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LARVAE OF NORTH AMERICAN SPECIES OF *PTERONARCYS* (PLECOPTERA: PTERONARCYIDAE)

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ABSTRACT

Larvae of the eight North American *Pteronarcys* (Plecoptera: Pteronarcyidae) species have been difficult or impossible to identify over the past century. This stems from the lack of rigorous comparisons of reared material. The absence of a reliable key diminishes the importance of *Pteronarcys* larvae in aquatic ecological and biomonitoring studies. We provide comparative larval descriptions and a key illustrated with high resolution photographs of important diagnostic characters for the eight North American species of *Pteronarcys*. Earlier descriptions are reviewed and supplemented with new photographs, illustrations and morphometric data to aid in the separation of morphologically similar species.

Keywords: Stonefly larvae, Plecoptera, Pteronarcyidae, *Pteronarcys*, North America

INTRODUCTION

The stonefly genus *Pteronarcys* Newman, 1838 is represented by eight valid species in North America (Stark & Szczytko 1982, Nelson 2000, DeWalt et al. 2017). Two more species, *P. reticulata* (Burmeister, 1839) and *P. sachalina* Klapálek, 1908, are known from Mongolia (Judson & Nelson 2012) and western Asia (Teslenko 2009), neither of which are the focus of this treatment. Stark & Szczytko (1982) determined that *Pteronarcys* sensu Zwick (1973) was a polyphyletic taxon, finding that the genus *Allonarcys* Needham & Claassen, 1925 was a synonym of *Pteronarcys*, supporting the suppositions of Nelson & Hanson (1971). Nelson & Hanson (1971) originally recognized six species groups, whereas Stark & Szczytko (1982) only recognized three species groups within *Pteronarcys*. Larvae of species that possessed abdominal spines were formerly placed in *Allonarcys* as the *P. scotti* group, and those without abdominal spines in two groups as the *P. californica* group (western) and the *P. dorsata* group (largely eastern).

Given their large size and widespread distribution, larvae and adults of the stonefly genus *Pteronarcys* have often captured the attention of aquatic scientists. Larval descriptions and illustrations have been provided for *P. biloba* Newman, 1838 (Smith 1917, Claassen 1931, Ricker

Table 1. Abbreviations and terminology used in morphometric analysis of *Pteronarcys* larvae.

APP (Anterior Pronotal Projection) Fig. 1	Projection located at the anterior corners of the pronotum.
PPP (Posterior Pronotal Projection) Fig. 1	Projection located at the posterior corners of the pronotum.
APPBW (Anterior Pronotal Projection Basal Width) Fig. 1	A measure of the basal width of the anterior pronotal projection. This feature is measured in dorsal view.
APPMH (Anterior Pronotal Projection Median Height) Fig. 1	The measurement of a line drawn from the midpoint of the base to the apex of the projection. Measured in dorsal view.
APPA (Anterior Pronotal Projection Angle) Fig. 1	Angle formed at the intersection of two straight lines extended from the edges of the anterior pronotal projection.
PPPA (Posterior Pronotal Projection Angle) Fig. 1	Angle formed at the intersection of two straight lines extended from the edges of the posterior pronotal projection.
AAMP (Mean Angle of Male Plate) Fig. 3	Angle measured ventrally at the apex of two lines drawn from the lateral edges of the plate on the 8th segment of males of *P. dorsata* and *P. pictetii*.
SL (Abdominal Segment Length) Fig. 2	A straight line measured medially and extending from the anterior to posterior edge of respective abdominal segment.
SW (Abdominal Segment Width) Fig. 2	A straight line measured medially from the two lateral edges of the respective segment.
PIM (Projection Inner Margin) Fig. 2	A straight line measured on the inner (posterior) margin of abdominal projections that extends from the base to the apex of the projection. Measured in dorsal view.
POM (Projection Outer Margin) Fig. 2	A straight line measured on the outer (anterior) margin of abdominal projections that extends from the base to the apex of the projection. Measured in dorsal view.

1952, Tarter et al. 1975), *P. californica* Newport, 1848 (Smith 1917, Claassen 1931, McCafferty 1981, Ward et al. 2002), *P. comstocki* Smith, 1917 (Frison 1942, Ricker 1952, Nelson et al. 1977), *P. dorsata* (Say, 1823) (Smith 1917, Shepard & Stewart 1983, Stewart & Stark 1988, Stark et al. 1998), *P. pictetii* Hagen, 1873 (Frison 1935, Poulton & Stewart 1991), *P. proteus* Newman, 1838 (Smith 1917, Claassen 1931, Ricker 1952), *P. princeps* Banks, 1907 (Claassen 1931), and *P. scotti* Ricker, 1952 (Ricker 1952, Shepard & Stewart 1983).

Smith (1917) provided one of the first treatments of this family in North America, providing useful descriptions and illustrations for both larvae and adults of *P. biloba, P. californica*, *P. dorsata* and *P. proteus* and the adult female of *P. comstocki.* Claassen (1931) provided another much needed review of this family with more complete larval descriptions for existing members of the family and the first larval description and illustration of *P. princeps.* The first larval description of *P. pictetii* was provided by Frison (1935), as *P. nobilis* Hagen, 1861. Later the larvae of *P. comstocki* were described and illustrated by Frison (1942) as *Pteronarcys* species. Frison (1942) also discussed his inability to provide a reliable means to separate the larvae of *P. pictetii* with *P. dorsata* despite the availability of reared, associated material. Ricker (1952) described the larvae and adults of *P. scotti* and was also the first to associate *P. comstocki* with Frison's (1942) description of *Pteronarcys* species. Ricker (1952) also provided a means of separating *P. proteus* and *P. scotti* based on characteristics of the abdominal spines. Despite his efforts to distinguish these two species in areas of the southern Appalachians where the ranges overlap, separation is difficult using his characters. A more recent key to mature larvae from the southeastern United States was provided by Stark

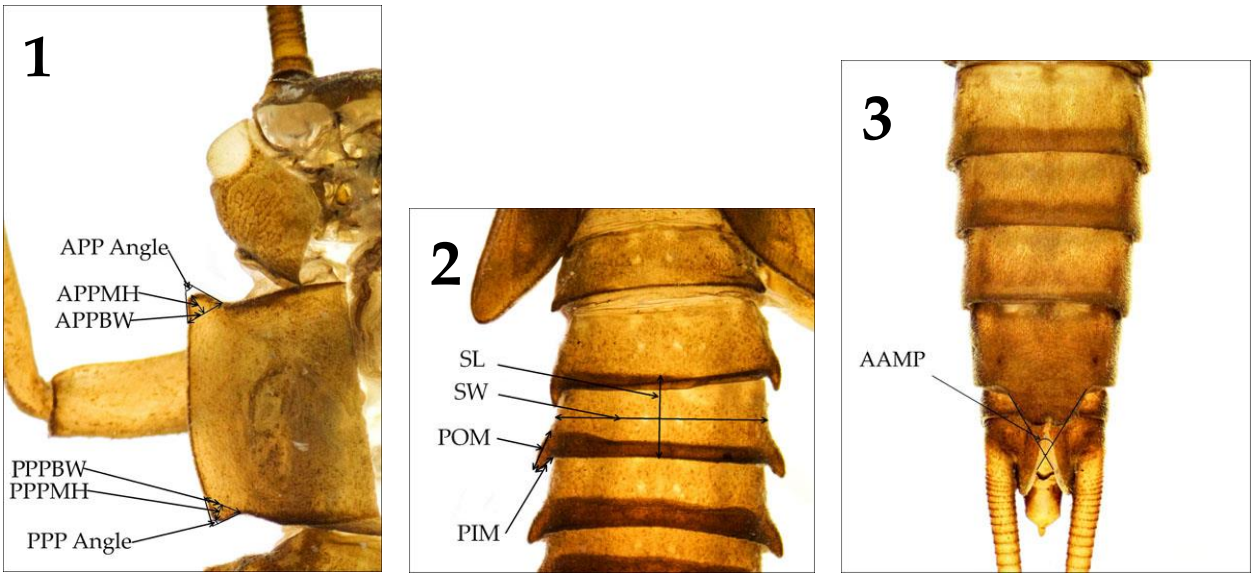

Fig. 1. Pronotal projection morphometrics; APP Angle (Anterior Pronotal Projection Angle), APPMH (Anterior Pronotal Projection Median Height), APPBW (Anterior Pronotal Projection Basal Width), PPP Angle (Posterior Pronotal Projection Angle), PPMH (Posterior Pronotal Projection Median Height), PPPBW (Posterior Pronotal Projection Basal Width).
Fig. 2. Abdominal projection morphometrics; SL (Segment Length), SW (Segment Width), POM (Projection Outer Margin), PIM (Projection Inner Margin).
Fig. 3. Process of AB9 in male of *P. pictetii* showing measured AAMP angle.

(2017), but it lacks a comprehensive analysis of the usefulness of the characters for separating the species.

Despite the fact that written descriptions exist for all eight species, some descriptions are incomplete and none of them present a rigorous analysis capable of putting this century-old problem to rest. Because of this, no synoptic key to the larvae exists that includes all eight North American species. The purpose of this paper is to provide a comprehensive review of larval characters and assess each for their ability to separate larvae of all eight species. Using these characters we present a key that separates mature larvae of North America species of *Pteronarcys*.

MATERIALS AND METHODS

Reared adult specimens, associated exuvia, and directly associated mature larvae (adult characters under larval cuticle) were examined using a Zeiss Stemi 200-C dissecting stereomicroscope. Photographs of important characters were taken using a Cannon Rebel T3i attached to the dissecting microscope. Multiple digital images were stacked using Zerene Stacker to provide greater image depth of field. Drawings were based on individual specimens and diagnostic characteristics used were compared with collections from other localities.

In an effort to provide quantitative morphological characters, character lengths and angles were measured using ImageJ digital measurement software (Rasband 2015). Table 1 lists the various morphometric characters assessed and their abbreviations used in text and figures. APP and PPP basal width, median height, and angle of pronotal projections (Fig. 1) were measured for all eight taxa. Additional analyses of larval abdominal projections were conducted on *P. biloba*, *P. proteus* and *P. scotti.* These included the length and width of abdominal segments and the associated inner and outer margins of the abdominal spines (Fig. 2). All measurements were taken at a fixed (10X) zoom in

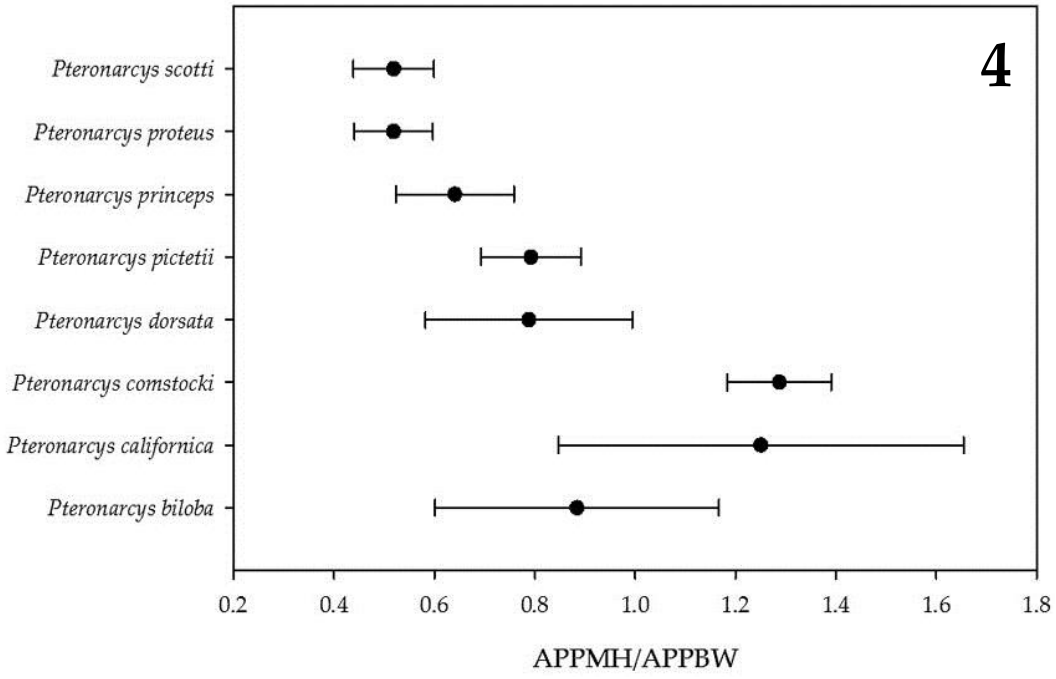

Fig. 4. APPMH/APPBW pronotal ratios for *P. biloba* (n=11), *P. californica* (n=8), *P. comstocki* (n=6), *P. dorsata* (n=26), *P. pictetii* (n=16), *P. princeps* (n=9), *P. proteus* (n=17) and, *P. scotti* (n=14).

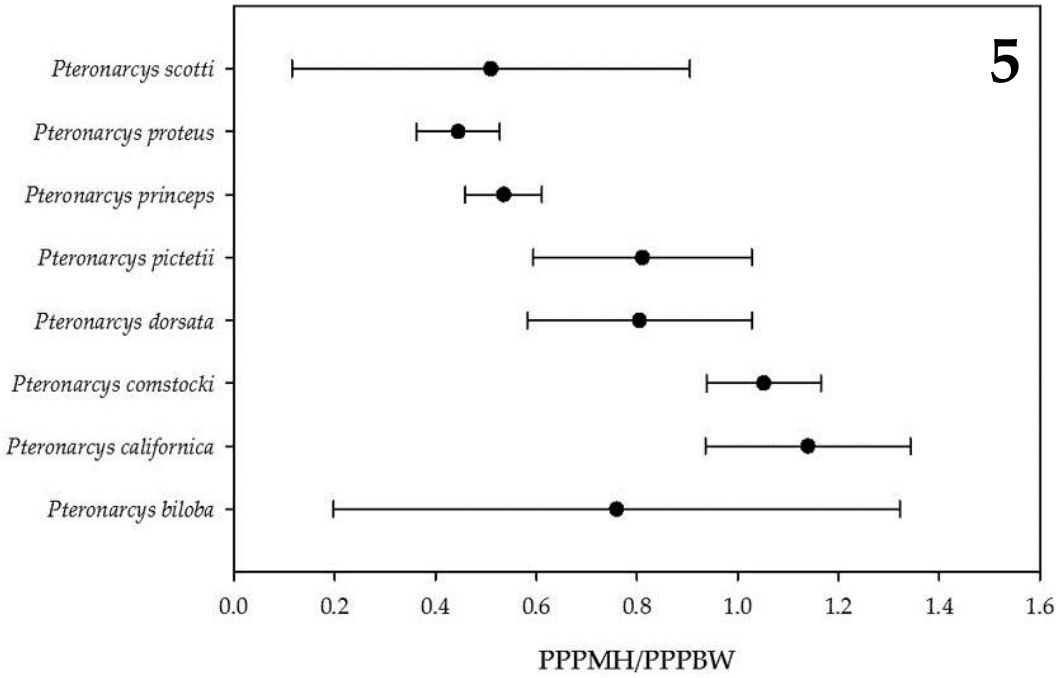

Fig. 5. PPPMH/PPPBW pronotal ratios for *P. biloba* (n=11), *P. californica* (n=8), *P. comstocki* (n=6), *P. dorsata* (n=26), *P. pictetii* (n=16) , *P. princeps* (n=9), *P. proteus* (n=17) and, *P. scotti* (n=14).

dorsal view. A non-parametric linear regression model was used in an attempt to provide quantitative boundaries for the separation of the three species using the abdominal morphometric ratios. This analysis was performed using the "party package" in R (Torsten et al. 2006, R Core Team 2016).

Additional analysis of the rearward process on the ninth sternum of males of *P. dorsata* and *P. pictetii* was performed by drawing lines caudally from the two lateral margins and measuring the resulting angle formed at the intersection of the two lines (measured in ventral view) (Fig. 3). Last instar larvae that could be positively identified or reared specimens with associated exuvia, were used in this analysis.

Once data were compiled, means and standard deviations were calculated to determine the amount of intraspecific and interspecific variability for each character. We also used R (R Core Team 2016) to perform linear regression trees on morphometric ratios from available material to determine the most useful character for separating morphologically similar species.

Specimens used in this study were borrowed from the following institutional collections: Lake Champlain Research Institute, State University of New York at Plattsburgh, New York (LCRI), C. P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, Colorado (CSUIC), The Illinois Natural History Survey, Champaign, Illinois (INHS), The Canadian National Insect Collection, Ottawa, Ontario (CNC) the Bill P. Stark Collection, Mississippi College, Clinton, Mississippi (BPSC), and the North Carolina Department of Environmental Protection, Raleigh, North Carolina (NCDEP). Specimen data used in this study are available at MaterialExaminedPteronarcysKey.csv.

