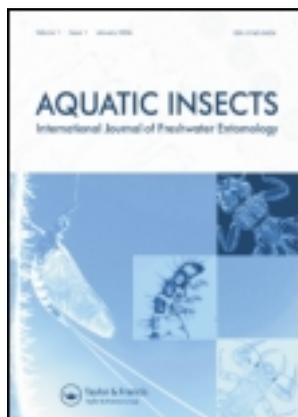


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A new species of *Acentrella* Bengtsson (Ephemeroptera: Baetidae) from New York and New England (USA), redescription of the nymph of *A. parvula* (McDunnough), and key to known adult males of Nearctic *Acentrella*

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A new species *Acentrella rallatoma* (type locality: Connetquot River, Oakdale, NY, USA) is described from nymphs and reared adults. Additional specimens were studied from southeastern New York, southeastern New Hampshire, coastal Connecticut, and Martha's Vineyard, MA, USA. Nymphs can be separated from those of other Nearctic species by: scraper-like outer incisors of mandibles, cerci alternately banded from bases to tips, and row of robust bristle-like setae (with modified tips) on dorsal edge of femora. Male imagoes can be separated from those that lack hind wings by: distinctive colour pattern of abdominal terga, and genitalia with pigmented sclerotised penes cover. Comparative analysis of *A. rallatoma* with other Nearctic species revealed a lack of comparative data on nymphs of its presumptive sister species *A. parvula*. To facilitate future studies of this group, the nymph of *A. parvula* is redescribed and regional differences are discussed. Abdominal colour patterns of *A. parvula* that vary over its range from Florida, USA to Labrador, Canada are illustrated. Problems concerning genus-level diagnostic characters for *Acentrella* nymphs and adults are discussed to facilitate placement of future taxa. To complement existing keys to Nearctic nymphs of *Acentrella* a provisional key to the known adult males is given.

Keywords: Ephemeroptera; Baetidae; *Acentrella*; new species; *A. parvula*

Introduction

The genus *Acentrella* was first established by Bengtsson (1912) based on studies of the adults and nymphs of the higher latitude species *A. lapponica*. The original description, published in German, was brief and lacked a discrete comparative diagnosis. The somewhat vague general features given by Bengtsson (1912), as an ad hoc diagnosis for the genus, seems to have been the ultimate cause of problems of later workers (Edmunds and Traver 1954; Müller-Liebenau 1965, 1969) trying to decide whether *Acentrella* was a group within *Baetis* or a valid separate genus. The subsequent interpretation of those earlier workers that *Acentrella* did not merit

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generic status was reversed by Müller-Liebenau (1981) who re-established *Acentrella* based on her studies of *Pseudocloeon*. The decision reached by Müller-Liebenau (1981) was supported by Waltz and McCafferty (1987) in their revision of *Acentrella*. As part of their revision, Waltz and McCafferty (1987) provided the first detailed comparative character analysis and formal diagnosis of *Acentrella*. Although the results of their work have been accepted by most mayfly specialists, some still consider *Acentrella* as a subgenus of *Baetis* (Novikova and Kluge 1987; Tiunova 2008a, b). Since the analysis by Waltz and McCafferty (1987) several new species have been added to *Acentrella*: *A. almohades* Alba-Trecedor and El Alami, 1999 (Palaeartic); *A. feropagus* Alba-Trecedor and McCafferty, 2000 (Nearctic); *A. barbara* Jacobus and McCafferty, 2006 (Nearctic); *A. nadineae* McCafferty, Waltz and Webb, 2009 (Nearctic); *A. charadra* Sroka and Arnekleiv, 2010 (Palaeartic); *A. diptera* Kluge and Novikova 2011 (Palaeartic); and *A. scabriventris* Kluge and Novikova 2011 (Palaeartic). The discovery of these new species both increases our knowledge of the diversity of *Acentrella* and strains the applicable limits of the current diagnosis. Globally, *Acentrella* contains about 22 species (~13 Palaeartic, two Holarctic, and seven Nearctic species) that are broadly distributed across the northern hemisphere with most species occurring in to cool-cold streams and rivers.

Despite the continued addition of new species to *Acentrella*, there are persistent problems diagnosing nymphs and adults. The recent summary of published diagnostic characters for *Acentrella* given by Sroka and Arnekleiv (2010) demonstrates the difficulties that exist. New work by Kluge and Novikova (2011), which offers a restricted definition of the genus for the Palaeartic *Acentrella*, does not resolve the problems of character variation among the Nearctic species of *Acentrella*. The establishment of the genus *Plauditus* (Lugo-Ortiz and McCafferty 1998b) has added another problem because of the overlap of many characters between the two genera and the lack of detailed comparative diagnoses for adults and nymphs of both *Plauditus* and *Acentrella*. Recently, some of the diagnostic character differences between *Acentrella* and *Plauditus* were reviewed by Wiersema (2000), but he stopped short of providing full comparative diagnoses. Jacobus and McCafferty (2006) and McCafferty et al. (2009) describe new North American species of *Acentrella* and comment on character variation in the genus, but do not discuss genus-level diagnostic problems. Here we present the description of a new species in the genus *Acentrella* from streams of the lowland coastal drainages of the North-Eastern Coastal Zone Ecoregion (Griffith et al. 2009) that encompasses parts of New York and New England, USA. Morphological study of the new species revealed problems in diagnosing nymphs and adults of *Acentrella* and *Plauditus* because of character overlap that will be discussed. Further, study of *A. parvula* (presumed sister species of the new species) showed that there was no detailed comparative description of the nymph of *A. parvula*. Thus, the nymph of *A. parvula* is redescribed and regional variation in some characters discussed and illustrated. Finally, to supplement the recent key to North American nymphs of *Acentrella* (Jacobus and McCafferty 2006) a provisional key to known adult males of North American *Acentrella* is provided.

Materials and methods

Nymphs from the Connetquot and Croton Rivers, New York were reared in the laboratory either at SUNY Plattsburgh or Southern Connecticut University to obtain the adult stages. Live nymphs were collected using a standard D-frame kick

net and transferred to 500 ml plastic jars filled with stream water from the collections site. Jars were aerated with portable pumps and slightly chilled for transport to the laboratory. In the laboratory nymphs were examined under a microscope to determine sex and developmental state. Nymphs were then placed in plastic dome-lid cups with mesh sides that were inserted in aerated water-jacket containers and maintained in a cool water bath or a living stream (Frigid Units, Toledo, OH, USA) to regulate the temperature of the rearing containers. Subimagos were removed upon emergence and placed in separate containers to make the final moult. Imagos were preserved in 80% ethanol with the associated nymphal exuviae.

All specimens were observed for morphological characters, colouration, and colour patterns under stereoscopic and compound light microscopes (up to 1000 × magnification). Mouth and body parts of the nymphs were dissected in 80% ethanol and slide mounted in Euparal[®]. Male genitalia were examined and illustrated intact. Adult wings were also examined and illustrated intact. Standard terminology for adult anatomy and morphology was used (Tsui and Peters 1975; Kluge 1994). All measurements were made using a calibrated ocular micrometer (nearest 0.10 mm). Measurements were made from entire specimens and/or parts with the specimens held as flat as possible (without inducing distortion) using sections of broken glass microscope slides and cover slips. Conventions for standard measurements described by Hubbard (1995) were followed. Means and standard deviations (SD) were calculated for all continuous data. Student's *t*-test (Sokal and Rohlf 1995) was used to test for differences between means. Lengths of the foreleg segments of the male imago were standardised to the length of the foretibia and expressed as ratios. Colours were referenced to standard colour tiles for natural history specimens given by Smithe (1975). Colours beyond the standard range of values were described as simply as possible. Eggs were dissected from a reared female imago in 80% ethanol. Eggs were removed from the lower oviduct (to minimise differences possibly related to maturation) with a 2 µl adjustable micropipette, dehydrated in 100% propanol for 10 min and mounted in Euparal[®]. Chorionic features of eggs were observed under phase contrast microscopy (400 and 1000 ×).

Specimen abbreviations and symbols

♂ = male imago; ♀ = female imago; S♂ = male subimago; S♀ = female subimago; N♂ = male nymph; N♀ = female nymph; Nex = nymphal exuviae; **FAMU** = Florida A&M University, Tallahassee, FL; **MCZ** = Museum of Comparative Zoology, Harvard University, Cambridge, MA; **NEL** = Northeast Ephemeroptera Laboratory, Department of Biology, Southern Connecticut State University, New Haven, CT; **UNH** = Entomology Collection, University of New Hampshire, Durham, NH; **TTOR** = The Trustees of Reservations, Islands Regional Office, Vineyard Haven, MA; **YPM** = Peabody Museum of Natural History, Yale University, New Haven, CT. Deposition of all specimens is with the institutions listed for each record. Latitude and longitude coordinates are given, where possible, in positive and negative decimal degree format.

Systematic accounts and key

Acentrella rallatoma sp. n. (Figures 1–16)

Material examined. **Holotype, USA:** New York: Suffolk Co., Connetquot River, headwaters, Connetquot State Park, jct. of blue and green trails [40.7863N/-73.1685W], 20-V-2008, L.

Myers, B.C. Kondratieff, and R.W. Baumann, 1♂ (reared in lab 27-V-2008), 1♂Nex [FAMU]; **Allotype**, USA: New York: Putnam Co., Croton River, dnstr. Rt-65 bridge [41.446446N/-73.555912W], 20-VI-2010, S.K. Burian, 1♀ (reared in lab 21-VI-2010), 1 ♀Nex [FAMU]; **Paratypes**, USA: New York: Suffolk Co., Connetquot River, headwaters, Connetquot State Park, jct. of blue and green trails [40.7863N/-73.1685W], 20-V-2008, L. Myers, B.C. Kondratieff, and R.W. Baumann, 2♂N, 1, 1♂Nex (in 1 vial); same, 13♂N, 19♀N (in 1 vial) [FAMU]; Suffolk Co., Connetquot River at Bunces Bridge, Connetquot State Park [40.7720N/-73.1589W], 20-V-2008, L. Myers, B.C. Kondratieff, and R.W. Baumann, 3♂N, 5♀N [YPM]; Suffolk Co., Connetquot River, headwater, at Veterans Memorial Hwy., Connetquot State Park [40.7918N/-73.1659W], 17-VI-2008, L. Myers, 3♂N, 2♀N [CSUC].

Other material studied. USA: Connecticut: New Haven Co., Branford River, Branford [precise coordinates unknown, but believed to be close to 41.29704N/ -72.80116W], 11-VI-1978, W.G. Downs, 3♂N, 9♀N [YPM]; Massachusetts: Dukes Co. (Martha's Vineyard), Tisaquam River, State Rd., Chilmark/West Tisbury town line [41.3775N/-70.67692W], elev. 5 m, 31-V-2007, collector ?, 1♂N, 4♀N [TToR]; same, 18-VI-2007, collector ?, 4♀N [TToR]; same, 9-VII-2007, 5♂N, 18♀N [TToR]; same, 25-VII-2007, collector ?, 4♂N, 4♀N [TToR]; same, 22-VIII-2007, collector ?, 3♂N, 2♀N [TToR]; same, 13-IX-2007, collector ?, 2♀N [TToR]; same, Mill Brook, North Rd., West Tisbury [41.40235N/-70.678216W], elev. 13 m, 31-V-2007, collector ?, 2♀N [TToR]; same (second vial), 31-V-2007, G.D. Whitmore, 5♂N, 8♀N [UNH]; same, 18-VI-2007, collector ?, 4♂N, 12♀N [TToR]; New Hampshire: Belknap Co., Suncook River, 2 km S of Gilmanton Ironworks, White Oak Rd. [43.40213N/-70.290794W], elev. 169 m, 29-V-2008, D.S. Chandler, 1♀N [UNH]; same, 1-VI-2008, D.S. Chandler, 1♀N [UNH]; same, 10-VI-2008, D.S. Chandler, 1♂N [UNH]; same, 15-VII-2008, D.S. Chandler, 1♂N [UNH]; Hillsborough Co., Nissitissit River, 5 km SE of Brookline, elev. 67m [42.7051N/-71.6204W], 7-VI-2005, S. Grieve, E. Wolf, and D.S. Chandler, 1♂N, 2♀N [UNH]; same, Middle Fork of Piscataquog River, 3.22 km NE of New Boston, elev. 103.6m [43.0019N/-71.6615W], 18-VI-2003, G.D. Whitmore, 1♀N [UNH]; New York: Putnam Co., Croton River, riffle dnstr. of Rt. 65 bridge [41.446446N/-73.555912W], 20-VI-2010, S.K. Burian, 3♂, 4♀, 1S♂, 5S♀ (all adults reared), 13 Nex (4♂, 9♀), 6♂N, 13♀N [NEL].

