

A new species of *Acentrella* Bengtsson (Ephemeroptera: Baetidae) from Great Smoky Mountains National Park, USA

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Abstract

Acentrella barbarae sp. n. is described from eggs, larvae, and imagines collected from Great Smoky Mountains National Park, North Carolina and Tennessee, USA. Larvae were collected from cobble-
pebble substrate in stream rapids. Life stages were associated by rearing. Eggs have longitudinal chorionic ridges with small, longitudinal furrows. Larvae are distinguished by having segment 3 of the labial palp apically rounded, abdominal terga with posteromedian projections, and tibiae and tarsi with relatively short setae on the outer margins. Imagines are distinguished by the colouration and posterior elevation of abdominal terga. Other *Acentrella* larvae occur in the same streams as the new species, including *A. parvula*, which we report from Tennessee for the first time. We provide an updated key to the larvae of North American *Acentrella* species.

Keywords: *Acentrella barbarae*, new species, Baetidae, Ephemeroptera, Nearctic, identification key

Introduction

An undescribed larva of a small minnow mayfly (Ephemeroptera: Baetidae) was discovered among benthic samples collected in conjunction with the All Taxa Biodiversity Inventory (ATBI) of Great Smoky Mountains National Park (GRSM) (Sharkey 2001; Jacobus & McCafferty 2003, 2005). The examination of all life stages confirmed that a new species was represented, which we describe below. This is one of several new species of aquatic insects discovered as a direct result of the intensive ATBI efforts in GRSM (e.g. Etnier et al. 2004; Petersen et al. 2004), and it marks a further addition to the distinctive and vulnerable aquatic insect fauna of the southern Appalachians (Morse et al. 1993, 1997).

Seven species of the genus *Acentrella* Bengtsson now are known from the Nearctic region (McCafferty et al. 1994; Alba-Tercedor & McCafferty 2000; Wiersema 2000; Randolph & McCafferty 2001, 2005). The other six North American *Acentrella* species are: *A. alachua* (Berner, 1940); *A. feropagus* Alba-Tercedor & McCafferty, 2000; *A. insignificans* (McDunnough, 1926); *A. lapponica* Bengtsson, 1912; *A. parvula* (McDunnough, 1932), and *A. turbida* (McDunnough, 1924).

Alba-Tercedor and McCafferty (2000) regarded previous reports of *A. lapponica* from North America, including that of McDunnough (1936), as being misidentifications of their new species, *A. feropagus*. Randolph and McCafferty (2005) subsequently reported *A. lapponica* larvae from Alaska. The species formerly known as *Acentrella ampla* Traver, 1932, recently was transferred to the genus *Heterocloeon* McDunnough, subgenus *Jubilatum* McCafferty & Jacobus (McCafferty et al. 2005).

Material and methods

During May 2005, the undescribed larva from GRSM was reared to the imago, using the apparatus described by Jacobus and McCafferty (2004). Eggs dissected from reared females were examined via scanning electron microscopy at the Life Sciences Microscopy Center, Purdue University. The new species is included in the genus *Acentrella* based on the chorionic reticulations of the egg, the setation of legs and structure of the mouthparts and abdominal terga of the larva, and the shape of the genital forceps of the male imago (Müller-Liebenau 1969; Waltz & McCafferty 1987; Jacob 1991; Alba-Tercedor & El Alami 1999; Wiersema 2000).

Material examined is deposited in the Canadian National Collection of Insects, Agriculture and AgriFood Canada, Ottawa, Ontario [CNC], and the Purdue University Entomological Research Collection, West Lafayette, Indiana, USA [PERC]. Some of the PERC material will be deposited in the Great Smoky Mountains National Park Research Collection, Gatlinburg, Tennessee, USA [GSMC].

Taxonomy

Acentrella barbarae sp. n. (Figures 1–14)

Type material. *Holotype* [PERC]. ♂ larva (final instar), Tennessee, Blount Co., Mill Cr. at Abrams Falls Trailhead, Great Smoky Mountains National Park, 35°35'26"N, 83°51'10"W (NAD27), 14-V-2001, CD & RP Randolph, LM Jacobus. *Paratypes* [PERC]. Four larvae (parts on slide), same data as holotype.