RESULTS AND DISCUSSION

We used pronotal measurements to provide measurable characteristics to aid in the description of the pronotal projections traditionally defined in the literature with relatively subjective terminology. *Pteronarcys californica* and *P. comstocki* possessed the most well developed pronotal projections with acute apices: *P. californica* (n=8) APPMH/APPBW=1.25 ± 0.40 SD (Fig. 4), PPPMH/PPPBW=1.14 ± 0.20 (Fig. 5); *P. comstocki* (n=6) APPMH/APPBW=1.29 ± 0.10 (Fig. 4), PPPMH/PPPBW=1.05 ± 0.11 (Fig. 5); *P. californica* (n=8) APPA=27.50 ± 9.64 (Fig. 6), PPPA=33.38 ± 8.11 (Fig. 7), *P. comstocki* (n=6) APPA=31.83 ± 8.06 (Fig. 6), PPPA=31.83 ± 8.42 (Fig. 7). Intermediate development of the pronotal projections was noted for: *P. biloba* (n=11) APPMH/APPBW=0.88 ± 0.28 (Fig. 4), APPA=39.55 ± 13.87 (Fig. 6), PPPMH/PPPBW=0.76 ± 0.56 (Fig. 5), PPPA=67.55 ± 9.53 (Fig. 7) and *P. princeps* (n=9) APPMH/APPBW=0.64 ± 0.12 (Fig. 4), APPA=44.67 ± 14.87 (Fig. 6), PPPMH/PPPBW=0.54 ± 0.08 (Fig. 5), PPPA=67.44 ± 9.06 (Fig. 7). Intermediate development with similar measurements were also observed for: *P. dorsata* (n=26) APPMH/APPBW=0.79 ± 0.21 (Fig. 4), APPA=40.96 ± 20.77 (Fig. 6), PPPMH/PPPBW=0.80 ± 0.22 (Fig. 5), PPPA=45.52 ± 12.45 (Fig. 7) and *P. pictetii* (n=16) APPMH/APPBW=0.79 ± 0.10 (Fig. 4), APPA=38.69 ± 10.04 (Fig. 6), PPPMH/PPPBW=0.81 ± 0.22 (Fig. 5), PPPA=47.50 ± 13.08 (Fig. 7) with *P. dorsata* displaying the greatest variability among the two species (Figs. 4-7). The pronotal projections of both *P. proteus* and *P. scotti* displayed relatively weak development: *P. proteus* (n=17) APPMH/APPBW=0.52 ± 0.08 (Fig. 4), PPPMH/PPPBW=0.44 ± 0.08 (Fig. 5); *P. scotti* (n=14) APPMH/APPBW=0.52 ± 0.08 (Fig. 4), PPPMH/PPPBW=0.51 ± 0.40 (Fig. 5) and obtuse pronotal projections: *P. proteus* (n=17) APP Angle=71.18 ± 9.28 (Fig. 6), PPP Angle=86.13 ± 9.76 (Fig. 7), *P. scotti* (n=14) APP Angle=64.43 ± 9.44 (Fig. 6), PPP Angle=90.57 ± 9.31 (Fig. 7).

Several of the diagnostic characters originally suggested by Ricker (1952) to separate mature larvae of *P. proteus* and *P. scotti* were found to be unreliable for distinguishing mature larvae of these two closely related species. Ricker (1952) reported that the longest abdominal projections measured along the posterior margin are equal to 1/3 to 1/4 of the length of the respective segment for *P. proteus.* For *P. scotti*, he indicated that the longest projections measured along the posterior margin are equal to 1/5 to 1/6 of the length of the respective segment. Although not specifically stated by Ricker (1952), we interpreted these ratios as representing our proposed PIM/SL morphometric ratio (Fig. 2).

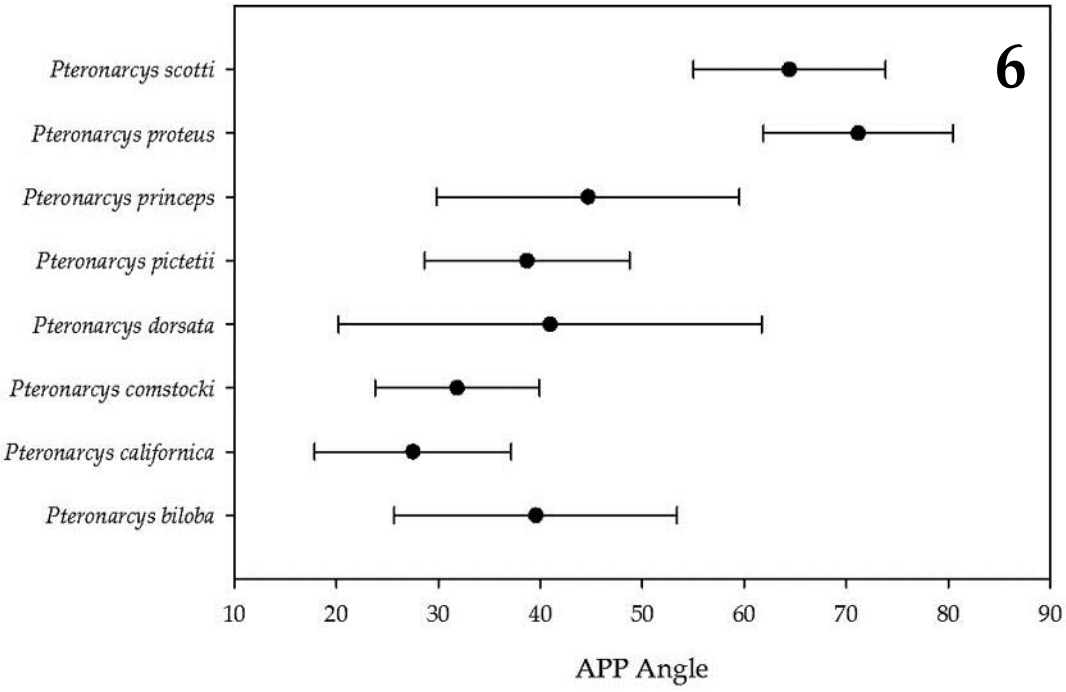

Fig. 6. APP Angle pronotal ratios for *P. biloba* (n=11), *P. californica* (n=8), *P. comstocki* (n=6), *P. dorsata* (n=26), *P. pictetii* (n=16) , *P. princeps* (n=9), *P. proteus* (n=17) and, *P. scotti* (n=14).

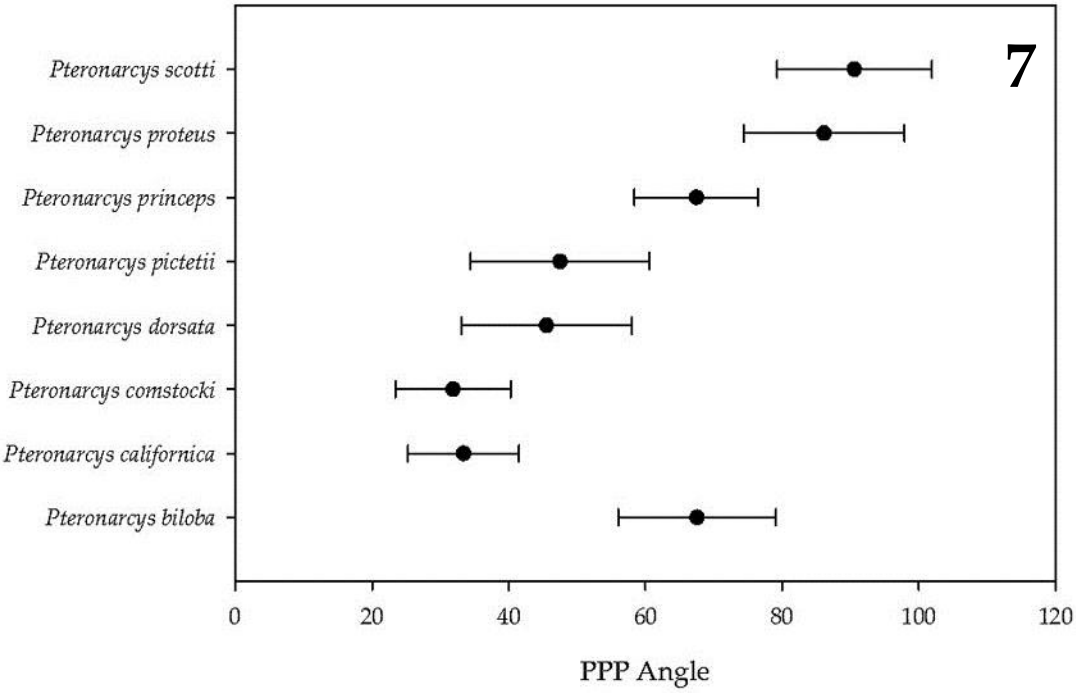

Fig. 7. PPP Angle pronotal ratios for *P. biloba* (n=11), *P. californica* (n=8), *P. comstocki* (n=6), *P. dorsata* (n=26), *P. pictetii* (n=16) , *P. princeps* (n=9), *P. proteus* (n=17) and, *P. scotti* (n=14).

There was considerable overlap on all abdominal segments for PIM/SL (Fig. 8), PIM/SW (Fig. 9) and POM/SL (Fig. 11) between *P. scotti* and *P. proteus*, which accounts for much of the difficulty in separating these two species using the abdominal projection characteristics described by Ricker (1952). Results of a linear tree regression found marginally significant differences in the POM/SW on AB4: *P. proteus* (n=17) =0.21 ± 0.04 vs. *P. scotti* (n=14)=0.15 ± 0.03 (Figs. 10, 12). AB6 measurements showed similar differences: *P. proteus*=0.17 ± 0.04 vs. *P. scotti*=0.12 ± 0.03 (Figs. 10, 12).

Additional differences were observed in the shape and orientation of the spines in lateral view of AB5-7. In *P. proteus* the spines of AB5-7 when viewed laterally are well defined rugose triangular projections, the dorsal edge projecting caudally perpendicular to the posterior margin of the segment (Figs. 50, 53). In *P. scotti,* the projections on AB5-7 viewed laterally appear as low rugose ridges that project minimally from the posterior margin on AB5 and are nearly imperceptible on AB6-7 (Figs. 58, 61).

The antennae of *P. proteus* have a distinctive medial pale band of varying length (Figs. 56, 57), this band was absent on all of the *P. scotti* examined (Figs. 64, 66). This character should be used with caution because the yellow band can become faded and difficult to observe in the exuvia and older preserved specimens. *Pteronarcys biloba* also has a yellow medial band on the antennae but can be easily differentiated based on the lateral abdominal projections.

While examining material for this study, a large proportion of *P. dorsata* larvae exhibited a convex lateral bulge on the pronotum that was clearly illustrated in Smith's (1917) illustration of this species. A subsequent illustration of this species in Stewart & Stark (2002) did not show this feature. This convex bulge is large enough to exceed the level of the pronotal projections in most specimens examined from the eastern range of this species (New York, Virginia to Mississippi) (Figs. 32, 33). The bulge was less developed but present in populations of the Midwest (Michigan, Minnesota, Wisconsin) (Fig. 31) and undeveloped in more northern portions of its range (northwestern Canada and the Hudson Bay area of northern

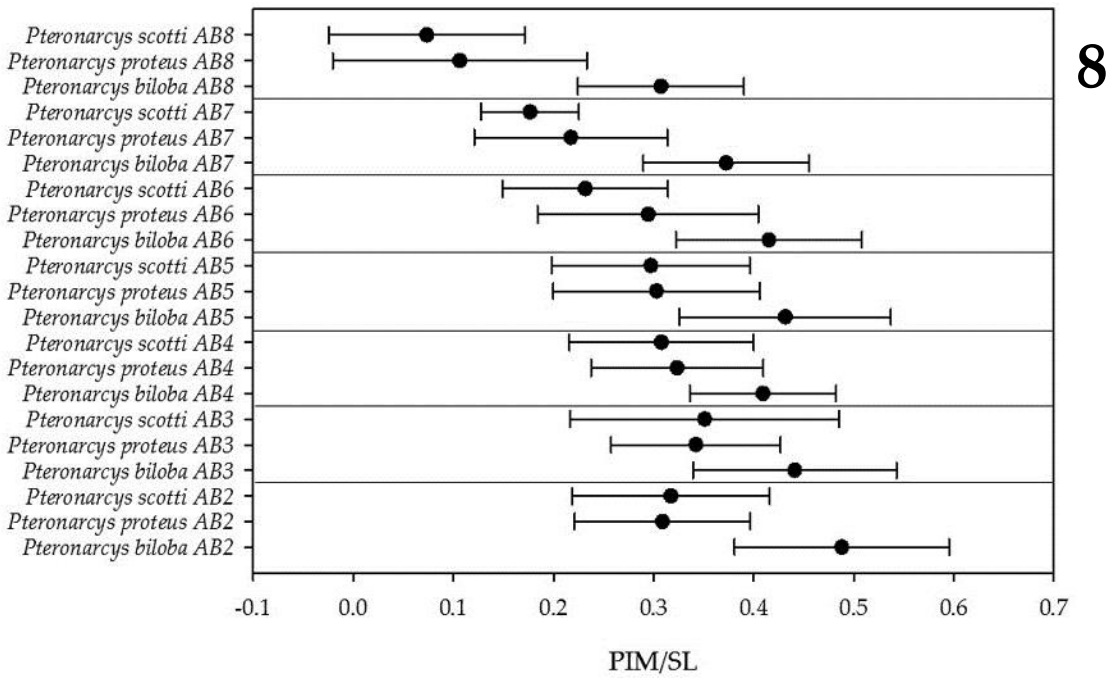

Fig. 8. PIM/SL ratio AB2-AB8 for *P. biloba* (n=11), *P. proteus* (n=17) and *P. scotti* (n=14)

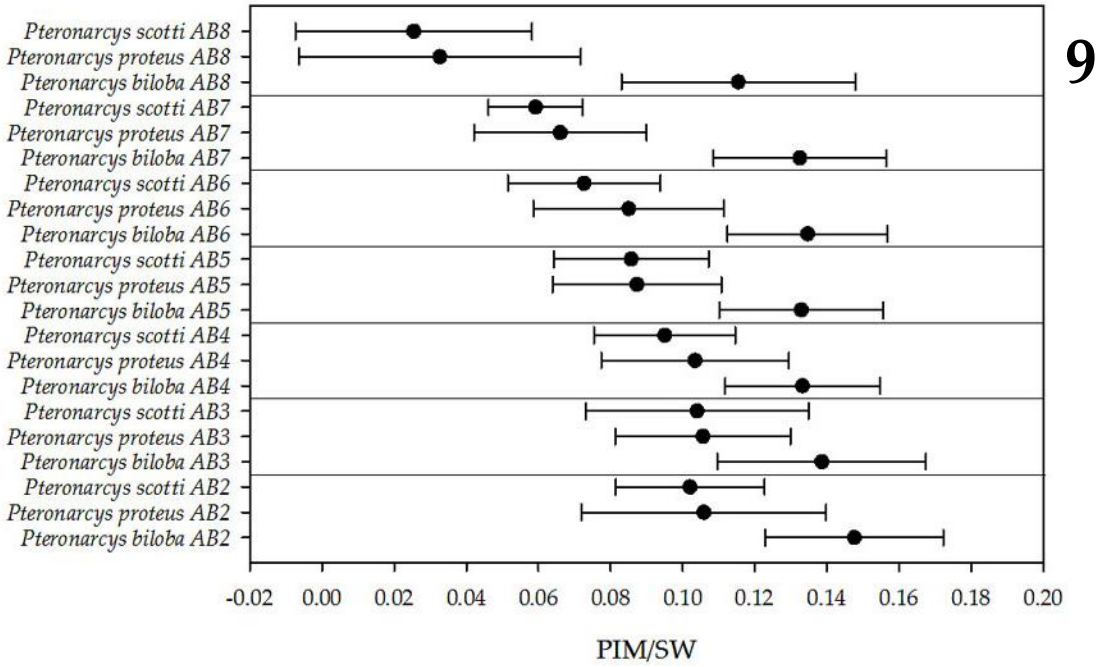

Fig. 9. PIM/SW ratio AB2-AB8 for *P. biloba* (n=11), *P. proteus* (n=17) and *P. scotti* (n=14)

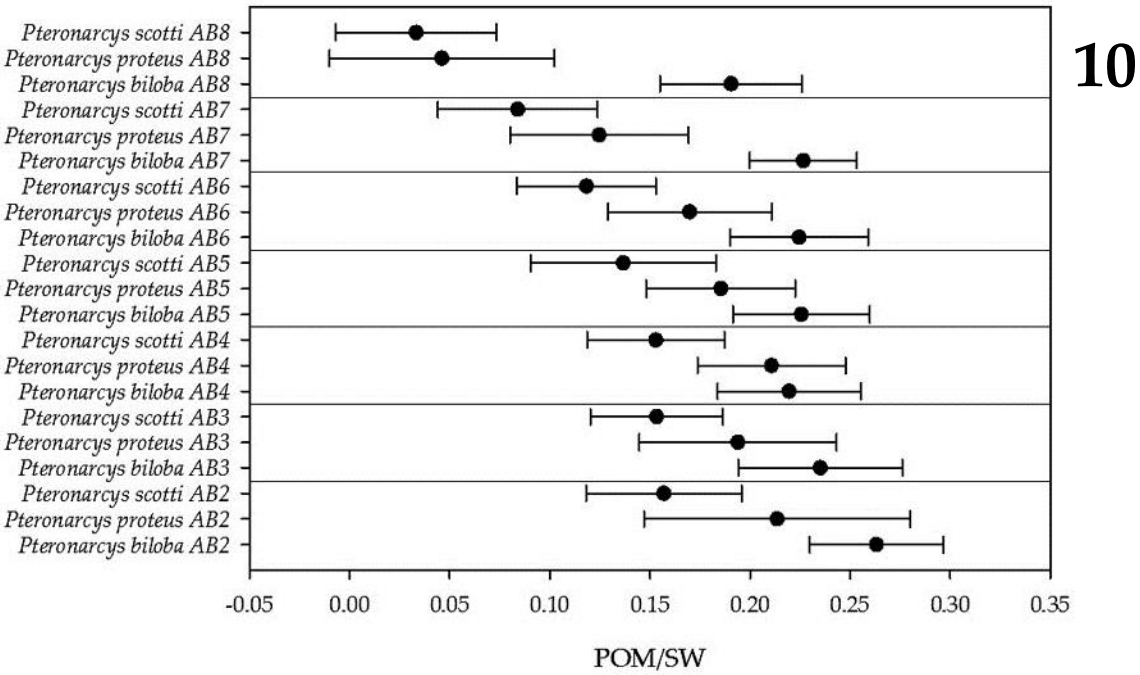

Fig. 10. POM/SW ratio AB2-AB8 for *P. biloba* (n=11), *P. proteus* (n=17) and *P. scotti* (n=14)

Quebec) (Fig. 34). Poulton & Stewart (1991) illustrated the pronotum of *P. pictetii* with a convex bulge on the lateral margin that appears to exceed the level of the pronotal projections. During our examination of *P. pictetii* specimens, we did observe a small convex lateral bulge on the pronotum but no specimens were examined where the bulge exceeded the level of the pronotal projections (Figs. 40, 41, 42).

