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A REVIEW OF THE GENUS *SOLIPERLA* (PLECOPTERA: PELTOPERLIDAE)

Bill P. Stark¹

ABSTRACT.— The western Nearctic stonefly genus *Soliperla* is reviewed and six species are recognized. *Soliperla sierra* (Calif.) and *S. tillamook* (Ore.) are described as new to science and illustrations of diagnostic features are presented for all species. Males and nymphs are keyed and a phylogeny for the group is proposed.

Soliperla was proposed by Ricker (1952) as a monotypic subgenus of *Peltoperla* to contain *P. thyra* Needham & Smith. At that time the species was known only from the male holotype but Jewett (1954) described the female along with males and females of two additional species, *P. campanula* and *P. quadrispinula*; the nymph of *P. campanula* was also described at this time. Jewett (1955) described the fourth member of the group, *P. fenderi*, from a single male. These species have remained poorly known since their discovery, with only synoptic notes and regional keys (Jewett 1959, 1960) appearing until Stark and Stewart (1981) gave additional characters that supported Illies's (1966) elevation of the group to generic status.

During recent field work with colleagues in Washington, Oregon, and California, *Soliperla* nymphs were common in splash zones of small streams and springs. Through this work, nymphs were associated for the four known species, and the additional material collected along with specimens obtained

from museums permits the first comprehensive treatment of *Soliperla*. Methods were given by Stark and Stewart (1981).

Soliperla Ricker

Peltoperla (Soliperla) Ricker 1952: 157. Type-species of subgenus: *Peltoperla thyra* Needham & Smith. Monotypic.
Soliperla Illies 1966:26.

Adults and nymphs of *Soliperla* are unusual among Nearctic Peltoperlidae in displaying distinctive pigmentation patterns. Adults are typified by a dark mesal pronotal stripe that contrasts sharply with the light yellow background (Figs. 23, 31), and nymphs have conspicuous white areas on the abdominal terga that contrast with the dark background (Figs. 4, 15). Monophyly for the group is asserted on the basis of the distinctive epiproct, with recurved crenulate apex and the membranous pair of lobes associated with the epiproct (Figs. 5, 13). The genus is currently known from the western Nearctic region from central California to Washington (Fig. 1).

Keys to *Soliperla* males

- 1. Mesoventral area of aedeagus with two irregular longitudinal rows of short, thick setae (Figs. 3, 30) 2
- Mesoventral area of aedeagus with short, thick setae, if present, not in longitudinal rows 3
- 2(1). Lateral aedeagal lobes terminating in sclerotized spine with 2–4 small subapical setae (Fig. 29) *sierra*

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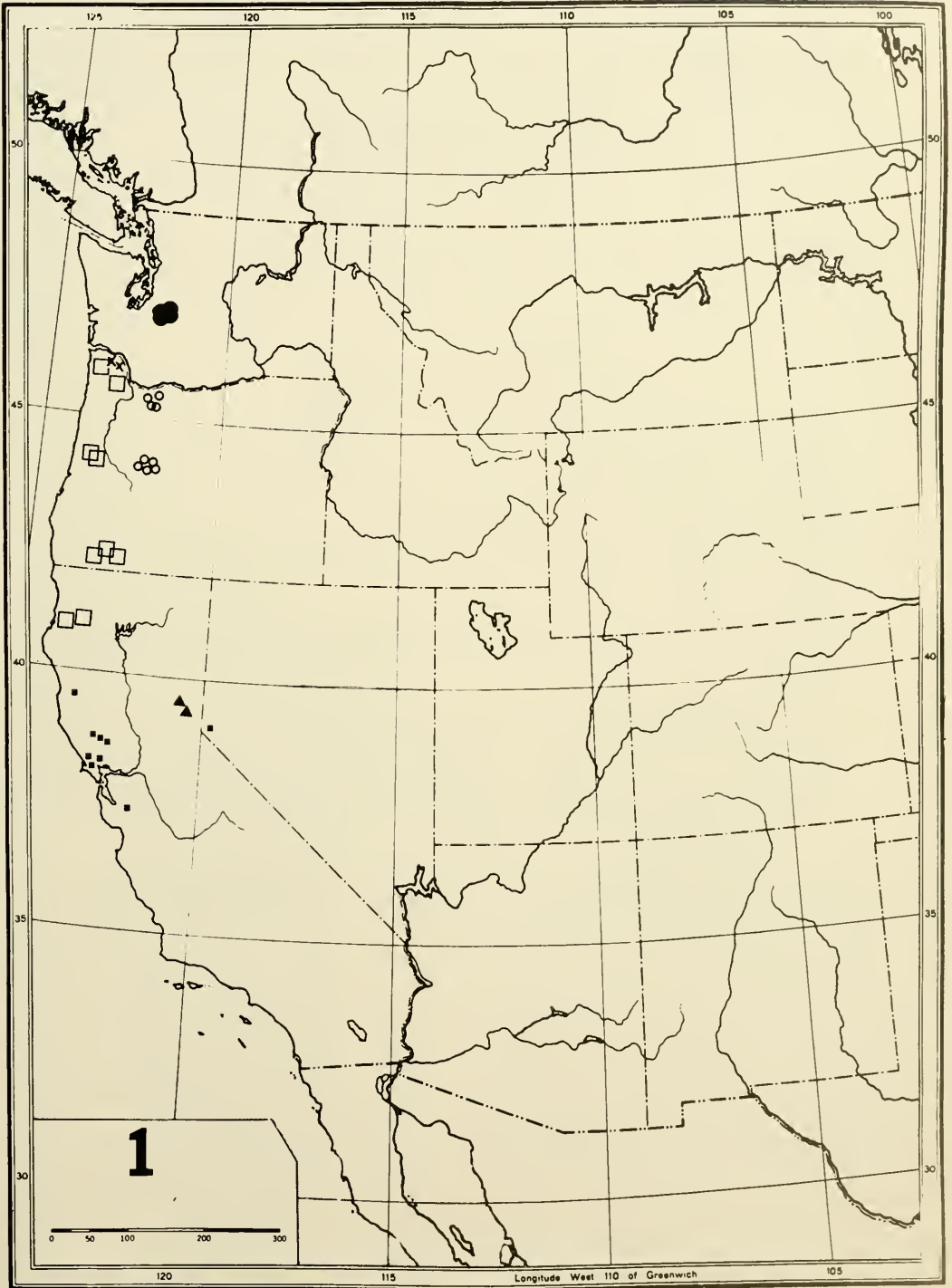


Fig. 1. Distribution of *Soliperla* species. *S. campanula* = open circles, *S. fenderi* = closed circles, *S. quadrispinula* = open squares, *S. sierra* = triangles; *S. thyra* = closed squares, *S. tillamook* = x.