Additional material examined [GSMC, PERC]. *Tennessee, Blount Co.* Eight larvae, Abrams Cr. at Cades Cove Picnic Area, 35°36'19"N, 83°46'30"W, 16-V-2001, CD & RP Randolph, LM Jacobus. Three larvae, Forge Cr. at Parsons Branch Rd. / Forge Cr. Rd., 35°34'14"N, 83°50'53"W, 18-V-2001, CD & RP Randolph, LM Jacobus. Six larvae, Middle Prong at Tremont Rd., about 50 m upstream from gate, 35°38'25"N, 83°41'23"W, 11-VI-2003, JM Webb, LM Jacobus. 14 larvae, two ♂ imagines, one ♀ imago (dissected for eggs), one ♂ subimago, associated exuviae, Mill Cr., near Abrams Falls Trailhead, 35°35'25"N, 83°51'08"W, 15-V-2005, LM & BLH Jacobus, CR Parker. Six larvae, Mill Cr. at Forge Creek Rd., 35°35'03"N, 83°50'17"W, 18-V-2001, CD & RP Randolph, LM Jacobus. 19 larvae, Mill Cr., near Rabbit Creek Trailhead, 35°35'26"N, 83°51'10"W, 11-VI-2003, JM Webb, LM Jacobus. Eight larvae, Parsons Branch at Parsons Branch Rd., 35°32'20"N, 83°53'54"W and 35°29'59"N, 83°56'02"W, 18-V-2001, CD & RP Randolph, LM Jacobus. Two larvae, Parsons Branch at jct Parsons Branch Rd. and Hwy 27/129, 35°29'59"N, 83°56'02"W, 18-V-2001, CD & RP Randolph, LM Jacobus. Four larvae, Tater Branch at Cades Cove Loop Rd., 35°36'26"N, 83°49'43"W, 11-VI-2003, JM Webb, LM Jacobus. One larva, stream at Cades Cove Loop Rd., 35°35'41"N, 83°47'14"W, 6-XII-2001, JF MacDonald, LM Jacobus.

Tennessee, Cocke Co. 10 larvae, Cosby Cr. at Cosby entrance to Park, 35°46'59"N, 83°13'06"W, 17-V-2001, CD & RP Randolph, LM Jacobus. One larva, Cosby Cr. at horse trail at Cosby Picnic Area, 35°45'25"N, 83°12'28"W, 17-V-2001, CD & RP Randolph, LM Jacobus.

Tennessee, Sevier Co. 11 larvae, Little R. at Elkmont Campground, 35°39'35"N, 83°35'04"W, 16-V-2001, CD & RP Randolph, LM Jacobus. Four larvae, same locale, but 35°39'36"N, 83°35'02"W, 12-VI-2003, C Camuto, JM Webb, LM Jacobus. Two larvae, trib. Jakes Cr. at Jakes Creek Trailhead, above Elkmont Camp, 35°38'45"N, 83°35'03"W, 16-V-2001, CD & RP Randolph, LM Jacobus.

North Carolina, Haywood Co. One larva, Big Cr. at Big Creek Picnic Area, 35°45'05"N, 83°06'31"W, 12-VI-2003, JM Webb, LM Jacobus.

North Carolina, Swain Co. One larva, Bradley Fork at Smokemont Campground, 35°33'27"N, 83°18'45"W, 24-IX-2002, PD & LM Jacobus. Two larvae, side rivulet of Deep Cr. at Deep Creek Campground, 35°27'39"N, 83°26'13"W, 03-VIII-2000, MW & PD & LG & LM Jacobus. One larva, Oconaluftee R. at Tow String, 35°32'30"N, 83°17'54"W, 9-IX-2001, L Sun et al. Three ♂ imagines, one ♀ imago, Oconaluftee R. under Blue Ridge Pkwy overpass, UV light trap, 18-VI-2001, DR Jones, RC Harrington. One ♂ imago, one ♀ imago, unnamed tributary of Oconaluftee R., 19-VI-2001. 15 ♂ imagines, Oconaluftee R. at Ravens Fork, UV light trap, 18-VI-2001, RC Harrington, DR Jones; five ♂ imagines, same locale, but 16-VII-2001; two ♂ imagines, same locale, but 16-VIII-2001; one ♂ imago, one ♀ imago, same locale, but 28-VIII-2001. Three ♂ imagines, unnamed tributary of Ravens Fork, UV light trap, 16-VII-2001, RC Harrington, DR Jones; one ♂ imago, same locale, but 16-VIII-2001. Two ♂ imagines, unnamed tributary of Ravens Fork, upstream of bridge to Ranger Station, UV light trap, 31-VII-2001, DR Jones, RC Harrington. Four larvae, Twentymile Cr. at Twentymile Trailhead, nr. Twentymile Ranger Station, 35°28'07"N, 83°52'34"W, 18-V-2001, CD & RP Randolph, LM Jacobus.

