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## CALIFORNIA SOLIPERLA RICKER, 1952 (PLECOPTERA: PELTOPERLIDAE), DISTRIBUTION AND TAXONOMIC CHARACTERS

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### ABSTRACT

New distribution records for the three California species of *Soliperla* Ricker, 1952, are presented and mapped. Male reproductive structures were examined with scanning electron microscopy to test their potential as taxonomic characters, and a preliminary taxonomic key to the larvae of California *Soliperla* species is presented. Male epiprocts appear to be less useful for distinguishing the species of California *Soliperla* males than has been shown for the species in Oregon and Washington.

**Keywords:** Plecoptera, Peltoperlidae, *Soliperla*, Distribution, Male reproductive structures

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### INTRODUCTION

Genus *Soliperla* Ricker, 1952, regarded as a Nearctic endemic, was last reviewed by Stark & Gustafson (2004) and currently includes eight species found in California, Idaho, Montana, Nevada, Oregon and Washington (DeWalt et al. 2017). Three species, *S. quadrispinula* (Jewett, 1954), *S. sierra* Stark, 1983, and *S. thyra* (Needham & Smith, 1916), are known to occur in California (Stark 1983), but questions remain about the stability of various populations and the validity of the male epiproct shape and dentition as a

taxonomic character for identifying males of *Soliperla* to their respective species. Consequently, we collected additional specimens of *S. sierra* from French Creek, Hopkins Creek and Nelson Creek, near the type locality, specimens of *S. quadrispinula* from Del Norte, Humboldt and Siskiyou counties, and we collected specimens of *S. thyra* from several sites and borrowed others from colleagues. This larger sample permits a re-evaluation with scanning electron microscopy of epiproct and aedeagal morphology for males of these species. California records of *Soliperla* are published in Barr



Fig. 1. *Soliperla sierra* adult habitus, Big Springs, Hwy 49, near Bassett, Sierra Co., California, Photo B. Stark.

& Shepard (in review), Jewett (1954, 1960), Nelson & Stark (1987), Stark (1983), and Stark & Gustafson (2004).

#### MATERIALS AND METHODS

Most male specimens were squeezed in the field in order to evert the aedeagus. The aedeagus was dissected from the body using micro scissors and the epiproct removed from the body using fine tipped forceps. Dissected body parts were serially dehydrated in 90, 95 and 100% ethanol solutions for 10 minutes each, and then transferred to dishes of hexamethyldisilizane for one hour. Dehydrated specimens were attached to specimen stubs with double stick copper tape and coated with gold-palladium using a Hummer sputter coater. Coated specimens were examined with an Amray 1810 scanning electron microscope.

Male specimens not everted in the field were mechanically everted in the lab. The abdomens of these specimens were clipped and boiled in 10%

KOH for 1-2 minutes. Extraneous tissues were removed with fine tipped forceps and fine dissecting pins made from minutens imbedded in Q-tip sticks. Pressure was alternately applied and released on sternum 9 until the aedeagus everted. The eversion process and examination took place under an Olympus SZH10 or Wild M5 dissecting microscope.

The origin of the *Soliperla* specimens examined in this study is denoted by codens provided within the specimens examined sections that correspond to private and public collections. Registered codens for public museums were obtained from the Global Registry of Biodiversity Repositories (<http://grbio.org>).

Bill P. Stark Collection, Mississippi College, Clinton, MS (BPSC)

Monte L. Bean Museum, Brigham Young University, Provo, UT (BYU)

C.P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, CO

(CSUIC)

Essig Museum of Entomology, University of California, Berkeley, CA (EMEC)

John B. Sandberg Collection, Paradise, CA (JBSC)

Jonathan J. Lee Collection, Eureka, CA (JJLC)

Larry E. Serpa Collection, Fairfax, CA (LESC)

Additional codens used to identify sources for published records include:

California Academy of Sciences, San Francisco, CA (CAS)

Oregon State University Collection, Corvallis, OR (OSAC)

Royal Ontario Museum Collection, Toronto, ON (ROM)

United States National Museum, Washington, D.C. (USNM)

Larval specimen records listed below under *Soliperla* sp. were field collected by scientists of the following organizations:

California Department of Fish & Wildlife Aquatic Bioassessment Lab (ABL)

State Water Resources Control Board Regions 1, 2, and 5 (SWRCB)

Sierra Nevada Aquatic Research Laboratory (SNARL)

Citizens Monitoring Groups (CMG)

## RESULTS AND DISCUSSION

### *Soliperla quadrispinula* (Jewett, 1954)

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:106>

Figs. (2-3, 8-9, 14)