- Lateral aedeagal lobes membranous apically with 2–4 small subapical setae (Fig. 2) *campanula*
- 3(1). Ventral aedeagal lobes with large sclerotized spine or a single long, thick seta (Figs. 19, 35) 4
- Ventral aedeagal lobes membranous with numerous scattered setae (Figs. 12, 45) 5
- 4(3). Ventral aedeagal lobes with sclerotized bilobed process (Fig. 35) *thyra*
- Ventral aedeagal lobes with a terminal long, thick seta (Fig. 19) *quadrispinula*
- 5(3). Ventral aedeagal lobes with irregular row of long, slender setae along apical margin (Fig. 12) *fenderi*
- Ventral aedeagal lobes with scattered short setae along apical margins (Fig. 45) *tillamook*

Preliminary key to nymphs
(*sierra* and *tillamook* unknown)

- 1. Some long setae in abdominal tergum 9 posterior fringe bent (Fig. 39); abdominal tergum 5 typically with lateral pale spots (Fig. 22) 2
- Long setae in abdominal tergum 9 posterior fringe straight (Fig. 6); abdominal tergum 5 typically without pale spots (Fig. 4) 3
- 2(1). Mesal area of abdominal tergum 8 posterior fringe with ca 20 clavate setae between long setae (Fig. 40); mesal pale spots on abdominal terga 5 and 6 rounded (Fig. 38) *thyra*
- Mesal area of abdominal tergum 8 posterior fringe with ca 5–7 clavate setae between long setae; mesal pale spots on abdominal terga 5 and 6 irregularly linear to triangular (Fig. 22) *quadrispinula*
- 3(1). Lateral pale spots on abdominal tergum 4 conspicuously larger than mesal spot (Fig. 15); known from Mt. Rainier, Washington *fenderi*
- Lateral pale spots on abdominal tergum 4 subequal to mesal spot in size (Fig. 4); widely distributed in northern Oregon *campanula*

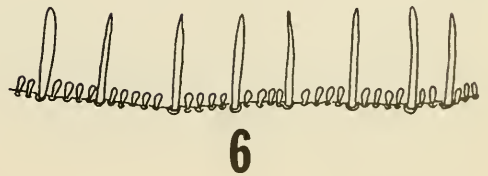
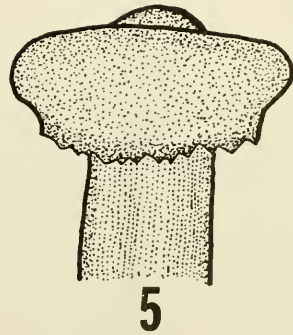
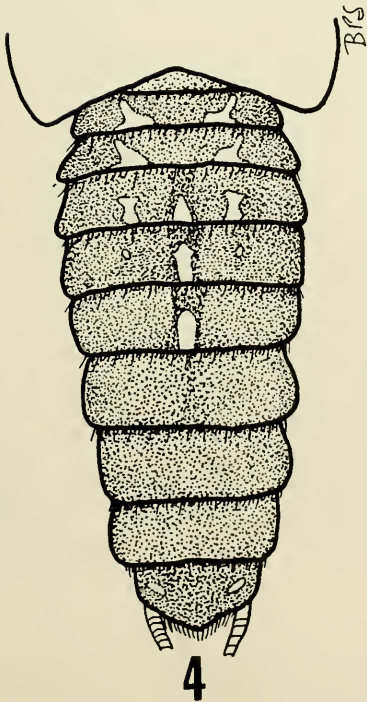
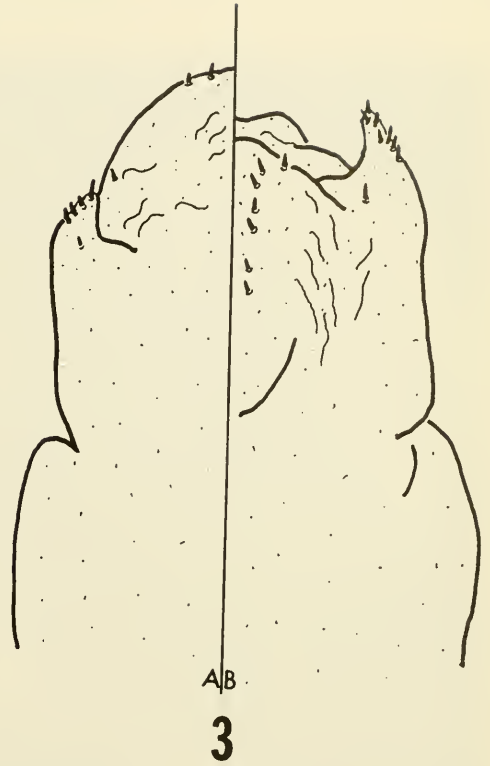
Soliperla campanula (Jewett)

Peltoperla (*Soliperla*) *campanula* Jewett 1954: 167. Holotype ♂ (CAS), Oxbow Springs, Hood River Co., Oregon

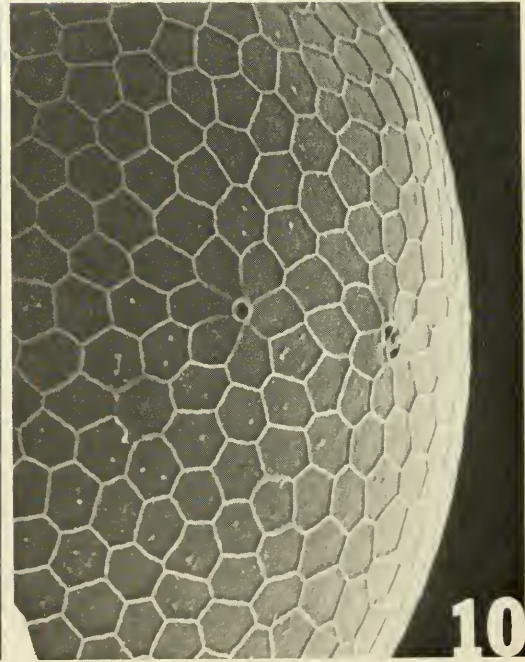
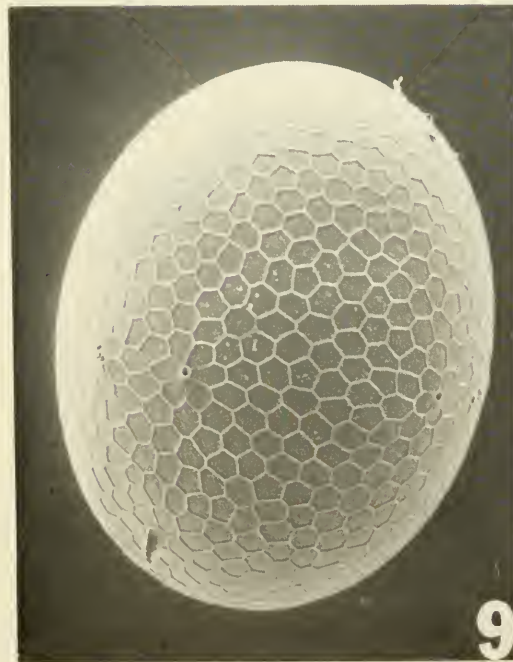
Jewett (1954) detailed the major diagnostic features of this species. Males are distinguished from other *Soliperla* by the structure of the epiproct and aedeagus. The anterodorsal face of the epiproct is about twice as wide as the stalk, and the lateral margins are curved inward near the crenulate antero-ventral surface (Fig. 5). Approximately 12–14 irregular teeth are present along this surface. The ventral aspect of the aedeagus includes a large mesal lobe and two small lateral lobes. The mesal lobe has two irregular rows of about 5–10 short peglike setae, and the lateral lobes have 2–4 subapical peglike setae (Fig. 3).

Females cannot be distinguished with certainty from several related species, and the eggs (Figs. 7, 8) also seem to lack features that would distinguish them from other members of the genus. The species is currently known only from northern Oregon (Fig. 1).