Etymology

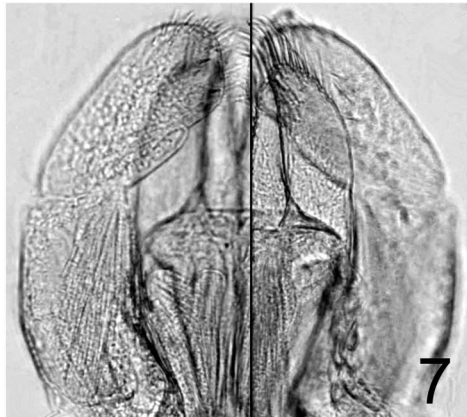
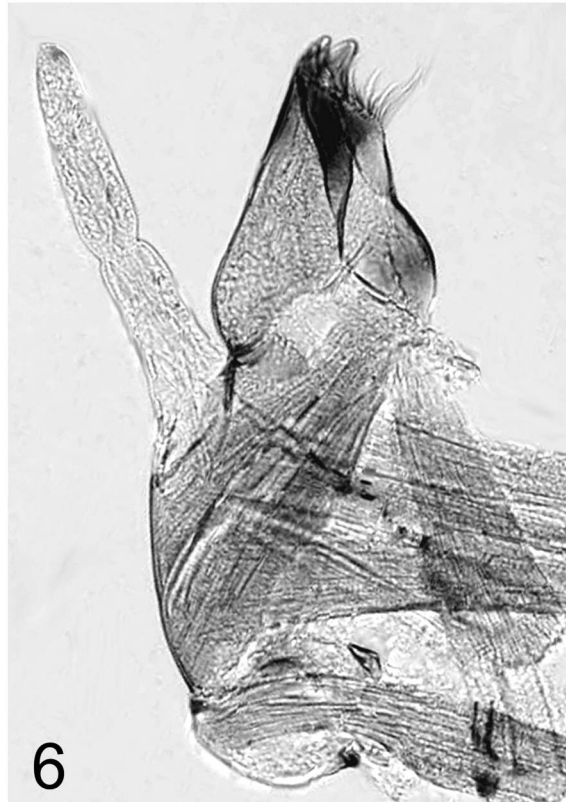
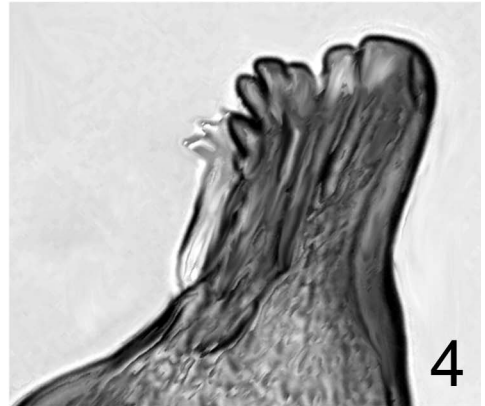
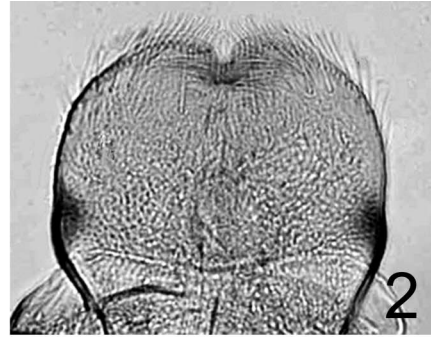
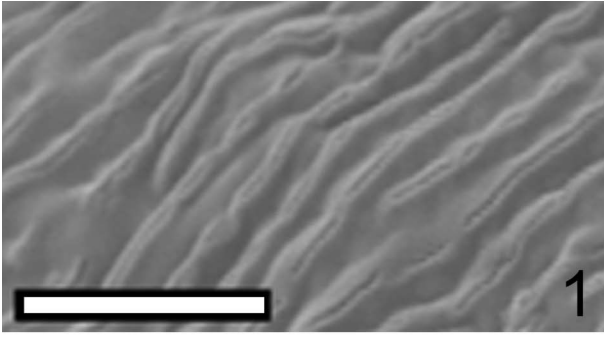
We name this species in honour of Dr. Barbara Lynn Hass, who was holding the rearing apparatus when the first subimago emerged.