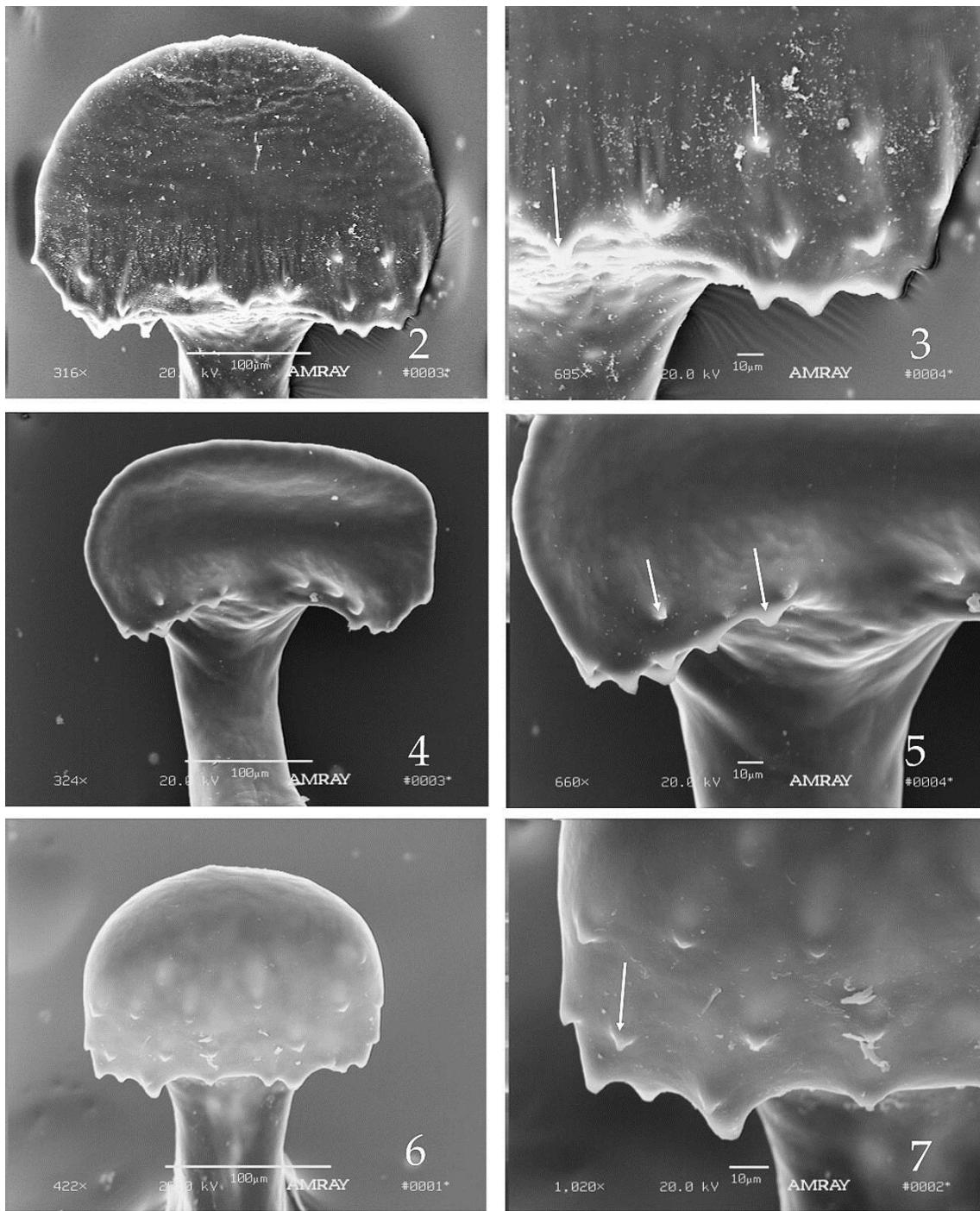
*Peltoperla* (*Soliperla*) *quadrispinula* Jewett, 1954:169. Holotype male (CAS), Wrangle Gap Camp, Jackson Co., Oregon.

*Soliperla quadrispinula*: Illies, 1966:26.

Published California records. **Del Norte Co.**, 3 mi NE Hiouchi, 1 June 1991, B. Stark, R.W. Baumann, C. Henderson, 1♂, 1L (BPSC). **Humboldt Co.**, Cedar Creek, Hwy 299, 31 May 1991, B. Stark, R.W.

Baumann, C. Henderson, 1♂ (BPSC). Same site, 25 April 1987, B. Stark, R.W. Baumann, C.R. Nelson, 2 larvae (BPSC). Grassy Creek, Fieldbrook, 22 May 1982, B. Stark, D. Ziegler, 6♂, 3♀, 54 larvae (BPSC, BYU). Ruby Creek, 3.8 miles E Berry Summit, 19 May 1998, C.R. Nelson, B. Stark, I. Sivec, S.W. Szczytko, 1♂ (BYU). **Trinity Co.**, Coffee Creek, 7 June 1934, E.C. Van Dyke, 1♂ (CAS).

Additional California records. **Del Norte Co.**, Small falls into Patrick Creek, 1 mile abv Hwy 199, Patrick Creek Rd, 41.886333, -123.852066, 24 May 2014, B. Stark, A. Harrison, 2♀ (BPSC). Small falls into Patrick Creek, Patrick Creek Rd, abv Shelly Creek, 41.90535, -123.85595, 24 May 2014, B. Stark, A. Harrison, 1L (BPSC). Tributary Smith River, Hwy 199, 1 mile NE Myrtle Creek, 1 June 1991, B. Stark, R.W. Baumann, C. Henderson, 1♀ (BPSC). **Humboldt Co.**, Boise Creek, Boise Creek Campground, Hwy 299, 1 May 2011, B.C. Kondratieff, J.B. Sandberg, 1♂ (CSUIC). Boise Creek, South Boise Creek Campground, 40.94367, -123.65679, 24 May 2006, J. Lee, 5♂, 4♀ (JJLC). Janes Creek, Trail 11, Arcata Community Forest, 27 May 2002, J. Lee, 2♀ (BYU). Jolly Giant Creek, Arcata, 40.900, -123.716667, 7 June 2005, R.W. Baumann, B.C. Kondratieff, 1♂ (BYU). Jolly Giant Creek, Arcata Community Forest, 40.87674, -123.06954, 22 May 2006, J. Lee, 1♂ (JJLC). Luffenholtz Creek tributary, Scenic Drive, 2 miles S Trinidad, 41.04187, -124.11910, 24 April 2015, J. Lee, 1♂, 1♀ (JJLC). Same site, 30 April 2015, J. Lee, 1♂ (JJLC). Puter Creek, South of Mad River Fish Hatchery, 40.84984, -123.99179, 31 May 2008, J. Lee, 5♂, 1♀ (JJLC). Rube Ranch Creek, Hwy 169, 5 miles NW Weitchpec, 41.22844, -123.77129, 12 May 2010, J. Lee, 1♂ (JJLC). Ruby Creek, 3.8 miles E Berry Summit, 40.907833, -123.7182167, 25 May 2014, B. Stark, A. Harrison, 2 larvae (BPSC). Same site, 7 June 2005, B.C. Kondratieff, R.W. Baumann, 1♂, 1♀ (CSUIC). Small seep above Ruby Creek, Hwy 299, 19 May 1998, S.W. Szczytko, B. Stark, C.R. Nelson, I. Sivec, 1♀, 7 larvae (BYU). Small stream, 2.4 miles E Berry Summit, Hwy 299, 7 June 2005, B.C. Kondratieff, R.W. Baumann, 6♂ (CSUIC). Same site, 20 May 2001, B. Stark, K.W. Stewart, 1♂ (BPSC). Unnamed stream, Hwy 299, milepost 31.48, 40.90485, -123.73644, 28 May 2008, J. Lee, 1♂



Figs. 2-7. California *Soliperla* male epiprocts. 2. *S. quadrispinula*, apical section of epiproct and upper stem, California, Humboldt Co., Unnamed stream near Berry Summit, Hwy 299. 3. *S. quadrispinula*, left half of anterior epiproct surface. 4. *S. sierra*, apical section and upper stem of epiproct, California, Sierra Co., Big Springs, Hwy 49. 5. *S. sierra*, right half of anterior epiproct surface. 6. *S. thyra*, apical section of epiproct and upper stem, California, Napa Co., 9 miles N Calistoga, Hwy 29. 7. *S. thyra*, right half of anterior epiproct surface.