Comparative material of Acentrella alachua (Berner) examined: **Holotype**, USA: Florida: Alachua Co., Gainesville, Cat. No. III-2239-1, No. 1269.2, 22-III-1939, L. Berner, 1♂ (emerged 3-25) [MCZ-Holotype Label # 25523]; **Allotype** of *Acentrella alachua*: Florida: Alachua Co., Gainesville, Cat. No. IV-1239-1, No. 1279.4, 12-IV-1939, L. Berner, 1♀ (emerged 4-14) [MCZ Type Label # 25523]; **Paratypes** of *Acentrella alachua*: Florida: Alachua Co., Gainesville, Cat. No. III-2339-1, No. 1269.4, 23-III-1939, L. Berner, 2♀ (vial contains label indicating 1 larval exuvium mounted on slide, VI-1983 by R.D. Waltz) [MCZ Paratype Label# 25523]; same, Cat. No. IV-1239-1, No. 1279.6, 12-IV-1939, L. Berner, 4♀ (vial contains label indicating 1 larval exuvium mounted on slide, VI-1983 by R.D. Waltz) [MCZ Paratype Label# 25523]; Marion Co., Rainbow Springs Run, Cat. No. III-940-1, No. 1409-9, 9-III-1940, L. Berner, 1♂, 1S♂, 6♀ [MCZ Paratype Label# 25523].

Other material of Acentrella alachua studied: USA, Florida: Alachua Co., Cellon Creek, culvert on Hwy. 441, 5-V-2003, J. Peters and K. Gaynor, 4 N (2♂N & 2♀N) [FAMU].

Male imago (in alcohol)

Body length: 4.00–5.54 mm (4.21 ± 0.9525 , mean \pm SD, $n = 4$); Forewing length: 4.00–4.58 mm (4.17 ± 0.2792 , $n = 4$); Caudal filaments: 7.92–9.25 mm (8.71 ± 0.6561 , $n = 4$).

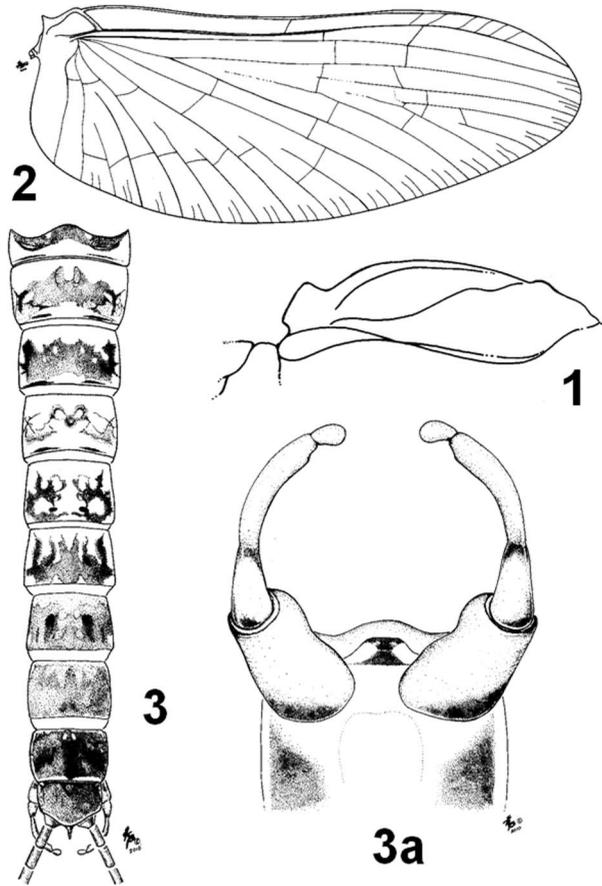
Head. Light brown with bases of ocelli dark brown. Antennae brown, scape slightly darker than pedicel and flagellum. Frons lateral of median ocellus extends forward as small, but distinctive point. Compound eyes turbinate and diverge from

their respective bases such that upper faceted surfaces are separated by a distance at least as great as width of median ocellus. Upper portion of compound eyes pale yellow ochre and stalk yellow with an orange band at base (band fades to brown after death and in alcohol entire upper portion can fade to pale buff-yellow). Lower portion of compound eyes spectrum orange with a slightly darker orange band medially (after preservation lower portion darkens to blue black). Posterior margin of head capsule with broad median notch.

Thorax. Mostly brown with more heavily sclerotised areas dark brown (almost raw umber). Less well sclerotised areas lighter brownish yellow and membranous areas appear white or chamois coloured. Pronotum rectangular and well developed, pale brown medial area flanked by darker brown patches that extend to the lateral margins. Mesonotum mostly brown with small pale areas at the lateral corners of the anteronotal protuberance (ANp), dorsal medial edges of posterior scutal protuberance (Psp), and base of scutellum (SL). Medial longitudinal suture (MLs), medial parapsidal suture (MP), anterior notal transverse impression (ANi), antelateroparapsidal suture (ALPs), and lateroparapsidal suture (LP) are all darker than base background colour. Parascutellum (PSL) slightly darker brown compared to background colour of mesonotum. Apex of SL and surface of infrascutellum (ISL) extremely dark Vandyke brown (almost black). ANp subconical (Figure 1) and MLs on anterior part of ANp is pale. Metanotum mostly brown with suture at junction with mesonotum dark brown. Posterior margin of metanotum dark brown. Pleural areas similar in colour to sclerotised areas of nota, but membranous parts pale yellow or cream coloured. Basiradiale (BR) and associated axillary sclerites dark reddish brown and contrast with much lighter brown major pleural sclerites. Sterna of pro- and pterothoracic segments brown, similar to base colour of mesonotum.

Wings. Forewing as in Figure 2. Wing membrane unpigmented except for extreme base where reddish brown pigment stains the base of the subcosta and a small vein that connects radius, medius, and cubitus veins. Wing membrane adjacent to subcosta also stained reddish brown. Stigmatic area semi-transparent to translucent with about 5 simple complete crossveins. Marginal space of stigma lack unattached intercalary veins. First marginal space below stigma usually lacks unattached intercalary veins, but occasionally may have an extremely small single marginal vein that may appear as a damaged area at the wing edge. Pairs of distinct marginal intercalary veins occur in spaces between all remaining major longitudinal veins, except for the last anal vein interspace. All major longitudinal veins and crossveins pale. Hind wings absent.

Legs. Ranges, means, and ratio values of segments of forelegs as follows: Femur 0.70–0.92 mm (0.78 [0.58], $n = 3$) (mean [ratio to tibia]); Tibia 1.28–1.45 (1.35 [1.00], $n = 3$); Tarsus₁ 0.06–0.08 (0.07 [0.05], $n = 3$); Tarsus₂ 0.41–0.65 (0.52 [0.38], $n = 3$); Tarsus₃ 0.30–0.53 (0.43 [0.32], $n = 3$); Tarsus₄ 0.20–0.28 (0.23 [0.17], $n = 3$); Tarsus₅ 0.14–0.16 (0.15 [0.11], $n = 3$). Coxa brown with greyish tints, base colour similar to pleural sclerites and nota. Trochanters mostly pale with slight tint of brown and grey shading similar to coxa. Forefemora tinted with dark neutral grey over light yellowish brown base colour, all colours darken toward base of femora and lighten toward apex. Foretibia pale except for distinct brown spot adjacent to joint with tarsal segment 1. Foretarsus₁ shaded with light brown. Tarsal segments 2–4 pale except for slight brown tints near apex of each segment. Foretarsus₅ pale. Tarsal claws both blunt and sharp and shaded with greyish brown. Segments of mid and



Figures 1–3a. *Acentrella rallatoma*, adult male. (1) Subconical ANP of mesoscutum, side view; (2) forewing; (3) abdominal terga II–X, dorsal view; (3a) genitalia, forceps and penes cover, ventral view. © Steven K. Burian.

hind legs pale and each with 4 tarsal segments. Tarsal claws of mid and hind legs marked similar to those of forelegs.

Abdomen. Abdominal terga as in Figure 3. Base colour white suffused with irregular brown patches varying in colour from raw umber to much lighter cinnamon. Cuticle of terga VII–X uniformly cinnamon coloured and transparent through which darker and more irregular pigmentation of soft tissue is visible. Tergite I mostly brown, about same colour as mesonotum, with pale band along posterior margin. Terga II–VI with more pale white areas and limited irregular brown patches. Posterior margins of terga I–IV with narrow brown transverse dashes. Tergite IV least pigmented appearing mostly white with a small median brown spot. Terga V–VII with pair of somewhat variable darker spots medially. Laterally most segments pale with brown shading not extending to the pleural regions, except for terga VII–X, which are uniformly pigmented. Spiracles, tracheal trunks, and large trachea of abdominal terga distinctively outline with black. Sterna mostly pale. Sternite VIII with faint brown shading. Sternite IX with dark brown shading laterally and light brown medially to base of genitalia (Figure 3a). Genitalia

as in Figure 3a, forceps with dark brown shading on ventral basal edge and apical edge at joint with segment 2. Genital forceps segment 1 with upper third of inner margin of forceps base distinctly concave. Segment 2 of forceps with limited faint brown shading at base and at constriction where conical basal portion transitions to more uniformly cylindrical upper portion. Segment 2 broadens slightly before the joint with segment 3 forming a slight inward projecting bulge. Forceps segment 3 is small and slightly longer than wide. Sclerotised trapezoidal penes cover present. Penes cover may be pigmented as in Figure 3a or pale, occasionally penes cover is retracted and not visible.

Caudal filaments. Cerci pale white lacking any bands. Median terminal filament vestigial, visible as a minute stub extending beyond posterior margin of tergite X.

Alternate abdominal colour morph. One of the males studied from reared nymphs exhibited a much lighter colour pattern of abdominal terga. Most of the differences occurred on terga II–VI, which were mostly pale white with extremely faint brown patches laterally and faint brown patches along posterior margins of terga II, III, V, and VI. Tergite IV was entirely pale. All other features of the abdomen and genitalia were the same.

Female imago (in alcohol)

Body length: 4.04–4.50 mm (4.22 ± 0.2009 , mean \pm SD, $n = 4$); Forewing length: 4.52–4.91 mm (4.69 ± 0.1880 , $n = 4$); Caudal filaments: 7.66 mm ($n = 1$, only one specimen reared with intact caudal filaments).

Head. Cuticle transparent pale orange-yellow. Clusters of opaque white material visible dorsally and laterally through cuticle. Frons light reddish brown, with area encircling bases of lateral ocelli pale greenish yellow. Median ocellus with black basal margin and only about $\frac{1}{2}$ – $\frac{2}{3}$ the size of lateral ocelli. Scape and pedicel of antennae reddish brown (same colour as frons), flagellum much lighter brown. Cuticle lateral to antennal sockets and beneath lateral ocelli streaked with reddish brown, area of intense colour does not reach compound eyes. Compound eyes small, upper (or dorsal) $\frac{1}{3}$ light yellow (dark areas between facets sometimes makes darker tints appear depending on viewing angle) and lower (ventral) $\frac{2}{3}$ darker orange-brown. The line dividing the different colour zones is visible laterally.

Thorax. Orange-yellow base colour of all sclerotised parts of thorax similar to that of head. Clusters of white material (as described on head) visible through the cuticle of the pro-, meso-, and metanota. Sutures and more heavily sclerotised dorsal, lateral and ventral parts of thoracic highlighted reddish brown. ANp of mesonotum subconical. Mesoscutum (MS) uniform pale brownish yellow (approximating to pale yellow ochre). Sublateroscutum (SLS) shaded with dark brown (approximating Vandyke brown). Spiracles and large trachea of thorax shaded with black and visible through cuticle.

Wings. Forewings similar in shape and arrangement of wing veins as described for male. Wing membrane lacks pigmentation except at base as noted for male. Hind wings absent.

Legs. Forefemora shaded with reddish brown over a pale orange-yellow base colour. Foretibia and tarsus pale tan to light brown. Middle and hind legs pale white or cream coloured.