A couplet in the key to the *Pteronarcys* of the Southeast U.S.A. by Stark (2017) separated *P. dorsata* from *P. pictetii* by the orientation of the anterior pronotal projections. These projections are oriented posterolaterally at the tip in *P. dorsata*; whereas, in *P. pictetii*, are pointed anterolaterally. There is variation in this character in both *P. dorsata* and *P. pictetii*. For *P. dorsata*, the orientation of the apex of the anterior pronotal projection ranged from posterolateral for specimens from Alberta, the Northwest Territories, Michigan, Virginia, and New York to anterolateral for specimens examined from Mississippi and Virginia. The apex of the anterior pronotal projection of *P. pictetii* examined during this study ranged from lateral to posterolateral orientation.

Harden & Mickel (1952) separated mature male larvae of *P. dorsata* from *P. pictetii* in Minnesota based on the shape of the rearward directed process on sternum 9. They noted that on male larvae of *P. pictetii* this process was triangular with the sides converging markedly caudad. In *P. dorsata*, the process is more rectangular with the sides being nearly parallel. Through our analysis clear differences were noted in the angle of this process between *P. dorsata* (n=9)at 33.11° ± 5.16 (Figs. 29, 35) and *P. pictetii* (n=11) at 63.91° ± 13.16 (Figs. 38, 43). Unpaired t-test results between these two species indicated statistically significant differences in the angle of this process ($p < 0.0001$). Our examination of available material of *P. pictetii* and *P. dorsata* confirmed the ability to separate mature males using the shape of the rearward projecting process on male larvae. Using the above morphological characteristics combined with the known geographic ranges of the two species, mature larvae may be reliably separated.

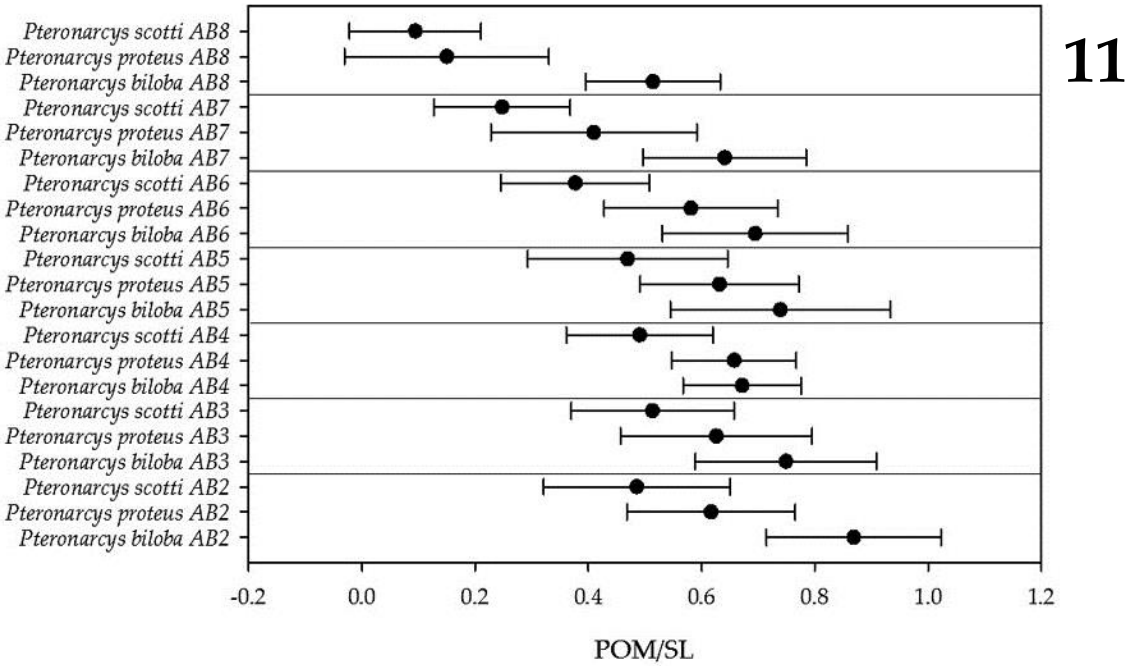

Fig. 11. POM/SL ratio AB2-AB8 for *P. biloba* (n=11), *P. proteus* (n=17) and *P. scotti* (n=14).

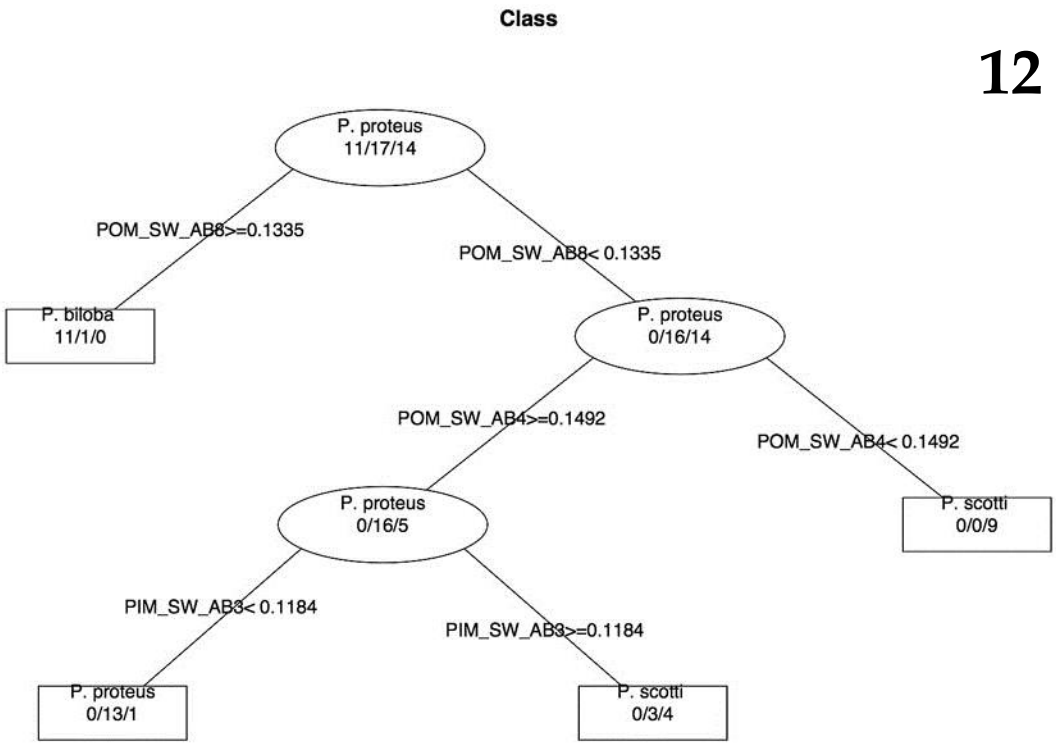

Fig. 12. Non-parametric linear regression tree comparing abdominal ratios for *P. biloba* (n=11), *P. proteus* (n=17) and *P. scotti* (n=14).

KEY TO MATURE LARVAE

1 Abdominal segments with conspicuous lateral projections (Figs. 13, 14, 17, 25, 27, 50, 51, 53, 54, 58, 59, 61, 62, 66) …… 5

1′ Abdominal segments without lateral projections (Figs. 18, 23, 28, 36, 37, 44, 45, 49) …….. 2

2 Supra-antennal plate developed into a semi-circular ridge (Figs. 16, 30, 39, 46, 48, 55, 60, 63); APP weakly developed, APPMH/APPBW < 1, and with rounded apices (Figs. 31, 36, 40, 44, 47, 49) …… 3

2′ Supra-antennal plate developed into a pointed semi-lunate conical projection visible dorsally (Figs. 19, 22); APP strongly developed APPMH/APPBW > 1, with pointed apices (Figs. 20, 21, 23) …… *P. californica*

3 APP oriented laterally occasionally appearing reflexed distally (Figs. 31, 32, 33, 34, 36, 40, 41, 42, 44) ……..... 4

3′ APP oriented anterolateral at a 45° angle (Figs. 47, 49) …….. *P. princeps*

4 Convex bulge on lateral margin of pronotum sometimes present but does not exceed the level of pronotal projections (Figs. 40, 41, 44); male larvae with rearward projecting process on abdominal sternum 9 triangular in shape and with sides nearly converging, resulting angle > 50° (63.91 ± 13.16) (Figs. 38, 43) ……..…. *P. pictetii*

4′ Convex bulge on lateral margin of pronotum produced often exceeding level of pronotal projections (Figs. 32, 36); male larvae with rearward projecting process on abdominal sternite 9 rectangular and with nearly parallel sides, resulting angle < 39 (33.11 ± 5.16) (Figs. 29, 35) ……..... *P. dorsata*

5 Prominent acute process on each mesothoracic wingpad lateral margin (Figs. 24, 27); supra-antennal plate developed into pointed, semi-lunate conical projections (Fig. 26); abdominal

projections with curved inner margins strongly developed on segments 1-8 (Figs. 25, 27), pronotal projections well developed with curved margins and sharp apices.; APPMH/APPBW ≥ 1.19 (Figs. 24, 27) ……..……. *P. comstocki*

5′ Prominent acute process absent from each mesothoracic wingpad, lateral margins smooth (Figs. 15, 17, 57, 66); supra-antennal plate developed into a low semi-circular ridge (Figs. 16, 55, 60, 63); APP not strongly developed, apices bluntly rounded; APPMH/APPBW ≤ 1.16 (Figs. 15, 17, 52, 57, 65, 66) …….. 6

6 Lateral abdominal projections on AB7 and AB8 reduced and inconspicuous, AB8 POM/SW < 0.13; APPA relatively obtuse ≥ 55° and with rounded corners (Figs. 52, 57, 65, 66) ……. 7

6′ Lateral abdominal projections conspicuous and well developed on AB1-8, AB8 POM/SW ≥ 0.13 (Figs. 1, 13, 14); APPA more acute < 55° (Figs., 15, 17) …….…….....……. *P. biloba*

7 Measured in dorsal view AB4 POM/SW < 0.15; AB6 POM/SW ≤ 0.12, lateral abdominal projections of AB5-7 nearly indiscernible, projecting past the posterior margin of the segment minimally in lateral view (Figs. 58, 61) ……... *P. scotti* (in part)

7′ Measured in dorsal view AB4 POM/SW ≥ 0.15; AB6 POM/SW > 0.12, lateral abdominal projections of AB5-7 well defined, rugose and triangular shaped in lateral view, the dorsal edge projecting caudally parallel to the lateral surface of the segment (Figs. 50, 53) or lateral abdominal projections of AB5-7 nearly indiscernible, projecting past the posterior margin of the segment minimally in lateral view (Figs. 58, 61) …….....….. 8

8 In dorsal view abdominal projections of AB1-7 well developed with the largest projections possessing a convex outer margin, appearing hook-shaped in dorsal view (Figs. 51, 54, 57); AB5-7 well defined, rugose and triangular shaped in lateral view, the dorsal edge projecting caudally parallel to the lateral surface of the segment (Figs. 50, 53), antennae with a distinctive medial yellow band (Figs. 56, 57) …… *P. proteus*

8′ In dorsal view lateral abdominal projections of AB1-7 less developed, outer margins of largest projections nearly straight (Figs. 59, 62, 66), lateral abdominal projections of AB5-7 nearly indiscernible, projecting past the posterior margin of the segment minimally in lateral view (Figs. 58, 61), antennae lacking distinctive yellow band (Figs. 64, 66) ….....…. *P. scotti* (in part)

Species Accounts and Material Examined

Pteronarcys biloba Newman, 1838

http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470669

(Figs. 13–17)

Remarks and Distribution. Previous descriptions of the larva of this species are adequate. The first description was provided by Smith (1917). Claassen (1931) later provided a more detailed description. This species can be reliably separated from other members of the genus based on the presence of the conspicuous abdominal projections on abdominal segments 1-8 (Figs. 13, 14), the lack of a prominent acute lateral projection on the mesothorax (Fig. 15), and the acute angle (APP > 55) of the anterior pronotal projection (Figs. 15, 17). The distribution of this species extends from Canadian Maritime Provinces south to Alabama (Nelson 2000).

Material examined. Canada, New Brunswick: Gloucester Co., Tobusintac River, off Hwy 8, 17 June 1993, 4♀, 4L, B.C. Kondratieff & R.W. Baumann (CSUIC); **Restigouche Co.**, Trout Brook, 5 June 1956, ♂, Exv., F.P. Ide & J.K. Malia (CNC); **Prince Edward Island: Prince Co.**, Mill River, Hwy 148 L. of Howlan, 19 June 1993, 2Exv, B.C. Kondratieff & R.W. Baumann (CSUIC); **USA, Georgia: Gilmer Co.,** Mountaintown Creek, State Hwy 2152, L 34.7500, W 85.5544, 9 February 2017, 4L, B.C. Kondratieff & C. Verdone (CSUIC); **New York: Albany Co.**, Catskill Creek, Rt. 145 nr. Cooksburgh, N 42.4183, W 74.2054, 21 May 2008, Exv, L. Myers, B.C. Kondratieff & R.W. Baumann (LCRI); **Cattaraugus Co.**, Connoisarauley Creek, East Otto Rd., Ashford, N 42.4247, W 78.6976, 24 June 2009, Exv, E.L. White (LCRI); **Clinton Co.**, Trib. to Canfield Brook, jct. Kennedy & Bart Merrill Rd.,

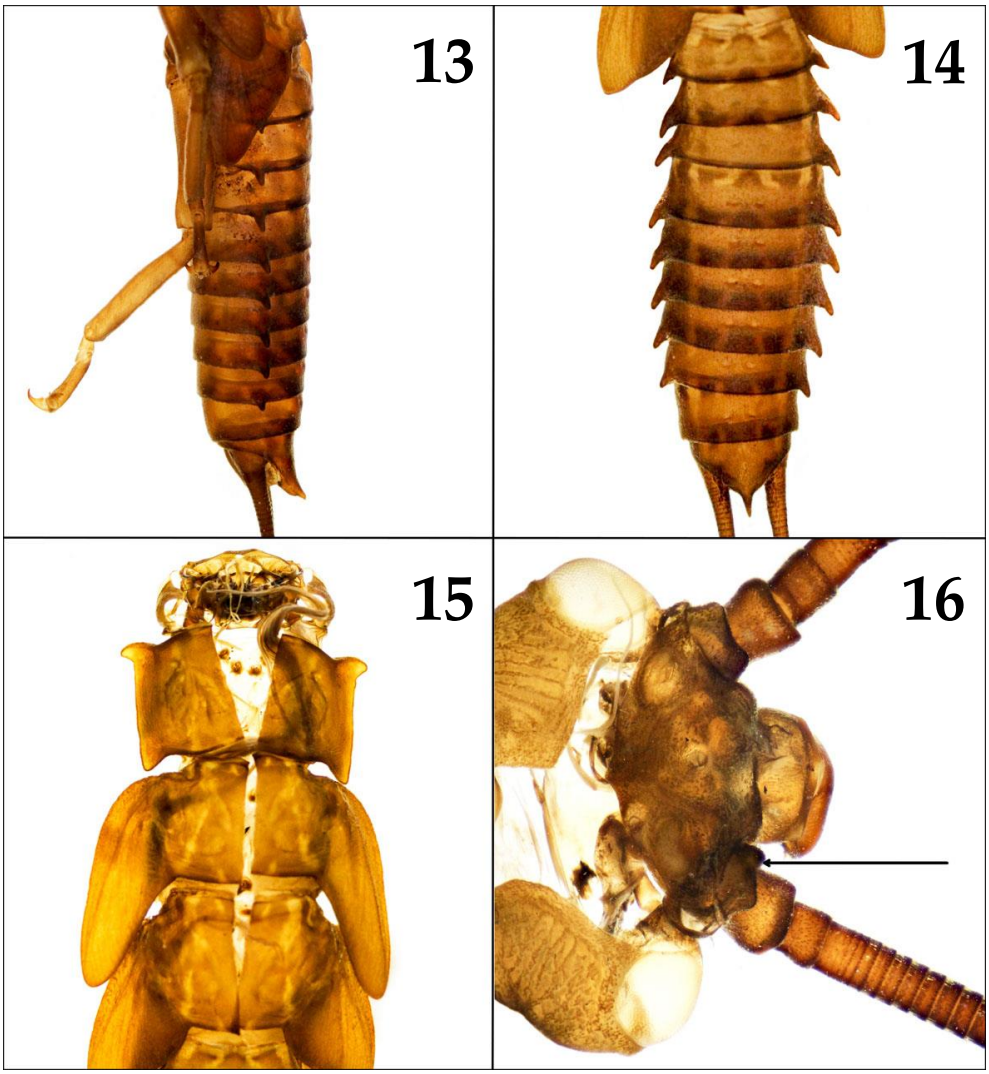

Fig. 13-16. *Pteronarcys biloba.* 13. Abdomen lateral view; New York: Franklin Co., N. B. Saranac River. 14. Abdomen dorsal view; New York: Franklin Co., N. B. Saranac River. 15. Head and Pronotum dorsal view; New York: Franklin Co., N. B. Saranac River. 16 Supra-antennal process dorsal view; New York: Franklin Co., N. B. Saranac River.