(JJLC). Same site, 11 July 2008, J. Lee, 2♂ (BPSC). Van Duzen River, Rainbow Bridge, 40.48058, -123.89093, 5 June 2009, J. Lee, 1♂ (JJLC). **Shasta Co.**, Montgomery Creek, Montgomery Falls, off Hwy 299, 24 May 2007, B.C. Kondratieff, R.W. Baumann, 1♂ (CSUIC). Roaring Creek, Big Bend Rd, N of Wengler, 24 May 2007, R.W. Baumann, B.C. Kondratieff, 1♂, 1♀ (BYU). **Siskiyou Co.**, McCloud River, Lower falls picnic area Hwy 89 E Mt Shasta, 41.24012, -122.02479, 23 May 2014, J.B. Sandberg, 1♂ (JBSC). **Trinity Co.**, Bidden Creek, Hwy 299, 25 April 1987, B. Stark, R.W. Baumann, C.R. Nelson, 3 larvae (BPSC). Same site, 40.78928, -123.45122, 10 May 2006, J. Lee, 1♂ (JJLC). Clear Creek & adjacent tributaries, Hwy 36, 2.6 mi E of Forest Glen CG, 40.37411, -123.36347, J.B. Sandberg, 2♂ (JBSC).

**Male epiproct.** Stark & Gustafson (2004) previously commented on variation in epiproct structure for this species. The SEM image in that study (Fig. 17 in Stark & Gustafson 2004), taken from a specimen collected in Elk River Canyon, Curry County, Oregon, shows the marginal armature consists of a single row of 19 irregularly spaced and sized teeth, with four additional submarginals and a width of 400  $\mu\text{m}$ ; a small median gap occurs between teeth on the marginal row. The epiproct used in this study, taken from a Humboldt County, California specimen (Figs. 2-3) lacks most of the marginal teeth but the total number of teeth on the anterior face and margin (20) is similar to the number on the Elk River Canyon specimen, the width (417  $\mu\text{m}$ ) is also similar, and both samples show a median gap in the marginal teeth.

**Male aedeagus.** Stark (1983) noted the total number of large setal spines, while often four, may be slightly more or less numerous due to extra or fewer spines on one or more aedeagal lobes. Three spines are visible on the specimen shown in Fig. 8, but the fourth is hidden. The largest visible spine (Fig. 9) is 300  $\mu\text{m}$  long. Each spine originates from a long slender sclerite.

**Larval abdominal pigment pattern.** Stark (1983) illustrated the pigment pattern for a specimen from the type locality in southern Oregon. This specimen had an obscure median circular spot on

tergum 7 and relatively large median pale spots on terga 5 and 6. An additional small pale median spot is present on tergum 4. This is fairly similar to the pattern shown in Fig. 14 from a Humboldt County, California specimen. The median spot shown on tergum 6 for the latter specimen is smaller than the one on tergum 5, and it is more circular than triangular. Six additional Humboldt County specimens show similar patterns. Based on these observations and supported by similar ones for *S. sierra* and *S. thyra*, we offer below a preliminary key to the larval *Soliperla* known from California.

**Distribution.** Published California records for *S. quadrispinula* are available from Del Norte (1 site), Humboldt (6 sites) and Trinity (1 site) counties (Jewett 1954; 1960; Nelson & Stark 1987; Stark 1983; Stark & Gustafson 2004). Herein, we report unpublished collections from five counties and 20 sites. The species also occurs in Oregon where it extends from Jackson and Curry counties in the South to Clatsop and Benton counties in the North (Stark 1983; Stark & Gustafson 2004). The California distribution is concentrated in four northwestern counties of Del Norte, Humboldt, Shasta and Trinity (Fig. 17). An additional female *Soliperla* specimen collected in Nevada County by B.C. Kondratieff and C.J. Verdone and tentatively identified as *S. quadrispinula* was not included in Fig. 17, or in the list of material examined for this species.