Abdomen. Orange-yellow base colour of terga and sterna similar to thorax and head. Clusters of white granular material (as described on head) absent on segments

I–VII, but visible through cuticle of segments VIII–X. Abdominal segments I–VI appear tinted light greenish yellow as result of eggs (which are slightly greenish in colour). Eggs in oviducts are clearly visible through the body wall. Abdominal terga I–VII have reddish brown lateral triangular patches that connect across the posterior margins of tergites. Abdominal terga VIII–X lack reddish brown lateral marks and appear lighter coloured because of white granular material. Terga VIII–X usually uniformly coloured, but may have slight tint of reddish brown shading laterally on terga VIII and IX. Sterna pale yellow with greenish tint from eggs. Trachea pigmented black and visible along lateral margins of each sternum.

Caudal filaments. Caudal filaments are pale white as in male. Medial terminal filament similar to that of male.

Eggs (in Euparal[®])

Maximum length: 0.110–0.140 mm (0.127 ± 0.0007 , mean \pm SD, $n = 21$); Maximum width: 0.070–0.100 mm (0.083 ± 0.0090 , $n = 21$).

Eggs oval to subspherical with extremely small chorionic features (Figure 4), but no obvious micropylar device. Chorion appears to be covered with rows of minute (~ 0.001 – 0.002 mm) ridges (only visible at $1000\times$) with regularly spaced gaps, and

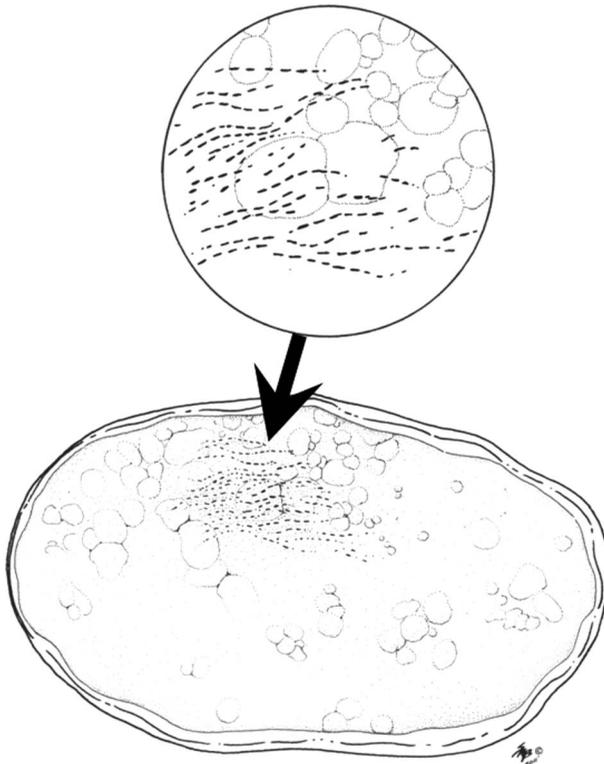


Figure 4. *Acentrella rallatoma*, egg. Detail of chorionic features shown at $1000\times$ (under phase contrast illumination). Marks shown are typical of entire surface of chorion. © Steven K. Burian.

thus give the appearance of dashed lines. All ridges are oriented parallel to the long axis of the egg.

Nymph (in alcohol, well developed or dark wing pad stage)

Body length ♂: 4.08–5.00 mm (4.43 ± 0.33589 , mean \pm SD, $n = 24$); Body length ♀: 3.62–5.36 mm (4.82 ± 0.4000 , $n = 28$); Head length ♂: 0.68–0.93 mm (0.83 ± 0.0509 , $n = 24$); Head length ♀: 0.78–0.88 mm (0.83 ± 0.0331 , $n = 28$); Antennal length ♂: 1.44–2.12 mm (1.81 ± 0.1835 , $n = 22$); Antennal length ♀: 1.72–2.28 mm (2.06 ± 0.1433 , $n = 25$); Length of foreleg segments: Femur ♂: 0.64–0.79 mm (0.70 ± 0.0461 , $n = 24$); Tibia + Tarsus ♂: 0.86–1.09 mm (1.00 ± 0.0660 , $n = 24$); Femur + Tibia + Tarsus ♂: 1.50–1.86 mm (1.70 ± 0.1027 , $n = 24$); Femur ♀: 0.62–0.88 mm (0.73 ± 0.0531 , $n = 27$); Tibia + Tarsus ♀: 0.82–1.09 mm (1.01 ± 0.0626 , $n = 27$); Femur + Tibia + Tarsus ♀: 1.50–1.88 mm (1.75 ± 0.1084 , $n = 27$); Length of cerci ♂: 3.20–4.56 mm (3.89 ± 0.4220 , $n = 18$); Length of cerci ♀: 3.28–4.70 mm (4.08 ± 0.3964 , $n = 23$).

Head. Dorsal and frontal aspects of head as in Figures 5 and 12. Vertex cuticle yellowish brown. Ecdysial suture white to cream colour and flanked by large irregular brown blotches that extend from behind lateral ocelli to occiput. Large upper portion of compound eyes reddish brown and rimmed with thin dark brown line. Small lower portion of compound eyes black. Most of frons and gena brown, except for small pale areas adjacent to lateral ocelli. Clypeus brown and ventral edges of frons and gena dark brown. Area of frons below antennal sockets concave, apparently to accommodate scape and allow base of antennae. Concave surface of cuticle speckled with small brown spots visible against lighter background. Antennae light brown, with scape and pedicel slightly darker than flagellum. Antennae usually directed ventrally following hypognathous orientation of head.

Mouthparts. Dorsal and ventral aspects of the labrum as in Figure 6. Labrum somewhat rectangular with shallow anterior median notch and small rounded lobe at base of notch. Dorsal surface with 1 pair of large distinctive setae medially flanked by a gap lacking setae and followed by an irregular row of 4–5 large setae similar to medial pair. Posterior portion of dorsal surface with scattered smaller hair-like setae. Long spine-like and hair-like setae along anterolateral margins, some long setae have minute fringed edges. Ventral surface as in Figure 6. Setae of ventral anterior margin have finely divided edges and extend beyond edge and of labrum. Ventral aspect of right and left mandibles as in Figures 7 and 8. Right mandible (Figure 7) with outer and inner incisors fused for about $\frac{2}{3}$ of their length. Outer incisor broad and flat apically, appearing scoop-shaped with only faint surface ridges (some populations have a few setae on inner surface near apex of outer incisor). Inner incisor with sharp pointed apex and small subapical tooth on edge nearest outer incisor. Edge of inner incisor adjacent to prosthema distinctly serrate. Prosthema of right mandible with 1 or 2 large apical spines and a subapical complex of smaller projections. Surface between base of prosthema and molar region lacks setae, but can have weak serrations. A tuft of setae, some large and ribbon-like, occur at beginning of molar surface. Outermost point of molar surface with 2 or 3 slender spines similar to apical spines of prosthema. Left mandible (Figure 8) with outer and inner incisors fused as in right mandible. Outer incisor broad and scoop-shaped as on right mandible (some populations have a few setae on inner surface near apex of outer incisor) and inner incisor with similar subapical tooth, but positioned deeper in notch between outer and inner incisors

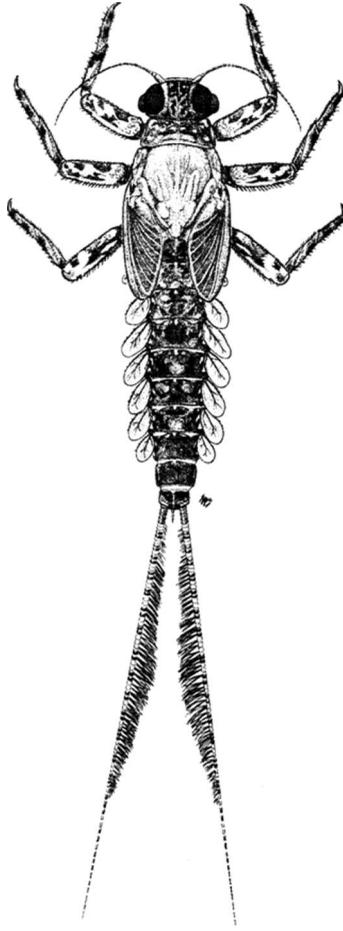
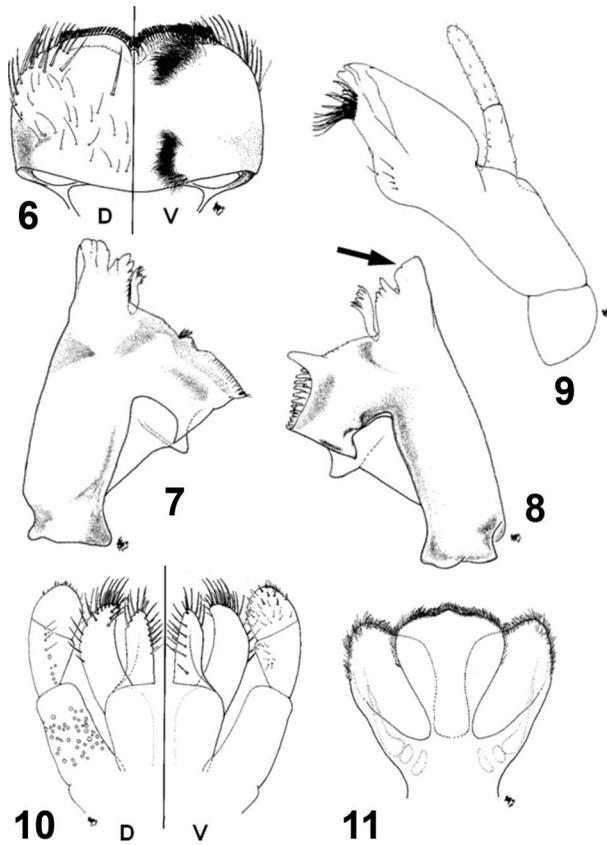


Figure 5. *Acentrella rallatoma*, near final instar male nymph, dorsal view. © Steven K. Burian.

than on right mandible. Edge of inner incisor adjacent to prostheta not serrate. Prostheta larger than on right mandible with broad base and apex. Most sharp spines of left prostheta larger and thicker than on prostheta of right mandible. Medial spines of left prostheta broad and blunt. Surface between base of left prostheta and molar surface lack setae and is weakly serrate. Molar surface with large distinctive tooth at innermost edge followed by about 12 smaller molar teeth with slender rounded tips. Many smaller rounded molar teeth fill out the remainder of the molar area. Maxillae as in Figure 9. Maxillary palpi with apex not reaching tip of galea-lacinia. Apex of galea-lacinia with 4 large teeth. Inner apical surface of galea-lacinia with 2 long and stout and 1 long and slender dentisetae adjacent to large apical teeth. Patch of 5 long hair-like setae beyond area of dentisetae. Row of 8 short, stout, curved setae below upper surface occupied by dentisetae and hair-like setae. Innermost curved setae in row are longest and setae become progressively shorter toward outer most point of row. Inner edge of galea-lacinia below apical setae broadly rounded with scattered small setae. Dorsal and ventral aspects of the labium as in Figure 10. Dorsal surface of glossa lack medial setae, only marginal



Figures 6–11. *Acentrella rallatoma*, nymphal mouthparts. (6) Labrum, left dorsal (D) and right ventral (V); (7) right mandible, ventral view; (8) left mandible, ventral view with arrow indicating rounded scraper-like outer incisor; (9) right maxilla, dorsal view; (10) labium, left dorsal (D) and right ventral (V); (11) hypopharynx, dorsal view. © Steven K. Burian.