Description

Egg. Length 116–120 μm . Width 80–84 μm . Shape ovoid; chorion with 100–110 longitudinal ridges spaced about 3 μm apart, and each ridge with shallow furrow (Figure 1).

Larva (preserved in 70% ethanol). Body length. 3.2–4.6 mm, cerci: 4.3–4.8 mm. Body colour: light brown.

Head. Occiput smooth, with variable brown maculation. Antennae 2 \times length of head capsule; scape and pedicel with scattered fine, hairlike setae; antennal pit shaded with brown. Frons smooth, without keel. Labrum (Figure 2) broadly rounded anteriorly, with anteromedial notch and with each side having one medial seta and four or five sublateral setae. Angulate mandible with no tufts of setae; incisors (Figure 3) with smooth inner margin and length about 1.3 \times width. Planate mandible with no tufts of setae; incisors (Figure 4) with serrate inner margin and length about 1.6 \times width; mola with two setae at base and one at tip. Hypopharynx (Figure 5) with lingua rounded and superlinguae broadly truncate. Maxilla (Figure 6) robust with oblique submedial row of four bristlelike setae and one bristlelike medial seta; crown setae furthest from incisors longest, extending just beyond tip of longest incisor; palp two segmented, total length reaching crest of maxilla, basal segment about 0.8 \times length of apical segment, apical segment with broadly rounded tip. Labium (Figure 7) compact; glossae slightly shorter than paraglossae and slightly attenuate; paraglossae round apically and slightly recurved; palps three segmented; length of palp segment 1 slightly longer than combined length of segments 2 and 3; segment 2 about 1.1 \times wider than segment 3, protruding slightly beyond inner margin of segment 3; segment 3 rounded apically, with length 0.9 \times width.



Thorax. Nota with variable light brown shading; mesonotum usually with medial, diffuse, dark spot between bases of wingpads; metanotum with broad posteromedial projection, extending about $0.15 \times$ length of abdominal tergum 1; hind wingpads absent. Femoral villopore relatively robust on middle and hind femora. Forefemur light brown with dorsal row of numerous bristlelike setae (length about $0.5 \times$ width of femur) and adjacent irregular row of tufts of small, fine setae, with one to five setae in each tuft; upper surface with scattered fine setae, creases and spiny ridges (Moriyama & McCafferty 1979, Figure 5) along proximal half only; ventral margin with scattered short, stout setae. Foretibia brown with diffuse, pale medial band; outer margin with scattered tiny, stout setae and row of hairlike setae (length about $0.4 \times$ width of tibia), hairlike setae usually occurring in tufts of two to five (tufts usually visible only with high magnification); inner margin with two longitudinal rows of sharp, stout setae; apex of inner margin with two pectinate setae + two tufts of hairlike setae; tibiopatella suture with one row of fine, hairlike setae along inner margin and tubercle at terminus (Figure 8); tubercle with two stout setae and one tuft of fine setae. Foretarsus dark brown with pale medial band; outer margin with row of bristlelike setae (length about $0.4 \times$ width of tarsus); inner margin with longitudinal row of short, stout setae, and parallel row of short, fine setae, and parallel row of setal tufts (cf. Moriyama & McCafferty 1979, Figure 16f), each tuft with two to four fine setae; dense tufts of long, simple setae present at apex. Claw with 11–14 denticles, increasing in size distally; preapical setae absent; tip of claw extending just beyond plane of denticle tips. Middle (Figure 9) and hind legs similar to foreleg. Sterna pale, with no ventral projections.