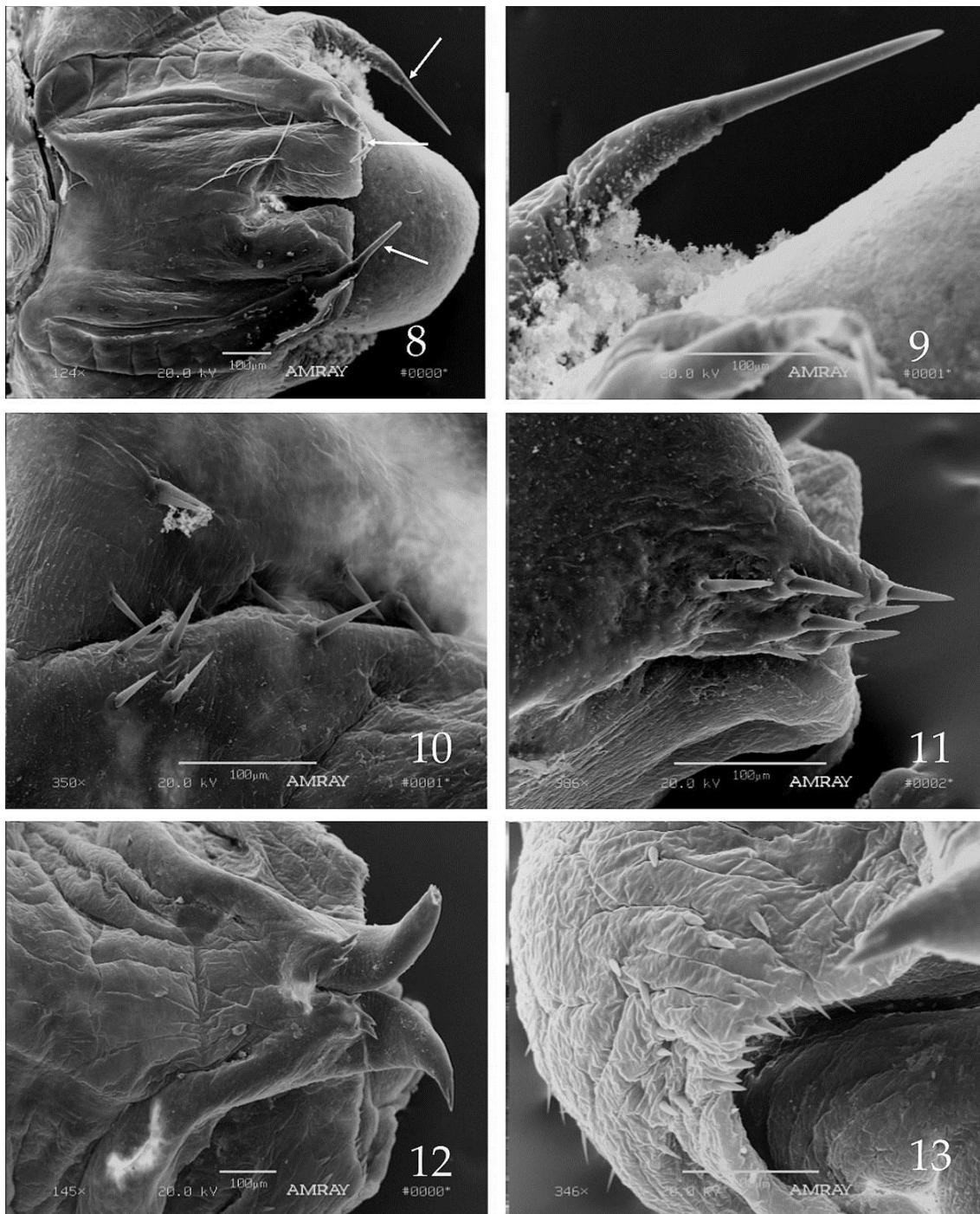
#### *Soliperla sierra* Stark, 1983

<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:105>

Figs. (1, 4-5, 10-11, 15)

*Soliperla sierra* Stark, 1983:36. Holotype male (USNM), French Creek, 1 mile N Caribou, Butt Reservoir Rd, Plumas Co., California.

Published California records. **Plumas Co.**, French Creek, 1 mile N Caribou, Butt Reservoir Rd, 25 June 1980, R.W. Baumann, J. Stanger, 6♂, 3♀ (USNM). **Sierra Co.**, Big Springs, Hwy 49, 2 miles W Bassett, 29 May 1991, B. Stark, R.W. Baumann, C. Henderson, 1♀ (BPSC). Same site, 27 June 2003, P.A. Opler, 4♂ (CSUIC). Same site, 24 June 1980,



Figs. 8-13. California *Soliperla* male aedeagal armature. 8. *S. quadrispinula*, apical aedeagal section bearing prominent spines, California, Humboldt Co., Unnamed stream near Berry Summit, Hwy 299. 9. *S. quadrispinula*, detail of large spine. 10. *S. sierra*, ventral aedeagal spine patch, California, Sierra Co., Big Springs, Hwy 49. 11. *S. sierra*, dorsolateral spiny aedeagal lobe. 12. *S. thyra*, large ventroapical aedeagal spines, California, Humboldt Co., Willow Creek, East Fork Confluence. 13. *S. thyra*, basolateral spine patch.

R.W. Baumann, J. Stanger, 13♂, 4♀ (BYU).

Additional California records. **Plumas Co.**, French Creek, Caribou Rd, NW of Caribou at water tank, 40.08635, -121.1549, 7 June 2017, B. Stark, J.B. Sandberg, 6♂, 6♀, 1L (BPSC). Same site, 7 June 2017, J.B. Sandberg, B. Stark, 9♂, 3♀ (JBSC). Waterfall tributary to Hopkins Creek, FR 23N16, 8.0 mi NE Gibsonville, 39.76537, -120.83298, 1 July 2017, J.B. Sandberg, 1♂, 3♀ (JBSC). Waterfall tributary to Nelson Creek, Quincy La Porte Rd, 10 mi S of East Quincy (Hwy 70), 39.84156, -120.85863, 24 June 2017, 2♀ (JBSC). **Sierra Co.**, Big Springs, Hwy 49, 2 miles W Bassett, 10 May 1982, D. Ziegler, K.W. Stewart, 2♀ (BPSC). Same site, 1 July 2008, P.A. Opler, 4♂, 1♀ (CSUIC). Same site, 5 July 2008, B.C. Kondratieff, R.W. Baumann, 2♀ (CSUIC). Same site, 17 June 2009, B.C. Kondratieff, R.W. Baumann, 18♂, 8♀ (CSUIC). Same site, 39.5965833, -120.6107667, 21 June 2009, B. Stark, A. Harrison, K. Nye, 15♂, 7♀ (BPSC). Same site, 25 June 2009, J. Lee, 5♂, 1♀ (JJLC, BPSC). Same site, 3 July 2010, B.C. Kondratieff, R.W. Baumann, 5♂ (CSUIC). Same site, 26 May 2014, B. Stark, A. Harrison, 2♂, 5 larvae (BPSC). Same site, 8 June 2014, D.E. Ruiter, N. Kang, 2♂ (CSUIC). Same site, 28 June 2014, B.C. Kondratieff, C.J. Verdone, 1♂ (CSUIC). Same site, 28 June 2015, B.C. Kondratieff, 1♀ (CSUIC).

**Male epiproct.** Stark (1983) and Stark & Gustafson (2004) present images and brief descriptions of the *S. sierra* epiproct based on a paratype specimen. The SEM image (Fig. 18 in Stark & Gustafson) shows an almost quadrangular shape, a wide toothless median gap along the marginal tooth row and 14 total teeth including 7 marginals and 7 submarginals. The anterior face of this specimen is 215 µm wide. The specimen examined in this study from Sierra County, California is oriented in an oblique fashion that emphasizes the width and the large toothless median gap. The SEM images of this specimen (Figs. 4-5) indicate 15 total teeth and a width of 268 µm.