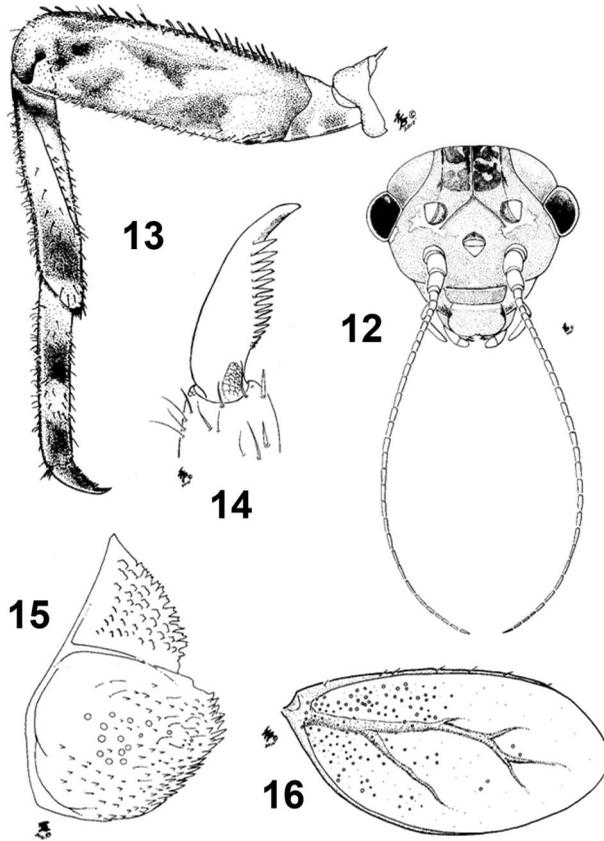
setae present. Paraglossa subequal to or slightly longer than glossa with 3 submarginal setae in row near apex and many longer spine-like setae present along outer margin. Labial palpi 3 segmented with inner apical margin of segment 3 rounded to slightly flattened. Dorsal medial surface of segment 2 with short row of 4 long setae. Ventral surface of segment 3 with many small hair-like and spine-like setae near medial margin. Dorsal surface of segment 1 with many small circular campaniform-like setae scattered across middle of segment. Same circular setae extend onto base of labium. Hypopharynx as in Figure 11. Lingua and superlinguae margined with small hair-like setae.

Thorax. Pronotum as in Figure 5. Pronotum brown with pale spots at anterolateral and posterolateral corners. Irregular dark brown to black marks across middle of pronotum. Posterior portion of pronotum slightly elevated above anterior portion. Mesonotum uniformly brown with some darker brown areas near base of wing pads. MS occasionally has slightly darker brown longitudinal streaks (Figure 5). Metanotum brown, similar base colour as mesonotum. Hind wing pads reduced to minute vestigial flaps. Pleural sclerites brown, similar to colour of mesonotum. Sterna mostly pale except for dark brown in and immediately around furcal pits.

Legs. Legs as in Figures 5, 13, and 14. Femora with dorsal row of large, brown, bristle-like setae that are usually narrow at base and broaden apically. Several of the large, bristle-like setae appear to have an apical pore or rough (almost fringed) edges surrounding a small apical recess. A few setae of the dorsal row taper from their base to a sharp symmetrical point. Lengths of most of the large dorsal setae were $\frac{1}{4}$ the width of respective femur. Secondary dorsal row of shorter hair-like setae parallels row of large bristle-like setae. A few setae of secondary row have blunt tips. Small villopore present on all femora, usually surrounded by spine-like setae. Most setae on femora restricted to dorsal and ventral edges. Campaniform-like setae occur along ventral edge of femora, becoming more numerous near joint with tibia. Tibiae with basal and apical brown bands (Figure 5, 13). Tibialpatellar suture long and distinct with row of small spine-like setae along ventral (or inner) edge. Two irregular rows of setae present along dorsal (or outer) edge of segment. Dorsal rows of setae mostly composed of short, scattered solitary hair-like setae and pairs of closely spaced long hair-like setae. Occasionally, single long hair-like setae occur along dorsal edge. Ventral apex of tibia with cluster of large spine-like setae surrounding a small tuft of hair-like setae. No flattened or ribbon-like setae occur in cluster. Tarsi with medial and apical brown band (Figure 5, 13). Ventral edge of tarsi with distinctive row of about 12 long spine-like setae. Dorsal edge of tarsi with few scattered long hair-like setae and irregular rows of short spine-like setae. Dorsal apex of tarsi with small group of hair-like setae. Tarsal claws as in Figure 14. Tarsal claws have a single row of 14–15 denticles. Apex of tarsal claws not excessively curved or hooked. Tarsal claws lack subapical setae.

Abdomen. Abdomen as in Figure 5. Terga brown with dark brown to black shading on segments II–VIII. Abdominal trachea tinted with black and visible through cuticle. Anterior margins of terga I–X with small pale medial spot. Occasionally on terga II–IX anterior median spot flanked by pair of small pale spots. Lateral margins of terga II–IX with longitudinal pale areas that often have an elongate brown spot, but often lateral pale areas obscured by position of gills. Posterolateral projections absent on all segments. Anterior margins of terga sinuate with anterior part of curved edge of tergite margined with dark brown and posterior part of curved edge pale. Colour of tergite X variable from solid brown with a small pale area adjacent to bases of cerci to an interrupted pattern of 2 large medial brown bands and anterolateral brown spots separated by a pale stripe. Posterior margins of terga with poorly developed row of spinules. Spinules range from extremely short blunt forms with one or more tips to large irregularly pointed forms with 1 or more sharp tips. Spinules usually darker than background colour of tergite. Scattered hair-like setae occur across terga, scale and tube setae are absent. Campaniform-like setae scattered along lateral margins of terga. Sterna brown, segments II–VII each with 2 pair of faint submedian dots. Sterna II–VIII with pair of transverse submedian pale spots along anterior margin. Pale spots on sternite IX merge with anterior margin. Posterior margin of sternite IX of male with shallow median notch, female lacks median notch. Paraprocts as in Figure 15. Edges with broad, irregular pointed spines and slender sharp spines. Campaniform-like setae occur on basal portion of paraproct.

Gills. Abdominal gills as in Figures 5 and 16. Abdominal gills usually oval with smooth, rounded outer margins. Edges of gills thickened and only have small, scattered hair-like setae. Gill trachea with most major branches oriented posteriorly and uniformly coloured. Gill membranes mostly transparent lacking any dark pigmentation. Many campaniform-like setae occur near base of gill.



Figures 12–16. *Acentrella rallatoma*, body parts of near final instar male nymph. (12) Head, frontal view; (13) right foreleg, dorsal surfaces and edges showing setae; (14) right foreclaw; (15) left paraproct; (16) abdominal gill 5. © Steven K. Burian.

Caudal filaments. Caudal filaments as in Figure 5. Medial terminal filament light brown and about as long as midline length of tergite X (usually only composed of 3 annuli). Cerci alternately banded dark and light over entire length, usually 2 or 3 brown annuli were separated by 2 pale annuli. Brown annuli have darkest shading along posterior margins. Cerci with light brown setae, as in Figure 5, that occur in groups of 4.

Etymology

The species name is a compound descriptive name formed from the Latin noun *rallum* (a type of scraper) and Greek noun *tomeus* (incisor) and stands in apposition. The name describes the morphology of the outer incisors of the nymph mandibles, which appear to be adapted for scraping rather than cutting.

Diagnosis

Male imagos of *Acentrella rallatoma* can be separated from those of other known North American species of *Acentrella* that lack hind wings by the following

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combination of characters: (1) distinctive coloration of abdominal as described herein and shown in Figure 3; (2) forefemora tinted with dark neutral grey over light yellowish brown base colour, colours darken toward base of femora and lighten toward apex, no reddish spots; (3) forewings lack unpaired marginal intercalary veins in first space below the stigma or have only a single extremely small vestigial vein in this 1 space ; (4) genital forceps segment 1 with distinctive indented inner apical margin and distinctive brown shading along base; (5) genital forceps segment 2 with distinctive brown shading on conical basal portion and slight apical expansion on inner surface near joint with terminal segment; (6) terminal segment of forceps only slightly longer than wide; and (7) penes cover coloured and shaped as in Figure 3a.

Although little is known about females of North American *Acentrella*, the following combination of characters of the female of *A. rallatoma* may prove useful for future comparative analysis: (1) distinctive orange-yellow base colour of head, thorax and abdomen combined with contrasting white granular material visible through cuticle; (2) reddish brown lateral triangular patches that connect across the posterior margins of abdominal terga I–VII; (3) slight greenish tint to dominant orange-yellow of abdominal terga; and (4) forelegs with femora shaded with reddish brown over a pale orange-yellow base colour, tibia and tarsus pale tan to light brown – all segments of mid and hind legs pale white or cream coloured; and (5) eggs with chorion covered with rows of short ridges separated by gaps appearing similar to dashed lines.

Nymphs of *A. rallatoma* can be separated from those of all other known North American species of *Acentrella* by the following combination of characters: (1) outer incisors of mandibles broad and flat at apex; (2) cerci alternately banded with brown from base to tips; (3) head, thorax, and dorsum of abdomen mostly brown to dark brown, lacking any large pale areas; (4) abdominal terga with small median pale spot on anterior margins and occasionally flanked by a small pair of submedian spots; and (5) femora with dorsal row of bristle-like setae usually about $\frac{1}{4}$ the width of the femora.

Discussion

Acentrella rallatoma is the third species of the Nearctic *Acentrella* discovered where cerci of the nymph are alternately banded from their bases to tips and is now the 9th species known from the Nearctic region. Nymphs of *A. rallatoma* are distinctly larger and more uniformly coloured compared to nymphs of *A.alachua* (Berner 1940) and *A. parvula* (McDunnough 1932). Analysis of body length means of nymphs at the same stage of development of *A. rallatoma* and *A. parvula* showed that the means for both sexes of *A. rallatoma* nymphs (δ 4.43 and ♀ 4.82) were significantly different ($\alpha = 0.05$) from those of both sexes of *A. parvula* nymphs (δ 3.45 and ♀ 4.00). Mature nymphs of *A.alachua* were not available for measurement, but the maximum value of 4.50 mm published by Berner (1940) suggests that body size of *A.alachua* would fall between *A. parvula* and *A. rallatoma*. In addition, the combination of broad scrapper-like outer incisors of the mandibles and short bristle like setae on the dorsal edge of the femora of *A. rallatoma* nymphs are unique. Despite the unique combination of these characters in *A. rallatoma* nymphs, somewhat similar features do appear in *A.alachua*, *A. barbarae*, *A. feropagus*, *A. lapponica* and *A. parvula*. Our study of

A. alachua nymphs showed them to have mandibles with rounded outer incisors that were mostly separated from the inner incisors. Other features of the mandibles and remaining mouthparts were quite different from those of *A. rallatoma* nymphs. In the description of the nymph of *A. barbarae* Jacobus and McCafferty (2006) include photographs of the outer incisors of nymph mandibles. These photographs show the outer incisors to have rounded apical edges and have a single, rounded tooth. Another feature of the mandibles that according to Wiersema (2000) most nymphs of *Acentrella* lack, is serrations on the inner edge of the incisor of the right mandible. He noted that *A. parvula* nymphs lack these serrations. Our study of *A. parvula* nymphs (from Florida to Labrador and west to Illinois) and *A. alachua* nymphs (from Florida) show that they have weak or minute serrations on the inner edge of the incisor of the right mandible. Although these are far less distinct than those of *A. rallatoma*, they share this character. Setae on the dorsal edge of femora of most *Acentrella* are usually long and have tips that taper to sharp, symmetrical points, but setae on the femora of *A. alachua*, *A. feropagus* and *A. lapponica* are not of this type and in-part approximate the condition that occurs on *A. rallatoma*. In *A. alachua* dorsal femoral setae are moderately long (about $\frac{1}{3}$ to $\frac{1}{2}$ the width of the femur) and have rounded tips. In *A. feropagus* dorsal femoral setae are short and relatively robust from their bases to sharp tips – thus these setae appear bristle-like, rather than the typical hair-like forms. In *A. lapponica*, dorsal femoral setae are also short, but have narrow bases and enlarge symmetrically to sharp tips. Neither *A. feropagus* nor *A. lapponica* seem to have any femoral setae with modified tips with pores as observed on *A. rallatoma*. The uniform dorsal row of hair-like setae, present on the tibiae and tarsi of other species of *Acentrella* (e.g. *A. turbida* (McDunnough 1924)) is absent from the tibiae and tarsi of *A. rallatoma*. Instead, tibiae and tarsi have irregular rows of setae composed of short, scattered solitary hair-like setae and pairs of closely spaced long hair-like setae. Occasionally, single long hair-like setae occur along the dorsal edge of these leg segments. This pattern is similar to that exhibited by *A. parvula* nymphs, but differs in *A. alachua* which have scattered long hair-like setae on the tibiae and usually have 6–7 long hair-like setae on the tarsi.

