Stewart, K.W., B.P. Stark, & L.L. Serpa. 2013. Larvae of the two North American species of *Calileuctra* (Plecoptera: Leuctridae). *Illiesia*, 9(01):1-13. Available online: http://www2.pms-lj.si/illiesia/papers/Illiesia09-01.pdf

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LARVAE OF THE TWO NORTH AMERICAN SPECIES OF *CALILEUCTRA* (PLECOPTERA: LEUCTRIDAE)

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ABSTRACT

Comparative larval descriptions and an updated generic diagnosis are provided for the two rare Nearctic species of the leuctrid genus *Calileuctra* Shepard & Baumann. The larva of the generotype *C. ephemera* Shepard & Baumann,was previously described, in part, from a single larva that was illustrated and subsequently lost, and the larval exuvium of a single reared male paratype. Larvae of *C. dobryi* Shepard & Baumann,were previously described in part from three individuals. Comparative descriptions utilize additional associated larvae, and SEM and light microscope study, providing additional characters. A key to the larval species is provided and differences in the molar structure of the right mandible of Leuctridae and Capniidae are discussed.

Keywords: *Calileuctra*, Plecoptera, Leuctridae, Larval descriptions

INTRODUCTION

The leuctrid genus *Calileuctra* Shepard & Baumann 1995, currently includes the two rare species *C. ephemera* Shepard & Baumann 1995, and *C. dobryi* Shepard & Baumann 1995, both known only from California. These species inhabit mostly intermittent headwater stream tributaries, including their type localities and additional sites. Adults are present from December to March, depending on seasonal precipitation; largest numbers have been collected in February. Based on the intermittent nature of the type localities and other known collection sites, and our unsuccessful collection attempts in drought years, the life cycle is probably a fast univoltine type, or fast semivoltine in successive drought years, similar to species of *Zealeuctra* (Snellen & Stewart 1979); this, and possible hyporheal occurrence of larvae until just before emergence, have made it difficult to get the timing right for collecting good numbers of mature larvae for study.

Shepard & Baumann (1995) gave a written

description of the single known larva of *C. ephemera* that they collected with the types. That larva, indicated as deposited in the California Academy of Sciences Museum, was subsequently lost before 2000. A habitus of it, drawn by Jean Stanger-Leavitt prior to its loss, was used with permission of R.W. Baumann for the partial description and illustration of the larva by Stewart & Stark (2002). Attempts by us to collect more larvae at the Capell Creek type locality in February, 2000, and early March, 2012, when it had only mud substrate or recent rainwater pools, were unsuccessful. Author (L. Serpa) has subsequently collected numerous adults and 15 larvae in sand-cobble substrates of pools from intermittent headwater tributaries, that flow variously, for up to nine months, located in oak-dominated areas of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and Redwood (*Sequoia sempervirens* (D.Don) Endl. forests in Mendocino County.

The four larvae of *C. dobryi*, studied and partially described by Stewart & Drake (2007), and an additional exuvium were available for this comparative study. Previous SEM's of mouthparts they described, of one larva, were reexamined for different views, along with further SEM's of one other larva, leaving two remaining as vouchers for possible future morphological study. Several attempts to collect more larvae of *C. dobryi* have been unsuccessful. In mid-February, 2000, author (K. Stewart), accompanied by Keith Dobry, for whom the species is named, attempted for two days to collect larvae and adults at the Ellsmere Canyon type locality, and other known intermittent area streams of sagebrush-oak woodlands in Los Angeles County, to no avail. A large population of adults, the 4 larvae and the exuvium were subsequently found in Silverado Canyon Creek in Orange County by K.W. Stewart and E.F. Drake from 2004-2006. The substrates of slower-flow habitats, where *C. ephemera* larvae have recently been found, may not have been adequately sampled for larvae at this site.

MATERIALS AND METHODS

Larvae were examined with light and scanning microscopy. Drawings were prepared using an Olympus SZH 10 or Wild M5 dissecting microscope with drawing attachment. Comparative SEM's were taken of specific body structures using an Amray1810D scanning electron microscope. The specimens studied are deposited in the B.P. Stark Collection, Mississippi College, Clinton, Mississippi, and L. Serpa personal collection. Because of the small sample size of larvae of these two rare species available for study, descriptions and the key do not address potential individual or geographic variation of characters. We have confidence in the field associations of larvae because of rarity of the species and that no congeners were found in any of the collection sites.