**Male aedeagus.** The structure and similarity of the aedeagus for this species to that of *S. campanula* was documented by Stark (1983). Both species have a median row or grouping of relatively short, thick

setal-spines on the ventral aedeagal surface (Fig. 10), and both have an anterolateral lobe with a close-set cluster of several additional short, thick setal spines (Fig. 11). The organization of the ventral setal-spine grouping for *S. sierra* is not clearly in two well-organized rows, whereas in *S. campanula* the two median rows are usually distinct. In addition, the anterolateral spine clusters are set on partially sclerotized lobes for mature specimens of *S. sierra*, but these lobes are membranous for specimens of *S. campanula* we have examined.

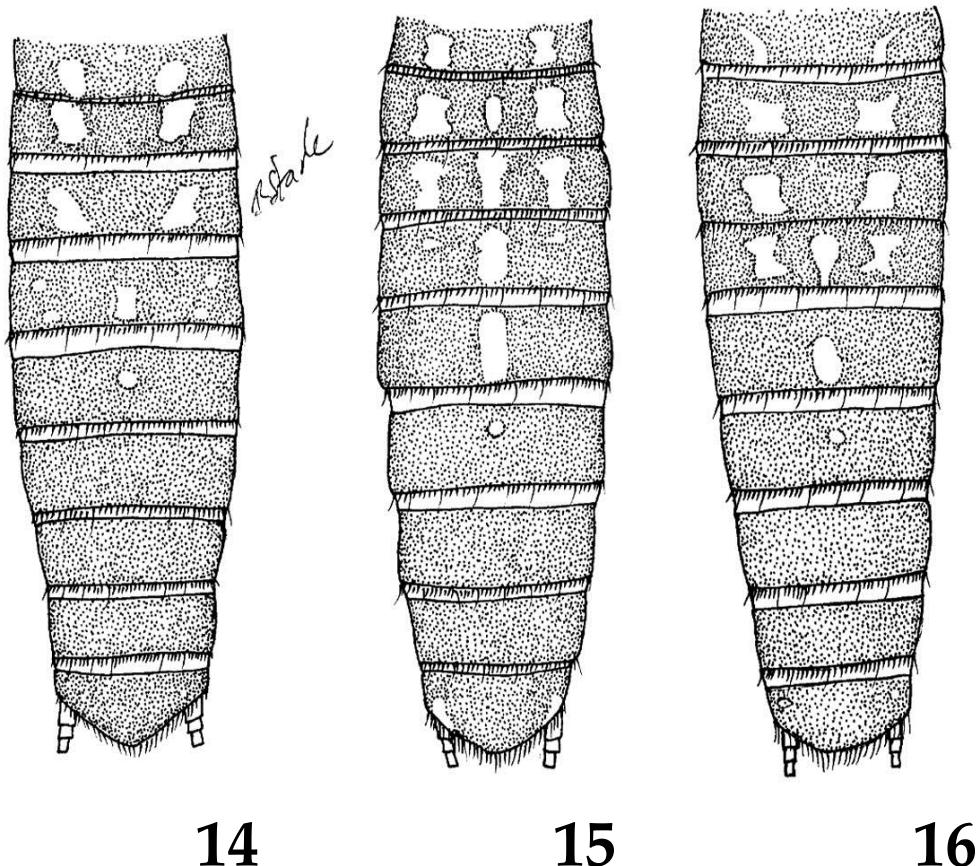
**Larval abdominal pigment pattern.** The larva of *S. sierra* is similar in body size and general features to those of known species. However, in the small sample available to us, the abdominal pigment pattern appears distinct from that of other *Soliperla* larvae known from California. Prominent, median longitudinal pale spots on terga 3, or 4-6 form an almost continuous median pale stripe on those segments. Tergum 7 often has a well defined circular median spot and the lateral pale spots on tergum 5 are much smaller than those on terga 2-4 (Fig. 15).

**Distribution.** Published records exist for only two sites for this species in Plumas and Sierra counties. During this study several additional specimens were collected at the Sierra County site near Bassett, California, and in Plumas County the species was collected at three additional sites near the type locality (French Creek at the water tank, Hopkins Creek tributary, and Nelson Creek tributary) (Fig. 17).

*Soliperla thyra* (Needham & Smith, 1916)  
<http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:102>  
Figs. (6-7, 12-13, 16)

*Peltoperla thyra* Needham & Smith, 1916:87. Holotype male (Cornell University), Nevada.  
*Soliperla thyra*: Illies, 1966:26.

Published California records. **El Dorado Co.**, Bridal Veil Falls, Hwy 50 abv Picnic Area, 14 May 1983, R.W. Baumann, Mower, 3♂ (BYU).



Figs. 14-16. California *Soliperla* larval abdominal color patterns, segments 2-10. 14. *S. quadrispinula*, California, Humboldt Co., Grassy Creek. 15. *S. sierra*, California, Sierra Co., Big Springs. 16. *S. thyra*, California, Glenn Co., Salt Creek.

**Glenn Co.**, Salt Creek near Alder Springs, 27 April 1987, B. Stark, R.W. Baumann, C.R. Nelson, 9♂, 1♀ (BPSC). **Lake Co.**, 6 miles S Middletown, 11 May 1926, 1♂ (CAS). Same site, 12 May 1926, 1♂, 5♀ (CAS). **Marin Co.**, Bill Williams Creek, Kentfield, 14 May 1983, R.F. Gill, 1♂ (BYU). Cascade Creek, Mill Valley, 25 April 1957, H.B. Leech, 1♂ (ROM). Same site, 20 May 1955, H.B. Leech, 1♀ (ROM). Mt. Tamalpais, 25 May 1974, D.G. Denning, 1♂ (BYU). Redwood Creek, near Mt. Tamalpais State Park, 22 April 1987, B. Stark, R.W. Baumann, C.R. Nelson (BYU). Trickle near Alpine Lake, 1 May 1955, S.W. Hitchcock, 1♂, 2 larvae (OSAC). **Mendocino Co.**, Small stream, Leggett, Hwy 101, 22 May 1982, B. Stark, D. Ziegler, 1♂, 1♀, 2 larvae (BPSC). Summit, Hwy 175, 23 April 1987, B. Stark, R.W. Baumann,

C.R. Nelson, 2♂, 13 larvae (BPSC). **Napa Co.**, 9 miles N Calistoga, Hwy 29, 21 May 1982, B. Stark, D. Ziegler, 4♂, 10♀, 4 larvae (BPSC). Angwin, April 1976, D. Ashley, 1♀ (BPSC). **Placer Co.**, Mad Canyon Creek, Mad River Rd, 5 miles E Foresthill, 16 May 1983, R.W. Baumann, Mower, 4♂, 6♀ (BYU). Skunk Canyon Creek, Mosquito Ridge Rd, 7 miles E Foresthill, 16 May 1983, R.W. Baumann, Mower, 1♂, 1♀ (BYU). **Santa Clara Co.**, Uvas Canyon, 25 May 1974, D.G. Denning, 1♀ (BYU). **Sierra Co.**, Mossey Falls, Hwy 49 near jct Indian Creek, 18 May 1983, R.W. Baumann, Mower, 1♂ (BYU).