N 44.7216, W 73.6687, 14 March 2009, L, L. Myers (LCRI); True Brook, Bridge on True Brook Rd., N 44.6470, W 73.7990, 12 November 2009, L, C. Binggeli & A. Grooves (LCRI); **Essex Co.**, North Branch Boquet River, Moss Rd., Lewis, N 44.3144, W 73.5176, 6 April 2010, ♀, Exv, L. Myers, reared 25 April 2010 (LCRI); Roaring Brook, River Rd. nr. Lake Placid, N 44.1503, W 73.7674, 22 May 2007, ♂, Exv, L. Myers, reared 27 May 2007 (LCRI); West Branch Ausable River, Notch on Rt. 86 in Wilmington, 10 May 2006, ♀, Exv, L. Myers (LCRI); **Franklin Co.**, North Branch Saranac River, Loon Lake Rd., N 44.5392, W 74.0515, 31 May 2006, Exv, L. Myers, reared 27 May 2006 (LCRI); **Lewis Co.**, Indian River, Cemetery Rd. off Rt. 812, N 43.9753, W 75.3701, 5 June 2008, Exv, L. Myers & R. Mowrey (LCRI); Independence River, Pine Grove Rd. N 43.7301, W 75.3655, 5 June 2008, ♀, Exv, L. Myers & R. Mowrey (LCRI); **Saint Lawrence Co.**, Trib. to Little River, Rt. 3 nr. Star Lake, N 44.1905,

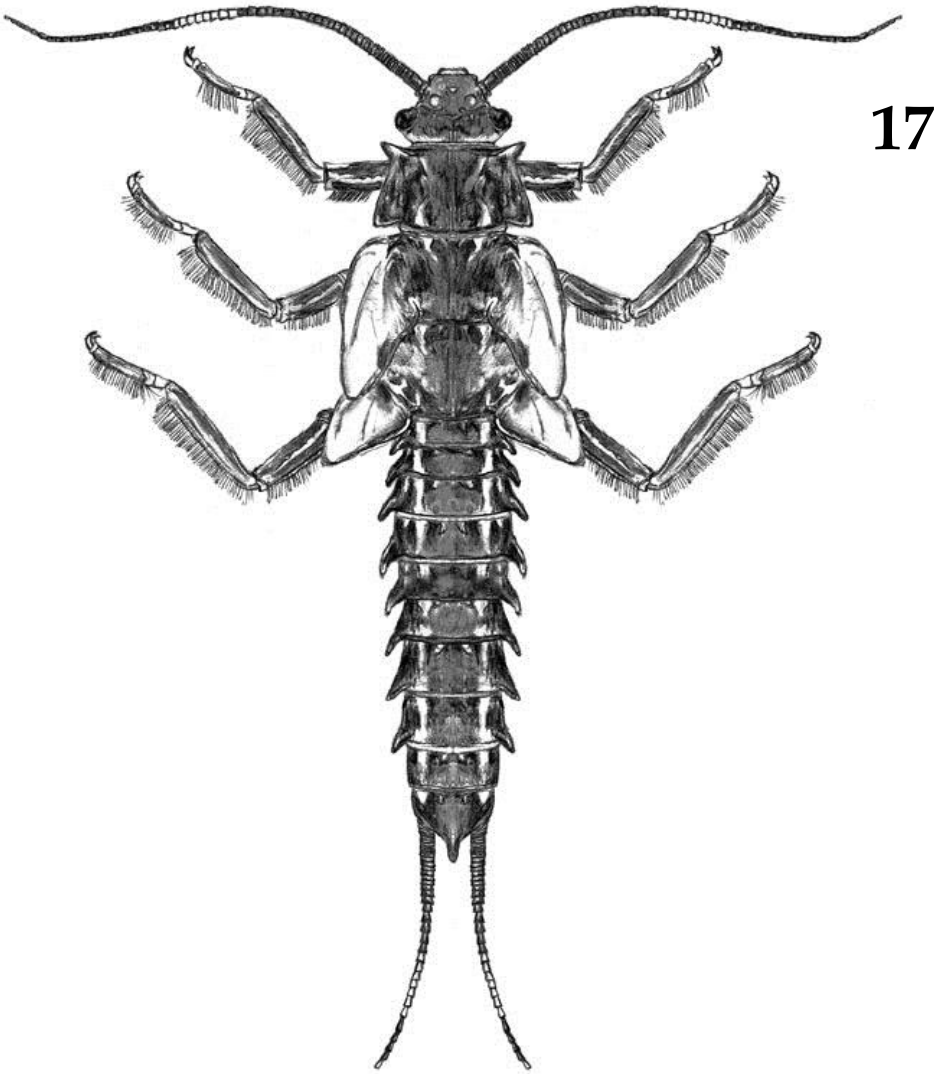

Fig. 17. *Pteronarcys biloba* - Larval habitus; New York: Clinton Co., Tributary to Canfield Brook.

W 75.0633, 2Exv, 5 June 2008, L. Myers & R. Mowrey (LCRI); **Warren Co.**, Hudson River, Glen Athol Rd., N 43.5786, W 73.8598, 30 June 2007, L, L. Myers & B.C. Kondratieff (LCRI); Vly Brook, Rt. 8 nr. Wevertown, N 43.6529, W 73.9228, 2 May 2008, ♂, Exv, L. Myers & R. Mowrey, reared 2 June 2008 (LCRI); **Tennessee**: **Carter Co.**, Doe River ca. 0.5 mi. below Roan Mountain State Park Welcome Center, 12 April 1998, ♂, Exv, D.A. & E.L. Etnier, reared 17 April 1998 (CSUIC); **West Virginia**: **Pocahontas Co.**, East Fork Greenbrier River, Forest Rd. 51 off Rt. 28, 26 April 1987, 3L, B.C. Kondratieff & R.F. Kirchner (CSUIC); **Randolph Co.**, Gandy Creek, Rt. 40, 15 May 1990, 2L, B.C. Kondratieff, J. Welch & R.F. Kirchner (CSUIC).

Pteronarcys californica **Newport, 1848**

http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470665

(Figs. 18–23)

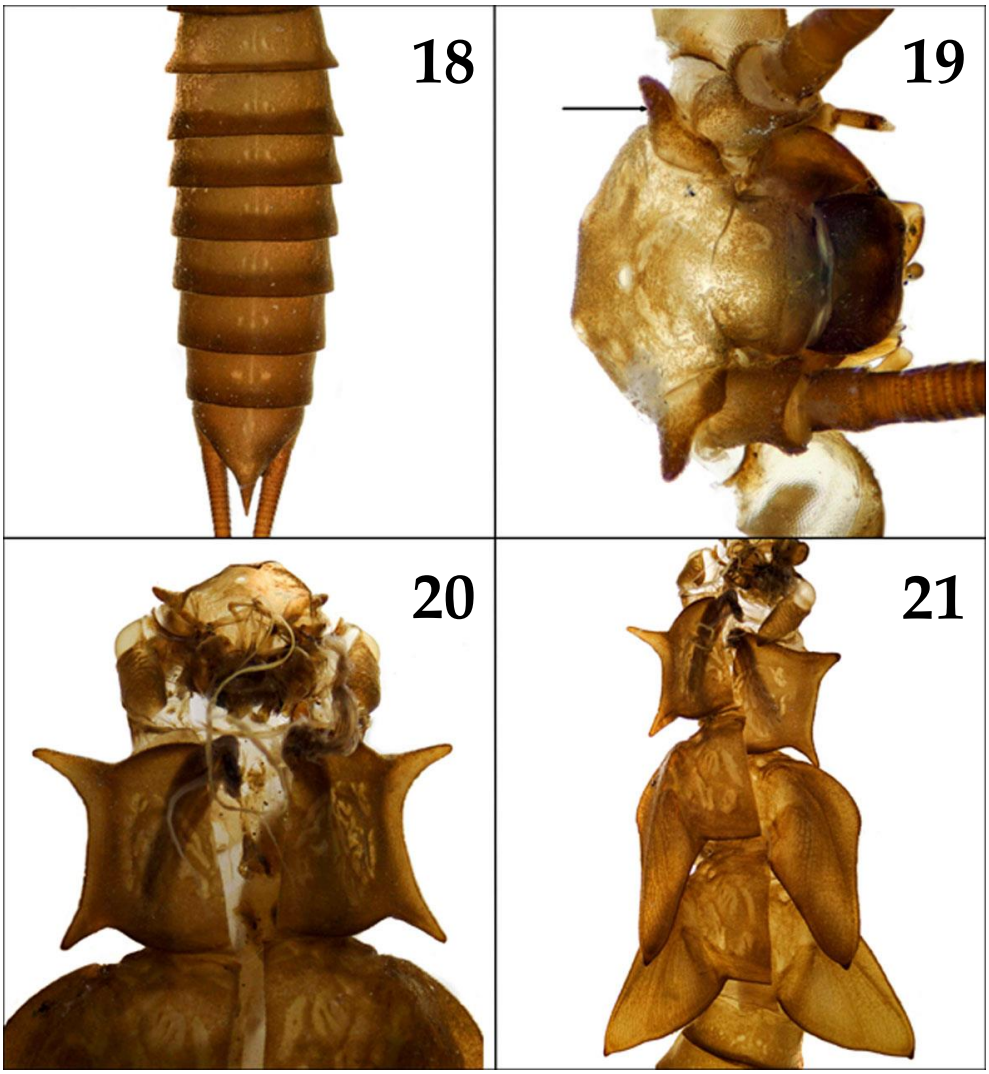

Fig. 18-21. *Pteronarcys californica* – 18. Abdomen dorsal; Colorado: Larimer Co., Poudre River. 19. Supra-antennal process dorsal view; Colorado: Larimer Co., Poudre River. 20. Head and pronotum dorsal view; Colorado: Larimer Co., Poudre River. 21. Head and thorax dorsal view; Colorado: Larimer Co., Poudre River.

Remarks and Distribution. Previous larval descriptions and illustrations are available for this species (Smith 1917, Claassen 1931, McCafferty 1981). It can be separated from larvae of other *Pteronarcys* based on the absence of lateral abdominal projections (Figs. 18, 23), well-developed, acutely pointed pronotal projections (Figs. 20, 23), pointed triangular wing pads (Figs. 21, 23), and a pointed, semi-lunate, conical supra-antennal process (Figs. 19, 22). This widespread and often abundant species is distributed throughout the Canadian Rockies from Alaska south to Arizona and west to the Coastal Ranges of far western North America (Jewett 1959, Baumann et al. 1977, Stewart & Oswood 2006).

Material Examined. Canada, British Columbia: Summerland, 12 May 1959, ♀, Exv, R.E. Leech (CNC); **USA, Colorado: Larimer Co.,** Big Thompson River, Viestenz Smith Park, 9 June 2005, ♀, 3Exv, R. Thorp (CSUIC); Big Thompson River, 1 mile N Drake, 7 October 2005, 3L, L. Myers (LCRI); Poudre River, Fort Collins, Lyons Park, 22 May 1987, ♀, Exv,

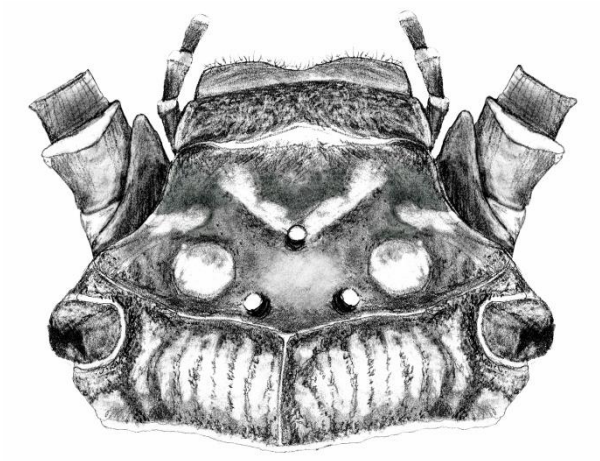

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Fig. 22. *Pteronarcys californica.* Supra-antennal process; Colorado, Grand Co., Colorado River.

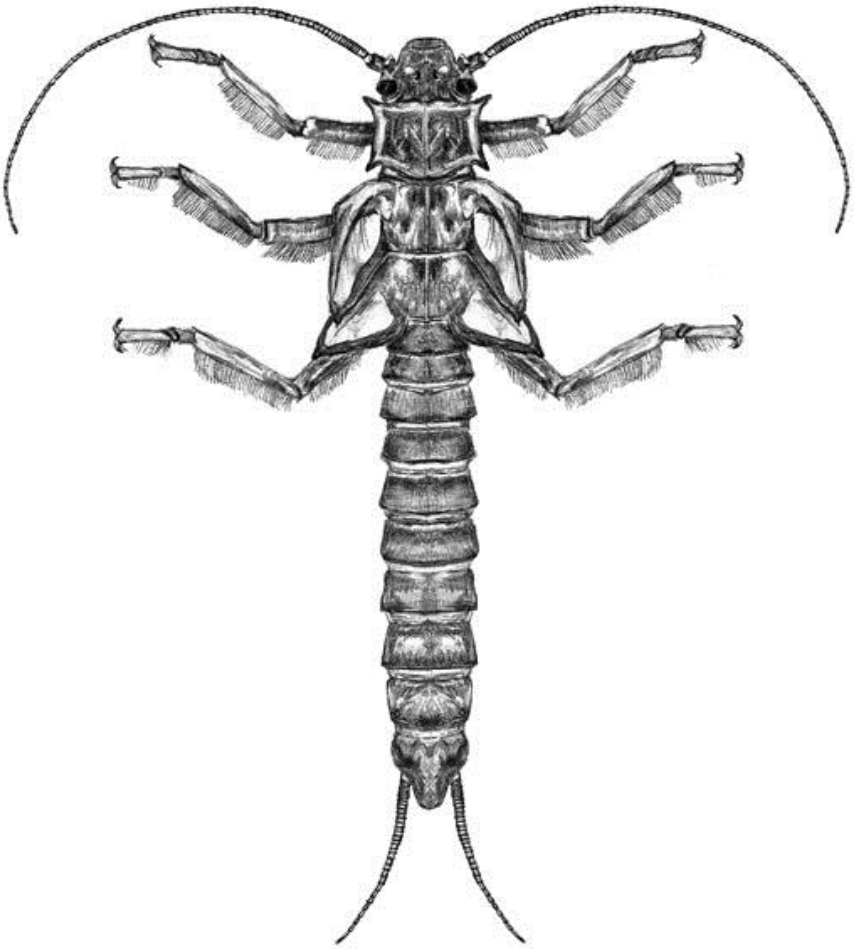

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Fig. 23. *Pteronarcys californica.* Larval habitus; Colorado, Grand Co., Colorado River.

B.C. Kondratieff (CSUIC); **Grand Co.**, Colorado River, US 40 below Byers Canyon, 4L, 28 April 2010, B. Heinold (CSUIC); **Oregon: Clackamas Co.**, Salmon River, submerged wood, 1 mi. W of Zig Zag, 27 December 1995, L, R. Durfee (CSUIC).

***Pteronarcys comstocki* Smith, 1917**
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470670
(Figs. 24–27)

Remarks and Distribution. This is the most infrequently encountered member of this genus. Scattered records are available from New Brunswick, Maine, New York, Pennsylvania, Virginia, West Virginia, and Kentucky (Nelson 2000). Larvae of *P. comstocki* are easily separated based on the well-developed curved abdominal projections on AB1-8 (Fig. 25), pointed, semi-lunate supra-antennal process (Fig. 26), acute, well developed pronotal projections, and the presence of

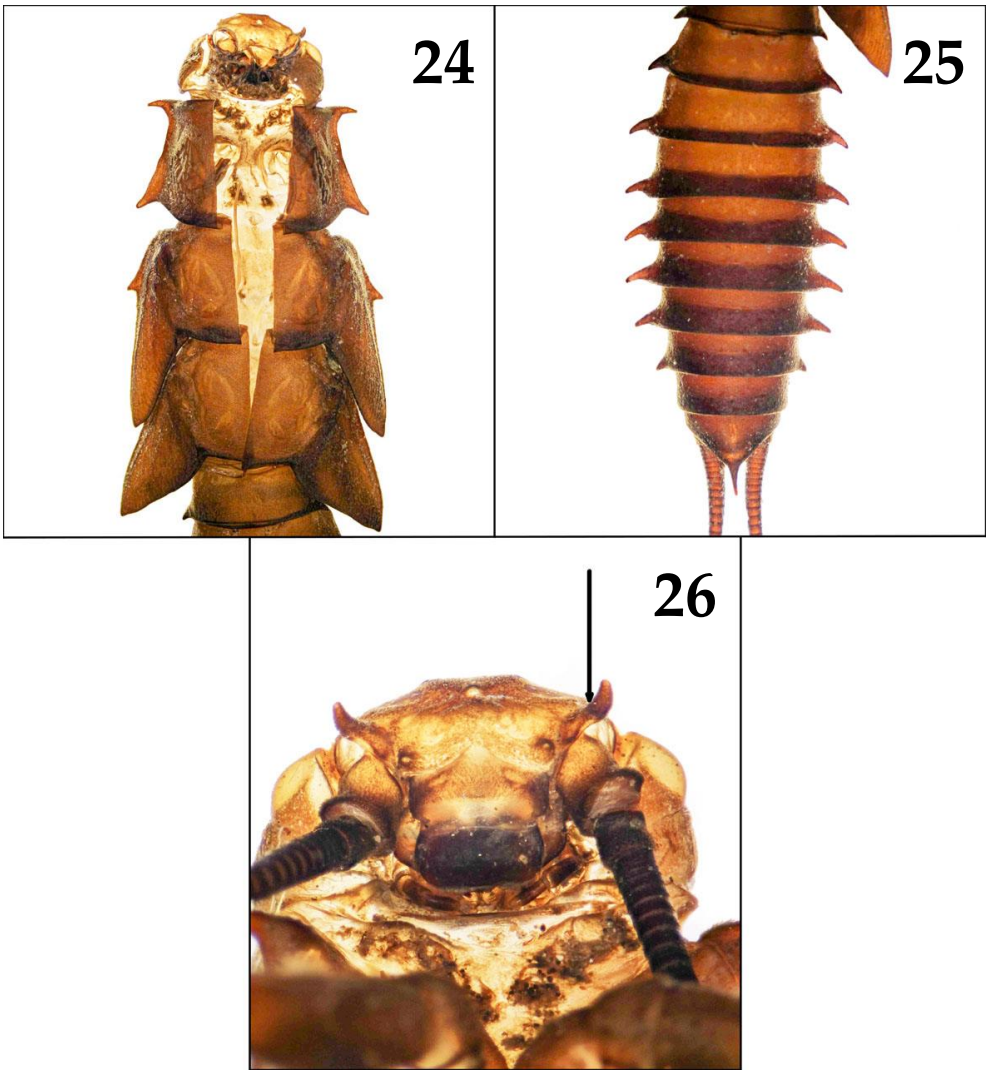

Fig. 24-26. *Pteronarcys comstocki.* 24. Pronotum and thorax dorsal view; New York: Essex Co., Tributary of Ausable River. 25. Abdomen dorsal view; New York: Essex Co., Tributary of Ausable River. 26. Supra-antennal process; New York: Essex Co., Tributary of Ausable River.