RESULTS AND DISCUSSION

Generic Diagnosis of *Calileuctra*

Following is an expanded and updated generic description of *Calileuctra* larvae from that of Stewart & Stark (2002) that was based on the partial description of *C. ephemera* larvae. The originally proposed combination of diagnostic *Calileuctra* characters included: 1) Ab_{1-7} divided by a pleural fold, (this character is shared only with the leuctrid genus *Megaleuctra* Neave, which is much larger and more setose, and with *Perlomyia* Banks, which has fused, terminally hairless paraprocts and a single stem of the mesosternal Y-ridge), 2) right mandible molar area with 8-10 stalked teeth in side view, (originally described by Stark & Stewart (2002) as a "scraping ridge"), and 3) a double stem of the mesosternal Y-ridge, (this character shared only with *Paraleuctra* Hanson and *Pomoleuctra* Stark & Kyzar, but both have much longer terminal cercomere hairs). These original characters are all supported by this study and the generic description, given below, is updated with revised and newly discovered characters, measurements, and illustrations. The further SEM study, with views into the right mandibular cup of *C. dobryi*, show stalked-tooth ridges similar to those described for *C. ephemera* by Shepard & Baumann (1995), and comparative side views of the cup of other leuctrid and capniid genera (Stewart & Stark 2002), suggest that the mandibular ridges found in leuctrid genera may be an additional character used in the difficult separation of larvae from these families.

Larval morphology. Body length ♂ 5-7mm, ♀ 6-8mm, light colored body with little pigmentation and generally few hairs (Figs. 1, 21). Antennae with 60-64

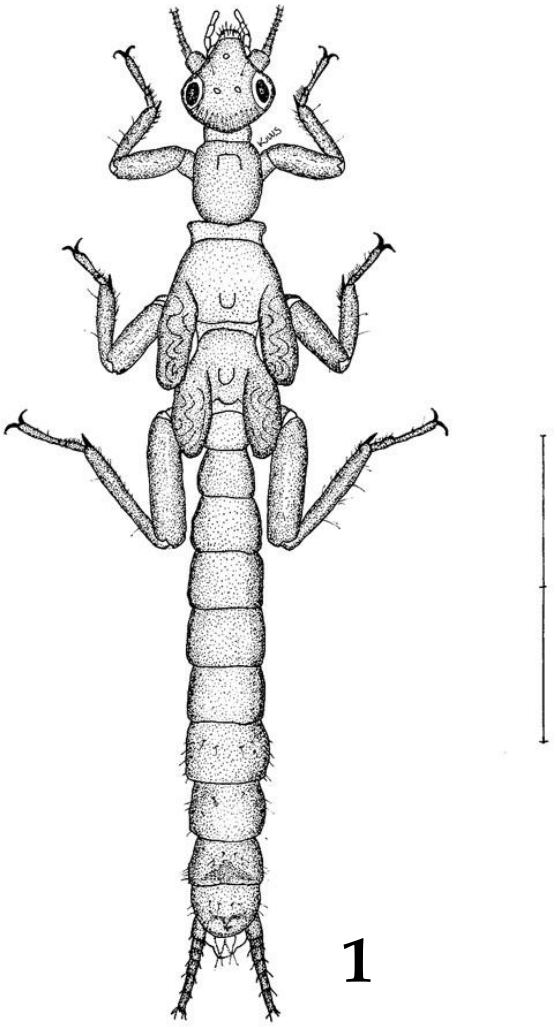
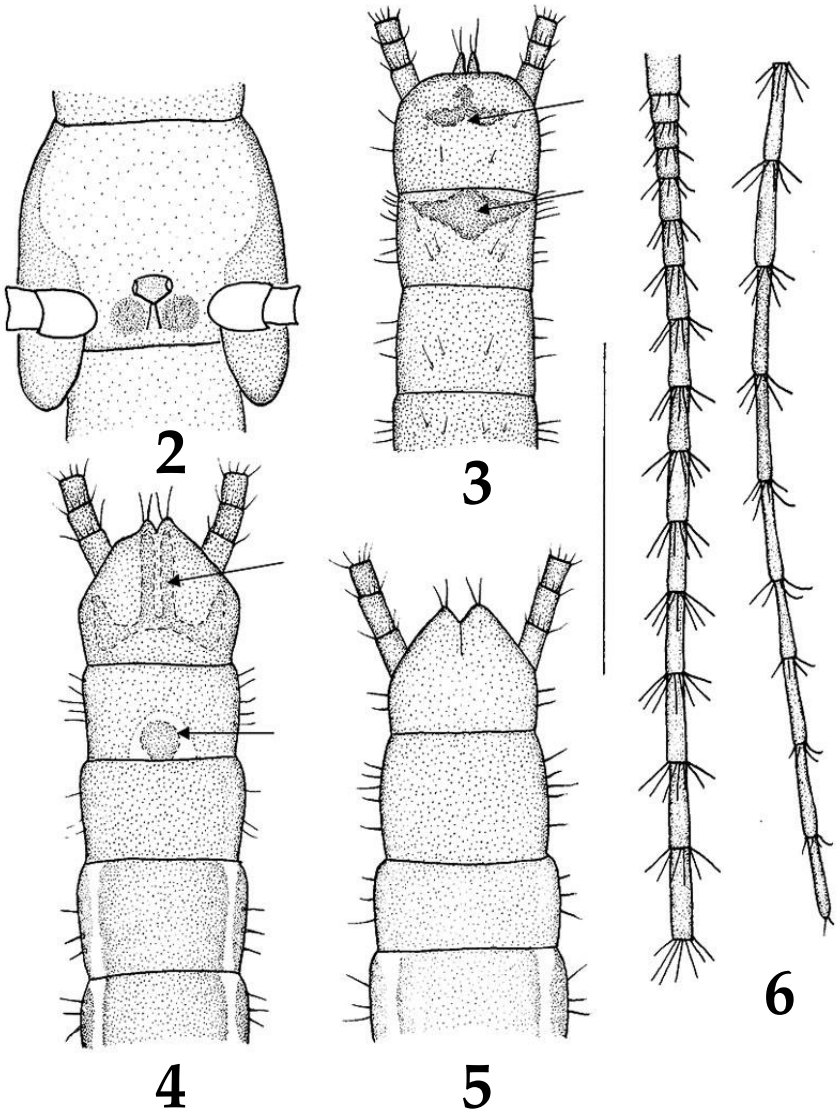