Abdomen (Figures 10–12). Gills simple and ovate; tracheation fine and dark, with most tracheae extending from main trunk towards inner margin; margins smooth, with fine, hairlike setae. Tergum 1 with anteromedial emargination. Terga each with pair of faint, brown, median spots and dark brown posterior margin; terga 2 and 6 usually dark brown medially; tergum 7 sometimes dark brown medially. Tergal surfaces with creases, scattered fine setae, and few tiny setal pits. Terga thickened posteriorly; posterior marginal spines variably blunt or truncate and in irregular row; terga 1–6 or 2–6 with posteromedial protuberance and sparse, posteromedial tuft of small setae or spicules (Figures 10 and 11); protuberances most pronounced on anterior segments between forewingpads (Figure 12). Sterna pale to light brown, with scattered fine setae; dark lateral tracheation; very faint, paired, submedial spots; and paired, anterolateral friction pads. Cerci pale to light brown, with broad, diffuse, brown regions sometimes present at base, middle, and tip; segments serrate apically, usually with slightly curled, simple seta between each serration; surfaces of segments with creases and scattered, fine setae; inner margin of most segments with tuft of setae; length of setae in tuft $3.5 \times$ length of respective segment. Median caudal filament reduced to stub; stub shorter than length of tergum 10.

Male imago (preserved in 70% ethanol). Length. Body 4.8–5.0 mm, forelegs 3.3–3.5 mm, forewings 4.2–4.5 mm, cerci 9.0–9.5 mm.

Head. Colour brown; antennal scape, pedicel, and flagellar segments brown. Dorsal portion of turbinate eyes orange and round, length $1.2 \times$ width; stalk height $0.3 \times$ width of dorsal portion. Turbinate eyes separated by distance approximately equal to width of lateral ocellus.

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 Figures 1–7. (1) *Acentrella barbarae* n. sp. Egg chorion (scalebar = 10 μ m), (2) *Acentrella barbarae* n. sp. Larva. Labrum, dorsal view, (3) *Acentrella barbarae* n. sp. Larva. Incisors, angulate mandible, (4) *Acentrella barbarae* n. sp. Larva. Incisors, planate mandible, (5) *Acentrella barbarae* n. sp. Larva. Hypopharynx, (6) *Acentrella barbarae* n. sp. Larva. Maxilla, (7) *Acentrella barbarae* n. sp. Larva. Labium, dorsal (right) and ventral (left) views.

Thorax. Nota, pleura, and sterna brown with dark brown shading. Anterior process of mesothorax (Kluge 1994, Figure 3; Waltz 1994, Figure 1; Ishiwata 2000, Figure 27) subconiform. Forewings translucent with stigmatic area white and veins light brown; marginal intercalaries paired, length of each intercalary approximately one-half distance between adjacent veins. Forefemur brown, lighter medially; foretibia light brown; foretarsal segments pale. Middle and hind legs pale with smoky brown tint; middle and hind femora with thin, diffuse, light brown band distally.

Abdomen. Segments 1–6 pale with smoky brown tint; segments 7–10 tan. Terga with variable black tracheation laterally and posterior margins dark brown. Anterior terga usually elevated posteriorly (similar to Figure 11); with small median tubercle sometimes on posterior margin of tergum 2. Tergum 2 dark brown medially and laterally, with pair of small pale median spots. Tergum 3 dark brown laterally, sometimes brown medially, with pair of small, dark brown, transverse dashes medially. Tergum 6 brown medially and anterolaterally, with dark brown median stripe and pair of small pale median spots (Figure 13). Tergum 7 sometimes with brown shading medially. Pleural folds black, each usually with dark spiracular dot. Sterna pale to light brown, with variable black tracheation laterally; sterna 6 and 7 often with brown shading; some sterna occasionally with diffuse, medioposterior, dark brown maculation. Caudal filaments white.