Another feature of the nymph of *A. rallatoma* of comparative interest is the rather uniform brown colouration. Nymphs of the southeastern US species *A. alachua* are mostly pale with distinctive brown spots on abdominal terga III and V (Berner 1940, 1950). The trans-continental *A. parvula* have a much greater range of contrasting colour patterns on abdominal terga. Although the details of their variation is discussed below, the relatively consistent colour pattern of nymphs of these species includes paired large pale lateral marks, with an irregular median brown area, on tergite IV; anterior margins of terga II–IX with a small median pale spot; and lateral margins of terga I–IX with longitudinal pale spots that nearly surround an elongate brown spot (which are usually covered by gills). Brown shading is usually present in the gill membranes of *A. parvula*, but apparent lack of colour in gills in nymphs from the Connecticut River (verified by rearing) and extremely faint colour in the gills of some nymphs from Labrador indicate that much variation in this character exists over the geographic range. All known populations of *A. rallatoma* lack gill pigmentation.

Adult males of *A. rallatoma* are distinctly larger than those of *A. parvula*, but only a little larger than those of *A. alachua*. Statistical analysis of body length

means of all available specimens of *A. rallatoma* and males of the type series of *A. alachua* showed them not to be significantly different ($\alpha = 0.05$). Because this result is based on small sample sizes (*A. rallatoma* $n = 4$; *A. alachua* $n = 3$) it should be re-evaluated as more material becomes available for study. Males of *A. rallatoma* and *A. alachua* seem to have similarly coloured eyes, head and thorax. The major differences between males of these two species are the more colourful patterning on abdominal terga of *A. rallatoma* and subtle variation in male genitalia. The male genitalia are best observed intact because subtle features of soft tissues are quite susceptible to distortion when mounted on a slide; specifically, the shape of the forceps base and the length and shape of forceps segments 2 and 3. However, the sclerotised sub-trapezoidal penes cover is sometimes difficult to view on intact specimens because pigmentation can be faint and it may be hidden from view by soft tissues. Our comparative study of the genitalia of *A. rallatoma* with the holotype and paratypes of *A. alachua* showed that genital forceps differed as follows: (1) inner edge of segment 1 not as consistently indented on both right and left forceps compared to *A. rallatoma*; (2) basal part of segment 2 of *A. alachua* was more cylindrical than *A. rallatoma*; (3) segment 3 of *A. alachua* was longer than that of *A. rallatoma*; (4) penes cover was not visible on any specimen of *A. alachua* in contrast to usually being visible and pigmented in *A. rallatoma*.

Females of *A. parvula*, *A. alachua* and *A. rallatoma* seem to have similar colour and colour patterns and differ mostly in body size, with *A. rallatoma* being the largest and *A. parvula* the smallest. Except for differences in size it is not currently possible to separate the female imagos of these species. In general, species level diagnostic characters for adult males and females of *A. rallatoma*, are best viewed on newly emerged or freshly collected specimens. Problems concerning changes in colour that occur at some point after preservation in ethanol described by McCafferty, Wigle and Waltz (1994) for *A. turbida* also seem to occur for specimens of *A. rallatoma*.

Lastly, although the alternately banded cerci of the nymphs of *A. rallatoma* hint at its association with other such species of *Acentrella*, it is by no means typical of most Nearctic members of the genus. For example, the somewhat shorter and more bristle-like setae on the dorsal edges of femora is a stark contrast to the much longer and more hair-like setae of the two most recently described Nearctic species (i.e. *A. barbarae* and *A. nadineae*). Only the Arctic species *A. lapponica* and *A. feropagus* have similarly short femoral setae. These differences, as well as variation among other characters, were sufficient to make initial generic placement uncertain and require evaluation of the null hypothesis (species is a member of no known genus). Comparative character analysis of the new species (described herein) showed that there was sufficient character concordance with known genera *Acentrella* and *Plauditus* to reject the null hypothesis in favour of the alternate hypothesis (species is a member of a known genus). However, the lack of detailed comparative diagnoses for these presumed sister taxa made it unexpectedly difficult to evaluate character variation and to determine which characters were most informative. Diagnostic characters published (or discussed) for *Acentrella* (Bengtsson 1912; Waltz and McCafferty 1987; Wiersema 2000) and *Plauditus* (Lugo-Ortiz and McCafferty 1998a, b; McCafferty and Waltz 1998; McCafferty and Jacobus 2001) were carefully evaluated. The results showed that the new species had more characters that fell within the range of variation known for *Acentrella* than it did with *Plauditus*.

Moreover, the character study revealed that for nymphs, commonly used characters of leg setation and shape of the third segment of labial palps (we observed overlap in labial palp characters in specimens of *Plauditus dubius*, *P. gloveri* and *P. virilis* from northeastern North America) were often too variable, when used alone, to correctly diagnose either genus. Perhaps the single most informative feature was the spinules on the posterior margins of abdominal terga. For *Acentrella*, the general form of these spinules was poorly developed and irregular with sharp and often multidentate tips. The alternate form, typical of *Plauditus*, was unidentate well-developed and regular spinules with broad tips that were usually pointed (and sometimes rounded). The potential importance of this tergal character for nymphs of *Acentrella* was discussed by Waltz and McCafferty (1987), but for some reason was overlooked in subsequent treatments of the genus. This feature, when used with those of the foreleg, mouthparts, hind wing pads and gill characters (i.e. elongate shape, distinctly branched trachea and occasional pigmentation) seems to provide the best means of diagnosing nymphs of *Acentrella*.

Biology

Mature nymphs of *A. rallatoma* were collected from the streams in Connecticut, New York and New Hampshire from late May through early June and initially indicate a univoltine lifecycle with emergence, mating and oviposition in the late spring. But recently we discovered a sample taken in August 1995 from the Croton River, NY, that had mature nymphs of *A. rallatoma*. This now indicates a possible second generation, hence a bivoltine life cycle with adults present in late spring and late summer. In the laboratory under natural light conditions subimagos emerged in late afternoon or early evening and moulted to the imago stage by the next morning. Emergence was completed at the water surface with subimagos quickly flying away to the top of the rearing cups.

In the field (i.e. Croton River site) nymphs were observed clinging to edges of large gravel and cobble substrates in shallow riffles between pools. Coarse benthic substrates were covered with algae and detritus that were easily dislodged from the surface by rubbing with hands. The dark brown body colour and alternate banding of caudal filaments allowed nymphs to blend in well against the dark background of gravel and cobble. In the Connetquot River (type locality) nymphs were collected from long runs with patches of shifting sand and organic materials mixed with gravel. At the time of the collections, water levels were high and abundant coarse detritus was present in the stream.

Distribution

Known populations of *A. rallatoma* inhabit shallow riffles and transitional runs of 2nd–3rd order streams. Streams with *A. rallatoma* have relatively low gradients and are either tributaries of large rivers or drain directly to the ocean.

Acentrella rallatoma is now known from four streams of the North-Eastern Coastal Zone (Southern New England Coastal Plains and Hills, Long Island Sound Coastal Lowland, and Gulf of Maine Coastal Plain subsections), three streams in the Atlantic Coastal Pine Barrens (Cape Cod/Long Island subsection), and one stream of the North-Eastern Highlands (Worcester/Monadnock Plateau subsection) ecoregions (Griffith et al. 2009). This is a diverse area that includes the south-

western portion of Long Island, adjacent mainland area surrounding New York City, southwestern and northeastern Connecticut, almost all of Rhode Island, most of eastern Massachusetts including Cape Cod, Martha's Vineyard, and Nantucket Islands, and all of the coastal region of New Hampshire inland to the region south of Lake Winnepesaukee. Streams with *A. rallatoma* are widely separated and either part of separate, large and internally diverse hydrologic units (e.g. Hudson River and Merrimack River drainages) or drain directly to the ocean (e.g. Branford and Connetquot Rivers). Except for the site-specific microhabitat similarities such as substrate, flow and temperature, the most important feature shared by these sites is their proximity to the coast or mainstem of a major river system. The lack of additional records from reasonably well-sampled streams further inland within the same hydrological units is puzzling and suggests that this could be a relictual distribution from a period when there were extensive coastal stream systems on the exposed continental shelf. Emery (1987) summarised the fossil and geological evidence indicating that a complex terrestrial ecosystem replete with streams existed on the continental shelf from at least 14-6 ka ago (shelf habitats are believed to have been completely inundated by 6 ka ago). Before this period there would have been many interconnected drainages and small separate drainages providing a wide range of relatively low-gradient cool-cold stream habitats. Although no fossils of aquatic insects have been recovered from the submerged shelf to confirm their previous existence there, the relatively rapid recolonisation of deglaciated inland habitats, that probably started about 14 ka ago when terrestrial plants began to track north (Davis and Jacobson 1985), suggests that immigrant source populations were not far from the glacial front and individuals from shelf-stream populations would have contributed to colonisation of new inland streams. The progressive loss of shelf stream habitats from 14-6 ka ago would have fragmented and isolated stream insect populations on the continental shelf. Ultimately, all shelf populations were eliminated and only those that successfully colonised upland streams survived as relicts of the shelf community. The likelihood of this scenario is strengthened by studies of the distribution of freshwater copepods (Stemberger 1995) and freshwater fish (Schmidt 1986), as well as the current lack of records from deep within the major hydrologic units of northeastern North America.

The alternate possibilities that the present distribution pattern of *A. rallatoma* is the result of a widespread species of inland origin being reduced across its range via anthropogenic effects, or only being able to colonise specific unique habitats following deglaciation, are tenable only if the species was once widespread across the interiors of major drainages and/or had some specific life history requirement that was only met in habitats that were minimally disturbed or had some unique quality. The current lack of records from the interiors of the major drainages of northeastern North America does not support the fragmentation of a once widespread species. Further, all the streams with *A. rallatoma* are in areas that have been heavily populated and developed by modern humans for over 300 years. These areas have histories of landscape disturbance dating to the late 1700s and between 1830 and 1880 almost all of the first growth forest of southern New York and New England was cleared for agriculture and charcoal production (Sanderson and Brown 2007; Sanderson 2009). This history of stream habitat and landscape disturbance precludes any of these streams from harbouring 'unique' minimally disturbed habitats. In fact, streams with similar characteristics as those with *A. rallatoma* are quite common throughout northeastern North America. Thus, the presence of a particular species,

such as *A. rallatoma*, must at least in part be for some reason other than the presence of unique habitat features.

Lastly considering the similarities between *A. parvula* and *A. rallatoma* nymphs (the most commonly collected life stage of these taxa) perhaps a better question concerning the distribution of *A. rallatoma* is, are there any older records of *A. parvula* that are actually misidentified *A. rallatoma*? Records of *A. parvula* are spotty in northeastern North America (Burian and Gibbs 1991; Burian and Bednarik 1994; Chandler, Whitmore, Burian and Burger 2006) and it is quite possible that at least some are *A. rallatoma*. Re-examination of specimens previously reported from coastal Connecticut as *A. parvula* (listed in Burian and Bednarik 1994 as *B. armillatus*) showed them to be misidentified *A. rallatoma*. The same was true for all specimens of *A. parvula* reported by Whitmore (2008) for Martha's Vineyard. Unfortunately it was not possible to retrieve specimens for all previous northeastern records of *A. parvula* to test this hypothesis further, but we know that both *A. rallatoma* and *A. parvula* occur in the Piscataquog River system of southeastern New Hampshire and at least *A. parvula* occurs in the Connecticut River, New England's largest river. Thus, the probability of specimens being misidentified from similar river systems seems high. This could complicate the determination of range inland boundaries of both species. However, based on current distribution data, there are still no known exceptions to the mostly inland distribution pattern of *A. parvula* and mostly coastal distribution pattern of *A. rallatoma*. We hope that data presented here will aid future biogeographic studies of these species.