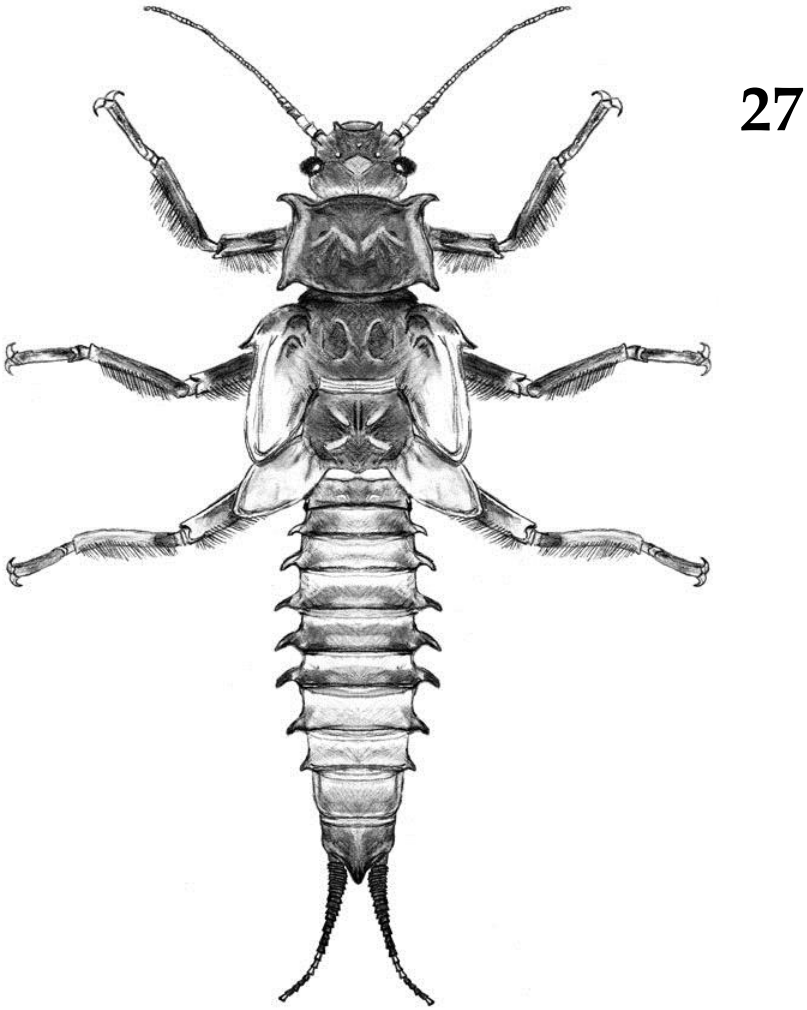

Fig. 27. *Pteronarcys comstocki.* Larval habitus; Virginia: Highland Co., Back Creek.

a sharply pointed process on the mesothorax (Fig. 24, Fig. 27).

Material Examined. USA, New York: Essex Co., Boquet River, Rt. 9N South of Elizabethtown, N 44.2125, W 73.5839, 23 May 2008, 2Exv, L. Myers, B.C. Kondratieff & R.W. Baumann (LCRI); East Branch Ausable River, Andrus Rd. Upper Jay, N 44.3139, W 73.7856, 25 June 2008, Exv, L. Myers (CSUIC); East Branch Ausable River, Rt. 9 Ausable Forks, N 44.4379, W 73.6795, 8 April 2015, 3L, L. Myers (LCRI); Keene NY, Tributary of Sable River, 20 June 1941, Exv, T.H. Frison & H.H. Ross (CNC); **Vermont: Windsor Co.,** White River, Crossing Rt. 100 S. Quarry Hill Rd., N 43.8976, W 72.8217, 2 April 2014, L, L. Myers (LCRI); **Virginia**: **Highland Co.**, Back Creek, CR 600/603 Bridge, 29 December 1981, ♂, ♀, 2Exv, reared 4 April 1982, B.C. Kondratieff & R.F. Kirchner (CSUIC).

***Pteronarcys dorsata* (Say, 1823)**

http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470662

(Figs. 28–36)

Remarks and Distribution. The geographical range of this widespread species extends from eastern North America south to Florida and Louisiana and across Canada to Alaska (Earle 2009, Nelson 2000,

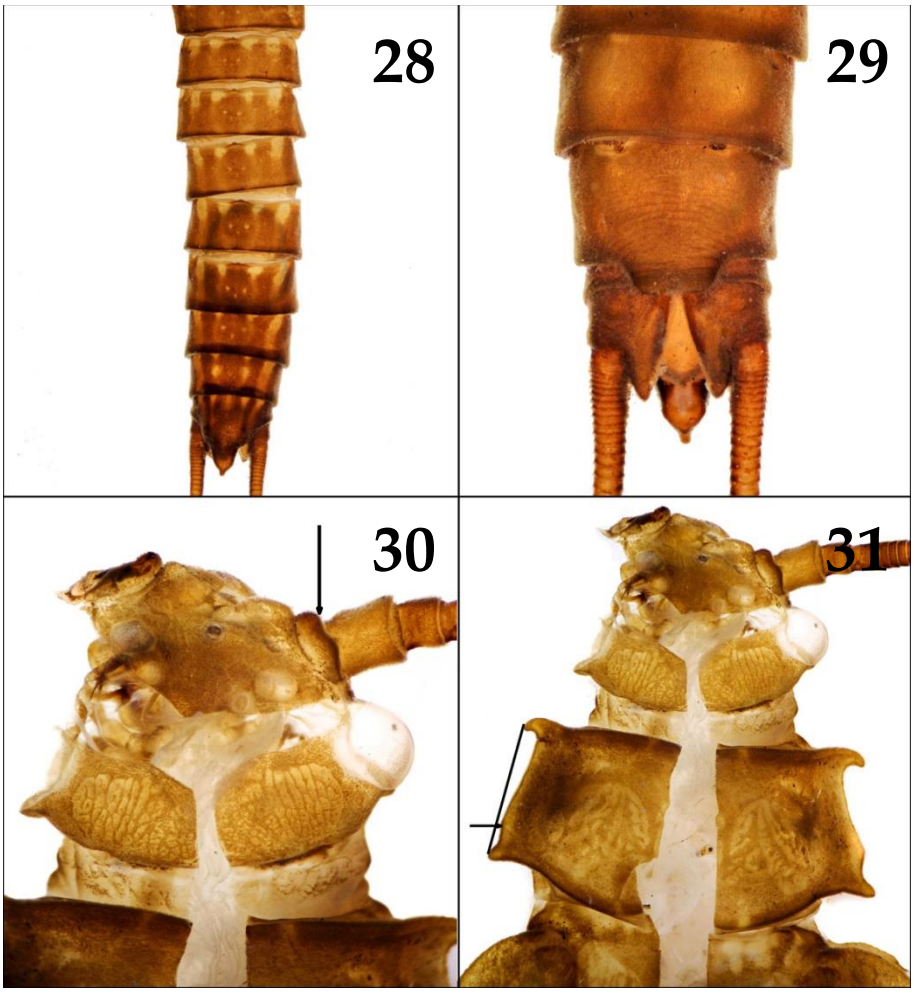

Fig. 28-31. *Pteronarcys dorsata.* 28. Abdomen dorsal view; Michigan: Otsego Co., West Branch Sturgeon River. 29. Ventral view of process on AB 9 of male; Michigan: Otsego Co., West Branch Sturgeon River. 30. Supra-antennal process; Michigan: Otsego Co., West Branch Sturgeon River. 31. Pronotum dorsal view; Michigan: Otsego Co., West Branch Sturgeon River.

Stewart & Oswood 2006). Mature larvae of this species can be separated from others based on the lack of abdominal projections (Figs. 28, 36), supra-antennal plate developed into a semi-circular ridge (Fig. 30), the presence of a convex lateral bulge on the pronotum that often exceeds the level of pronotal projections (Figs. 32, 36), and a broadly rectangular process on sternum 9 of male larvae, the resulting angle=33.11 ± 5.16 (Figs. 29, 35).

Material Examined. Canada, Alberta: Wood Buffalo Co., McMurray, 1 June 1953, 2♀, Exv, S.E. Ball (CNC); **Northwest Territories:** Johnny Hoe River, 2 August 1971, L, J.F. Flanagan (CNC); Trail River, NWT, 19 September 1971, L, FWI pipeline project (CNC); Hearne Channel, Great Slave Lake, 18-20 July 1947, Exv, W.E. Ricker (CNC); Source of Mackenzie River, Great Slave Lake, Mackenzie Canada, 31 July 1965, 2♀, Exv, W.E. Ricker (CNC); **Quebec:** River Malian, 1968, L (CNC); Lac Aigneau, 4 July 1955, 7N, W.E. Ricker (CNC); **USA, Michigan: Benzie Co.**, Platte River: Honor at Zimmerman Rd., N 44.6602, W 86.0186, 26 March 2011, ♀, Exv, R.E. DeWalt & M. Pessino, reared 17 May 2011 (INHS); **Charlevoix Co.,** North Branch Boyne River: 1.4 km

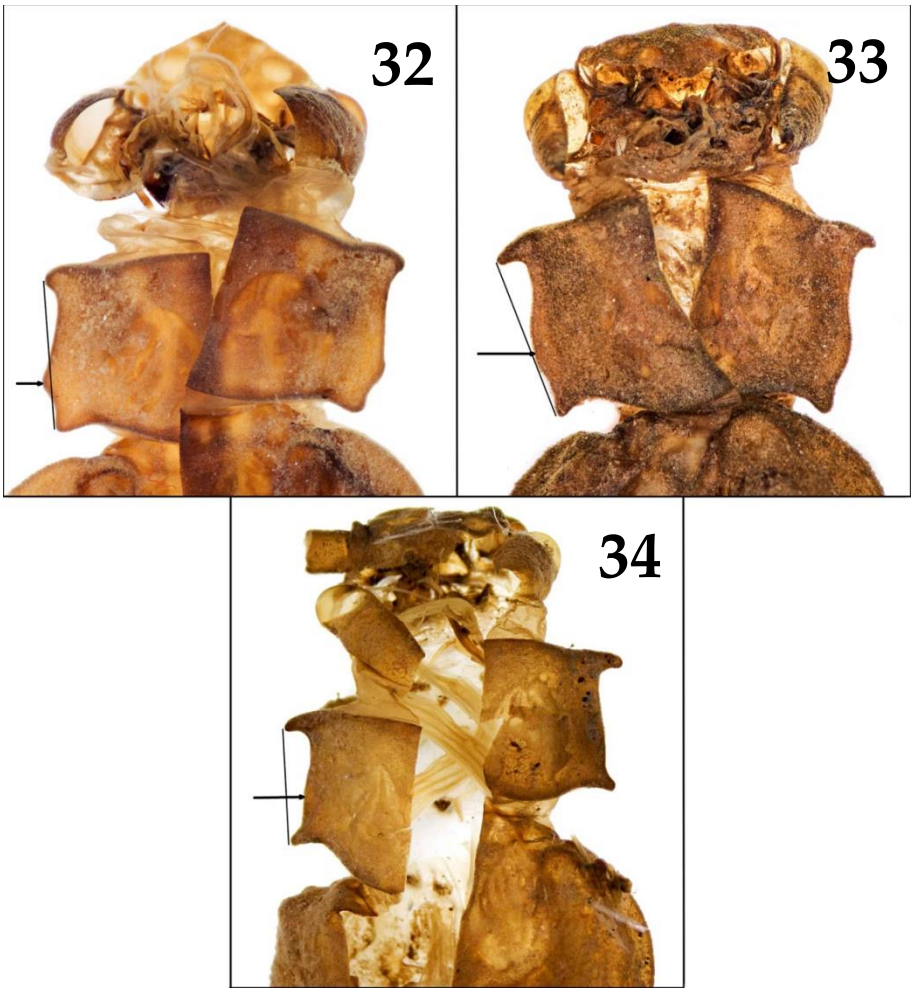

Fig 32-34. *Pteronarcys dorsata.* 32. Pronotum dorsal view; Virginia: Montgomery Co., Little River. 33. Pronotum dorsal view; New York: Sullivan Co., Delaware River. 34. Pronotum dorsal view; Canada: Northwest Territories, Source of Mackenzie River, Great Slave Lake.

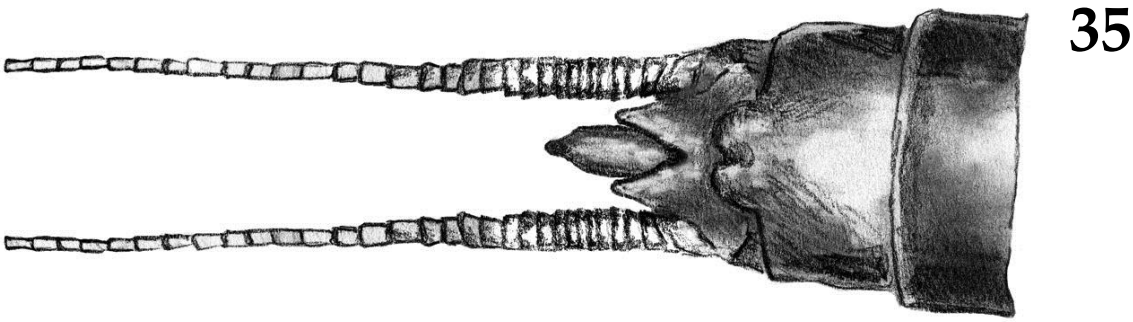

Fig. 35. *Pteronarcys dorsata.* Process of male sternum 9; Mississippi: Simpson Co., Westville Creek.

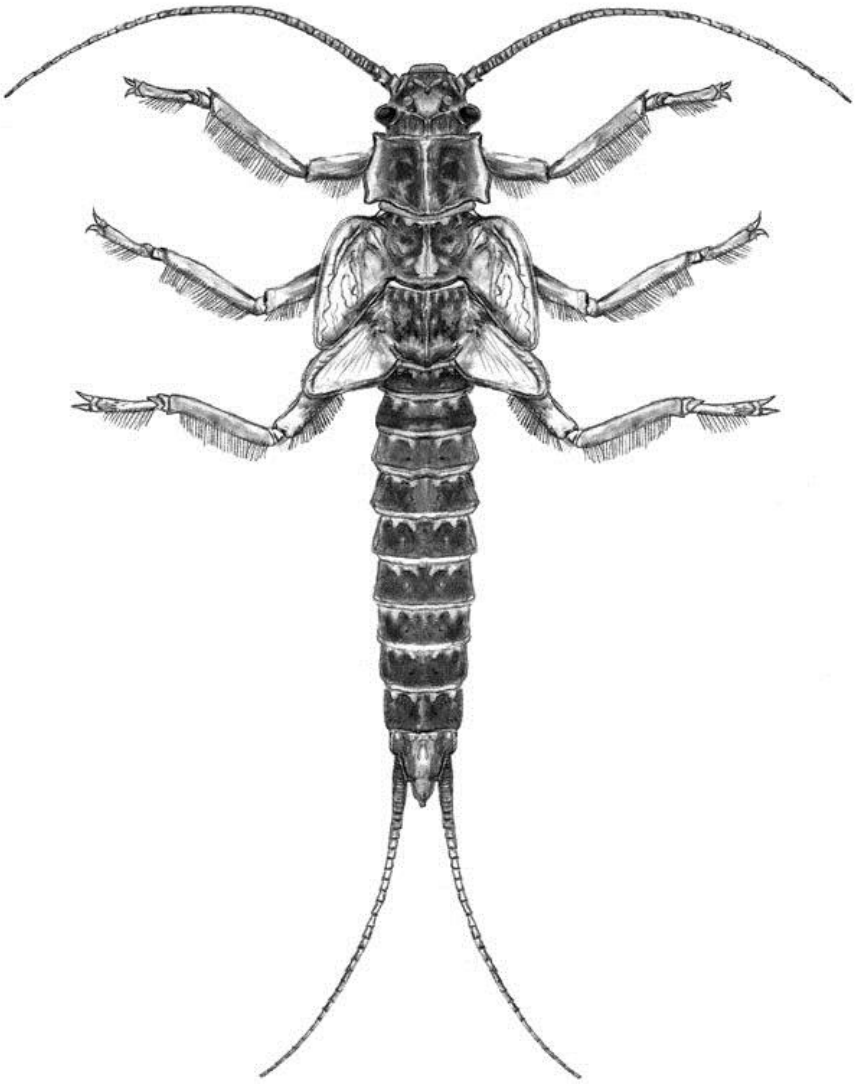

Fig. 36. *Pteronarcys dorsata.* Larval habitus; Mississippi: Simpson Co., Westville Creek.