Genitalia (Figure 14). Forceps basal segment with shallow, broadly rounded, inner-medial emargination; forceps segment 2 subcylindrical basally, constricted medially, and flared distally; forceps segment 3 slightly recurved and weakly expanded distally, length nearly 2 × width; subgenital projection short and emarginate.

Diagnosis

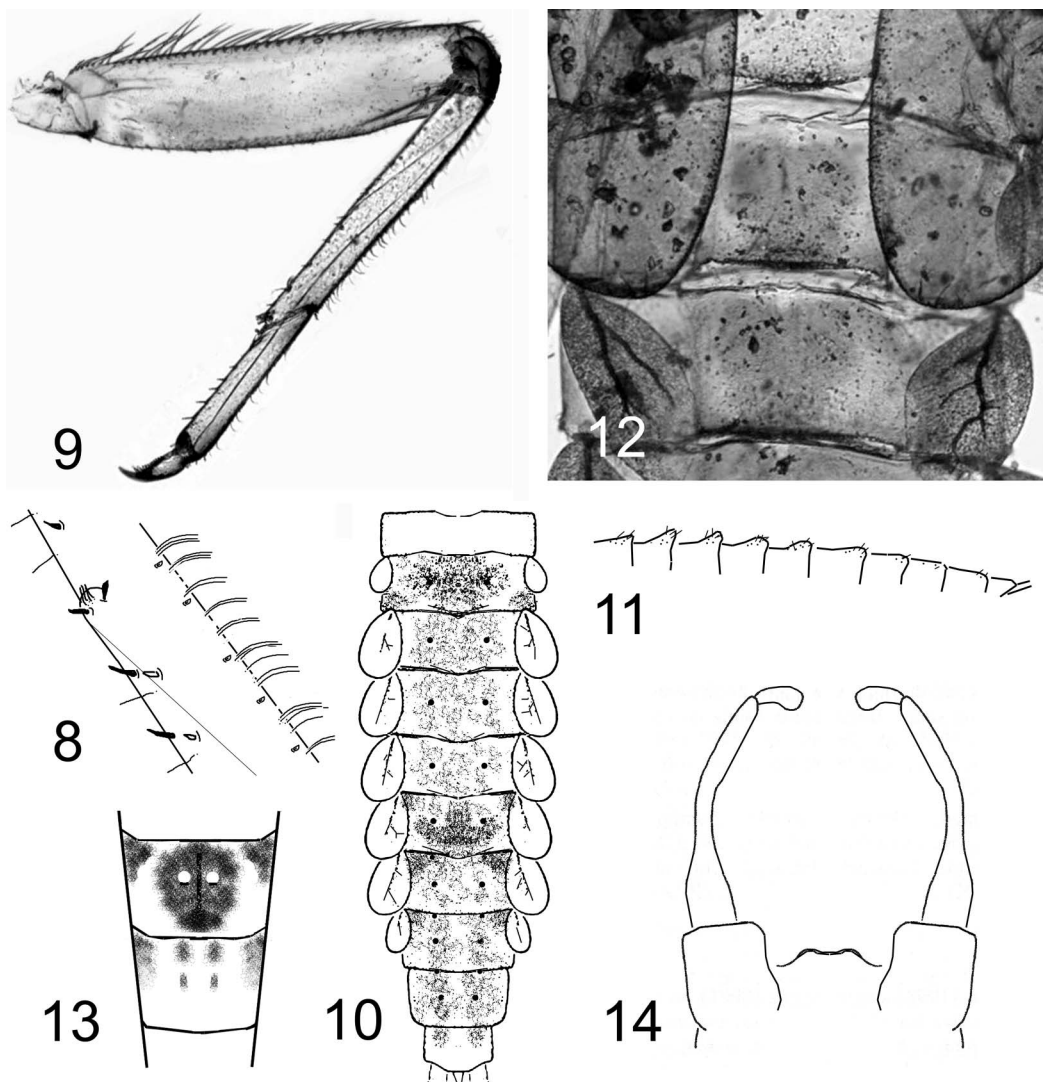
Egg

Acentrella barbarae eggs have chorionic ridges similar to those documented for other species of the genus *Acentrella* Bengtsson (Kopelke & Müller-Liebenau 1982, Figures 41–42; Alba-Tercedor & El Alami 1999, Figures 14–18). Unlike these other species, however, the chorionic ridges of *A. barbarae* have small longitudinal furrows (Figure 1).