Fig. 1. *Calileuctra ephemera* pharate larval male habitus. Scale line = 2 mm.

segments, each with apical circlet of very short hairs or sensillae. Mouthparts Type 1 (herbivorous-detritivorous; Stewart & Stark 2002). Labrum and clypeus with numerous setae. Lacinia triangular and palmate, with 2 large, round-tipped apical teeth, dorsal and ventral rows of sharp spines, and a scalloped palm surface (Figs. 7, 8). Right mandible with short, rounded-tipped apical cusps and molar cup in side view with 8-10 short, stalked teeth (Figs. 11, 26); these teeth are manifested as curved ridges extending well onto the cup surface (Fig. 27). Left mandible with similar apical cusps; its molar cup with about 12 long, outer, finger-like teeth (Fig. 12) and inner surface with raised, transverse ridges (Fig. 13). Pronotum quadrangular, with no marginal setae and no distinct pattern (Figs. 1, 21). Mesosternal Y-ridge with a double stem, arms reaching to posterior corners of furcal pits, and a transverse ridge connecting anterior corners of furcal pits (Fig. 2). Wingpads with few, or no, hairs, 3 or more times longer than wide and with their longitudinal axes nearly parallel to body axis; hind wings slightly shorter than fore wings (Figs. 1, 21). Legs slightly increasing in size posteriorly; femora and tibiae with appressed, fine clothing hairs, scattered, short thick hairs (Fig. 14), and tarsal segments 1, 2 with a double row of short thick setae (Fig. 15). Abdominal terga without a posterior fringe of setae and variable