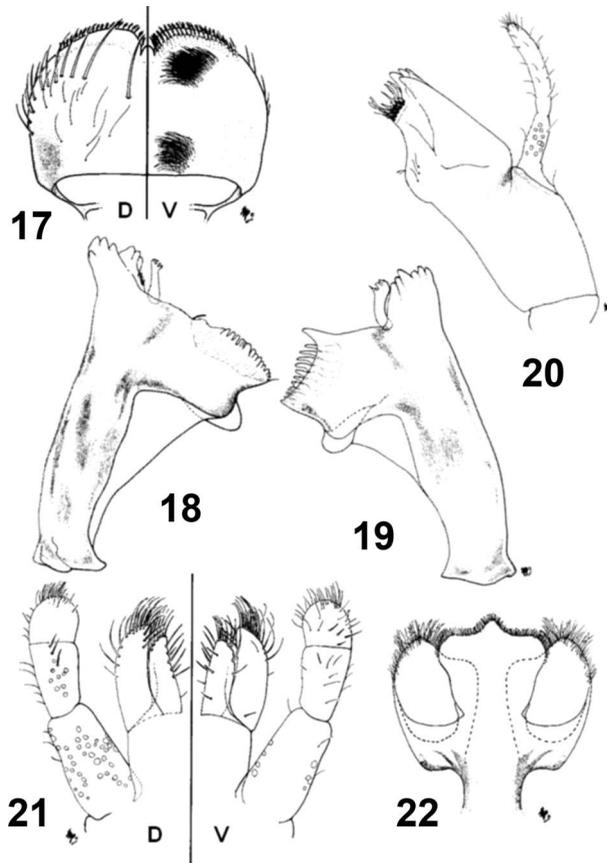
Acentrella parvula (McDunnough 1932) (Figures 17–31)

Material examined. **USA:** Connecticut: Hartford Co., Connecticut River, King's Island boat ramp, from upstream side of near island [41.963055N/-72.60722W], 27-VI-1997, S.K. Burian, 1♂, 1 Nex (NEL); same, 20-VII-1998, S.K. Burian, 1♂N (NEL); Florida: Gadsden Co., trib. to Flat Creek [30.525833N/-84.82500W], 27-IV-1999, 1♂N; Illinois: Winnebago Co., Rockford, Kishwaukee River, 22-VII-2009, no collector recorded, 1♂N, 11♀N (NEL); New Hampshire: Hillsborough Co., Piscataquog River, 4.02 km E. of Goffstown, elev. 55m, 6-VI-2003, G.D. Whitmore, 1♀N (UNH). **CANADA:** Labrador: Labrador City, 20-VII-1982, M. Colbo and (?) Walsh, 1♂N, 1♀N (NEL); Menihek, (quantitative sample 9, 3-2006), 22-VII-2006, R.J. Pupedis, 9♂N, 8♀N (YPM).

Nymph (in alcohol, well developed or dark wing pad stage)

Body length ♂: 3.00–3.96 mm (3.45 ± 0.3089 , mean \pm SD, $n = 13$); Body length ♀: 3.00–4.88 mm (4.00 ± 0.0829 , $n = 13$); Head length ♂: 0.64–0.80 mm (0.73 ± 0.0540 , $n = 12$); Head length ♀: 0.66–0.80 mm (0.71 ± 0.04845 , $n = 12$); Antennal length ♂: 1.22–2.10 mm (1.63 ± 0.3698 , $n = 7$); Antennal length ♀: 1.50–2.12 mm (1.78 ± 0.2028 , $n = 10$); Length of foreleg segments: Femur ♂: 0.46–0.66 mm (0.57 ± 0.0658 , $n = 11$); Tibia + Tarsus ♂: 0.66–0.98 mm (0.85 ± 0.1081 , $n = 11$); Femur + Tibia + Tarsus ♂: 1.12–1.62 mm (1.42 ± 0.1707 , $n = 11$); Femur ♀: 0.48–0.78 mm (0.64 ± 0.0797 , $n = 10$); Tibia + Tarsus ♀: 0.78–0.94 mm (0.86 ± 0.0481 , $n = 10$); Femur + Tibia + Tarsus ♀: 1.30–1.66 mm (1.50 ± 0.1164 , $n = 10$); Length of cerci ♂: 2.28–3.56 mm (2.98 ± 0.5340 , $n = 4$); Length of cerci ♀: 3.12–3.72 mm (3.41 ± 0.2763 , $n = 5$).

Head. Vertex yellowish brown with thin white to cream coloured line along ecdysial suture. Occasionally wider pale areas occur along ecdysial suture on vertex



Figures 17–22. *Acentrella parvula*, nymphal mouthparts. (17) Labrum, left dorsal (D) and right ventral (V); (18) right mandible, ventral view; (19) left mandible, ventral view; (20) right maxilla, dorsal view; (21) labium, left dorsal (D) and right ventral (V); (22) hypopharynx, dorsal view. © Steven K. Burian.

and occiput. Ecdysial suture flanked by wide rows of irregular brown blotches extending from the occiput to frons, terminating just before the Y-division of the suture. Males have more distinctive brown blotches on head compared to females. Females tend to have more rectangular or elongate blotches on vertex. Markings of head capsule are especially distinctive on early instar nymphs. Edges of head capsule surrounding upper portion of compound eyes of males dark brown. Dark rim around compound eyes of females occasionally wider than in males. Irregular pale spots between lateral ocelli and lower edge of compound eye. Posterior edge of frons with W-shaped pale spot along frontoclypeal suture. Area of frons near inner edges of antennal sockets slightly concave. Flagellum of antennae light brown to tan. Scape and pedicel of antennae may be pale white or cream coloured or light brown matching flagellum colour. Female nymphs often have entirely tan or brown antennae compared to more variable male nymphs. Head capsule of female nymphs also tends to be frequently unicolourous lacking distinct median brown marks.

Mouthparts (Figures 17–22). Dorsal and ventral aspects of labrum as in Figure 17. Labrum with broadly rounded outer margin and shallow anterior median notch with

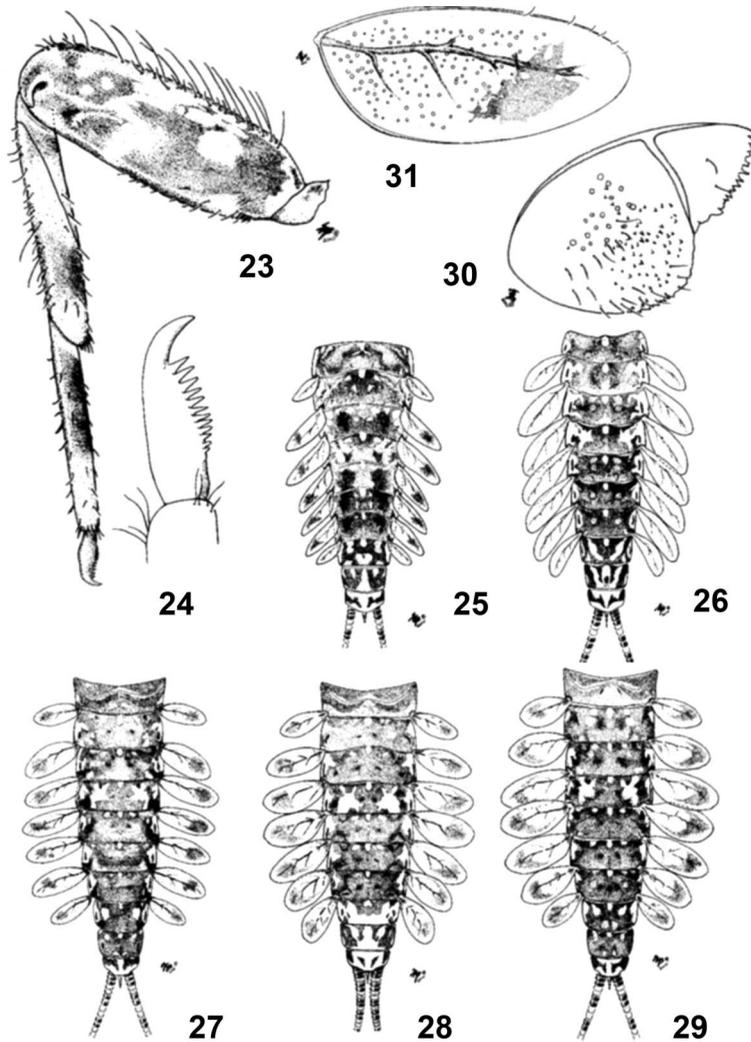
small rounded median lobe. Dorsal surface with median pair of large, slender setae separated from lateral row of 5–6 similar but smaller setae that extend to the anterolateral edge of labrum. Posterior half of labrum with scattered long, hair-like setae that merge laterally with marginal setae. Several of the long, dorsal marginal setae have tips with 2 or 3 minute divisions making them appear brush-like at high magnification. Ventral surface of labrum with anterior and posterior fields of setae on either side of the midline. Anterior edge of ventral surface with row of setae extending from medial notch to anterolateral corners. Ventral setae of anterior margin finely biserrate and tips extend past the anterior margin of the labrum. Ventral aspect of right and left mandibles as in Figures 18, 19. Right mandible with outer and inner incisors fused except for tips where a small apical cleft is present (Figure 18). Inner margin of incisor next to prosthema with minute row of elongate spine-like projections, most with transparent tips – thus appearing as a row of weak serrations. Right prosthema as in Figure 18. Surface of right mandible between base of prosthema and molar region slightly roughened, but not distinctly serrate and lacks setae. Single tube-seta or ribbon-like seta present at the transition between upper surface and molar surface. Molar surface with single small apical spine. Left mandible with incisors fused as on right mandible, but apical cleft small or lacking (Figure 19). Margin of inner incisor next to prosthema lack minute spines or weak serrations. Left prosthema as in Figure 19. Surface of left mandible between base of prosthema and molars lacks setae and serrations. Maxillae as in Figure 20. Maxillary palpi 2 segmented with apex not reaching the tip of the galea-lacinia. Both segments of palpi with scattered hair-like setae and basal segment with several campaniform-like setae. Apex of galea-lacinia with 4 large teeth. Subapical area of setae with 2 large, thick dentisetae and 1 long, slender dentisetae. Apex of setal patch with cluster of 5 long, slender setae. Inner later edge of setal patch with distinct row of 8 short, curved setae. Margin of galea-lacinia below apical setal patch broadly rounded with few scattered small hair-like setae. Dorsal and ventral aspects of the labium as in Figure 21. Dorsal surface of glossae lack setae, only marginal setae present. Dorsal surface of paraglossae lack setae except for submarginal row of 3 long setae near apex. Ventral surface of glossae and paraglossae as in Figure 21 with a few small scattered setae. Paraglossae distinctly longer than glossae, with long apical setae and on outer margins. Labial palpi 3 segmented. Dorsal surface as in Figure 21 with short row of 3 setae near anterior margin of segment 2 and many campaniform-like setae across much of segment 1. Dorsal surface of segment 3 lacks setae except for apex, inner margin broadly rounded to slightly truncated. Ventral surface of labial palpi as in Figure 21, numerous hair-like setae scattered across segments 2 and 3, but segment 1 has almost no setae. Hypopharynx as in Figure 22.

Thorax. Pronotum brown with pale spot at both anterolateral and posterolateral corners. Secondary pale spots occur slightly posterior of major pale spots on anterolateral corners and slightly medial of major spots on posterolateral corners. Dark brown irregular marks present medially on either side of median suture and near inner edges of major pale spots. Male occasionally with longitudinal paired pale spots on either side of median suture. Females lack longitudinal paired pale spots and tend to have more uniformly brown pronotum with just small lateral pale spots. Anterior portion of pronotum concave or depressed relative to posterior portion. Brown colour of pronotum seems to diffuse into the adjacent area of the cervical membrane behind the head forming a distinctive brown U-shaped mark. Mesonotum mostly brown in both sexes with some darker brown areas lateral to bases of wing pads. Single large pale

spot occurs at base of each wing pad. A small pair of pale spots present on either side of MLs and small pale spots scattered about lateral to bases of forewing pads. Metanotum mostly brown, slightly darker than mesonotum. Hind wing pads present as minute flaps. Pleural sclerites brown. Prosternum brown, meso- and metasterna pale except for area of furcal pits, which are brown.

Legs. All legs as in Figure 23. Femora patterned as in Figure 23, with a single row of about 20 long dorsal setae and secondary row of smaller setae. Several of the long dorsal setae have narrow bases and gradually become enlarged or broadened apically. Some long setae of dorsal row with broad tips appear to have a small hole apically and trapped air within the tips shows some to be hollow for at least $\frac{1}{2}$ their length. Long setae with broad tips only occur from midpoint of row to base of row. Setae from midpoint of row to apex have sharp tips. Dorsal setae are $\frac{1}{2}$ or slightly greater than $\frac{1}{2}$ width of femur. Ventral edges of femora with scattered hair-like setae and larger spine-like setae. Small villopore on ventral edge of femora surrounded by spine-like setae. Ventral edge of femora with many campaniform-like setae from villopore to femoral-tibial joint. Tibiae with basal and apical brown bands, as in Figure 23. Dorsal edge with 2–8 long hair-like setae and scattered short hair-like setae. Tibialpatellar suture short, only extending about $\frac{1}{2}$ the length of the segment and not margined with long stout setae. Outer apex of tibiae with distinctive ribbon-like seta of variable length and with cleft tip. Inner apex of tibia with small group of large sharp setae. Tarsi with brown band as in Figure 23. Inner edge with row of 7 stout spine-like setae. Outer edge with scattered hair-like setae and occasionally more robust spine-like setae. Tarsal claws as in Figure 24. All claws have a single row of about 12 denticles and apex of claw distinctly curved inward.