Larva

The new species is distinguishable from all other baetids with greatly reduced median caudal filaments by having the following combination of characteristics: a compact labium (Figure 7), tibiae and tarsi with relatively few and short setae along their outer margins (Figures 8 and 9), a femoral villipore (McCafferty & Waltz 1990), the absence of hind wingpads or vestiges of such, abdominal terga with distinct posteromedian elevations (Figures 10–12) and without scales or scale bases, gills with smooth margins, and the median filament reduced to a length less than the length of abdominal tergum 10.

Acentrella turbida (e.g. six larvae, Tennessee, Blount Co., Mill Cr., near Abrams Falls Trailhead, 35°35'25"N, 83°51'08"W, 15-V-2005, CR Parker, LM & BLH Jacobus [PERC]; one larva, Tennessee, Cocke Co., Cosby Cr. at Cosby entrance to Great Smoky Mountains National Park, 35°46'59"N, 83°13'06"W, 17-V-2001, CD & RP Randolph, LM Jacobus [PERC; misidentified as *A. ampla* by McCafferty et al. 2004]) has been collected together with *A. barbarae*. Some of these larvae have slight posteromedian humps on anterior



Figures 8–14. (8) *Acentrella barbarae* n. sp. Larva. Details of foretibia, (9) *Acentrella barbarae* n. sp. Larva. Middle leg, (10) *Acentrella barbarae* n. sp. Larva. Abdomen, dorsal view (drawn from specimens preserved in alcohol). (11) *Acentrella barbarae* n. sp. Larva. Abdominal terga, lateral view, (12) *Acentrella barbarae* n. sp. Larva. Exuviae, abdominal terga 1–3, (13) *Acentrella barbarae* n. sp. (drawn from specimens preserved in alcohol, not mounted on slides). Abdominal terga 6–7, dorsal view. (14) *Acentrella barbarae* n. sp. (drawn from specimens preserved in alcohol, not mounted on slides). Male genitalia, ventral view.

abdominal terga, but these humps are much less elevated than the projections of *A. barbarae*. *Acentrella turbida* is distinguished most easily from *A. barbarae* by having much longer and more numerous outer marginal setae on the tibiae and tarsi (McCafferty et al. 1994, Figure 4).

Acentrella alachua and *A. parvula* have tibiae and tarsi with relatively few and short setae (Wiersema 2000, Figure 5), similar to those of *A. barbarae*. These latter two *Acentrella* larvae are distinguishable from *A. barbarae* by having cerci with many alternating dark bands (Bernier & Pescador 1988, Figure 169), abdominal terga that lack posteromedian elevations,

and tibiae with a few long setae. *Acentrella parvula* has been reported from North Carolina (McCafferty et al. 2004), and it has been collected from at least one of the streams inhabited by *A. barbarae* (one larva, Tennessee, Blount Co., Abrams Cr. at Abrams Creek Ranger Station, 35°36'37"N, 83°56'06"W, 18-V-2001, CD & RP Randolph, LM Jacobus [PERC]). *Acentrella alachua* has been reported from North Carolina (Pescador et al. 1999).

Based on its general appearance and the colouration of its cerci, *A. barbarae* might be confused with *Plauditus cingulatus* (McDunnough, 1931), which has been reported to occur also in Tennessee and North Carolina (Long & Kondratieff 1996; Pescador et al. 1999). For comparative purposes, we examined the male imago holotype and associated larval exuviae of *P. cingulatus*: Canada, Quebec, Mid Yamaska R., Knowlton, Foster Power Plant, 10-VII-1930, GS Walley, type 3285 [CNC]. *Plauditus cingulatus*, in contrast to our new species, lacks posterior elevations on the abdominal terga of imago and larva. Furthermore, the larva of *P. cingulatus* has segment 3 of the labial palp distinctly truncate (cf. Lugo-Ortiz & McCafferty 1998, Figure 7; McCafferty & Waltz 1998, Figure 5), typical of the genus *Plauditus* Lugo-Ortiz and McCafferty, rather than *Acentrella*, which has a palp that is generally rounded at the tip (Waltz & McCafferty 1987, Figure 2; Jacob 1991, Figures 3a and b; Wiersema 2000, Figure 1).