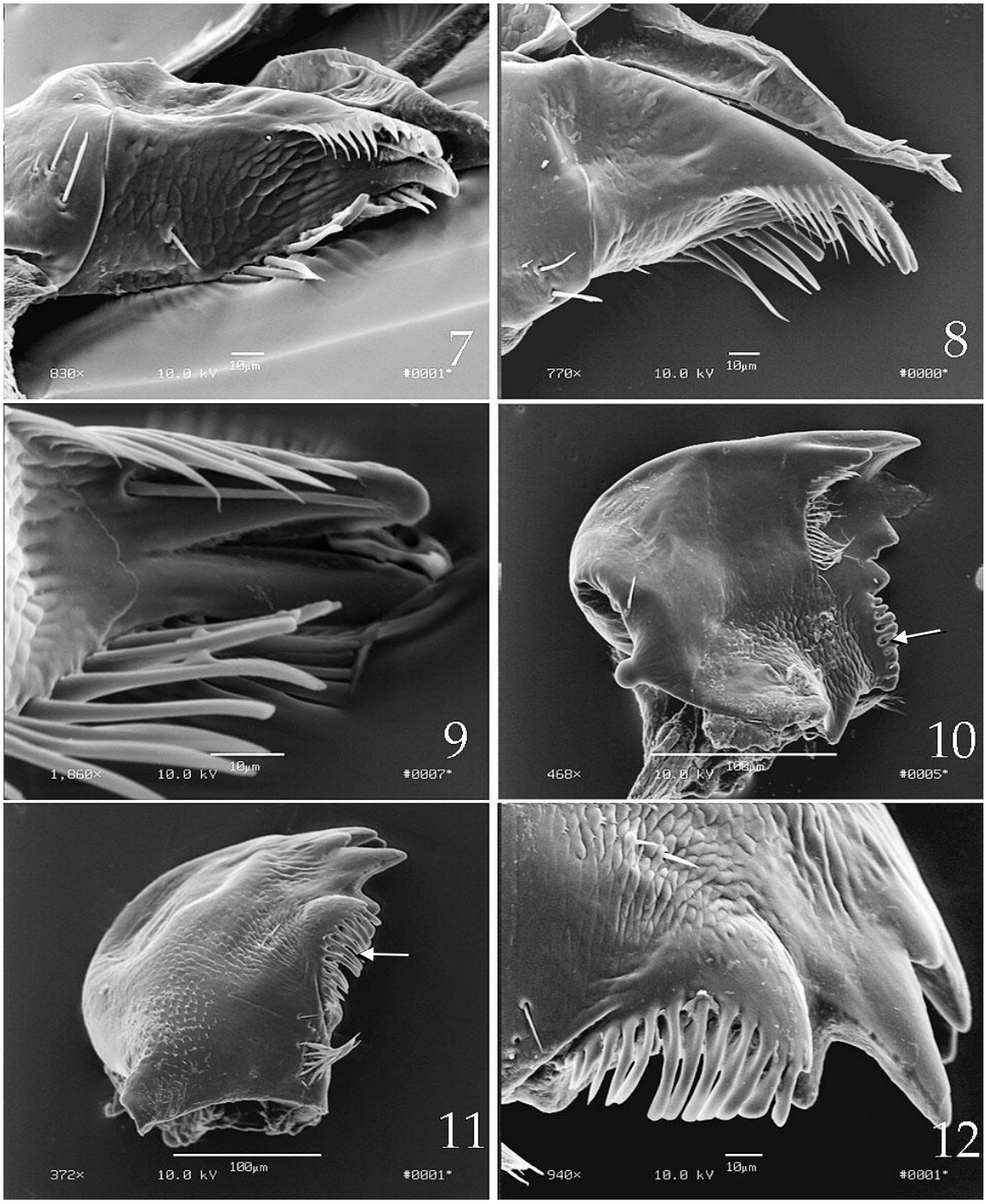


Figs. 2-6. *Calileuctra ephemera* larval characters. 2. Male mesosternum. 3. Pharate male terminalia, dorsal. 4. Pharate male terminalia, ventral. 5. Female terminalia, ventral. 6. Cercus, dorsal. Scale line = 1mm, arrows = developing male genitalic features.

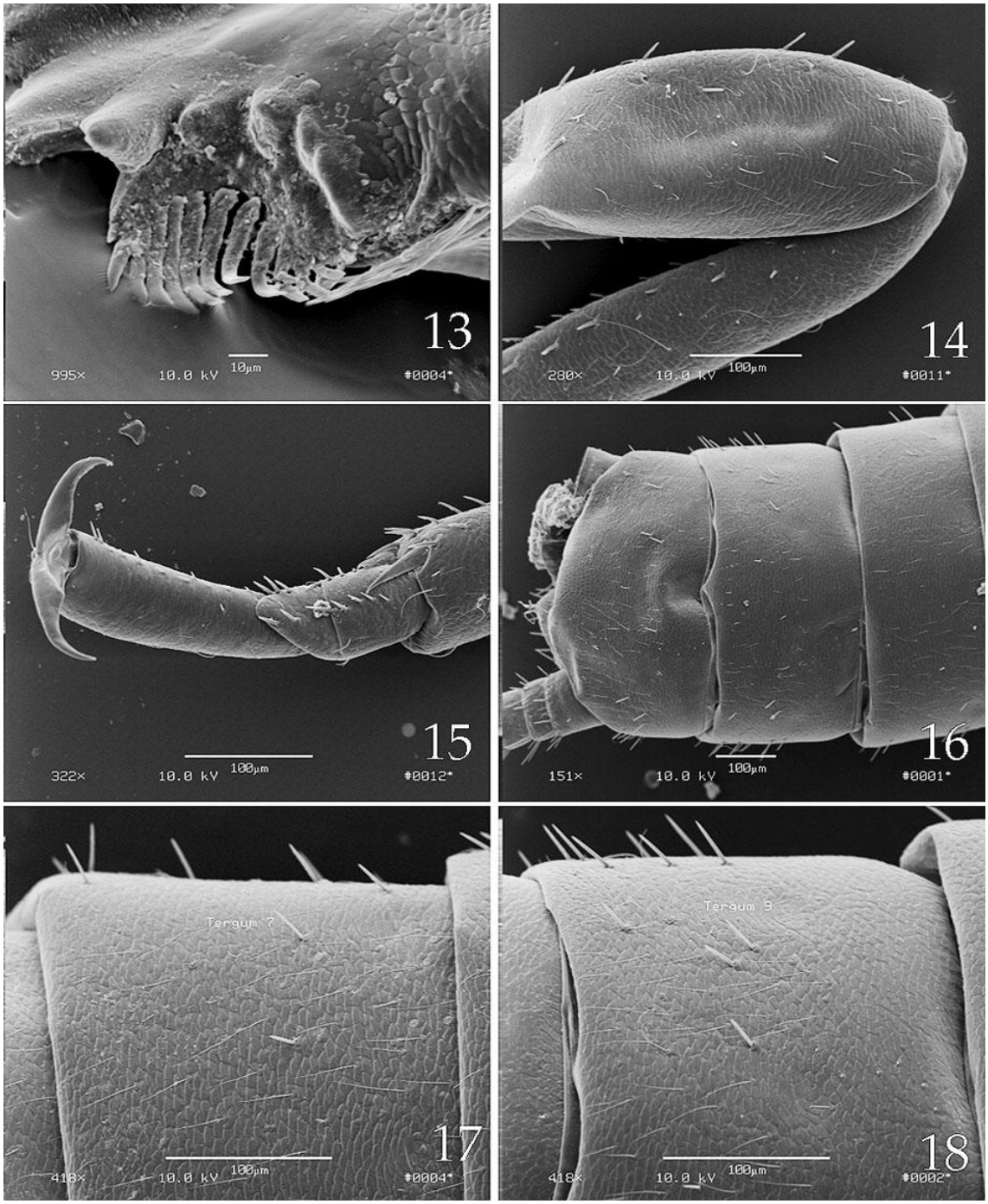
surface setation between species; pleural fold on segments 1-7 (Figs. 5, 23). Developing male genitalia evident dorsally and ventrally (Figs. 1, 3, 4) just prior to emergence. Paraprocts only incompletely fused at base (Fig. 5), each with a pair of terminal hairs (Figs. 1, 3, 4, 5). Cercal segments 20-22, each with apical circlet of more than 12 stiff setae, half as long as, or longer than, following segment (Figs. 6, 20, 24).