N Boyne Falls at US 131, N 45.1802, W 84.9141, 25 March 2011, ♂, Exv, R.E. DeWalt & M. Pessino, reared 20 April 2011 (INHS); Jordan's River, 2 km S East Jordan at Rogers Rd., N 45.1325 W 85.1240, 25 March 2011, ♀, Exv R.E. DeWalt & M. Pessino, reared 6 May 2011 (INHS); **Mason Co.**, Big Sable River, 2 km NNW Free-soil at Custer Rd., N 44.1897, W 86.2210, 26 March 2011, ♀, Exv, R.E. DeWalt & M. Pessino (INHS); Same as previous, ♀, Exv, R.E. DeWalt & M. Pessino, reared 19 May 2011 (INHS); **Osceola Co.,** Pine River, 2.5 km NE Deguts at Norman Rd., N 44.0634, W 85.5482, 26 March 2011, ♀, Exv, R.E. DeWalt & M. Pessino, reared 16 May 2011 (INHS); Same as previous, ♂, Exv (INHS); **Otsego Co.,** West Branch Sturgeon River, 5.5 km NNW Vanderbilt at Thumb Lake Rd., N 45.1859 W 84.6976, 25 March 2011, ♂, Exv, R.E. DeWalt & M. Pessino, reared 4 May 2011 (INHS); **Minnesota: Cook Co.,** Cascade River, 13 km W Grand Marias at CR-45, N 47.74667, W 90.5255, 4 March 2012, ♀, Exv, R.E. DeWalt & M. Pessino, reared 24 April 2011, (INHS); **Mississippi: Simpson Co.,** Westville

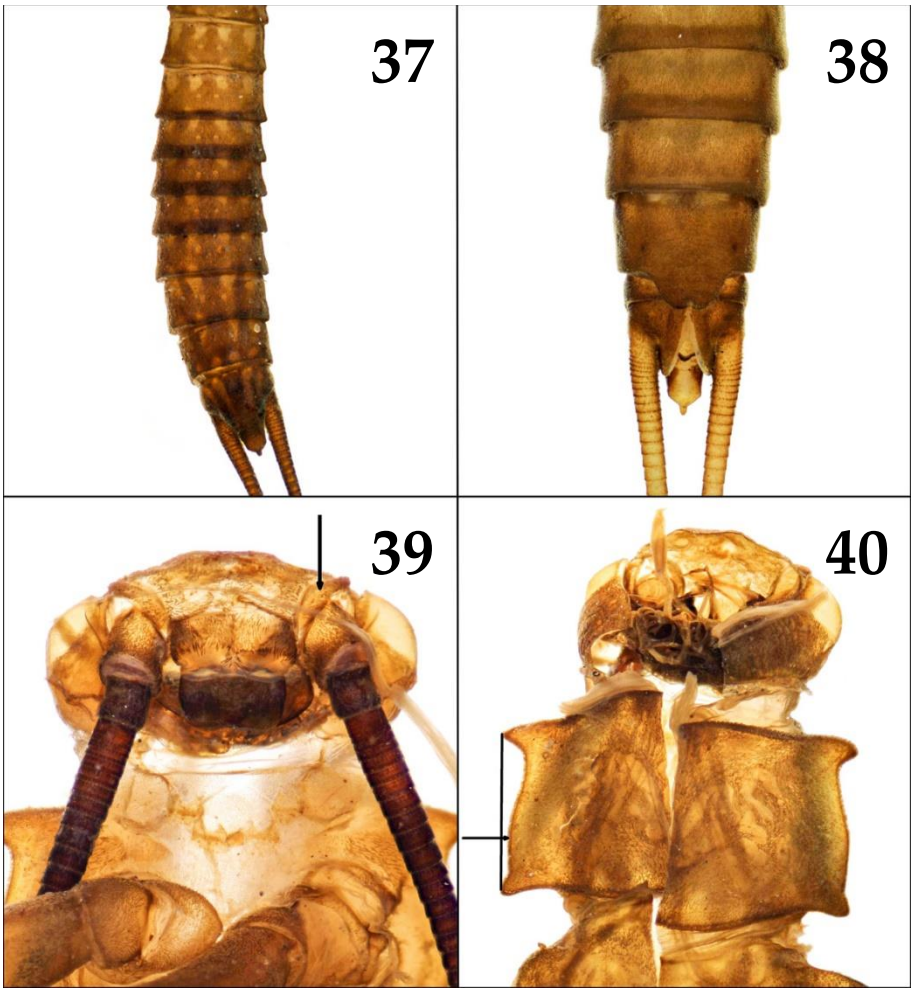

Fig. 37-40. *Pteronarcys pictetii.* 37. Abdomen dorsal view; Nebraska: Hall Co., Platte River. 38. Abdomen ventral view; Wisconsin: Dunn Co., Red Cedar River. 39. Supra-antennal process; Nebraska: Hall Co., Platte River. 40. Pronotum dorsal view; Nebraska: Hall Co., Platte River.

Creek, 21 January 1999, L, B. Stark (BPSC); Mill Creek, Hwy 472, 16 February 1979, 2L , B. Stark (BPSC); Same data as previous, 25 January 1993, 2L, B. Stark (BPSC); Westville Creek, Pinole, 12 February 1998, L, J. Wise (BPSC); **New York**: **Sullivan Co.,** Delaware River, Rt. 55, Berryville, Highland, N 41.4764 W 74.9129, 28 May 2009, Exv, E. White, P. Novak & G. Kenney (LCRI); **Virginia: Greene Co.,** Rapidan River, Ruckersville, 21 March 1940, ♀, Exv, Frison, Mohr, & Hawkins (CNC); **Montgomery Co.,** Little River, Rt. 787, 8 November 1980, 6♂, 4♀, 6L, 22Exv, B.C. Kondratieff (CSUIC).

***Pteronarcys pictetii* Hagen, 1873**

http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470663

(Figs. 37–44)

Remarks and Distribution. This species mostly occurs in the upper Midwest, however scattered records are available from Pennsylvania west to Nebraska and Colorado south to Arkansas and Kentucky (Nelson 2000, Zuellig et al. 2006). Mature larvae of this species can be separated from the closely related *P. dorsata* by the presence of a convex lateral bulge that does not exceed the level of the

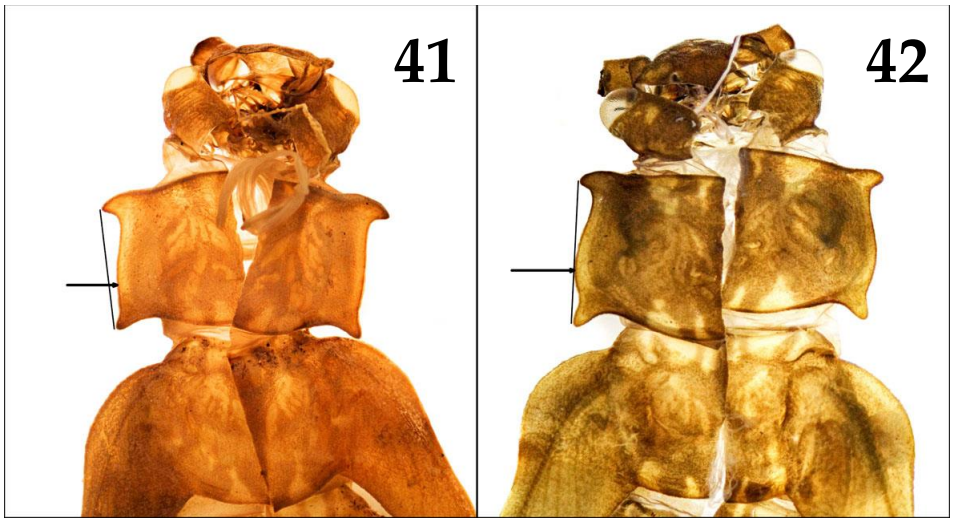

Fig. 41-42. *Pteronarcys pictetii.* 41. Pronotum dorsal view; Nebraska: Red Willow Co., Republican River. 42. Pronotum dorsal view, Wisconsin: Dunn Co., Red Cedar River.

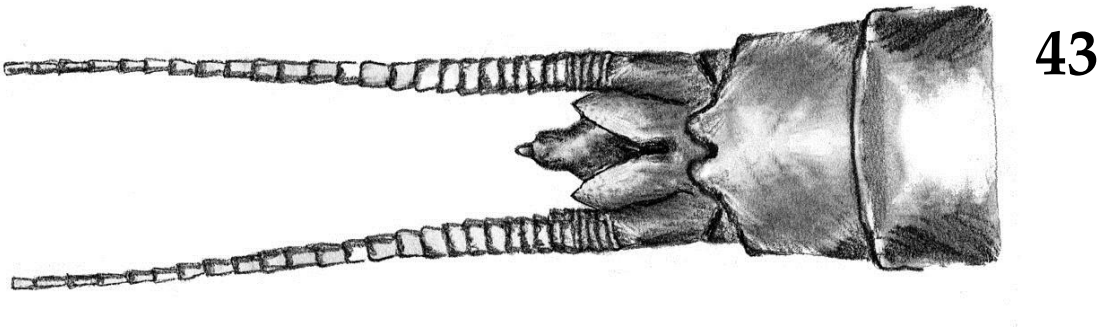

Fig. 43. *Pteronarcys pictetii*. Process of male sternum 9; Nebraska, Deuel Co., South Platte River.

pronotal projections (Figs. 40, 41, 44) and the approximate triangular shape of the rearward projecting process on sternum 9 of male larvae, the resulting angle=63.91 ± 13.16 (Figs. 38, 43).

Material Examined. USA, Colorado: **Sedgwick Co.,** South Platte River, Julesburg, N 40.9542, W 102.3872, 7 March 2008, 2L, B. Heinold & E. Peachey (CSUIC); **Nebraska: Cherry Co.**, Niobrara River, Rt. 83, 9 April 1996, 2L, B.C. Kondratieff & R.W. Baumann (CSUIC); **Deuel Co.**, South Platte River, Big Springs, Hwy 38, N 41.3889, W 102.0750, 7 March 2008, ♀, 3L, Exv, B. Heinold & E. Peachey (CSUIC); **Hall Co.**, Platte River, Grand Island, Mormon State Park, 10 April 1996, ♂, ♀, 2Exv, B.C. Kondratieff & R.W. Baumann, reared 20 April 1996 (CSUIC); **Hayes Co.**, Frenchman River, Rt. 6 W of Hamlet, 19 February 1994, 2♂, 2Exv, reared 26 March 1994, B.C. Kondratieff & H. Rhodes (CSUIC); Same as previous, ♂, ♀, 2Exv (CSUIC); **Red Willow Co.**, Republican River, 1 mi. S of Perry, 19 February 1994, ♂, Exv, reared 26 March 1994, B.C. Kondratieff & H. Rhodes (CSUIC); Same data as previous, ♂, ♀,

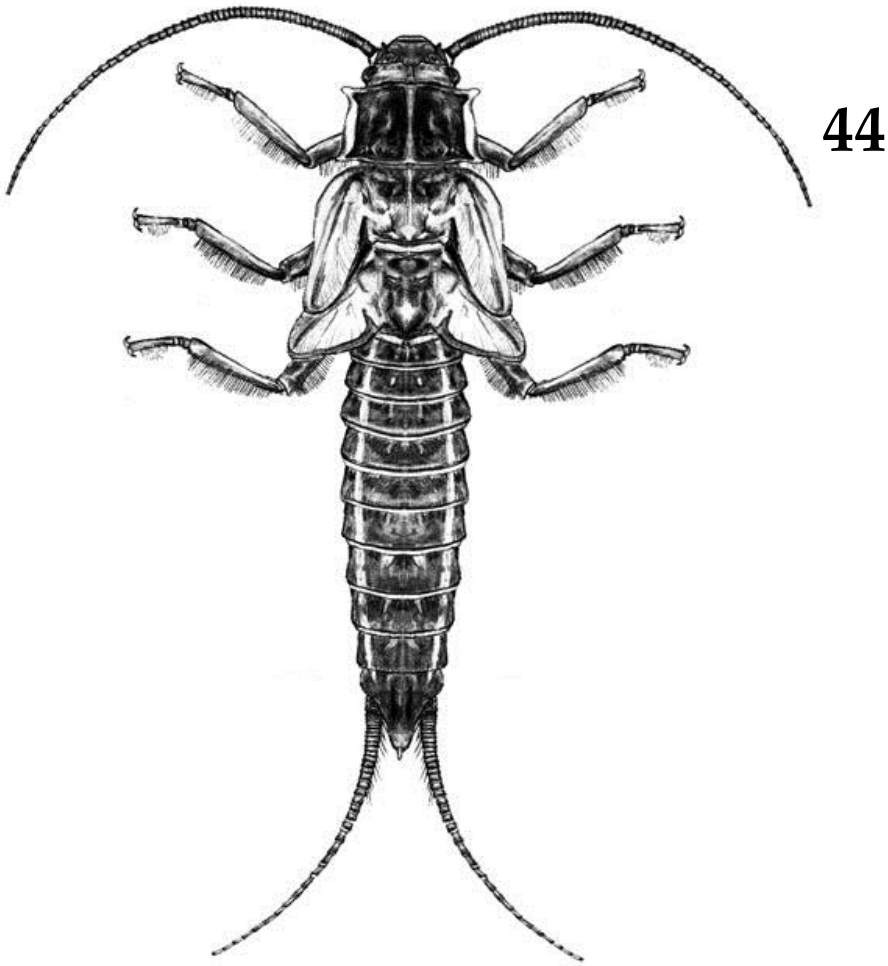

Fig. 44. *Pteronarcys pictetii.* Larval habitus; Nebraska: Deuel Co., South Platte River.

Exv, reared 28 March 1994 (CSUIC); **Thomas Co.**, Dismal River, Rt. 83, 9 April 1996, ♂, ♀, L, 2Exv, B.C. Kondratieff & R.W. Baumann (CSUIC); Middle Loup River, Jct. Rts. 2 and 83, 9 April 1996, ♂, Exv, B.C. Kondratieff & R.W. Baumann (CSUIC); **Wisconsin: Dunn Co.,** Red Cedar River, Sand Creek at CR-V, N 45.1683, W 91.6874, 21 March 2011, ♂, Exv, R.E. DeWalt & M. Pessino, reared 6 May 2011 (INHS); Same as previous, ♂, Exv, reared 9 May 2011 (INHS).

***Pteronarcys princeps* Banks, 1907**

http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470666

(Figs. 45–49)

Remarks and Distribution. This species is common in the Pacific Northwest with scattered reports from British Columbia, Idaho, Nevada, and Utah (Jewett 1959, Baumann et al. 1977, Stewart & Oswood 2006). It is sympatric with *P. californica,* but can be differentiated by the anterolateral orientation of the APP (Figs. 47, 49) and the semi-circular ridge shaped supra-antennal plate (Figs. 46, 48).

Material Examined. Canada, British Columbia: Cultus Lake, 13 March 1937, 3L, W.E. Ricker (CNC); Hatchery Creek, Cultus Lake BC, 7 May 1937, ♀, Exv, W.E. Ricker (CNC). **USA, California: Butte Co.**, Butte Creek, Humboldt Rd., above Colby Creek, N 40.1138 W 121.4952, 25 May 2014, 2♂, 3L,

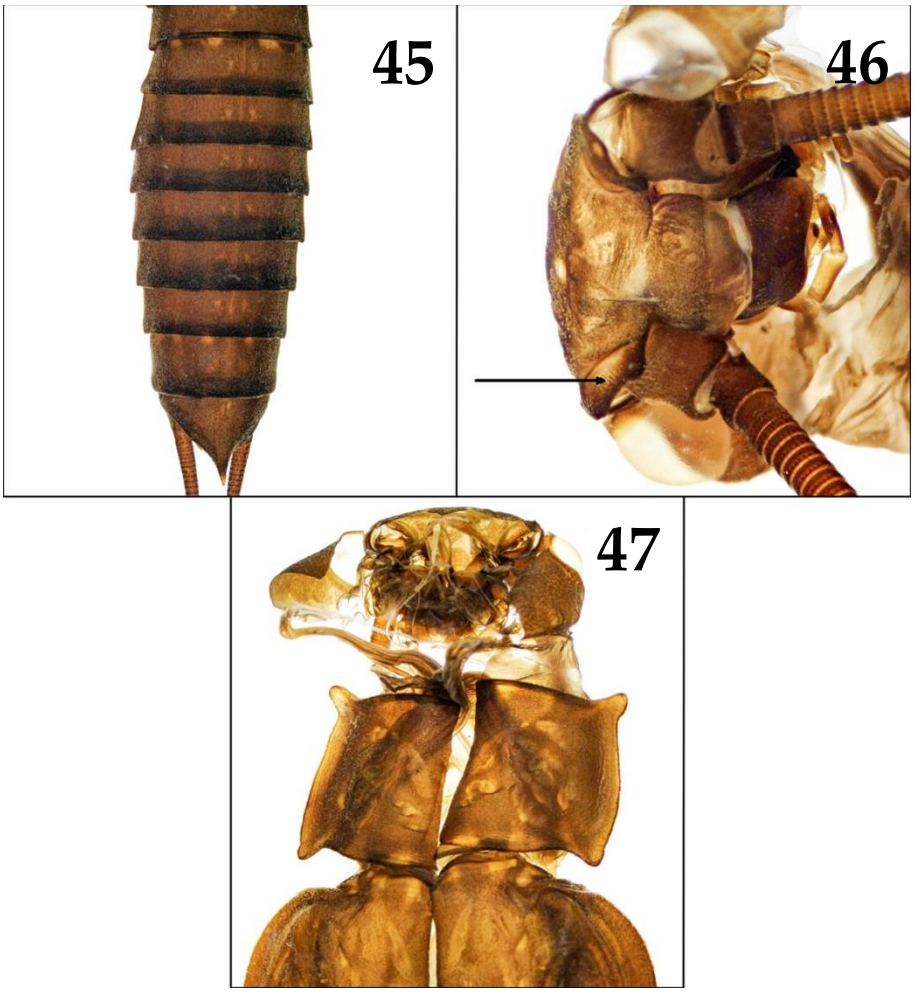

Fig. 45-47. *Pteronarcys princeps.* 45. Abdomen dorsal view; California: Butte Co., Butte Creek. 46. Supra-antennal process; California: Butte Co., Butte Creek. 47. Head and pronotum dorsal view; California: Butte Co., Butte Creek.

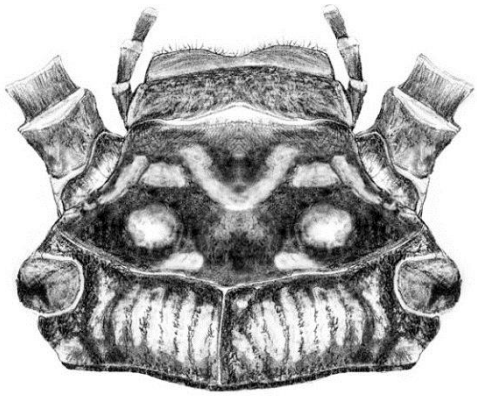

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Fig. 48. *Pteronarcys princeps.* Supra-antennal process; California: Siskiyou Co., Big Springs Creek.

