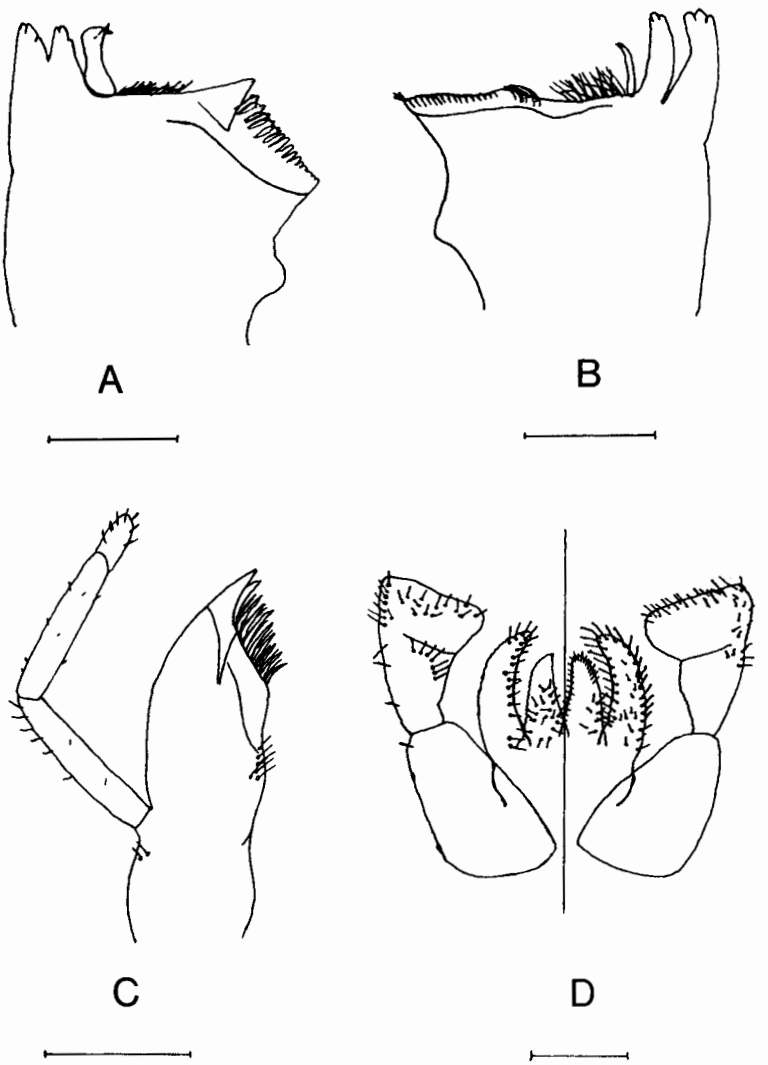

FIG. 6. Nymphal mouthparts of *Procloeon irrubrum* sp.nov.: (A) left mandible, (B) right mandible, (C) maxilla, and (D) labium. Scale line represents 0.2 mm.

Imago. Aside from pinned material, only one male imago and one female subimago were examined. Measurements are based on these two specimens. Lengths (mm): body 6.8 and 9.2, cerci 15.4 (broken in female), forewings 8.2 and 9.2, hind wings 1.1 and 1.2, width of hind wing one-quarter of length. Colouration: adequately described by McDunnough (1931) and Burks (1953) except for the following. Antennae in both sexes opaque yellow basally, becoming hyaline red-brown distally. Mesonotum paler than pronotum. Forewings yellowish basally. Male with discs of turbinate eyes bright yellow in live specimen. Abdominal terga I–VI yellow-olive. Posterior margin of tergum I red-brown. Terga II–IX each with scarlet mark resembling a round edged "W" with its base on posterior margin. Terga VII–IX opaque white with hyaline median and subdorsal stripes. Tergum X yellow-olive with opaque white median and subdorsal stripes. Sterna yellow-tan, sterna VII–IX