Species Accounts of Larvae

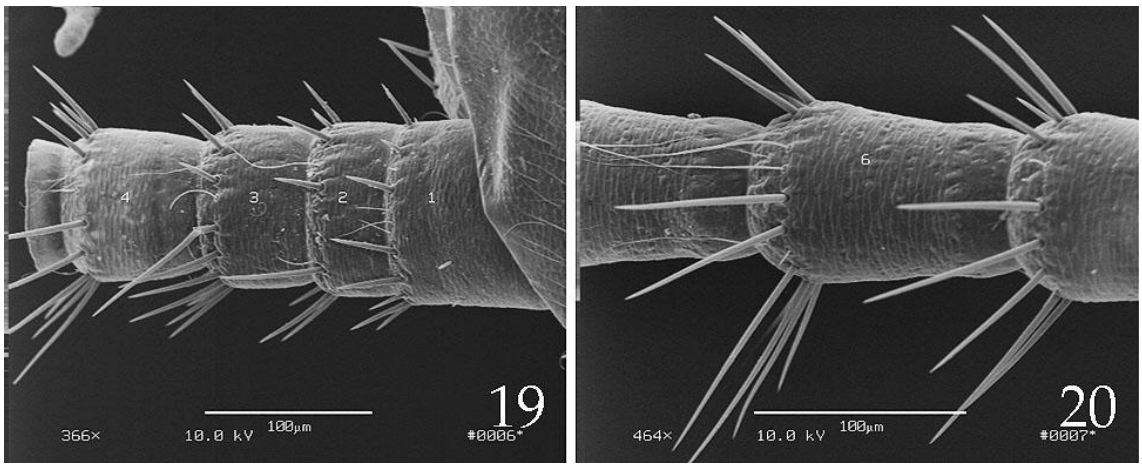
The following accounts include: 1) known distribution, 2) larvae, exuviae and adult material examined, and 3) description of characters not addressed in the generic diagnosis above, or that offer specific diagnosis, reinforcement or correction of original character descriptions of *C. ephemera* by Shepard & Baumann (1995) and Stewart & Stark (2002), and for *C. dobryi* by Stewart & Drake (2007). Descriptions and illustrations are based on typical, late instar individuals or exuviae from the few populations and individuals that were successfully field associated; therefore, they do not address possible variation of characters.



Figs.7-12. *Calileuctra ephemera* larval characters. 7. Lacinia, ventral. 8. Lacinia and galea, lateral. 9. Lacinia apex, ventral. 10. Right mandible, lateral. 11. Left mandible, outside. 12. Left mandible outside molar cup teeth. Arrows = molar cup.



Figs.13-18. *Calileuctra ephemera* larval characters. 13. Left mandible molar cup. 14. Left foreleg femur and tibia, anterior. 15. Left foreleg tarsus, ventral. 16. Abdominal terga 8-10. 17. Abdominal tergum 7. 18. Abdominal tergum 9.



Figs.19-20. *Calileuctra ephemera* cerci. 19. Basal 4 segments, dorsal. 20. Cercal segments 5, 6.

***Calileuctra ephemera* Shepard & Baumann**
(Figs. 1-6, 7-12, 13-18, 19-20, 33)

Distribution and collection site descriptions.