Abdomen. Abdominal colour patterns as in Figures 25–29. Much variability occurs in colour patterns of terga. Common colour pattern elements usually include: (1) small pale median spot on anterior margins of terga II–IX; (2) tergite IV with large irregular pale areas on either side of midline; and (3) terga I–III and V–VII usually mostly brown. Terga VIII–X with variable pale areas that can cover most of the tergites (as in Figures 25, 26 and 28) or terga VIII–IX mostly brown with pattern similar to preceding terga V–VII (as in Figures 27, 29). Tergite X usually with lateral brown patches connected to form transverse brown streaks that do not meet leaving a distinct pale longitudinal band. Terga II–IX with pale areas along lateral margins anterior to gill insertions, often encompassing a distinctive dark longitudinal spot. In some populations terga I–III have reddish brown patches infused laterally as part of background colour. Paired small dark submedian spots are frequently present on terga II–IX; sometimes these are obscured by general brown background colour of tergite. Lateral to distinctive pale spot on anterior margin of each tergite are often a pair of small pale spots positioned about midpoint of tergite. Darkly pigmented trachea occasionally visible on terga. Posterolateral projections absent on all segments. Anterior edges of terga sinuate and margined with black along anteriormost portions of curve. Row of poorly developed spinules at posterior margin of all terga. Spinules have either single sharp points or multiple points or ragged edges. Spinules usually slightly darker than background colour of terga. Terga with scattered hair-like setae and variable length tube-setae. Terga with few campaniform-like setae, mostly restricted to lateral margins. Abdominal sterna pale with faint brown shading laterally. Trachea of sterna pigmented with black. Sterna I–VIII with 2 pair of faint submedian spots (often these fade completely on ethanol



Figures 23–31. *Acentrella parvula*, nymphal bodyparts. (23) Right foreleg, dorsal surfaces and edges showing setae; (24) right foreclaw; (25) colour patterns of abdominal terga I–X on nymph from northern Florida, USA; (26) colour patterns of abdominal terga I–X on nymph from northern Connecticut, USA; (27–29) colour patterns of abdominal terga I–X typical of nymphs collected together from one site in Labrador, CANADA; (30) left paraproct; (31) abdominal gill 5. © Steven K. Burian.

preserved specimens). Posterior margin of male sternite IX with slight posterior median emargination, female lacks this feature. Paraprocts as in Figure 30. Inner edge of smaller distal portion with irregular teeth and surface with only few scattered hair-like setae. Larger proximal portion with several scattered campaniform-like setae. Edges of proximal portion mostly appear rough or ragged.

Gills. Abdominal gills typically as in Figure 31, but much regional variation occurs. Gills are generally asymmetrical ovals with smooth outer margins with only a few scattered hair-like setae. Expanded basal portion of inner margin produces the asymmetrical oval shape, but is variable with some individuals having less of an

expanded edge making their gills appear more symmetrical. Trachea usually darkly pigmented and most of the larger secondary branches are directed posteriorly. Gill membranes usually have some brown pigmentation apically, but brown colour can extend along posterior margin almost to gill insertion. Occasionally a small brown cloud occurs at the gill insertion and is completely separated from the larger apical pigmented area. In some specimens gill pigmentation is extremely faint or absent (gill pigmentation can also fade extensively after preservation in ethanol).

Caudal filaments. Caudal filaments occur as in Figures 25–29. Median terminal filament is short, tan; composed of about 3 annuli; and is about $\frac{1}{2}$ as long as tergite X. Cerci are alternately banded from bases to tips usually with 2 shaded annuli separated by 2 pale annuli. Inner margins cerci with light brown hair-like setae. Cercal setae usually in a tuft of 4–5 per annulus.

Diagnosis

Nymphs of *A. parvula* can be separated from all other North American species with completely banded caudal filaments by: (1) outer incisors of both mandibles mostly fused and with distinct apical teeth; (2) small body size of mature nymphs usually not greater than 3.50 mm for males and 4.00 mm for females; (3) long dorsal row of setae on femora; and (4) distinctive colour pattern of abdominal terga.

Discussion

Acentrella parvula was described by McDunnough (1932) from adults collected from southern Ontario, Canada. The nymph was also described in the same paper, but more as a supplement to the adult description because McDunnough was only able to tentatively associate the nymph with the adult by proximity of black wing pad stage nymphs at the type locality when adults of *A. parvula* were collected. McDunnough also commented on colour differences he observed in a series of imago collected from the Milk River of southern Alberta, Canada. Although McDunnough described the distinctive alternate banding of cerci, distinctive colour patterns of abdominal terga, and noted the small body size of *A. parvula* nymphs, no details of anatomy or morphology were given.

Ide (1937) discussed the nymph of *A. parvula* and presented additional details concerning coloration of the head thorax, legs, and abdomen as well as figures of the abdomen, caudal filaments, labial palp and left gill 4. He also commented on the unique alternate banding pattern on the cerci of nymphs and notes that McDunnough's (1932) description of the adult stages is accurate. The lack of information in these early discussions of nymphs of *A. parvula* seems, at least partly, the result of the unusual banding pattern on the cerci. This feature alone was sufficiently diagnostic that others were considered unnecessary. However, the discovery of *A.alachua* in Florida by Berner (1940) ended the once unique state of the alternately banded cerci. Nymphs of *A.alachua* are similar in some respects to those of *A. parvula*, but distinct differences do exist in body size, colour of the thorax, abdominal terga, cerci, morphology of mouthparts, and legs. Wiersema (2000) discusses the morphological similarities of *A.alachua* and *A. parvula* nymphs in support of his decision to move these species from *Plauditus* to *Acentrella*. Even though the drawings and comparative discussion presented by Wiersema (2000) are useful, there are many more anatomical and morphological features that were not

presented. The most recent treatments of *A. parvula* were those of Jacobus and McCafferty (2006) and McCafferty et al. (2009) who contrasted the diagnostic character of their new species *A. barbarae* and *A. nadineae*, respectively, but did not provide any new details on anatomy and morphology of *A. parvula* nymphs.

Details presented herein of the anatomy and morphology of the nymph of *A. parvula* should facilitate future comparisons with nymphs of existing species of *Acentrella* as well as any new taxa that may be discovered. Nymphs studied from the southern and northernmost part of the range of *A. parvula* showed much variation in abdominal coloration and colour pattern. Currently, it is not possible to discern any geographically consistent trends in these patterns. However, study of much larger and more widespread samples may reveal such patterns. Size, shape and pigmentation of abdominal gills was also quite variable with some populations lacking gill pigmentation (e.g. Connecticut – verified by rearing) and others with extensive shading (e.g. Labrador – but within the sample were some specimens with almost no shading). Gill shape seemed to be variable as well with southern specimens tending to have more apically acute gills and northern specimens tended to have gills with more broadly rounded tips. This phenomenon of geographic variation in gill shape has previously been documented for the widely distributed eastern Nearctic species *Choroterpes basalis* (Banks) (Leptophlebiidae) and is believed to be related to differences in habitat (Burian 1995). Currently, there is no evidence that subtle differences in gills of *A. parvula* nymphs indicate undiscovered cryptic species. Early instar nymphs had far more contrasting abdominal colour patterns of brown spots and marks against a much lighter background than mid to late instars, which had much more brown and reddish brown background colour, reducing the speckled appearance of the early instars. Despite differences in body colour and colour pattern, the morphology of mouthparts and legs seems relatively consistent among all specimens studied. Even body size at the black wing pad stage was reasonably stable over the geographic range studied.

Biology

Acentrella parvula nymphs with well-developed or black wing pads were reported from some sites in Canada as early as June (McDunnough 1932), but at most localities in USA nymphs at this stage of development usually are collected in July. McDunnough (1932) suggested that there were two generations (one in June and one in August), but there is no recent evidence supporting the notion that *A. parvula* has more than one generation per year anywhere except Florida. In fact, notes presented by McDunnough (1932) concerning a series of male imagos collected in July and August seem to contradict his idea of a closely spaced bivoltine lifecycle. It seems more likely that throughout most of its large range, *A. parvula* is univoltine with extended emergence from July through mid-September. Emergence data presented by Harper and Harper (1984) for a low gradient stream in southern Ontario support the hypothesis of a primarily univoltine life cycle. All specimens studied here support a July peak for northeastern populations. Moreover, nymphs from Labrador seemed to be at about the same state of development as nymphs from northern Connecticut collected close to the same day in July. The observation by Berner (1950) of the apparent non-seasonal lifecycle of *A. parvula* in northern Florida is the only known exception to the general univoltine pattern and the basis for Clifford (1982) to classify *A. parvula* as a multivoltine species.

In streams north of Florida *A. parvula* emerges when there are few other species of mayflies ready to emerge. The lack of specimens of early instar nymphs in the early fall suggests that eggs may delay hatching or that early instar nymphs seek refuge deep in the stream bed and may delay development until the following spring season. Nymphs seem to be collectors and occupy a wide range of benthic substrates from small cobble, medium–small gravel and coarse sand to areas that are mostly medium sand with some deposits of finer mineral particles and silt with patches of submerged grass and some filamentous algae. Adults are rarely seen and no swarms have been observed.

Distribution

Acentrella parvula qualifies as a transcontinental species with a range that extends from Florida and the southeastern USA (Berner and Pescador 1988) through the Midwestern USA (Randolph and McCafferty 1998) northwest to Alberta (McDunnough 1932), across eastern Canada (McCafferty and Randolph 1998) and the northeastern USA (Burian and Gibbs 1991; Jacobus and McCafferty 2001; Chandler et al. 2006; Whitmore 2008). Herein we report additional localities in Connecticut, USA and Labrador, Canada.

New couplets to include nymph of *A. rallatoma* in key of Nearctic species given by Jacobus and McCafferty (2006)

Couplet 4 of Jacobus and McCafferty (2006) has been expanded to include new species. The remaining parts of their key are unaffected.

4. Thorax and abdomen with extensive brown shading, pale areas limited; caudal filaments with distinct dark and light alternating groups of annuli..... 4a
- 4'. Thorax and abdomen without extensive brown shading; abdomen mostly pale with brown spots restricted except for distinctive pair of large brown spots on terga III and V and short brown median longitudinal dash on terga VI and VII (as in Berner 1940, figure 1; Berner 1950, figure 88); caudal filaments with extremely faint alternating groups of dark and light annuli; distribution southeastern USA..... *A.alachua*
- 4a. Outer incisor of mandibles with broad and flat apex (Figures 7 and 8); dorsal setae on femora short and bristle-like with blunt tips (Figure 13); dorsal colour pattern of the abdomen as in Figure 5; distribution coastal northeastern USA *A. rallatoma*
- 4a'. Outer incisor of mandibles with distinct apical teeth (Figures 18 and 19); dorsal setae on femora long and hair-like, at some are pointed (Figure 23); dorsal colour pattern of the abdomen as in Figures 25–29; distribution transcontinental Nearctic *A. parvula*

Key to known male imagos of Nearctic species of *Acentrella*

Male imagos can be keyed to genus using a modified version of the couplet from the adult key in Waltz and Burian (2008) – PDF copies of the modified couplet are available from SK Burian upon request. Currently, adults of *A. feropagus* and *A. nadineae* are not known.