Male imago

Acentrella barbarae male imagines have a combination of characters unique among known Baetidae. They have a shallowly emarginate subgenital projection (Figure 14), elevated posterior margins of anterior abdominal terga, forewings with marginal intercalaries that occur in pairs and with veins and crossveins that are not margined by colour, no hind wings, and the length of genital forceps segment 3 about two times its width. The abdominal tergal colour pattern (Figure 13) and dark pleural folds often are distinctive.

Notable morphological variability

The relative development of the protuberances of the abdominal terga is variable in imagines and larvae, as is often the case in other Baetidae (Jacobus & McCafferty 2001; Lugo-Ortiz et al. 2001), and sometimes they are difficult to discern. The dorsal elevation of these structures, rather than their posterior protrusion, is less variable; thus, a lateral view of specimens (e.g. Figure 11) is important for proper identification. The degree of sternal tracheation varies from bold and dark to very faint and barely visible (e.g. Kazlauskas 1963, Figures 49–51) for larvae and imagines. The faint colouration of the larval cerci is quite variable (see description above), and its visibility usually is affected when specimens are preserved in alcohol.

Biology

Larvae were collected with a D-frame dipnet only from cobble-pebble substrate in very clear, shallow (depth < 0.5 m) water, directly under sustained breaks in the stream surface. At one representative location (Bradley Fork, Smokemont Campground), water temperature was 15.3°C; pH was 7.3; and oxygen levels were near saturation.

Imagines have been collected from middle May through middle August, and larvae with black wingpads have been collected as late as early December, indicating the possibility of several generations per year. *Baetis tricaudatus* Dodds (Ephemeroptera: Baetidae) was emerging concurrently with the new species at Mill Creek, in May 2005.

Distribution

The only specimens we have seen are from GRSM, despite recent examination of long series of Baetidae from throughout North America (McCafferty et al. 2004, 2005) and sampling from Tennessee and North Carolina streams outside GRSM. Based on the material we have examined, *A. barbarae* appears to be most widespread in the Abrams Creek drainage system. DeWalt and Heinold (2005) emphasized the need for additional studies of this area.

Key to the larvae of North American *Acentrella* species

1. Tibiae and tarsi with dense row of long setae on dorsal margins..... 2
- 1'. Tibiae and tarsi with few or no long setae on dorsal margins. 3
2. Hind wingpads vestigial or absent; widespread distribution *turbida*
- 2'. Hind wingpads relatively well developed; known only from western and far northern North America..... *insignificans*
3. Hind wingpads vestigial (Wiersema 2000, Figure 4); caudal filaments with many dark and pale bands [identifications of specimens from the southeastern United States should be tentative in couplet 4, unless associated with imagines] 4
- 3'. Hind wingpads well developed or absent; caudal filaments either uniform in colour or faintly darkened medially and distally 5
4. Body and caudal filaments with dark and pale regions highly contrasting; distribution widespread [middle and hind femora of imago with “ruddy dash on lower edge anteriorly and a distinct, ruddy, lateral spot near apex and well beyond middle of joint” (McDunnough 1932)]..... *parvula*
- 4'. Body and caudal filaments of late instars with dark and pale regions much less distinctive; known only from southeastern United States [middle and hind femora of male imago without distinctive maculation (Berner 1940)]. *alachua*
5. Hind wingpads present; claw with preapical setae; abdominal terga without posterior elevations; known only from far northern North America..... 6
- 5'. Hind wingpads absent; claw without preapical setae; abdominal terga with mid-posterior elevations; known only from southeastern United States *barbarae*
6. Length of longest setae on dorsal margins of femora nearly one-third width of respective femur (Müller-Liebenau 1969, Figures 46e,f) *laponica*
- 6'. Length of longest setae on dorsal margins of femora much less than one-third width of respective femur (Moriyama & McCafferty 1979, Figures 13c,d) *feropagus*

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