Known from Putah Creek in Lake Co., tributaries and the main channel of Whitlow Creek, Mendocino Co., and the type locality, Capell Creek tributary in Napa Co., all in California. Capell Creek tributary and Putah Creek sites are both in the Putah Creek drainage but separated by about 34 miles. The type locality (Fig. 33) was described by Shepard & Baumann (1995), whereas the latter site consists of two small, adjacent stream channels; the larger, southern channel, from which the female specimen was collected, has a closed riparian canopy composed primarily of California Bay (*Umbellularia californica* (Hook & Arn.) Nutt.), Big-leaf Maple (*Acer macrophyllum* Pursh), Blue Oak (*Quercus douglasii* Hook & Arn.), Black Oak (*Q. kelloggii* Newberry), Canyon Live Oak (*Q. chrysolepis* Liebm.) and California Buckeye (*Aesculus californica* (Spach) Nutt.). Additional shading occurs from the surrounding mixed oak forest along adjacent steep slopes. Herbaceous streamside vegetation consists mostly of California Fescue (*Festuca californica* Vasey). Adult *Malenka depressa* (Banks), *Sweltsa pisteri* Baumann & Bottorff and *Soliperla thyra* (Needham & Smith) were swept from riparian vegetation by author Serpa, and larvae of *Oemopteryx vanduzeea* (Claassen) and an undetermined *Isoperla* were collected on other sample dates.

The Whitlow Creek tributary sites are located about 43 miles northwest of the Putah Creek site (or 74 miles northwest of the type locality) on property owned by the Conservation Fund in the Garcia River watershed, Mendocino County, California, and the site receives additional protection from an easement held by the Nature Conservancy. The intermittent tributaries flow through steep forested terrain, becoming relatively level near their junctions with the main channel of Whitlow Creek which retains water at least 9 months of the year. The tributaries flow for about 4-5 months of the year but probably have hyporheic springs (suggested by the presence of blind unpigmented amphipods, *Stygobromus* sp. and the blind isopod, *Callasellus californicus* (Miller)) which reach the surface only during the wet months. The portion of the forest in which *Calileuctra* specimens were collected includes a heavy oak component along with California Bay, Oregon Ash (*Fraxinus latifolia* Benth.), Tan Oak (*Notholithocarpus densiflorus* (Hook & Arn.) Manos, Cannon & S.H.Oh), California Buckeye, Big-leaf Maple and young Douglas fir. Oregon White Oak (*Quercus garryana* Douglas ex. Hook.) grow on the adjacent slopes, often extending over the stream and providing additional shading. Seventy six adult *C. ephemera* adults were swept or beat from riparian vegetation with the vast majority of specimens found on herbaceous *Festuca*, rushes or ferns. All larvae were

collected from pools where the sand-gravel substrate could be disturbed to a depth of at least 3 inches. Other stoneflies collected with *Calileuctra* include members of the *Capnia ventura* Nelson & Baumann complex (R.W. Baumann *in litt.*) and *Mesocapnia projecta* (Frison).

Material examined. CALIFORNIA: Lake Co., Putah Creek, Hwy 175, 3.5 mi N Middletown, 23.00 mile marker, 17 May 1998, C.R. Nelson, B. Stark, S.W. Szczytko, I. Sivec, 1♀ (C.R. Nelson Collection). **Mendocino Co.**, 15 collections by L.E. Serpa, 17-II-2010 to 16-IV-2012, mainly tributary complex of Whitlow Creek, 38°54′41.4″ - 38°55′0″N, 123°28′14″ - 123°28′38″W, 131.4 - 204.5 m elevation, 33♂, 47♀, 15 larvae. One pair of larvae and most adults deposited in L.E. Serpa collection, 1♂ and 2♀ deposited in R.W. Baumann collection, Monte L. Bean Museum, Brigham Young University, Provo, UT, and remaining larvae and a few adults deposited in B.P. Stark collection, Mississippi College, Clinton, MS.