Additional California records. **El Dorado Co.**, Bridal Veil Falls, Hwy 50, 38.77, -120.49, 19 June 2009, R.W. Baumann, B.C. Kondratieff, 1♂, 1♀

(BYU). El Dorado Ditch, 1 mile E of Pacific House, 38.7596, -120.4922, 1180 m, 8 June 2015, C.B. Barr, W.D. Shepard, 2♂ (JBSC), 1♂ (EMEC). Same site, 28 May 2015, C.B. Barr, W.D. Shepard, 1♀ (EMEC). Same site, 27 May 2016, C.B. Barr, W.D. Shepard, 1♂ (EMEC). Same site, 18 June 2016, C.B. Barr, W.D. Shepard, 1♂ (EMEC). Same site, 15 June 2017, C.B. Barr, W.D. Shepard, 2♂ (EMEC). **Humboldt Co.**, Willow Creek, East Fork confluence, 40.90849, -123.70783, 19 May 2008, J. Lee, 2♂, 1♀ (JJLC, BPSC). Same site, 15 June 2011, J. Lee, 1♂ (JJLC). **Lake Co.**, Putah Creek, 38.78528, -122.69250, 14 May 2012. L.E. Serpa, 1♂ (LESC). **Mendocino Co.**, North Fork Garcia River Tributary, 38.92056, -123.55028, 28 May 2008, L.E. Serpa, 1♂, 2♀ (LESC). Small stream, Leggett, Hwy 101, 22 May 1982, K.W. Stewart, D.D. Ziegler, 1♀ (BYU). **Santa Clara Co.**, Swanson Creek, Uvas Park, 11 May 1982, S.D. Smith, 1♀ (BYU). Uvas Creek, 4 km below Uvas Park, 11 May 1982, S.D. Smith, 1♂, 1♀ (BYU). Valpe Creek, 37.47167, -121.66675, 12 May 2005, L.E. Serpa, 1♂, 1♀ (LESC). **Sonoma Co.**, Courtship Creek, 38.34044, -122.59806, 25 April 1981, L.E. Serpa, 1♂ (LESC).

**Male epiproct.** Stark & Gustafson (2004) presented an image (Fig. 19 in Stark & Gustafson) of the epiproct from Glenn County specimens in which the epiproct stem gradually becomes wider near the apex and the lateral margins of the anterior face do not extend beyond those of the stem. In addition, the anterior face was 252 µm wide and heavily armed with a total of 37 marginal and submarginal teeth in 3+ rows. The specimen of *S. thyra* in our study from Napa County (Figs. 6-7) has the anterior face distinctly wider than the stem (175 µm, but narrower than that of the Glenn County specimen) and has smaller and far fewer (21) teeth.

**Male aedeagus.** Stark (1983) described and illustrated this distinctive structure from the holotype and from Napa County specimens. Herein, we provide additional images of the structure from a Humboldt County specimen. In all specimens examined by us, the ventral surface of the aedeagus bears a pair of prominent, curved

spines that arise from sclerites (Fig. 12). Additional small setal spines occur along the anterolateral margins (Fig. 13).

**Larval abdominal pigment patterns.** Stark (1983) described the larva of this species from Napa County specimens. In those specimens, terga 4 and 7 have small, circular, median pale spots and the median tergal spot on segment 5 is similar in shape to the lateral spots. In our study of Glenn County specimens the median spot on tergum 4 is absent and the median spots on terga 5-6 are similar in size and shape (Fig. 16).

**Distribution.** The holotype specimen of *S. thyra* is reported to be from "Nevada" (Needham & Smith 1916) and all other known specimens are from California, with most records coming from the Coast Range north of San Francisco. The northernmost record is from Willow Creek in Humboldt County and the southernmost from Uvas Canyon in Santa Clara County. The species is also known from the Sierra Nevada in El Dorado and Placer counties and it co-occurs with *S. quadrispinula* in the Willow Creek drainage of Humboldt County. However, *S. thyra* was collected on the main stem Willow Creek while *S. quadrispinula* occurred in its smaller, high gradient tributaries.

#### *Soliperla* sp. (Unidentified Larval Records)

The following 75 stream bioassessment records for 16 counties were obtained from the California Environmental Data Exchange Network (CEDEN <http://ceden.waterboards.ca.gov>). The query was limited to Surface <http://ceden.waterboards.ca.gov> Water Ambient Monitoring Program (SWAMP) projects. SWAMP bioassessment partners who collected samples from 1995 to 2015 included various state, federal, and regional agencies, and two citizen monitoring groups. Prior to the present study there were no characters that reliably separated *Soliperla* larvae to species. We provide these larval records (Fig. 18) to help define the range of the genus within the state.