MATERIAL EXAMINED.—Oregon: *Clackamas Co.*, Mt. Hood, near Timberline Lodge, 31-V-77, K. W. Stewart, S. W. Szczytko, 2 ♂ (reared) (NTSU); same location, 20-VII-67, S. G. Jewett, 1 ♀ (USNM); Mt. Hood, Still Crk. Cmp. Gnd., 12-VII-79, B. Stark, K. W. Stewart, 2 ♂ (BPS); trib. Still Crk, Mt. Hood, 17-VI-67, S. G. Jewett, 1 ♂ (USNM); Mt. Hood, 1.2 mi N Hwy 26, 20-VII-67, J. Wold (USNM); trib. Salmon Riv, Mt. Hood, 15-VII-54, S. G. Jewett 1 ♂ (USNM). *Hood River Co.*, Oxbow Springs, 26-V-40, S. G. Jewett, 1 ♂, 1 ♀ (OSU); Iron Crk, W of Bennett's Pass, 11-VII-68, E. Evans, 1 ♂, 2 ♀ (USNM). *Lane Co.*, McRea Crk, H. J. Andrews Exp. For., 6-VII-78, B. Frost, 1 ♂, 1 ♀ (OSU); Mack Crk, H. J. Andrews Exp. For., 25-VI-74, N. H. Anderson, 1 ♂ (OSU); 12.5 mi NE Blue Riv, H. J. Andrews Exp. For., 19-VII-78, B. Frost (OSU). *Linn Co.*, Ice Cap Crk, 7-VII-66, J. Bedea,



Figs. 2-6. *S. campanula*. Fig. 2. Aedeagus, lateral. Fig. 3. Aedeagus, A = dorsal, B = ventral. Fig. 4 Nymphal abdomen, dorsal. Fig. 5. Epiproct, anterodorsal. Fig. 6. Nymphal abdominal tergite 8, posterior fringe.

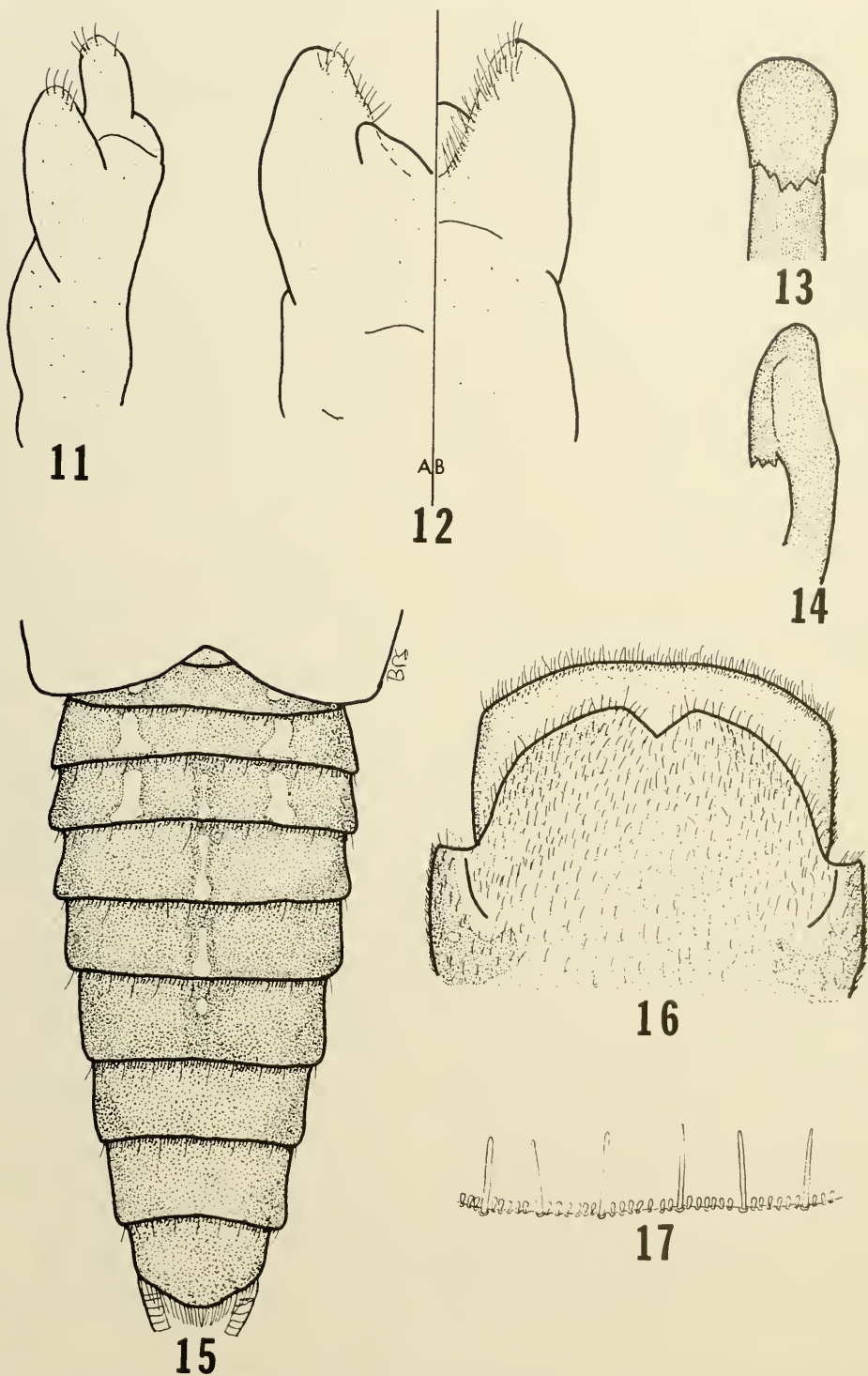


Figs. 7-10. *Soliperla* eggs. Fig. 7. *S. campanula*, 280X. Fig. 8. *S. campanula*, 1000X. Fig. 9. *S. fenderi*, 300X. Fig. 10. *S. fenderi*, 1000X.

2 ♂ (OSU); 14 mi NE Blue Riv, H. J. Andrews Expt. For., 6-VII-78, B. Frost 1 ♂ (OSU). *Multnomah Co.*, Wahkeena Falls, 3-V-47, S. G. Jewett, 2 ♂, 2 ♀ (ROM) (OSU); same location, 4-V-82, R. W. Baumann & S. G. Jewett, 1 ♂ (MLB).

Soliperla fenderi (Jewett)

Peltoperla (Soliperla) fenderi Jewett 1955: 145. Holotype ♂ (SGJ), Saint Andrews Crk, Mt. Rainier Natl. Pk., Washington



Figs. 11-17. *S. fenderi*. Fig. 11. Aedeagus, lateral. Fig. 12. Aedeagus, A = dorsal, B = ventral. Fig. 13. Epiproct, anterodorsal. Fig. 14. Epiproct; lateral. Fig. 15. Nymphal abdomen, dorsal. Fig. 16. Female sterna 8 and 9. Fig. 17. Nymphal abdominal tergum 8, posterior fringe.

Jewett's (1955) description of this species from a single male included diagnostic features of the epiproct and aedeagus. The anterodorsal face of the epiproct is about the same width as the shaft and is armed by about 5-6 teeth along the anteroventral surface (Fig. 13). The apical aedeagal section has two large membranous ventral lobes that have long slender setae in an irregular row along the distal margins (Fig. 12).

Females are distinguished on the basis of the shallow V-shaped notch on the subgenital plate (Fig. 16) and the eggs (Figs. 9, 10) are typical of the genus. This species is presently known only from Mt. Rainier National Park, but a single nymph collected by R. W. Baumann near Snoqualmie Pass could be this species (Fig. 1).