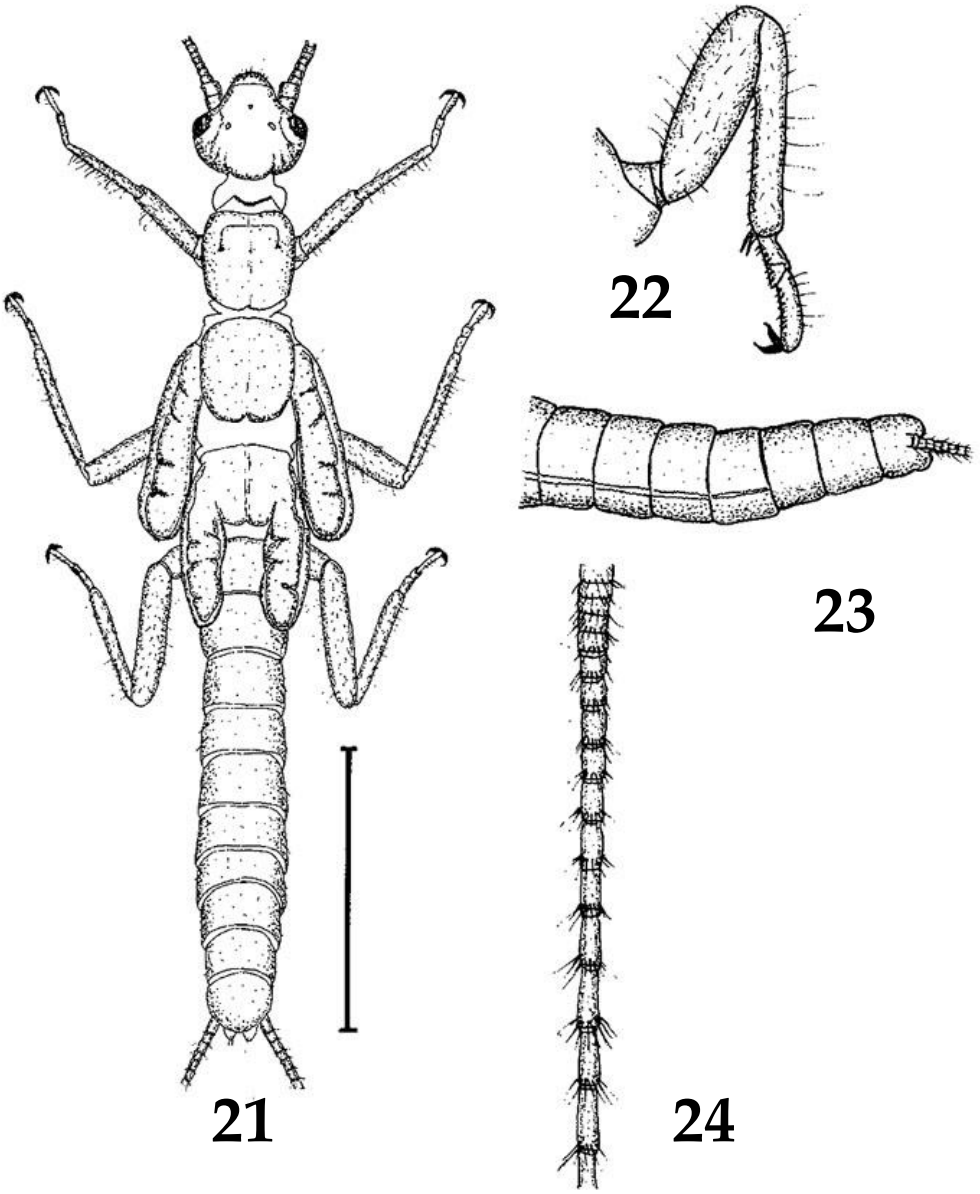
Characters of mature larvae. Color, pigmentation (Fig. 1), lacinia (Figs. 7, 8), general body, leg, and cercal setation (Fig. 1,) and mouthparts, typical of genus. Body length ♂ 5-6.5 mm, ♀ 6-8 mm. Head capsule width ♂ 0.66-0.75 mm, ♀ 0.75-0.84 mm. Antennal segments 60-64, each with very short apical circlet of hairs or sensillae. Lacinia triangular and palmate, with 2 rounded-tipped apical teeth, 8-10 dorsal and ventral rows of long, sharp spines, a long, trichoid sensilum arising from the base of one apical tooth (and as long as the tooth) (Fig. 9), and a scalloped palm surface. Right mandibular molar cup, in side view, with 8-10 stalked teeth that are manifested in both *Calileuctra* species as stalked ridges extending onto the cup (see inside surface of *C. dobryi* cup, Fig. 27). Left mandibular molar cup with about 12 long, curved, comb-like outer sharp teeth, and 3 or 4 raised transverse ridges (that in Fig. 13 are probably well worn). Mesosternum with a double stem of its Y-ridge (Fig. 2). Inside fore wingpad length ♂ 0.66-0.75 mm, ♀ 0.72-0.96 mm; inside hind wingpad length ♂ 0.51-0.63 mm, ♀ 0.60-0.78 mm. Foreleg femoral and tibial surface with sparse, short, stiff hairs, fine appressed clothing hairs, and few if any fringe hairs (Figs. 1, 14); apex of tibia with 2 heavy apical spines; tarsal segments 1, 2, with double ventral rows of short spines (Fig. 15). Abdominal terga with scattered, appressed clothing hairs, and segments 7-10 with thick, bristle-like setae, especially laterally, in dorsal view (Figs. 16-18); terga 7-8 (Fig. 17) without 2 diverging rows of short, thick sensillae (as present in *C. dobryi*, see Figs. 30, 31). Developing male genitalia evident dorsally and ventrally just prior to emergence (Figs. 3, 4). Cercal segments 20-24 (Fig. 6), each, except terminal few, with apical circlet of more than 15 stiff hairs (Fig. 20); hairs of basal segments only about half the length of following segment (Fig. 19).

Calileuctra dobryi Shepard & Baumann
(Figs. 21-24, 25-30, 31-32, 34)

Distribution and collection site descriptions. Known from two or possibly three sites in Los Angeles County and two sites in Orange County in Southern California. The Los Angeles County sites include the type locality in South Fork Elsmere Canyon, San Gabriel Mountains and East Fork Arroyo Sequit, Santa Monica Mountains (Fig. 34). In Orange County, Trabuco Canyon and Silverado Canyon in the Santa Ana Mountains are the known sites.