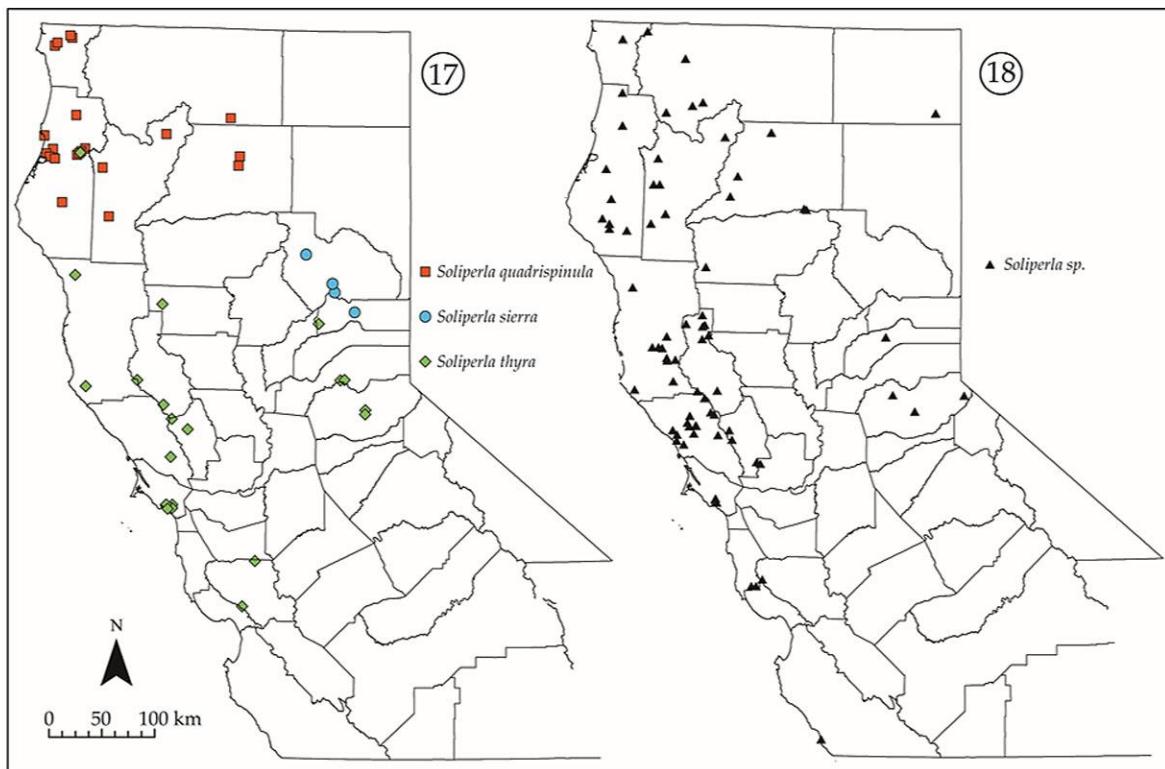


Fig. 17. Distribution of *Soliperla* species in California (*S. quadrispinula* = red squares, *S. sierra* = blue circles, *S. thyra* = green diamonds).

Fig. 18. Distribution of unidentified larval *Soliperla* specimens in California (*Soliperla* sp. = black triangles).

We also provide a preliminary key to California species of larval *Soliperla*. The key relies on the pattern of pale spots on abdominal terga 2-6 of late instar specimens. These spots are variable in size and shape, consequently, the key should be regarded as tentative.

#### Preliminary Key to California Late Instar *Soliperla* Larvae

- 1 Abdominal terga 4-6 typically with elongate, pale median spot (Fig. 15); known from Plumas and Sierra counties ..... *S. sierra*
- 1' Abdominal terga 5-6 typically with variably shaped, pale median spot (Fig. 16); widely distributed in Coast Range and at scattered sites in the Sierra Nevada; uncommon in Plumas and Sierra counties ..... 2

- 2 Median pale spot on abdominal tergum 6 almost as large as median pale spot on abdominal tergum 5 (Fig. 16); median spots on terga 5-6 usually elongate ..... *S. thyra*
- 2' Median pale spot on abdominal tergum 6 less than half as large as median spot on abdominal tergum 5 (Fig. 14); median spots on terga 5-6 often bell or triangular in shape ..... *S. quadrispinula*

California larval records of *Soliperla* from the CEDEN Exchange Network. **Del Norte Co.** Dunn Creek, ~1.4 mi above Black Cr., 41.92939101, -123.5725438, 28 August 2012, ABL, 2L. Kelly Creek, ~0.7 mi above MF Smith River, 41.855326, -123.852390655, 14 September 2010, ABL, 1L. **El Dorado Co.** Bald Mountain Canyon Creek, above Rock Cr., 38.872554, -120.7434805, 27 September 2011, ABL, 1L. Hidden Valley Creek above confluence, 38.87197, -119.96403, 30 July