MATERIAL EXAMINED.— Washington: *Pierce Co.*, Mt. Rainier Natl. Pk. spring seeps along St. Andrews Crk, 13-VII-79, B. Stark, K. W. Stewart, 1 ♀ (reared) 7 nymphs (BPS); same location, 29-VI-81, K. W. Stewart, W. Shephard, 10 ♂, 6 ♀ (reared); small stream at Reflection Lk, 14-VII-79, B. Stark, K. W. Stewart 1 ♂ (reared) (NTSU). Seeps along Puyallap Riv, 29-VI-81, K. W. Stewart, W. Shephard, 1 ♂, 2 ♀ (reared) (NTSU). Christina Falls, 15-VI-69, R. W. Baumann, 1 ♂ (MLB).

Soliperla quadrispinula (Jewett)

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

Jewett's (1954) description suggested that the aedeagus of this species, as the name implies, has four prominent spines. I have found considerable variation in this character even within individuals taken from the same locality. However, all males examined had a single long, thick seta on each ventral lobe (Fig. 19); the variation occurs in the number of these setae on the dorsal lobes. The range of variation seen in this character extends from no setae (found on one male from Oak Crk, Benton Co., Oregon) to 4 setae (found on several individuals from Jackson Co., Oregon). The epiproct, as Jewett (1954) indicated, is similar to that of *S. campanula*, but the dorsal carina on the anterodorsal face is not developed mesally and the lateral margins near the anteroventral surface curve outward (Fig. 20).

The female and egg (Figs. 25, 26) are indistinguishable from several others in the genus. The species has the largest known range for any member of the genus. Records

are presently from northern Oregon (Clatsop Co.) to northern California (Humboldt and Trinity Cos.). Adults reared from Fieldbrook, California, mated readily in captivity but did not mate with *S. thyra* specimens from Napa Co., California.

MATERIAL EXAMINED.— California: *Humboldt Co.*, Grassy Crk, Fieldbrook, 22-V-82, B. Stark, D. Ziegler, 6 ♂, 3 ♀ (reared), 54 nymphs (BPS) (NTSU). *Oregon:* *Benton Co.*, Parker Crk, 1-VII-71, G. Steyskal, 1 ♂ (USNM); Oak Crk, 8-VI-79, P. Hammond, 3 ♀ (BK); same location, 10-13-V-69, C. Kerst, 1 ♂ (OSU); same location, 4-7-VI-68, 1 ♀ (OSU). *Clatsop Co.*, Osweg Crk, 2 mi E Elsie, 30-V-64, S. G. Jewett, 1 ♂ (ROM). *Jackson Co.*, 1.5 mi N Wrangle Cmp., 8-VII-79, B. Stark, K. W. Stewart, 19 ♂, 4 ♀, 4 nymphs (BPS) (NTSU); 15 mi S Talent, 8-VII-79, B. Stark, K. W. Stewart, 6 ♂, 3 ♀, 6 nymphs (BPS) (NTSU). *Josephine Co.*, Lake Crk, Oregon Caves Natl. Mon., 9-VII-79, B. Stark, K. W. Stewart, 1 ♀ (reared) (BPS). *Yamhill Co.*, 5 mi E Hack Crk Rd-Hwy 5 jct, 13-V-82, K. W. Stewart, D. Ziegler, 1 ♀ (reared) (NTSU).

Soliperla sierra, n. sp.

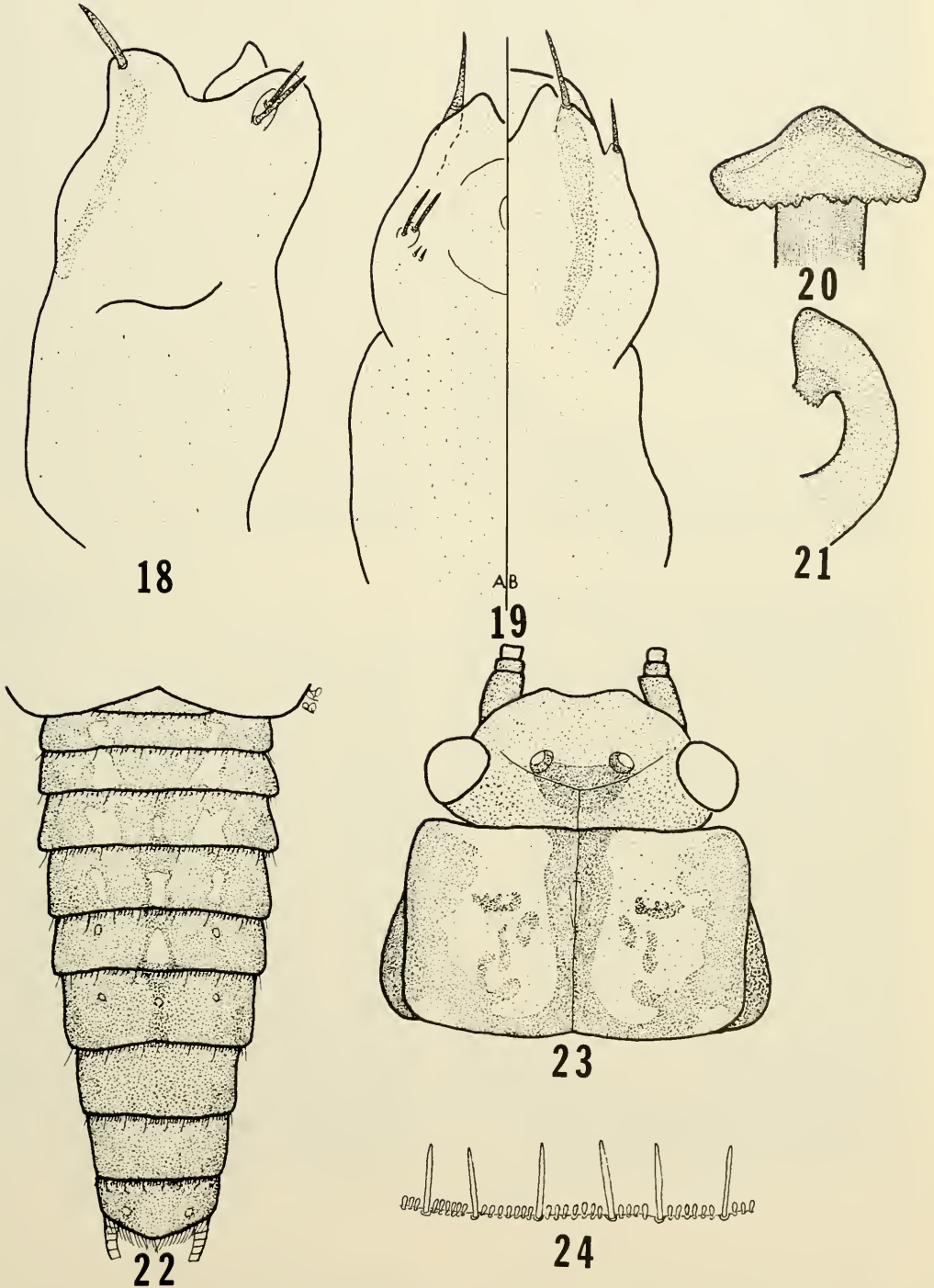
MALE.— Body length, 10 mm; forewing length, 12 mm. General color yellow patterned with light brown. Head without brown markings; pronotum with long light spot in mesal dark stripe (Fig. 31). Anterodorsal face of epiproct about 2× wide as stalk, lateral margins curved to anteroventral margin; mesal teeth widely separated (Fig. 32). Ventral lobe of aedeagus with 2 irregular mesal rows of about 5-8 short, thick setae; lateral lobes with a large conical terminal spine and about 2-4 subapical short, thick setae (Fig. 30).