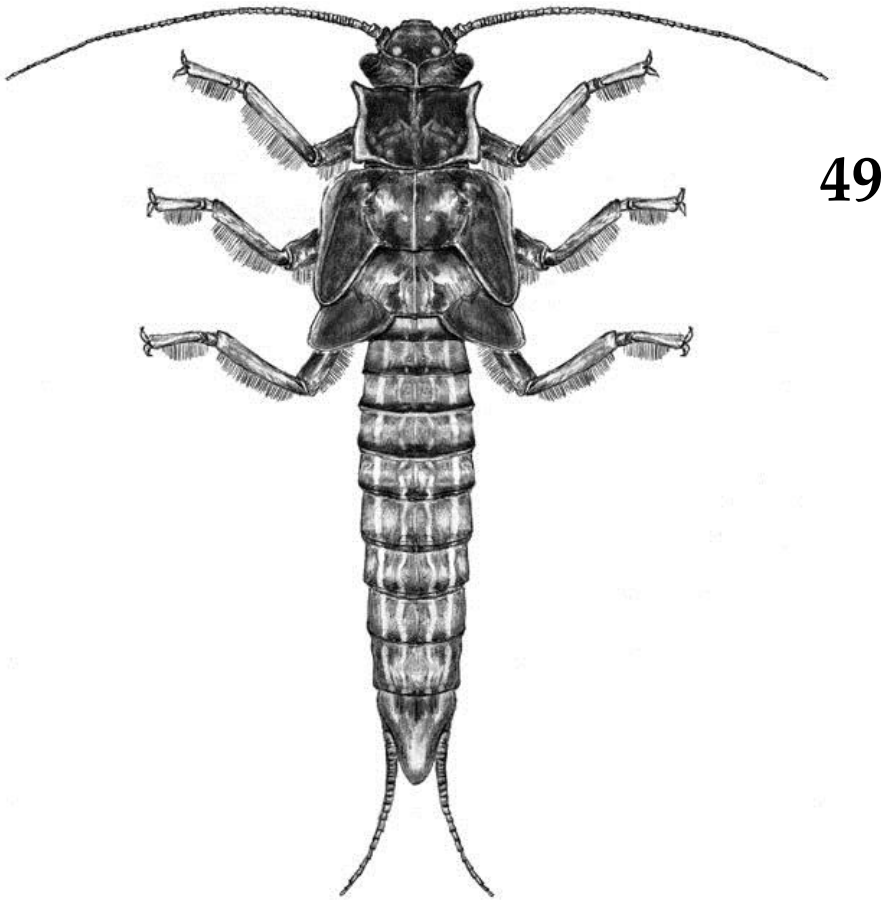

Fig. 49. *Pteronarcys princeps* - Larval habitus; California: Siskiyou Co., Big Springs Creek.

B.C. Kondratieff & C. Verdone (CSUIC); Butte Creek, Humboldt Rd. NW of Butte Meadows, N 40.0016, W 121.5364, 25 May 2014, 4♂, Exv, B.C. Kondratieff & C. Verdone (CSUIC); **Nevada Co.**, Rock Creek, North Bloomfield Rd., N 39.3024, W 120.9785, 24 May 2014, 4♀, Exv, B.C. Kondratieff & C. Verdone (CSUIC); **Siskiyou Co.**, Big Springs Creek, Mt. Shasta City Park, N 41.3281, W 122.3269, 23 May 2014, 6♂, 2♀, 2L, Exv, B.C. Kondratieff & C. Verdone (CSUIC); **Oregon: Clackamas Co.**, Salmon River, submerged wood, 1 mi. W of Zig Zag, 27 December 1995, L, R. Durfee (CSUIC).

***Pteronarcys proteus* Newman, 1838**
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470671
(Figs. 50–57)

Remarks and Distribution. This species ranges from Quebec south along the Appalachians to West Virginia and Kentucky (Nelson 2000). Larvae of this species are most similar to *P. scotti* but can be distinguished by the spines on the abdominal segments. In *P. proteus*, spines of AB 1-7 are well developed with the largest projections possessing a convex outer margin and appearing hook-shaped in dorsal view (Figs. 51, 54, 57). When viewed laterally, the spines of AB5-7 are well defined, rugose, triangular shaped projections, the dorsal edge projecting caudally, parallel to the lateral surface of the segment (Figs. 50, 53). Measured in dorsal view AB-4 POM/SW ≥ 0.15; AB-6 POM/SW > 0.12 (Care should be used in the use of these ratios due to marginal overlap in observed measurements with

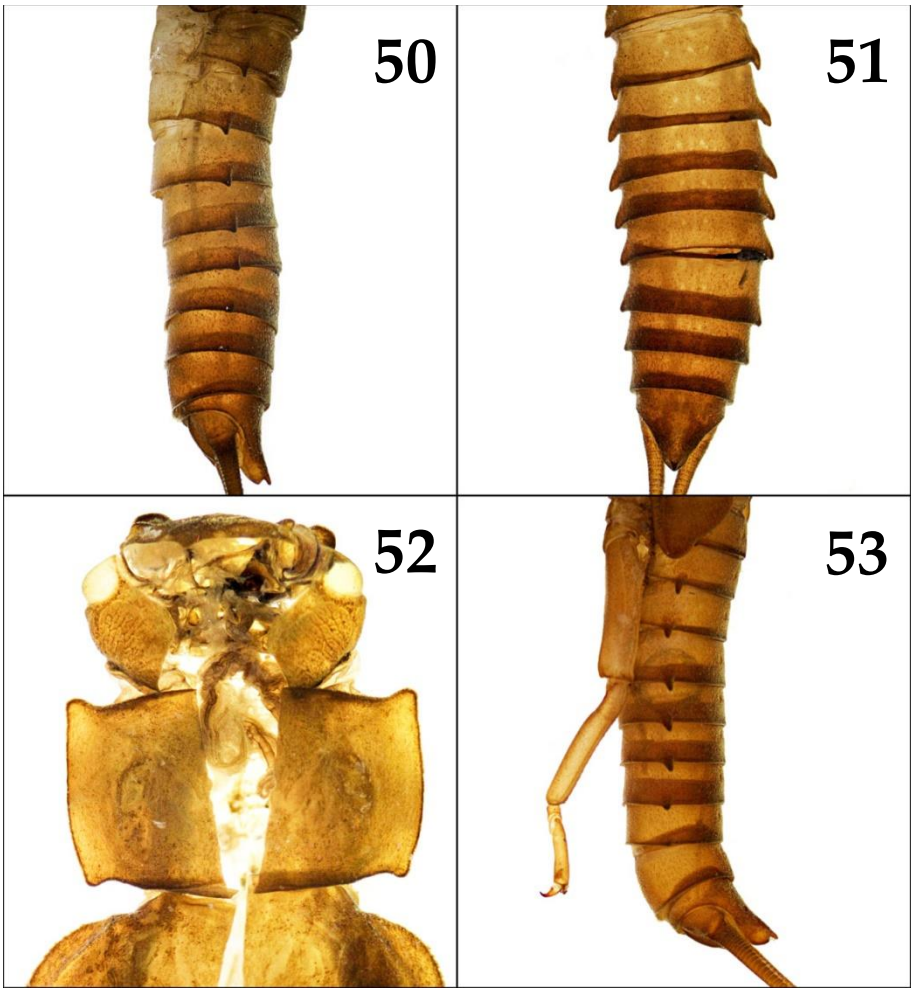

Fig. 50-53. *Pteronarcys proteus.* 50. Abdomen lateral view; New York: Essex Co., Roaring Brook. 51. Abdomen dorsal view; New York: Essex Co., Roaring Brook. 52. Head and pronotum dorsal view; New York: Essex Co., Roaring Brook. 53. Abdomen lateral view; Virginia: Botetourt Co., Bear Wallow Creek.

P. scotti) (Figs. 10, 51, 54). Live and recently preserved specimens also possesses a distinctive median yellow antennal band that is absent in *P. scotti* (Figs. 56, 57).

Material Examined. USA, Massachusetts: Berkshire Co., Wright Brook, Falls Rd. nr. NY border, N 42.1084, W 73.4807, 4 May 2013, L, L. Myers (LCRI); **New York: Cattaraugus Co.**, small stream, Limestone Run Rd., 0.3 mi. S Ridge Run Rd., N 42.0270, W 78.7010, 11 February 2012, ♀, Exv, L. Myers & B.C. Kondratieff, reared 16 April 2012 (LCRI); **Columbia Co.,** Tributary Green River, SE Austerlitz at Harvey Mountain Rd., N 42.3063, W 73.4667, 26 May 2011, ♀, Exv, R.E. DeWalt & M. Pessino, reared 16 May 2011 (INHS); **Delaware Co.**, Spring-fed trib. to Emory Brook, Rt. 28 Fleischmanns, N 42.1511, W 74.5224, 27 May 2009, ♂, Exv, L. Myers & B.C. Kondratieff, reared 10 June 2009 (LCRI); **Essex Co.**, Cold Brook, Rt. 9, S. Poke-O-Moonshine, N 44.3869, W 73.5081, 6 April 2010, ♂, Exv, L. Myers, reared, 25 May 2010 (LCRI); Cold River, High Peaks Wilderness Area, N 44.0886, W 74.2653, 11 May, 2006, ♀, Exv, L. Myers (LCRI); Pettigrew Brook, Bonnieview Rd. nr. Wilmington, N 44.4302, W 73.8003, 15 March 2006, 3L, L. Myers & R. Younghanz (LCRI); Roaring Brook, River Rd.

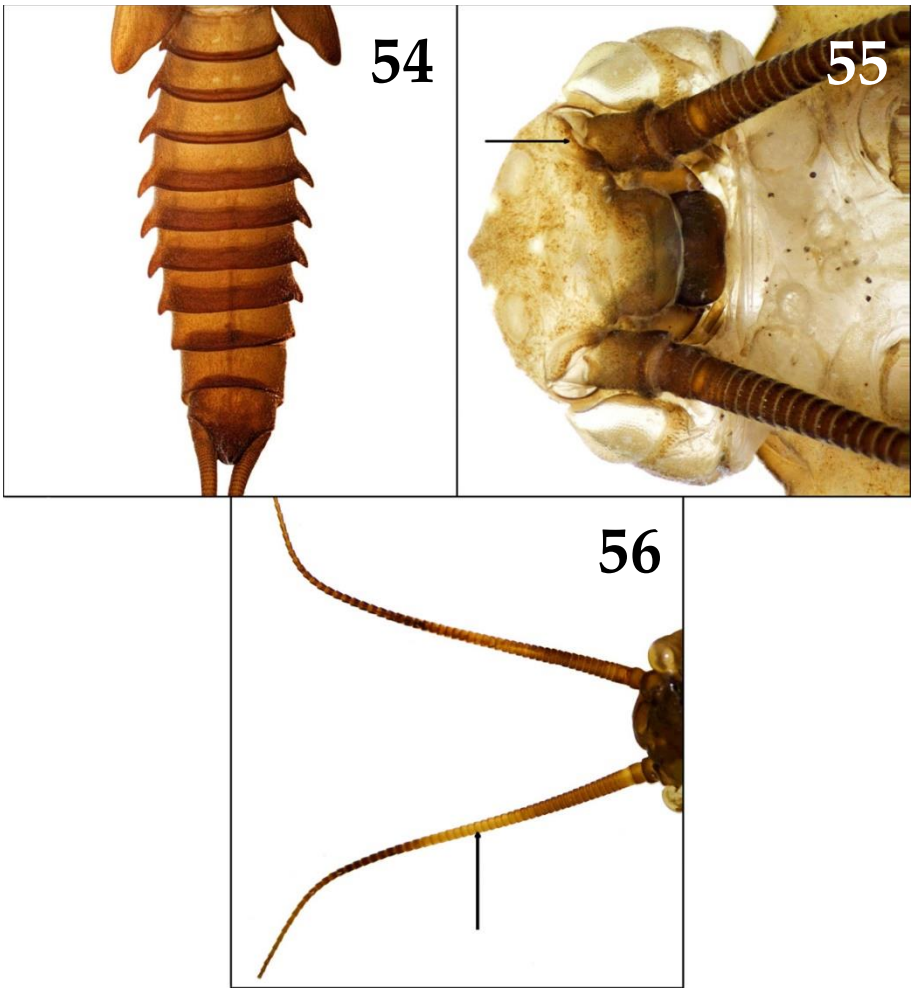

Fig. 54-56. *Pteronarcys proteus.* 54. Abdomen dorsal view; Virginia: Botetourt Co., Bear Wallow Creek. 55. Supra-antennal process; New York: Essex Co., Roaring Brook. 56. Antennae; New York: Delaware Co., Spring-fed tributary to Emory Brook.

nr. Lake Placid, N 44.2866, W 73.9324, 22 May 2007, ♂, Exv, L. Myers, reared 27 May 2007 (LCRI); **Greene Co.**, Batavia Kill headwaters, end of Rt. 56, Windham, N 42.2888, W 74.1141, 18 June 2008, Exv, L. Myers (LCRI); **Warren Co.**, Small trib. to Lake George, Rt. 9N nr. Cotton Point, N 43.5183, W 73.6740, 1 May 2008, ♂, Exv, L. Myers, reared 25 May 2008 (LCRI); **Washington Co.**, Shelving Rock Brook, Shelving Rock Rd., N 43.5519, W 73.5963, 30 April 2008, ♂, ♀, 2Exv, L. Myers, reared 18 May 2008 (LCRI); Same data as previous, ♂, ♀, 2Exv, reared 12 May 2008 (LCRI); **North Carolina: Ashe Co.**, Three top Creek, off SR 1100 Below Long Hope Creek, N 36.4107, W 81.6196, 28 August 2013, L, S. Beaty, E. Fleek & D. Black (NCDEP); **Caldwell Co.,** Jackson Camp Creek, SR 1372, N 36.0694, W 81.5925, 23 May 2011, 10L, S. Beaty, E. Fleek & D. Black (NCDEP); **Caswell Co.**, Hogans Creek, SR 1301, N 36.4392, W 79.5153, 11 August 2010, 2L, B. Crouch, S. Beaty & V. Holland (NCDEP); **Chatham Co.,** East Branch Price Creek, 14 November 1997, L, S. Beaty, E. Fleek & D. Black (NCDEP); **Guilford Co.**, Reedy Fork, SR 2128, N 36.1728, W 79.9533, 10 September 2013, 2L, S. Beaty, E. Fleek & D. Black (NCDEP); **McDowell Co.**, South Muddy Creek, SR 1764, N 35.6500, W 81.8550, 9 July 2012, 2L, M. Walters, E. Fleek & S.

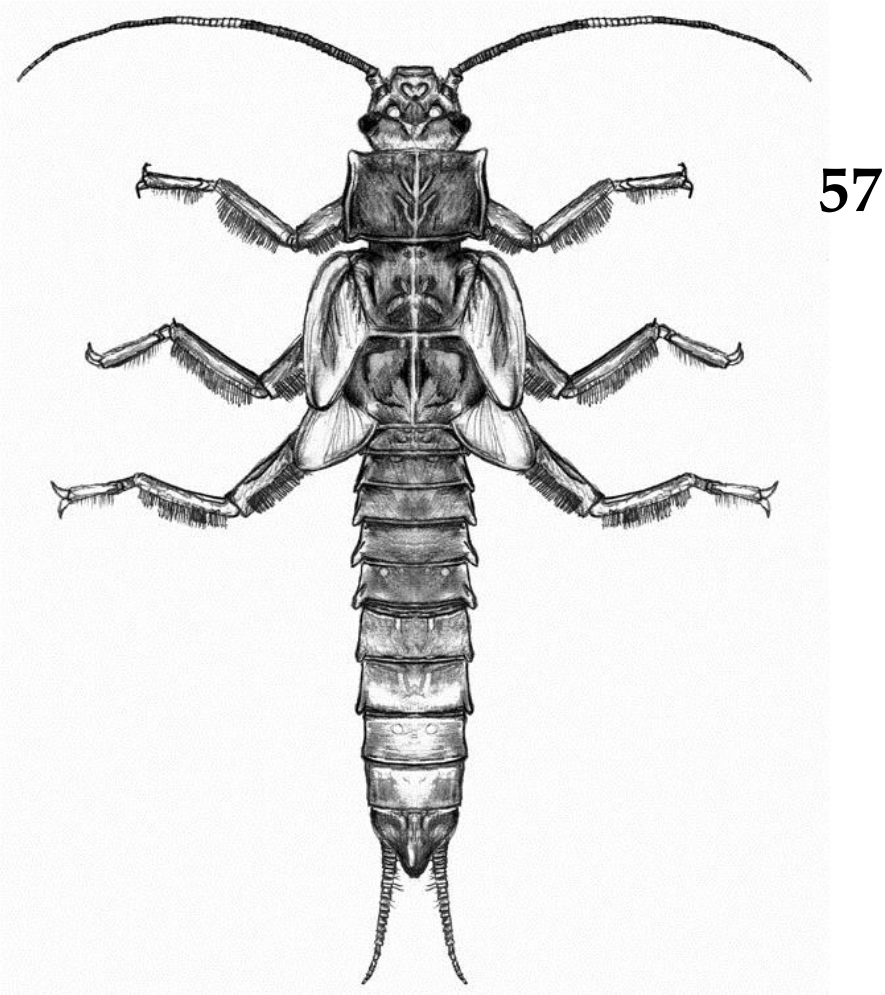

Fig. 57. *Pteronarcys proteus.* Larval habitus; Massachusetts: Berkshire Co., Wright Brook.