2001, SNARL, 1L. Sly Park Creek, ~1.5mi below Park Creek Rd., 38.7349, -120.5041, 22 June 2015, ABL, 1L. **Humboldt Co.** Brock Creek, ~2 miles above Eel River., 40.22275, -123.72062, 14 August 2002, ABL, 1L. Freshwater Creek HC-DS, 40.74293, -123.97782, 3 September 2015, ABL, 3L. Grizzly Creek, ~0.2mi above Van Duzen River, 40.48843, -123.90767, 24 September 2003, ABL, 1L. Little Pine Creek, ~3 miles upstream from Pine Creek, 41.11777, -123.81514, 21 August 2002, ABL, 1L. Pecwan Creek WF, ~2 miles above Pecwan Creek, 41.39686, -123.83009, 22 August 2002, ABL, 1L. Salmon Creek, ~4mi above Pine Dr., 40.23387, -123.91645, 3 June 2014, ABL, 1L. Squaw Creek, ~0.6 miles upstream from Grasshopper Rd., 40.31673, -123.99758, 8 August 2002, ABL, 6L. Unnamed Trib. to Salmon Creek, 40.23447, -123.91526, 4 June 2014, ABL, 1L. **Lake Co.** Bear Creek, below FS road 17NO2, 39.35314, -122.77651, 27 June 2005, ABL, 2L. Blue Slides Creek, above Bear Creek, 39.319333, -122.8453617, 7 June 2012, ABL, 2L. Copper Butte Creek, ~0.5mi above Eel River, 39.42944444, -122.84444444, 29 June 2004, ABL, 2L. Horse Creek, above Eel River, 39.524613, -122.8521869, 26 July 2011, ABL, 18L. Panther Creek, ~2.6mi above Welch Cr., 39.44605152, -123.0289344, 25 July 2011, ABL, 2L. Seigler Creek, ~1mi below Seigler Valley, 38.8853, -122.66473, 14 June 2003, CMG, 1L. Skeleton Creek, ~0.3mi above Nye Campground, 39.44159, -122.82022, 27 June 2002, ABL, 2L. **Marin Co.** Cataract Creek, 37.9325, -122.63555, 19 April 2001, ABL, 17L. Little Carson Creek, 37.96722, -122.64945, 19 April 2001, ABL, 3L. **Mendocino Co.** Big River SF, ~0.2mi above Montgomery Creek, 39.23667, -123.39222, 4 September 2003, ABL, 1L. Doolin Creek Middle Reach, 39.12817, -123.22369, 20 June 2002, SWRCB, 1L. Duncan Creek Upper Reach, 38.95381, -123.14825, 26 June 2002, SWRCB, 1L. Eldridge Creek, ~4mi above Seward Creek, 39.24027778, -123.3241667, 9 June 2004, ABL, 6L. Fox Creek above Eel River SF, 39.74028, -123.62972, 11 August 2015, ABL, 2L. Garcia River at SF Garcia at Eagles Bend, 38.8702, -123.56669, 28 August 2012, SWRCB, 1L. Gibson Creek Upper Reach, 39.14972, -123.22889, 20 June 2002, SWRCB, 3L. Hoil Creek, ~2mi above Tyler Creek, 38.87519, -122.88173, 26 July 2001, ABL, 1L. Mariposa Creek Upper Reach, 39.33444, -123.23583, 25 June 2002, SWRCB, 14L. Mill Creek, North Fork Upper Reach, 39.13778, -123.13417, 19 June 2002, SWRCB, 9L. York Creek Upper Reach, 39.23444, -123.28139, 28 June 2002, SWRCB, 2L. **Modoc Co.** Upper Mill Creek, 41.27906, -120.28458, 11 June 2004, SWRCB, 1L. **Monterey Co.** Prewitt Creek, above Hwy 1, 35.935546, -121.46781, 22 June 2010, ABL, 2L. **Napa Co.** Heath Canyon Creek, 2.2 km upstream of confluence with Sulphur Springs, 38.47124, -122.48879, 29 May 2012, SWRCB, 2L. Ritchie Creek above gabion wall in Napa-Bothe State Park, 38.55078, -122.52137, 2 May 2008, SWRCB, 2L. Spencer Creek, ~0.8mi above Green Valley Rd., 38.283767, -122.21725, 13 June 2011, ABL, 1L. **Nevada Co.** Roscoe Creek, ~0.3mi above McKilligan Creek, 39.36668386, -120.8275635, 09 June 2015, ABL, 1L. **San Mateo Co.** Butano Creek, 2km downstream of Butano Creek source, 37.22664, -122.2412, 4 June 2013, SWRCB, 1L. Oil Creek, 37.22935, -122.19052, 9 April 2002, ABL, 1L. **Santa Clara Co.** Upper Stevens Creek, 37.2871, -122.126, 12 April 2002, ABL, 1L. **Shasta Co.** Bald Mountain Creek, above McCloud River, 41.095661, -122.136006021, 4 August 2010, ABL, 1L. Clear Creek SF, ~2.9mi above Andrews Cr., 40.54267911, -122.5801735, 17 July 2014, ABL, 1L. Digger Creek, ~0.5mi above South Fork, 40.44283, -121.72449, 22 October 2014, ABL, 2L. Rock Creek, ~1mi below Onion Cr., 40.4531, -121.75377, 21 October 2014, ABL, 5L. West Squaw Creek, below Early Bird Mine, 40.71569, -122.5015, 27 September 1999, CMG, 1L. **Siskiyou Co.** Duck Lake Creek, ~0.8 miles upstream from French Creek, 41.33837, -122.9178, 13 September 2000, ABL, 1L. Johns Meadow Creek ~1mi above S. Russian Creek, 41.3075, -123.0336111, 17 July 2007, ABL, 2L. McNeal Creek, ~1mile SW of South Fork Salmon River, 41.24444, -123.32795, 24 July 2014, ABL, 1L. Unnamed Creek, ~2mi above Tompkins Creek, 41.70845, -123.13085, 01 August 2001, ABL, 1L. **Solano Co.** Wild Horse Creek, 480m upstream of confluence with Dug Road Creek, 38.27053, -122.1737, 29 May 2013, SWRCB, 1L.

**Sonoma Co.** Angel Creek, 38.60556, -122.97917, 25 October 1995, CMG, 2L. Bear Creek, 38.69817, -122.72928, 30 April 1997, SWRCB, 1L. Blue Jay Creek, 38.53506, -123.13433, 2 May 1997, SWRCB, 1L. Briggs Creek, 38.6817, -122.6899, 25 April 1997, SWRCB, 2L. Felta Creek, 38.58139, -122.88258, 20 October 1995, SWRCB, 1L. Gray Creek, 39.37343, -120.02822, 7 May 1997, SWRCB, 1L. Kidd Creek Upper Reach, 38.50092, -123.08764, 25 June 2002, SWRCB, 4L. Mark West Creek, ~0.4mi above Weeks Cr., 38.50709, -122.64294, 22 June 2009, SWRCB, 1L. Mill Creek, 38.584, -122.88736, 17 April 1997, SWRCB, 19L. Mt. Jackson Creek, ~0.5 above Westside Road, 38.51478, -122.90522, 17 June 2002, SWRCB, 1L. Palmer Creek, 38.57367, -122.95706, 24 October 1995, SWRCB, 1L. Sheephouse Creek, 38.44944, -123.08944, 2 May 1997, SWRCB, 1L. Squaw Creek Upper Reach, 38.818, -122.80067, 20 June 2002, SWRCB, 4L. Ward Creek, 38.5365, -123.13769, 02 May 1997, SWRCB, 2L. Willow Creek, 38.41831, -123.01272, 17 October 1995, SWRCB, 1L. Wine Creek Upper Reach, 38.66304, -122.95647, 1 July 1999, SWRCB, 2L.

**Tehama Co.** Flood Creek, ~1mi above Thomes Cr., 39.93522175, -122.8290681, 10 August 2011, ABL, 5L.

**Trinity Co.** Big Creek Trib., ~0.1 mile above Big Creek, 40.84723, -123.39963, 28 August 2001, ABL, 1L. Grassy Flat Creek, ~0.2 miles upstream from Hayfork Creek, 40.62725, -123.3729, 5 August 2000, ABL, 1L. Olson Creek, ~0.5mi above Hayfork Creek, 40.62472222, -123.4416667, 15 August 2007, ABL, 2L. Rattlesnake Creek, ~0.4mi above Flume Gulch Cr., 40.37818598, -123.2988996, 4 August 2011, ABL, 1L. Squirrel Gulch, ~2.2 miles upstream from East Side Rd., 41.0483, -122.6553, 15 August 2000, ABL, 5L. Van Duzen River, ~1.2mi above Zenia Rd., 40.29079, -123.45477, 11 July 2002, ABL, 2L.

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