FEMALE.— Body length, 12 mm; forewing length, 14 mm. General color similar to male. Subgenital plate large, parabolic, reaching posterior margin of sternum 9.

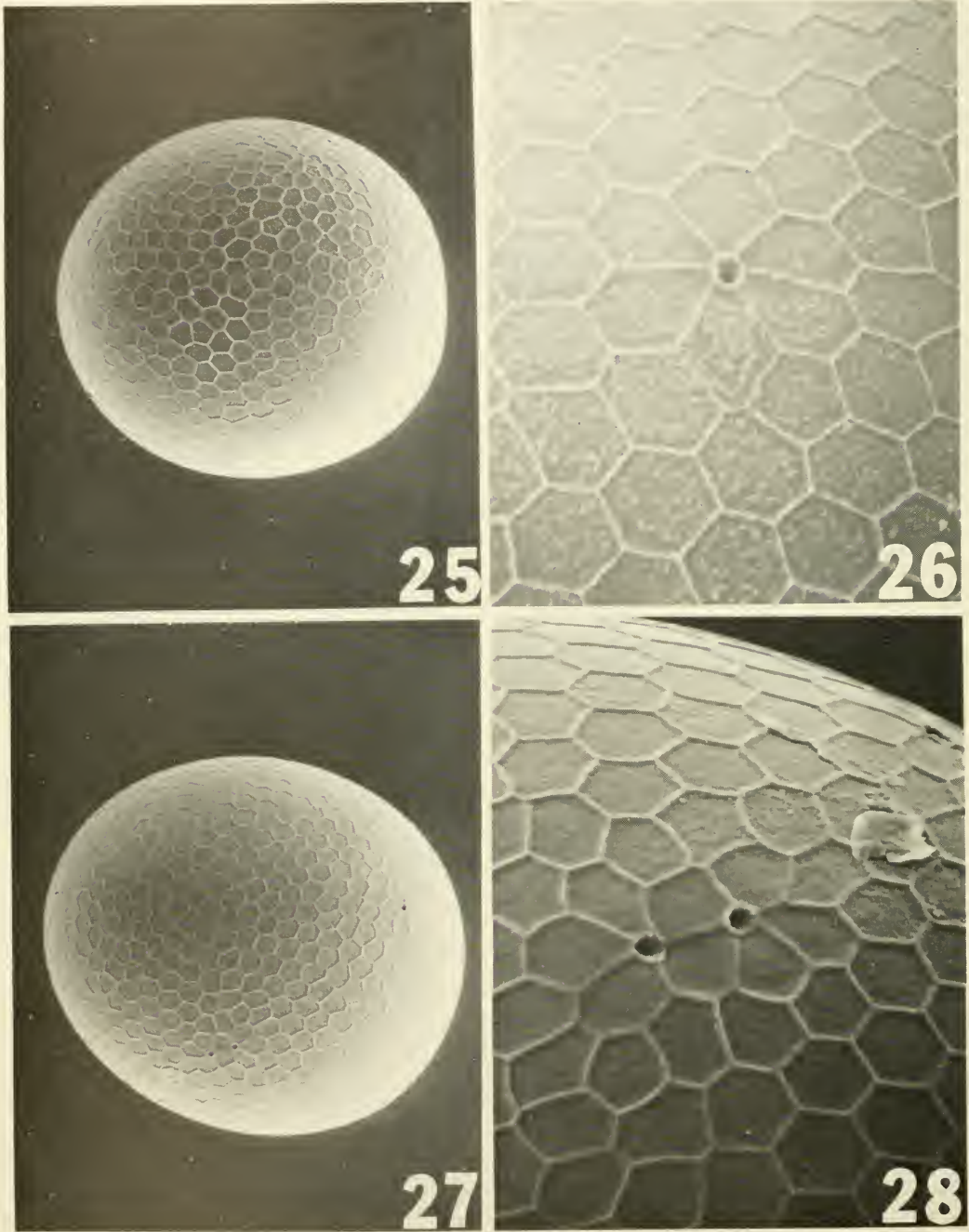
EGG.— Typical of the genus (Figs. 27, 28) but micropylar orifices are irregular rather than smooth.

TYPES.— Holotype (♂), allotype (♀), and 5 ♂ and 2 ♀ paratypes from Plumas Co., California, French Crk, 1 mi N Caribou, Butt Reservoir Rd, 25-VI-80, R. W. Baumann and J. Stanger, deposited in the U.S. National Museum (100090). Additional Paratypes: California: Sierra Co., Big Springs, Hwy 49, N Sierra City, 24-VI-80, R. W. Baumann, J. Stanger, 13 ♂, 4 ♀ (MLB).

ETYMOLOGY.— The specific name *sierra* refers to the mountain range in which it was collected.



Figs. 18-24. *S. quadrispinula*. Fig. 18. Aedeagus, lateral. Fig. 19. Aedeagus, A = dorsal, B = ventral. Fig. 20. Epi-proct, anterodorsal. Fig. 21. Epi-proct, lateral. Fig. 22. Nymphal abdomen, dorsal. Fig. 23. Female head and pronotum. Fig. 24. Nymphal abdominal tergum 8, posterior fringe.