1. Hind wings present..... 2
- 1'. Hind wings absent 3
2. Segment 3 of genital forceps about $4 \times$ as long as wide and maximum width of segment 3 about $\frac{2}{3}$ the maximum width of segment 2; abdominal terga II–VI light brown.....*A. lapponica*
- 2'. Segment 3 of genital forceps only about $3 \times$ as long as wide and maximum width of segment 3 no more than $\frac{1}{2}$ the maximum width of segment 2; abdominal terga II–VI greyish brown*A. insignificans*
3. Abdominal terga I–VI with posterior margins raised dorsally relative to anterior margins (as in Jacobus and McCafferty 2006, figures 10, 11); sclerotised penes cover between forceps basal segments is subtrapezoidal with shallow depression of top margin*A. barbarae*
- 3'. Abdominal terga I–VI lack raised posterior margins; sclerotised penes cover either indistinct or subtrapezoidal with a straight top margin or subrectangular with a straight top margin..... 4
4. Abdominal terga I–VI mostly olive brown or reddish brown [but note specimens preserved for some time in ethanol may appear to have terga III–VI mostly pale with brown blotched laterally; air drying specimens apparently restores some original coloration (McCafferty et al. 1994)] with posterior portion occasionally darker than anterior portion; genitalia usually with broad subrectangular sclerotised penes cover that can have brown shading medially *A. turbida*
- 4'. Abdominal terga I–VI hyaline white with reddish brown patches either laterally and/or medially; a pair of thin parallel reddish brown lines often present on terga I–VI; genitalia usually with subtrapezoidal sclerotised penes cover that can have brown shading medially or penes cover is inconspicuous 5
5. Forewing length about 4.58 mm; coloration of abdominal terga as in Figure 3; genitalia with subtrapezoidal sclerotised penes cover as in Figure 3a with brown hour-glass shaped mark medially..... *A. rallatoma*
- 5'. Forewing length 3.24–4.00 mm (usually < 4.00 mm); coloration of abdominal terga not as in Figure 3; terga II–VI hyaline white or pale yellow with reddish brown patches restricted to lateral areas and only a pair of thin parallel reddish brown longitudinal lines present medially (lines may be faint or faded on terga III–V); genitalia with transparent subrectangular sclerotised penes cover or cover is not visible..... 6
6. Femora of all legs with subapical reddish brown spot on dorsal surface..... *A. parvula*
- 6'. Femora of all legs pale without any reddish markings..... *A.alachua*

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References

- Alba-Tercedor, J., and El-Alami, M. (1999), 'Description of the nymphs and eggs of *Acentrella almohades* sp. n. from Morocco and southern Spain (Ephemeroptera: Baetidae)', *Aquatic Insects*, 21, 241–247.
- Alba-Tercedor, J., and McCafferty, W.P. (2000), '*Acentrella feropagus*, new species (Ephemeroptera: Baetidae): formal new name for North American *A. lapponica* sensu Morihara and McCafferty', *Entomological News*, 111(2), 137–139.
- Bengtsson, S. (1912), 'Neue Ephemeriden aus Schweden', *Entomologisk Tidskrift*, 33, 107–117.
- Berner, L. (1940), 'Baetine mayflies from Florida (Ephemeroptera)', *Florida Entomologist*, 23, 33–45, 9–62.
- Berner, L. (1950), *The Mayflies of Florida*, Gainesville: University of Florida Press.
- Berner, L., and Pescador, M.L. (1988), *The Mayflies of Florida* (rev. ed.), Gainesville: University of Florida Press.
- Burian, S.K. (1995), 'Taxonomy of the eastern species of *Choroterpes* Eaton (Ephemeroptera: Leptophlebiidae)', in *Current Directions on Ephemeroptera Research*, eds. L.D. Corkum and J.J.H. Ciborowski, Toronto: Canadian Scholars' Press, pp. 433–453.
- Burian, S.K., and Bednarik, A.F. (1994), 'The mayflies (Ephemeroptera) of Connecticut: an initial faunal survey', *Entomological News*, 105, 204–216.
- Burian, S.K., and Gibbs, K.E. (1991), 'The Mayflies of Maine: An Annotated Faunal List', *Maine Agricultural Experiment Station Technical Bulletin*, 142, 1–109.
- Chandler, D.S., Whitmore, G.D., Burian, S.K., and Burger, J.F. (2006), 'The mayflies (Ephemeroptera) of New Hampshire: seasonality and diversity of stream fauna', *Transactions of the American Entomological Society*, 132, 25–73.
- Clifford, H.F. (1982), 'Life cycles of mayflies (Ephemeroptera) with special reference to voltinism', *Quaestiones Entomologicae*, 18, 15–90.
- Davis, R.B., and Jacobson, Jr., G.L. (1985), 'Late glacial and early Holocene landscapes in northern New England and adjacent areas of Canada', *Quaternary Research*, 23, 341–368.
- Edmunds, G.F. Jr., and Traver, J.R. (1954), 'An outline of a reclassification of the Ephemeroptera', *Proceedings of the Entomological Society of Washington*, 56, 236–240.
- Emery, K.O. (1987), 'Georges Cape, Georges Island, Georges Bank', in *Georges Bank*, eds. R.H. Backus and D.W. Bourne, Cambridge, Massachusetts: MIT Press, pp. 38–39.
- Griffith, G.E., Omernik, J.M., Bryce, S.A., Royte, J., Hoar, W.D., Homer, J.W., Keirstead, D., Metzler, K.J., and Hellyer, G. (2009). Ecoregions of New England (color poster with map, descriptive text, summary tables, and photographs). United States Geological Survey, Reston, Virginia. <http://www.epa.gov/wed/pages/ecoregions.htm>.
- Harper, F., and Harper, P.P. (1984), 'Phenology and distribution of mayflies in a southern Ontario lowland stream', in *Proceedings of the 4th International Conference on Ephemeroptera*, eds. V. Landa, T. Soldan and N. Tonner. České Budejovice: Czechoslovak Academy of Sciences, Institute of Entomology, pp. 243–251.
- Hubbard, M.D. (1995), 'Toward a standard methodology for the description of mayflies (Ephemeroptera)', in *Current Directions in Research on Ephemeroptera*, eds. L.D. Corkum and J.J.H. Ciborowski, Toronto: Canadian Scholars' Press, pp. 361–369.
- Ide, F.P. (1937), 'Descriptions of eastern North American species of baetine mayflies with particular reference to the nymphal stages', *Canadian Entomologist*, 69, 219–231, 35–243.
- Jacobus, L.M., and McCafferty, W.P. (2001), 'The mayfly fauna of New York State (Insecta: Ephemeroptera)', *Journal of the New York Entomological Society*, 109, 47–80.
- Jacobus, L.M., and McCafferty, W.P. (2006), 'A new species of *Acentrella* Bengtsson (Ephemeroptera: Baetidae) from Great Smoky Mountains National Park, USA', *Aquatic Insects*, 28, 101–111.

- Kluge, N.Ju. (1994), 'Pterothorax structure of mayflies (Ephemeroptera) and its use in systematics', *Bulletin de la Société Entomologique de France*, 99(1), 41–61.
- Kluge, N.Ju., and Novikova, E.A. (2011), 'Systematics of the mayfly taxon *Acentrella* (Ephemeroptera: Baetidae), with description of new Asian and African species', *Russian Entomological Journal*, 20, 1–56.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1998a), 'New larval variants and distributional records for *Plauditus cestus* (Ephemeroptera: Baetidae)', *Great Lakes Entomologist*, 31, 201–204.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1998b), 'A new North American genus of Baetidae (Ephemeroptera) and key to *Baetis* complex genera', *Entomological News*, 109, 345–353.
- McCafferty, W.P., and Jacobus, L.M. (2001), 'Revision to *Plauditus cestus* and *P. gloveri* (Ephemeroptera: Baetidae)', *Entomological News*, 112, 305–310.
- McCafferty, W.P., and Randolph, R.P. (1998), 'Canada Mayflies: a faunistic compendium', *Proceedings of the Entomological Society of the Ontario*, 129, 47–97.
- McCafferty, W.P., and Waltz, R.D. (1998), 'A new species of the small minnow mayfly genus *Plauditus* (Ephemeroptera: Baetidae) from South Carolina', *Entomological News*, 109, 354–356.
- McCafferty, W.P., Waltz, R.D., and Webb, J.M. (2009), '*Acentrella nadineae*, a new species of small minnow mayflies (Ephemeroptera: Baetidae)', *Proceedings of the Entomological Society of Washington*, 111, 12–17.
- McCafferty, W.P., Wible, M.J., and Waltz, R.D. (1994), 'Systematics and biology of *Acentrella turbida* (McDunnough) (Ephemeroptera: Baetidae)', *Pan-Pacific Entomologist*, 70, 301–308.
- McDunnough, J. (1924), 'New Canadian Ephemerae with notes, II.', *Canadian Entomologist*, 55, 90–98, 13–122, 128–133.
- McDunnough, J. (1932), 'New species of North American Ephemeroptera II.', *Canadian Entomologist*, 64, 209–215.
- Müller-Liebenau, I. (1965), 'Revision der von Simon Bengtsson aufgestellten *Baetis*-Arten (Ephemeroptera)', *Opuscula Entomologica*, 30(1–2), 79–123.
- Müller-Liebenau, I. (1969), 'Revision der europäischen Arten der Gattung *Baetis* Leach, 1815 (Insecta, Ephemeroptera)', *Gewässer und Abwässer*, 49/49, 1–214.
- Müller-Liebenau, I. (1981), 'Review of the original material of the baetid genera *Baetis* and *Pseudocloeon* from the Sunda Islands and the Philippines described by G. Ulmer, with some general remarks (Insecta: Ephemeroptera)', *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut*, 78, 197–208, 1 pl.
- Novikova, E.A., and Kluge, N.Ju. (1987), '[Systematics of the genus *Baetis* (Ephemeroptera, Baetidae), with description of new species from Middle Asia.]', *Vestnik Zoologii*, 1987(4), 8–19.
- Randolph, R.P., and McCafferty, W.P. (1998), 'Diversity and distribution of the mayflies (Ephemeroptera) of Illinois, Indiana, Kentucky, Michigan, Ohio, and Wisconsin', *Ohio Biological Survey Bulletin, New Series*, 13, (1), vii+ 188 p.
- Sanderson, E.W. (2009), *Mannahatta: A Natural History of New York City*, New York: Abrams Books.
- Sanderson, E.W., and Brown, M. (2007), 'Mannahatta: An ecological first look at the Manhattan landscape prior to Henry Hudson', *Northeastern Naturalist*, 14, 545–570.
- Schmidt, R.E. (1986), 'Chapter 5: Zoogeography of the northern Appalachians', in *The Zoogeography of North American Freshwater Fishes*, eds. C.H. Hocutt and E.O. Wiley, New York: Wiley-Interscience Publication, John Wiley and Sons.
- Smithe, F.B. (1975), *Naturalist's Color Guide*, New York: The American Museum of Natural History.
- Sokal, R.R., and Rohlf, F.J. (1995), *Biometry* (3rd ed.), New York: W.H. Freeman and Co.
- Sroka, P., and Arneklev, J.V. (2010), 'Two new species of *Acentrella* Bengtsson, 1912 (Ephemeroptera, Baetidae) from Kazakhstan with notes on the Palearctic fauna', *Zootaxa*, 2693, 1–20.
- Stemberger, R.S. (1995), 'Pleistocene refuge areas and postglacial dispersal of copepods of the northeastern United States', *Canadian Journal of Fisheries and Aquatic Sciences*, 52, 2197–2210.

- Tiunova, T.M. (2008a), 'Composition and the structure of zoobenthos communities of microbiotopes in the metarhithral of small foothill river the temperate-cold-water type', *Vladimir Ya. Levanidov's Biennial Memorial Meetings*, 4, 31–45.
- Tiunova, T.M. (2008b), '[Mayflies (Insecta, Ephemeroptera) of the Zheya River Basin (Amurskaya Oblast)]', in *Freshwater Ecosystems of the Amur River Basin*, Vladivostok: Dal'nauka.
- Tsui, T.P., and Peters, W.L. (1975), 'The comparative morphology and phylogeny of certain Gondwanian Leptophlebiidae based on the thorax, tentorium, and abdominal terga (Ephemeroptera)', *Transactions of the American Entomological Society*, 101, 505–595.
- Waltz, R.D., and Burian, S.K. (2008), 'Chapter 11 Ephemeroptera', in *An Introduction to the Aquatic Insects of North America* (4th ed.), eds. R.W. Merritt, K.W. Cummins, and M.B. Berg, Dubuque, Iowa: Kendall/Hunt Publishing, pp. 181–225.
- Waltz, R.D., and McCafferty, W.P. (1987), 'Systematics of *Pseudocloeon*, *Acentrella*, *Baetiella*, and *Liebebiella*, new genus (Ephemeroptera: Baetidae)', *Journal of the New York Entomological Society*, 95, 553–568.
- Whitmore, G.D. (2008), 'The macroinvertebrate stream fauna of Martha's Vineyard, with records from southeastern mainland Massachusetts', *Transactions of the American Entomological Society*, 134, 431–458.
- Wiersema, N.A. (2000), 'A new combination for two North American small minnow mayflies (Ephemeroptera: Baetidae)', *Entomological News*, 111, 140–142.