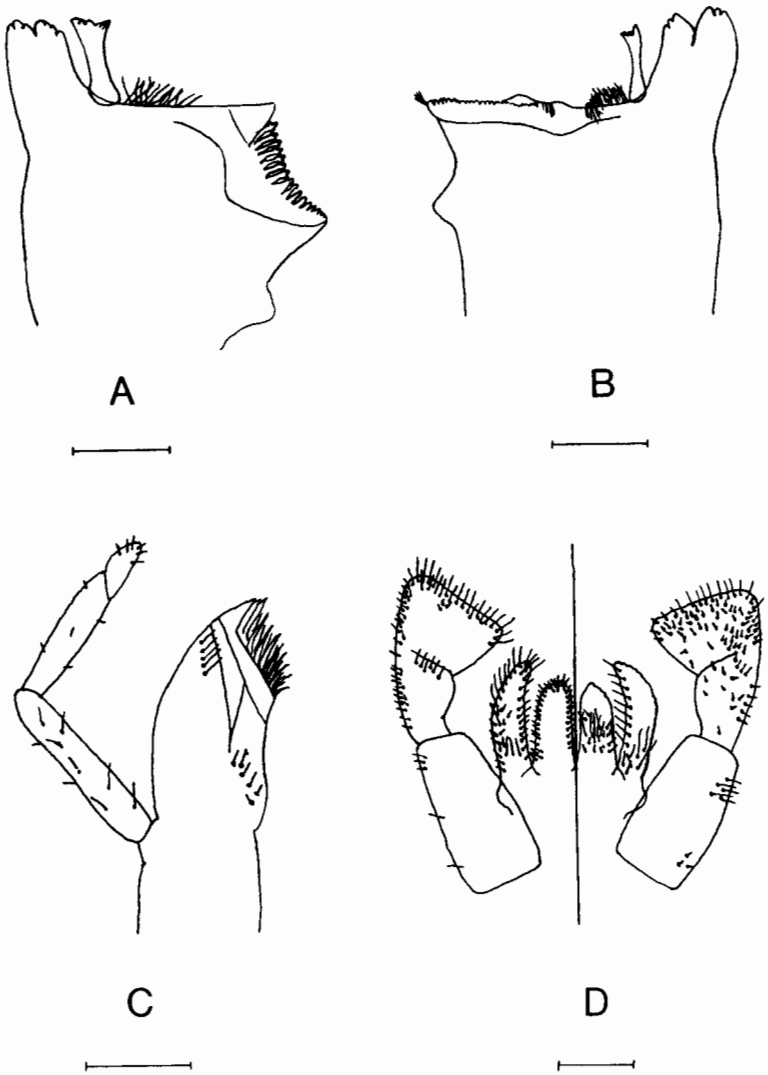

FIG. 7. Nymphal mouthparts of *Procloeon quaesitum* (McDunnough): (A) left mandible, (B) right mandible, (C) maxilla, and (D) labium. Scale line represents 0.2 mm.

marked with opaque white. Females with posterior margin of abdominal terga I–X red-brown. Terga I–VI white with faint median red-brown shading. Terga VII–X opaque white with pale hint of red "W"'s observed in males. Sterna I–VI, each with hyaline white on anterior half and opaque white on posterior half. Sterna VII–IX opaque white with sub-ventral hyaline lines. Hind wings with costal process erect or highly curved, anterior margin rounded, distal margin round. Male genitalia with posterior margin of penal plate broadly rounded (Fig. 1C).

Nymph. Two mature nymphs and one immature nymph were examined. Mature nymphs were measured. Lengths (mm): body 7.9 and 9.3, antennae 2.7 and 3.6, median terminal filament 3.7, cerci 4.0. Colour pattern as in Figure 2D. Mouthparts as in Figure 7. All

legs light brown to tan, brown spot near distal ends of femora and at basal ends of tibiae. All femora distal with row of long setae along and across dorsal margins of distal ends. All tibiae with distinct proximal row of long setae along dorsal margins and arcing across edges. Wing pads with dark brown markings resembling veins. Abdominal terga with posterior spines long and narrow, evenly spaced with gaps and one or two very small spines in between. Lateral spines absent from segment I, on some specimens absent from segments I–III (Table 1). Longest lateral spines one-sixth to one-seventh length of segment IX. Bilamellate gills on segments I–VI and unilamellate gills on segment VII. Most gills were heavily damaged so that no drawing could be provided of gills on segment V (Fig. 4D). Median terminal filament and cerci hyaline brown with dark band every fourth intersegmental membrane. Dark band of segments about three-quarters distad. Caudal filaments unmarked distal of this band.

Specimens Examined. Holotype: male imago, Seven Persons Creek, Medicine Hat, Alberta, Canada, 17 June 1930, J.H. Pepper (CNC). Allotype: female imago with subimaginal exuviae, same data (CNC). Paratypes: 1 male imago, same locale, 12 June 1930, J.H. Pepper (CNC); 2 male and 3 female imagoes, same locale, 17 June 1930, J.H. Pepper (CNC). Others: 3 nymphs, 2 male imagoes, 8 female imagoes and subimagoes from Alberta, British Columbia, and Manitoba.

Distribution. This species is known in Canada from Alberta, British Columbia, and Manitoba and in the United States from Illinois.

DISCUSSION

The genus *Procloeon* sensu McCafferty and Waltz (1990) includes all former *Centroptilum* in which the males lack a prominent medial spine between the forceps bases and do not have an elongated terminal segment of the forceps. However, Lowen and Flannagan (1991) have suggested that *Centroptilum album* McDunnough and *C. conturbatum* McDunnough, which McCafferty and Waltz (1990) include in *Procloeon*, are closely related to *C. bifurcatum* McDunnough and *C. victoriae* McDunnough, which McCafferty and Waltz (1990) include in *Centroptilum*. The possibility exists that *Centroptilum* and *Procloeon* sensu McCafferty and Waltz are both paraphyletic assemblages of species. A larger number of species and characters must be examined before phylogenetic analysis can be attempted.

Procloeon quaesitum and *P. pennulatum* can be considered to belong to the same species group because both are large species whose nymphs have secondary gill lamella on segments I–VI. *Procloeon rufostrigatum* and *P. rubropictum* form a different species group in which the species are smaller and the nymphs have bilamellate gills on segment I only. In addition, the male imagoes of the *P. rufostrigatum* species group have a lateral row of red transverse dashes along the abdomen. *Procloeon irrubrum* does not fit either of these species groups. The adults are small in size but lack any red colouration and the nymphs have unilamellate gills on all segments.

The distribution of lateral abdominal spines does not seem to correlate with these proposed species groups (Table 1). But given the general state of reductionism in the Baetidae and the fact that the number is variable even within a species, we do not consider this a strong argument against the proposed species groups. The relative size of these spines is useful in distinguishing nymphs of *Procloeon* from *Centroptilum*. In *Procloeon* the longest lateral spine ranges in length from one-sixth to one-seventh the length of tergum IX whereas in *Centroptilum* nymphs the spines are absent or no longer than 1/10 the length of tergum IX (Lowen and Flannagan 1991). The two genera can also be separated by examination of the maxillary palp. In *Procloeon* the terminal segment is one-half or less the length of the penultimate segment whereas in *Centroptilum* nymphs these two segments are subequal.

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