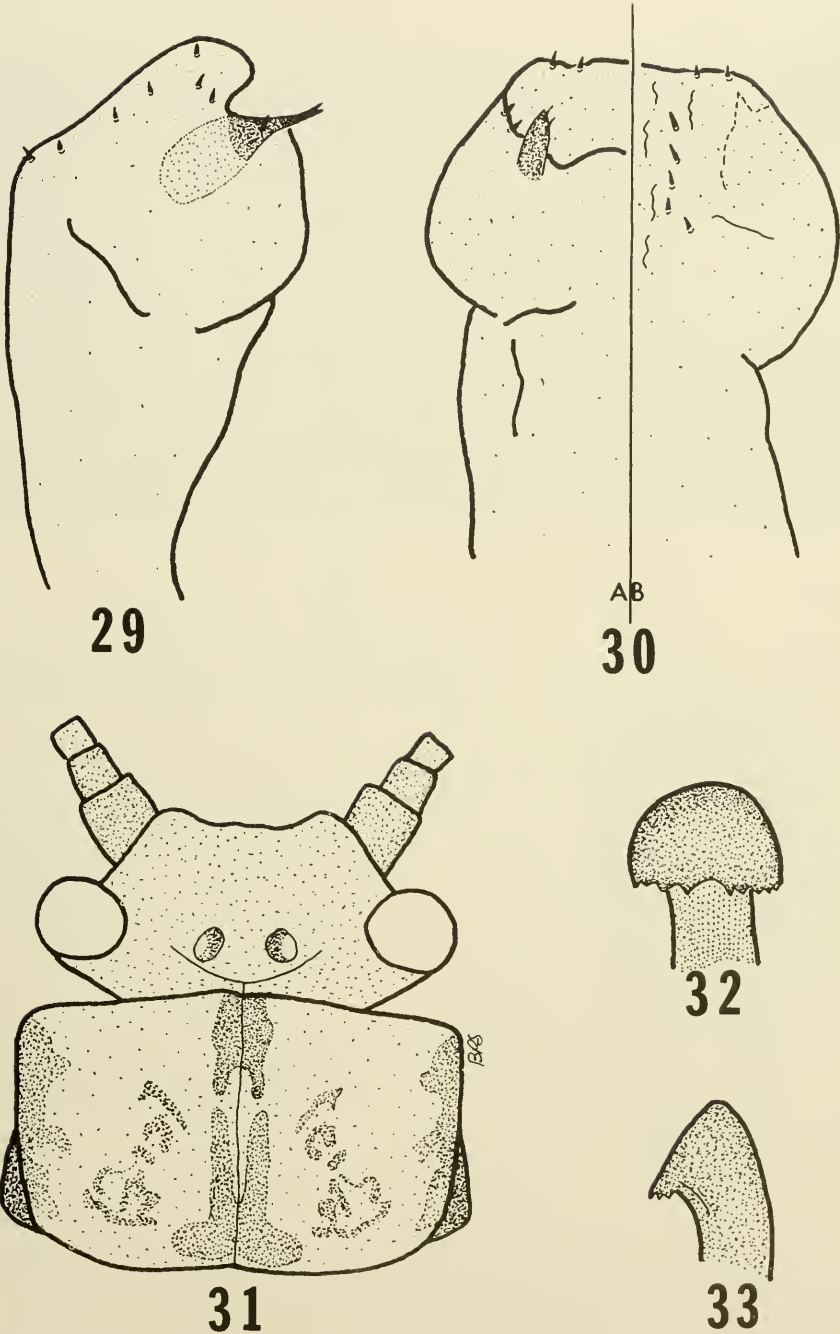


Figs. 25-28. *Soliperla* eggs. Fig. 25. *S. quadrispinula*, 240X. Fig. 26. *S. quadrispinula*, 1000X. Fig. 27. *S. sierra*, 240X. Fig. 28. *S. sierra*, 1000X.

Soliperla thyra (Needham & Smith)

Peltoperla thyra Needham & Smith 1916: 87. Holotype ♂ (Cornell Univ.), Nevada.
Peltoperla (Soliperla) thyra: Ricker 1952: 157.
Peltoperla (Soliperla) thyra: Jewett 1954: 167.

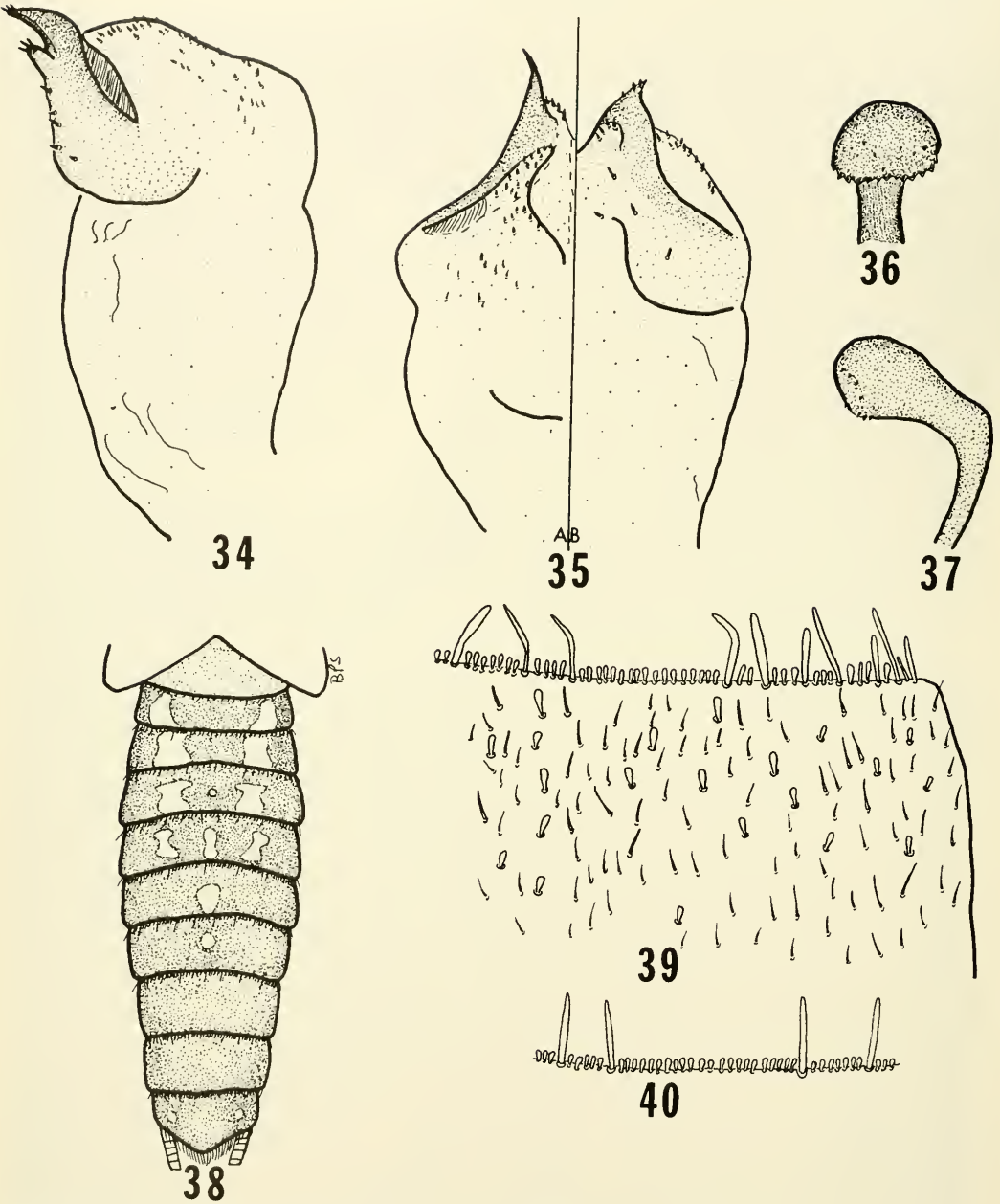
Jewett (1954) described the salient features of male and female genitalia and discussed the holotype specimen. After examining the holotype, I concur with Jewett in his usage of *thyra*. The anterodorsal face of the epiproct



Figs. 29-33. *S. sierra*. Fig. 29. Aedeagus, lateral. Fig. 30. Aedeagus, A = dorsal, B = ventral. Fig. 31. Female head and pronotum. Fig. 32. Epiproct, anterodorsal. Fig. 33. Epiproct, lateral.

is slightly wider than the stalk and about 10 irregular teeth are located along the anteroventral surface (Fig. 36). The ventral aedeagal lobes bear a partially sclerotized spinelike bilobed process; the ventral portion of the