Beaty (NCDEP); Crooked Creek, SR 1135, N 35.6055, W 82.1169, 10 July 2012, 7N, M. Walters, E. Fleek & T. Mormon (NCDEP); **Stokes Co.**, Crooked Creek, off SR 1626, N 36.5356, W 80.0767, 1 November 2011, L, S. Beaty, V. Holland & M. Walters (NCDEP); **Wilkes Co.**, Roaring River, SR 1990, N 36.2497, W 81.0442, 10 August 2011, 2L, M. Walters, E. Fleek & M. Hale (NCDEP); Fishing Creek, SR 2381, N 36.1833, W 81.0506, 3 November 2011, 3L, S. Beaty (NCDEP); Shell Creek, SR 2318, N 36.1327 W 81.3966, 19 April 2012, 3L, S. Beaty, M. Walters & V. Holland (NCDEP); Garden Creek, SR 1739 , N 36.3908, W 81.0711, 8 March 2014, 7L, M. Walters, V. Holland & E. Fleek (NCDEP); **Watauga Co.**, Norris Fork, SR 1337, N 36.2800, W 81.6766W, 27 August 2013, 2L, S. Beaty, E. Fleek & D. Black (NCDEP); **Vermont: Washington Co.**, Mill Brook, Jct. Rt. 100 and Fiddlers Green, N 44.1792, W 72.8375, 10 April 2013, L, L. Myers (LCRI); **Virginia**: **Bath Co.,** Wilson Creek, Rt. 629, 6 April 1979, ♂, Exv, S. Hiner (CSUIC); **Botetourt Co.,** Bear Wallow Creek, 0.5 miles S. Rt. 43,11 April 1979, ♀, Exv, B.C. Kondratieff, reared 23 April 1979 (CSUIC); **Giles Co.,** Small stream into Dismal Creek at Rt. 42, 15 March 1980, ♂, Exv, B.C. Kondratieff, reared 1 April 1980 (CSUIC); **Montgomery Co.,** Craig Creek, Rt. 621, 3 May 1980, ♂, Exv, B.C. Kondratieff, reared 12 May 1980 (CSUIC); **Nelson Co.,** South Fork Tye River, Rt. 56, 3 May 1980, ♂, Exv, B.C. Kondratieff (CSUIC); Small trib. of South Fork Tye River, Rt. 687,

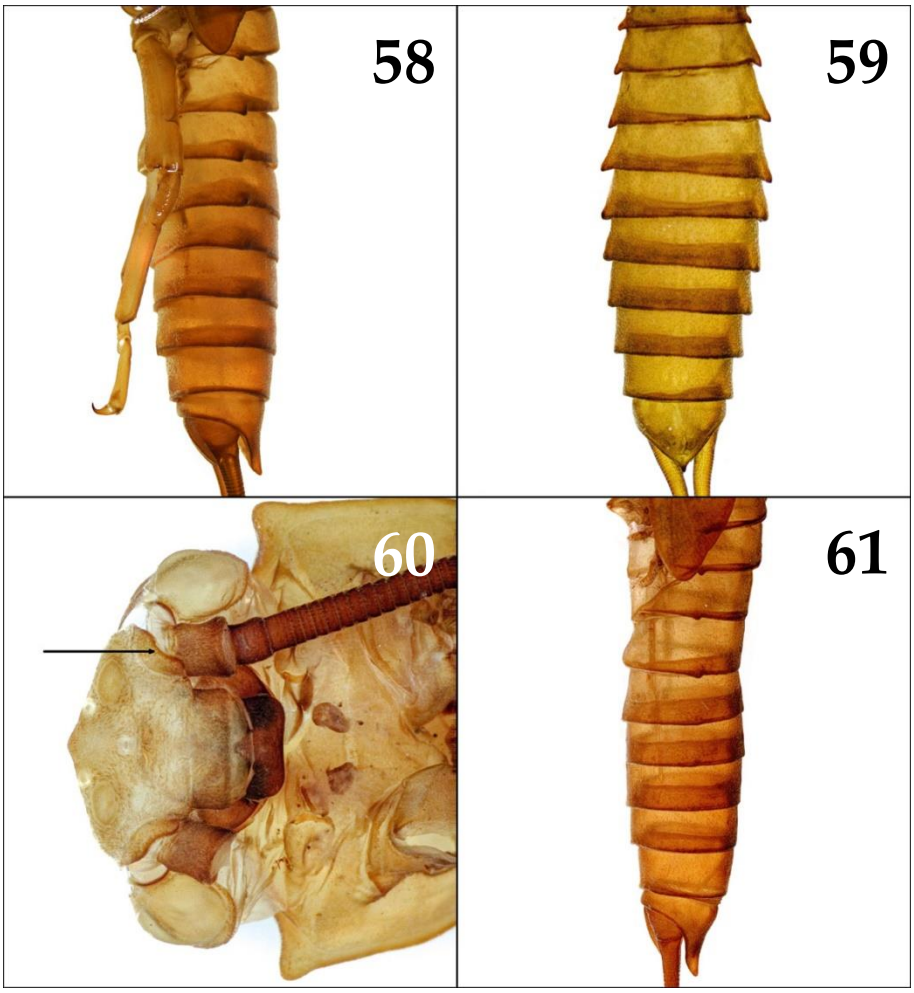

Fig. 58.-61. *Pteronarcys scotti.* 58 Abdomen lateral; Tennessee: Sevier Co., Little River. 59. Abdomen dorsal view; Tennessee: Sevier Co., Little River. 60. Supra-antennal process; Tennessee: Sevier Co., Little River. 61. Abdomen lateral view; Tennessee: Carter Co., Cades Cove Creek.

3 May 1980, ♂, Exv**,** B.C. Kondratieff, reared 11 May 1980 (CSUIC); **Patrick Co.,** Rock Castle Creek, Rt. 605 off Rt. 8, 14 April 1979, ♂, Exv, B. C. Kondratieff, reared 26 April 1979 (CSUIC); **Rockingham Co.,** Home Quarry Run, Rt. 257, 16 May 1971, ♂, Exv, S. Kirkland (CSUIC); **Tazewell Co.**, Cove Creek, Rt. 622, 1.5 miles NW of Cove Cr., 16 May 1994, 2L, B.C. Kondratieff & R.F. Kirchner (CSUIC).

***Pteronarcys scotti* Ricker, 1952**
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:470668
(Figs. 58–66)

Remarks and Distribution. When viewed dorsally the projections of AB1-7 in *P. scotti* are less developed than those observed in *P. proteus*, outer margins of largest projections appearing nearly straight in dorsal view (Figs. 59, 62, 66). Viewed laterally the spines of AB5-7 appear as low rugose ridges that are nearly indiscernible, projecting past the posterior margin of the segment minimally in lateral view (Figs. 58, 61). Measured in dorsal view AB4 POM/SW <0.15; AB6 ≤ 0.12 (Figs. 10, 59, 62). Additionally, this species lacks the distinctive medial yellow antennal band that is present in *P.*

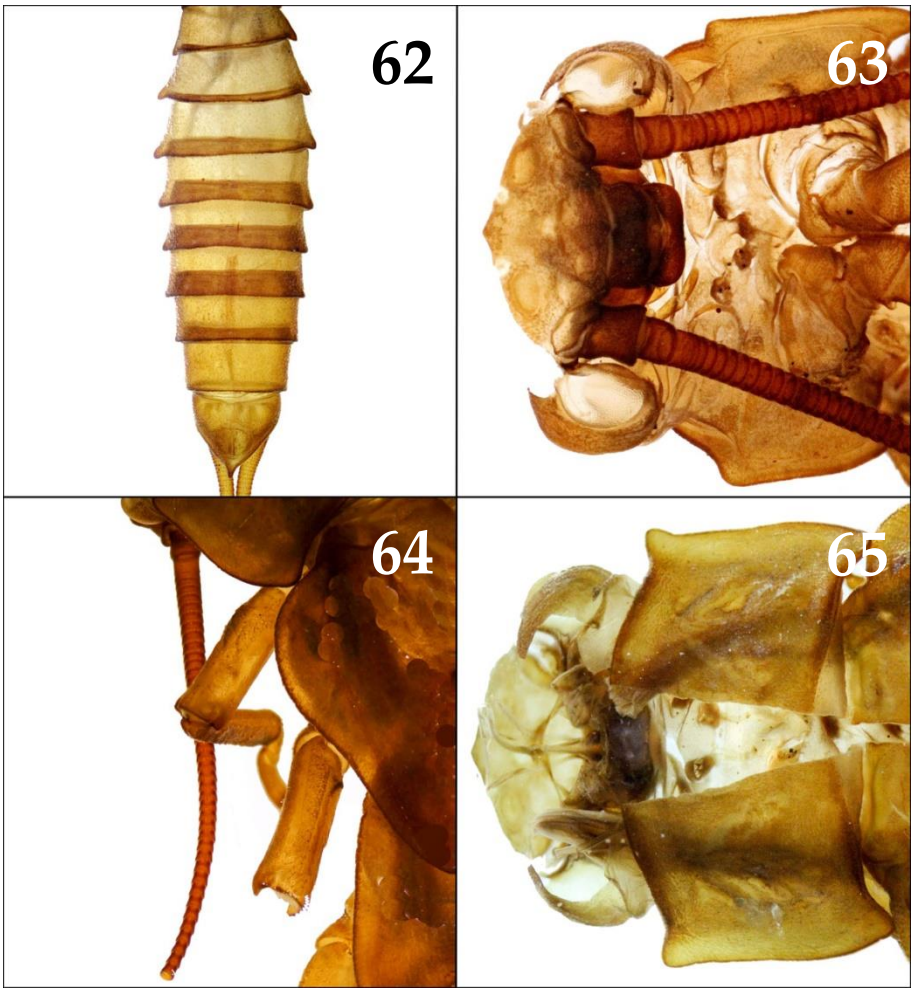

Fig. 62-65. *Pteronarcys scotti.* 62. Abdomen dorsal view; Tennessee: Carter Co., Cades Cove Creek. 63. Supra-antennal process; Tennessee: Carter Co., Cades Cove Creek. 64. Antennae; Tennessee: Sevier Co., Little River. 65. Pronotum; Tennessee: Sevier Co., Little River.

proteus (Figs. 64, 66). This species is restricted to the Appalachians with records available from Pennsylvania, Virginia, North Carolina, Georgia, South Carolina, and Tennessee (Nelson 2000).

Material Examined. USA, Georgia: Murray Co., Jigger Creek, East Cowpen Rd., N 34.9626, W 84.6386, 9 February 2017, 2L, C. Verdone & B.C. Kondratieff (CSUIC); **Rabun Co.,** Trib. to Overflow Creek, Overflow Creek Rd., N 34.9539, W 83.2216, 10 February 2017, 2L, C. Verdone & B.C. Kondratieff (CSUIC); **North Carolina: Alleghany Co.**, Little River, SR 1128, N 36.4677, W 81.1333, 5 September 2013, 3L, S. Beaty, V. Holland & M. Walters (NCDEP); **Avery Co.,** Horse Creek, US 19E, N 36.1016, W 81.9864, 7 August 2012, 2L, M. Walters, E. Fleek & M. Hale (NCDEP); **Buncombe Co.**, S. Hominy Creek, Dale Pen Rd., N 35.4882, W 82.7425, 1 June 2010, 10L, V. Holland & S. Beaty (NCDEP); **Caldwell Co.**, Jackson Camp Creek, SR 1372, N 36.0694, W 81.5925, 23 May 2011, 10L, S. Beaty, E. Fleek & D. Black (NCDEP); **Cherokee Co.**, Worm Creek, off US 19, N 35.1959, W 83.7893, 11 February 2015, 3L, E. Fleek, V. Holland & M. Walters (NCDEP); **Graham Co.**, Tulula Creek, SR 1275, N 35.3205, W 83.8025, 2 September 2014, 3L, S. Beaty, M. Walters & V. Holland (NCDEP); **Haywood Co.**, East Fork Pigeon River, Off US 276, Hungry Creek, N 35.4105, W 82.8100, 12 July 2006, 2L, S. Beaty

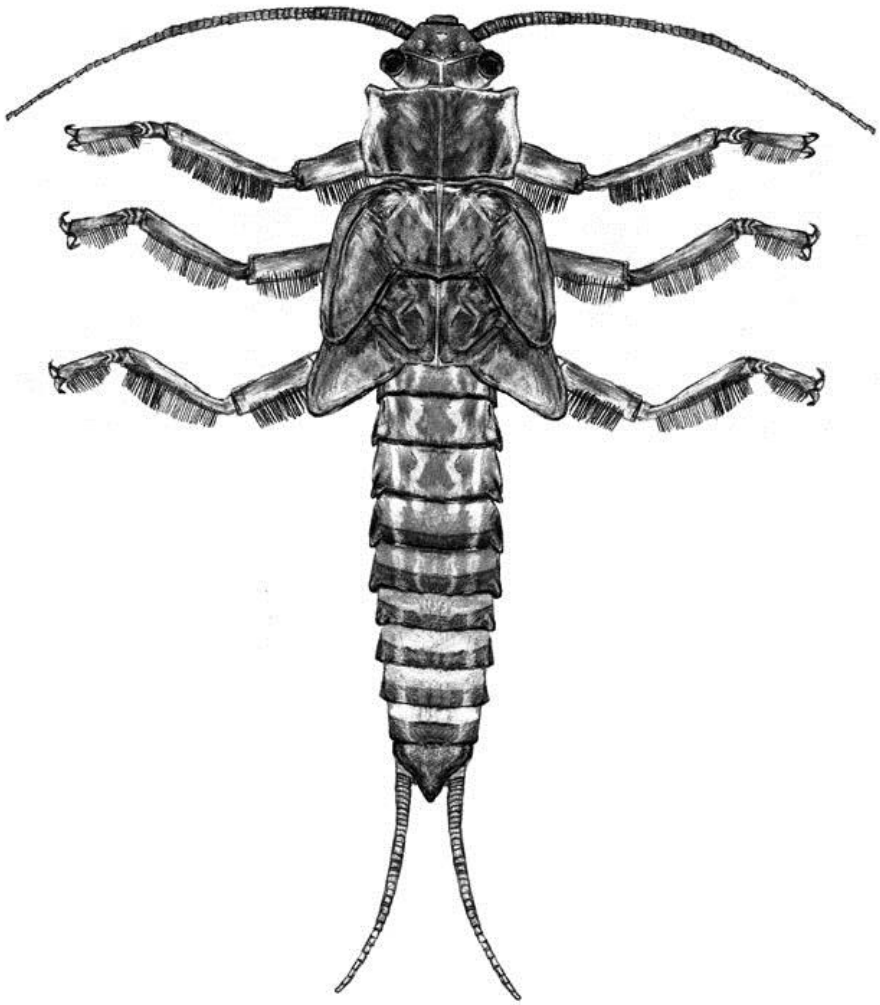

Fig. 66. *Pteronarcys scotti.* Larval habitus; North Carolina: Macon Co., Cullasaja River.

(NCDEP); Cove Creek, nr. Maggie Valley, 22 May 1970, ♂, Exv, B.C. Kondratieff & R.F. Kirchner (CSUIC); **Henderson Co.**, Mills River, SR 1337, N 35.3986, W 82.5950, 15 August 2007, 3L, S. Beaty, M. Walters & D. Black (NCDEP); Mills River, NC 191-280, N 35.3913, W 82.5680, 27 August 2010, 10L, M. Walters, E. Fleek & T. Mormon (NCDEP); **Jackson Co.,** Moses Creek, SR 1739, N 35.3147, W 83.1255, 16 September 2015, 10L, S. Beaty (NCDEP); **Macon Co.**, Clear Creek, SR 1618, N 35.0044, W 83.2113W, 15 July 2014, 4L, S. Beaty, E. Fleek & V. Holland (NCDEP); Cullasaja River, Rt. 28 N of Falls, 24 May 1993, ♂, 3Exv, B.C. Kondratieff & R.F. Kirchner (CSUIC); **McDowell Co.,** Catawba River, SR 1274, N 35.6144, W 82.2300, 10 July 2012, 4L, M. Walter, C. Tyndall, E. Fleek & T. Morman (NCDEP); **Transylvania Co.,** North Fork French Broad River, SR 1326, N 35.2013, W 82.8566, 27 July 2010, 10L, S. Beaty, E. Fleek & V. Holland (NCDEP); Indian Creek, US 64, N 35.1266, W 82.9147, 14 July 2014, 5L, S. Beaty, E. Fleek & V. Holland (NCDEP); **Watauga Co.**, Norris Fork, SR 1337, N 36.2800, W 81.6766, 27 August 2013, 3L, S. Beaty, E. Fleek & D. Black (NCDEP); **Wilkes Co.**, Garden Creek, SR 1739, N 36.3903, W 81.0711, 8 March 2014, 2L, V. Holland, M. Walters & E. Fleek (NCDEP); **Tennessee**: **Carter**

Co., Doe River ca. 0.5 mi. below Roan Mt. St. Park Welcome Center, 12 April 1998, ♂, Exv, D.A. & E.L. Etnier (CSUIC). **Sevier Co.,** Little River, Elkmont, 14 May 1939, ♀, Exv, Frison & Ross (CNC *Paratypes*); West Prong Pigeon River, at park headquarters, GSMNP, 21 April 1949, L, 3Exv, W.E. Ricker (CNC). Cades Cove Creek, 3.2 mi E Cable Mill, GSMNP, ♂, ♀, Exv, B.C. Kondratieff (CSUIC); **Virginia: Floyd Co.,** Dodd Creek, Rt. 8, 20 March 1980, ♂, Exv, B.C. Kondratieff, reared 28 March 1980 (CSUIC); **Grayson Co.,** Laurel Creek, Rt. 603, 22 April 1979, ♀, Exv, R. Firth, reared 9 May 1979 (CSUIC) **Pittsylvania Co.,** Sandy Creek, Rt. 58, 11 April 1981, ♀, Exv, B.C. Kondratieff, reared 20 April 1981 (CSUIC); **Washington Co.,** Big Laurel Creek, Rt. 603, Konnarock, 19 April 1980, 3♀, 3Exv, B.C. Kondratieff, reared 15 May 1980 (CSUIC).

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