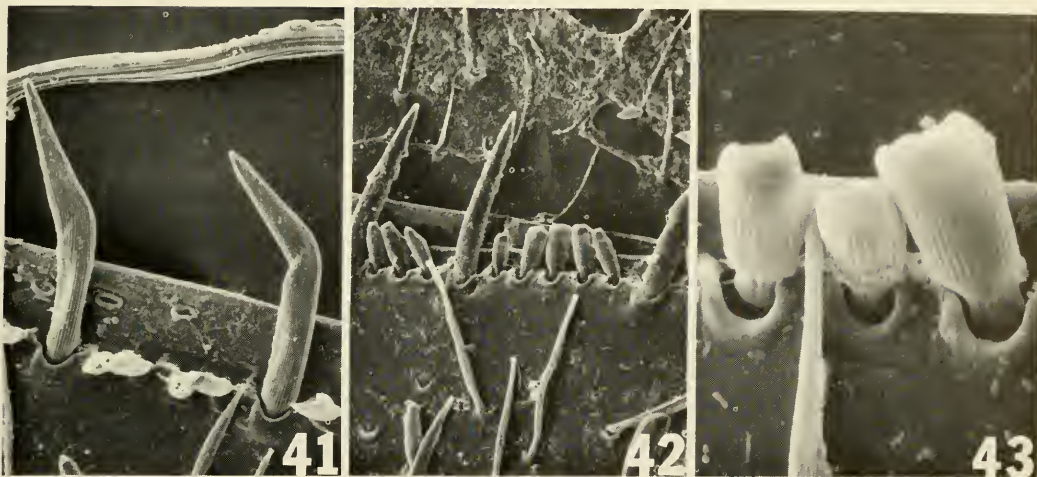
process is less heavily sclerotized and bears about 6-8 short, thick setae, including an apical cluster (Fig. 35). The dorsal membranous lobes bear several scattered short, thick setae (Fig. 35).



Figs. 34-40. *S. thyra*. Fig. 34. Aedeagus, lateral. Fig. 35. Aedeagus, A = dorsal, B = ventral. Fig. 36. Epiproct, anterodorsal. Fig. 37. Epiproct, lateral. Fig. 38. Nymphal abdomen, dorsal. Fig. 39. Nymphal abdominal tergum 9. Fig. 40. Nymphal abdominal tergum 8, posterior fringe.

The female and egg appear indistinguishable from several other members of the genus. The species is known from scattered localities around the San Francisco area, but no specimens have been taken in Nevada or eastern California except the holotype (Fig. 1).

MATERIAL EXAMINED.—California: *Marin Co.*, Cascade Crk, Mill Valley, 25-IV-57, H. B. Leech, 1 ♂ (ROM); same location, 20-V-55, H. B. Leech, 1 ♀ (ROM); trickle nr. Alpine Lk, 1-V-55, S. W. Hitchcock, 1 ♂, 2 nymphs (OSU); Mt. Tamalpais, 25-V-74, D. G. Denning, 1 ♂ (MLB). *Mendocino Co.*, sm. stream at Leggett, 22-V-1982, B. Stark, D. Ziegler, 1 ♂, 1 ♀, 2 nymphs (NTSU). *Napa Co.*, 9 mi N Calistoga, Hwy 29, 21-V-82, B. Stark, D. Ziegler, 4 ♂, 10 ♀, 4 nymphs (2 ♂, 6 ♀ reared)



Figs. 41–43. *S. thyra* nymphal setae. Fig. 41. Bent setae, posterior fringe tergum 9, 700X. Fig. 42. Straight and clavate setae, posterior fringe tergum 8, 600X. Fig. 43. Clavate setae, posterior fringe tergum 8, 2800X.

(BPS); Angwin, IV-76, D. Ashley, 1 ♀ (BPS). *Santa Clara Co.*, Uras Canyon, 25-V-74, D. G. Denning, 1 ♀ (MLB). Nevada: no additional data (Holotype ♂) (Cornell).

Soliperla tillamook, n. sp.

MALE.— Body length, 11 mm; forewing length, 13 mm. General color yellow patterned with brown. Anterodorsal face of epiproct slightly wider than stalk; anteroventral surface with about 7–9 teeth (Fig. 46). Ventral and lateral lobes of aedeagus membranous with scattered apical short, thin setae (Fig. 45).

FEMALE.— Body length, 13 mm; forewing length, 15 mm. Subgenital plate large, parabolic, reaching to posterior margin of sternum 9.

TYPES.— Holotype (♂) and 1 ♂ paratype from Clatsop Co., Oregon, Osweg Crk, 2 mi E Elsie, 13-VI-64, S. G. Jewett. Holotype deposited in the Oregon State University museum. Allotype (♀) and 1 ♂ paratype from Clatsop Co., Oregon, trib. Big Crk, Salmon Hatchery, 28-V-49, S. G. Jewett (OSU).

ETYMOLOGY.— The specific name honors the Tillamook Indians, who inhabited the area near the type locality.

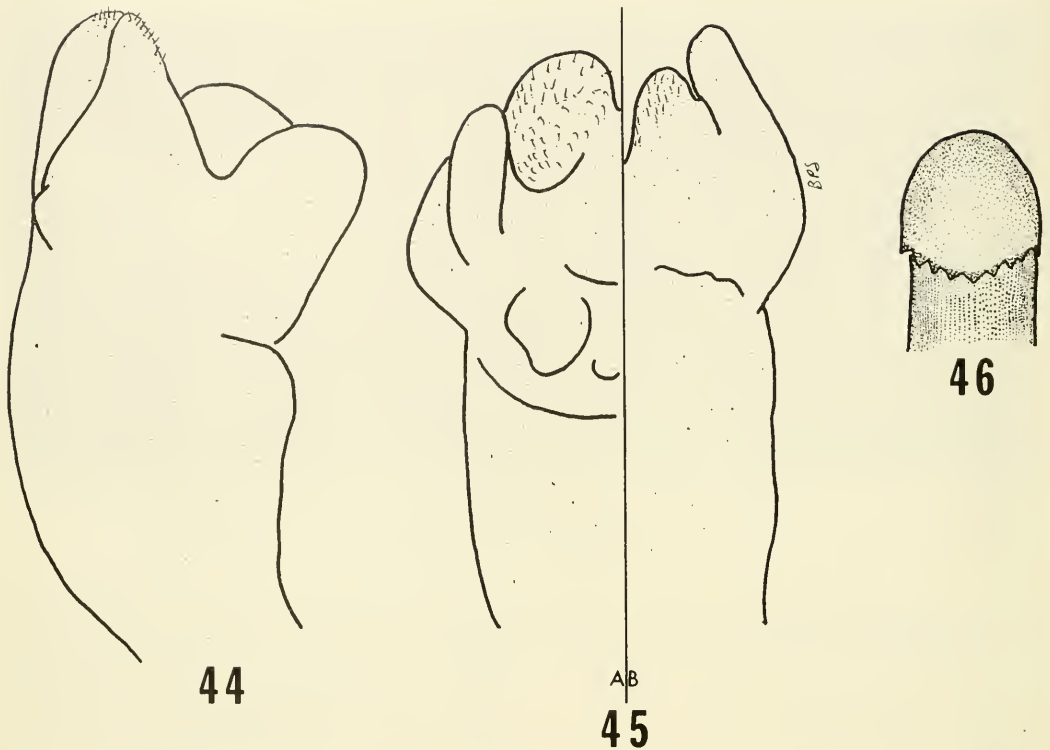
DISCUSSION

In this study several characters suitable for making phylogenetic inferences were ob-

served. Most of these have been selected from male genitalic structures since the egg, nymph, and female show little apparent variation. A taxonomic out group (TOG) consisting of *Yoraperla* and *Sierraperla* was formed to assist in inferring polarity of selected characters (Watrous and Wheeler 1981).

1. *Aedeagal setae.* Two variations of setae occurring on the ventral lobes were noted in the TOG and TIG (taxonomic in group). In *Yoraperla* and *Sierraperla* these setae are not appreciably thickened. Fine setae also occur in *Soliperla fenderi* and *S. tillamook* (Figs. 12, 45), but in other *Soliperla* species these setae are distinctly thickened (Figs. 3, 19). This is most conspicuous in *S. quadrispinula*, in which the setae are also longer than usual. Hence, thickened setae are regarded as apomorphic.

2. *Epiproct tip.* Within *Soliperla* several species have the epiproct tip expanded into a process that is much wider than the epiproct base (Figs. 5, 20), but in other species the epiproct tip is about as wide as the base (Fig. 13). Since *Yoraperla* and *Sierraperla* lack a developed epiproct, the TOG was expanded to include other Nearctic peltoperlid genera (*Tallaperla*, *Peltoperla*, and *Viehoerla*). In this group, both *Peltoperla* and *Viehoerla* have narrow epiproct tips, and in *Tallaperla* the epiproct is poorly developed (Stark and Stewart 1981). Hence, the expanded epiproct



Figs. 44-46. *S. tillamook*. Fig. 44. Aedeagus, lateral. Fig. 45. Aedeagus, A = dorsal, B = ventral. Fig. 46. Epiproct, anterodorsal.

tip of *S. campanula*, *S. quadrispinula*, *S. sierra*, and *S. thyra* is regarded as apomorphic.

3. *Subgenital plate margin*. The apex of the female subgenital plate is emarginate (*Sierraperla*) or notched (*Yoraperla*) in the TOG, but most *Soliperla* have a large parabolic plate that is entire along the margin. Only *S. fenderi* has a notched plate, but this notching is considered nonhomologous to that in the TOG and the notched plate is regarded as apomorphic.

4. *Outline of ventral aedeagal lobe*. In *Yoraperla*, *Sierraperla*, and several *Soliperla* species, the ventral aedeagal lobe is divided longitudinally by a cleft into lateral lobes (Figs. 12, 35). In two *Soliperla* species (*S. campanula* and *S. sierra*) the apical margin of this lobe is entire; hence, this is considered to be the apomorphic feature.

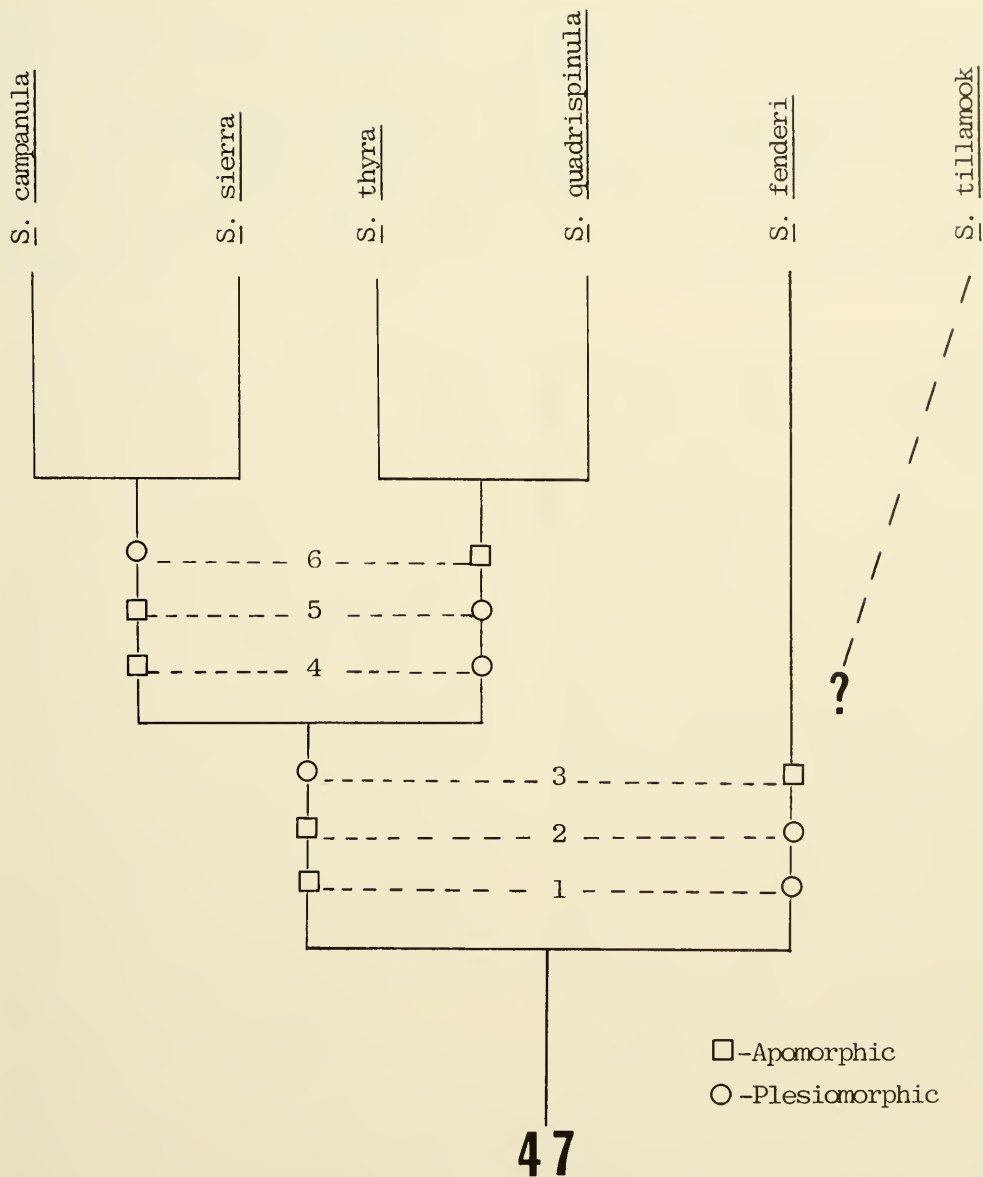
5. *Arrangement of aedeagal setae*. Typically in *Yoraperla*, *Sierraperla*, and *Soliperla* species the setae on the ventral aedeagal lobe are scattered, but in two species (*S. camp-*

anula and *S. sierra*) these setae form two irregular mesal rows (Figs. 3, 30). This latter variation is considered apomorphic.

6. *Sclerotization of ventral aedeagal lobe*. The TOG and most *Soliperla* species have entirely membranous ventral aedeagal lobes, but in *S. thyra* and *S. quadrispinula* these lobes are sclerotized (Figs. 19, 35). This latter modification is considered apomorphic.

These six characters were used to derive the cladogram shown in Fig. 47. This analysis must be regarded as tentative due to the limited number of characters utilized. The position of *S. tillamook* could not be determined since it exhibits the plesiomorphic condition for each of the six characters.

It seems probable, given the apparent high degree of endemism in the genus, that additional species await discovery from the Olympic Peninsula, Mt. Baker, and other isolated areas of the Pacific Northwest. It is hoped material from these areas and a larger sample of *S. tillamook* will permit rigorous testing of this cladogram.



47

Fig. 47. Proposed phylogeny for *Soliperla* species. See text for explanation.

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Stewart and D. Ziegler gave valuable assistance in collecting and rearing efforts. S. W. Szczytko (University of Wisconsin, Stevens Point) and S. Faison (University of Mississippi Dental School) assisted in preparing SEM micrographs. This study was supported, in part, by NSF grant DEB 78-12565.

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