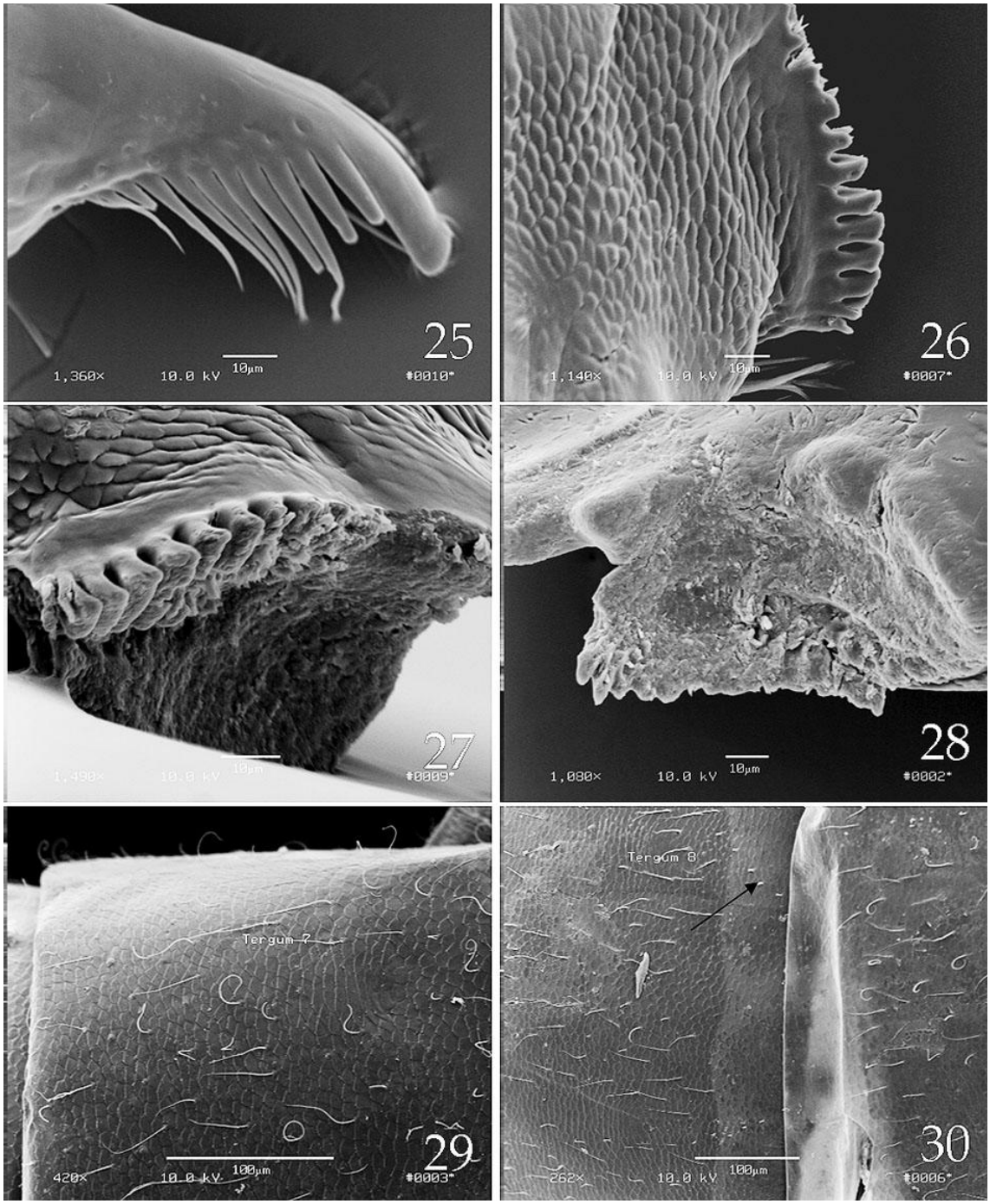
Material examined. Orange Co., 6 collections by K.W. Stewart and E.F. Drake 6-IV-2004 to 22-II-2006, same locality vicinity, Silverado Creek, Silverado Canyon, at gravel low water crossing 161m above Forest Boundary Gate, 33°44′55″N 117°34′58″W, 117♂, 19♀, 3 pairs in-copula, 4 larvae, 1 exuvium. Deposited in B.P. Stark collection, Mississippi College, Clinton MS.

Characters of mature larvae. (some measurements and counts, as done for *C. ephemera,* were not made because of the few larvae available for study). Color, pigmentation, general body and cercal setation (Fig. 21), and mouthparts typical of genus. Body length 7-8 mm. Head capsule width (1♀ larva) 0.75 mm. Antennal segments 60-64, each with very short apical circlet of hairs or sensillae. Lacinia triangulate and palmate, with 2 rounded-tipped apical teeth, 8-10 dorsal and ventral rows of long, sharp spines (Fig. 25), and a scalloped palm surface. Right mandibular molar cup outer margin, in side view, appears as a row of blunt-tipped, stalked teeth (Fig. 26) that are actually the outer edges of 10-12 stalked ridges extending well onto the inner cup surface (Fig. 27). Left mandible molar cup with comb-like outer teeth

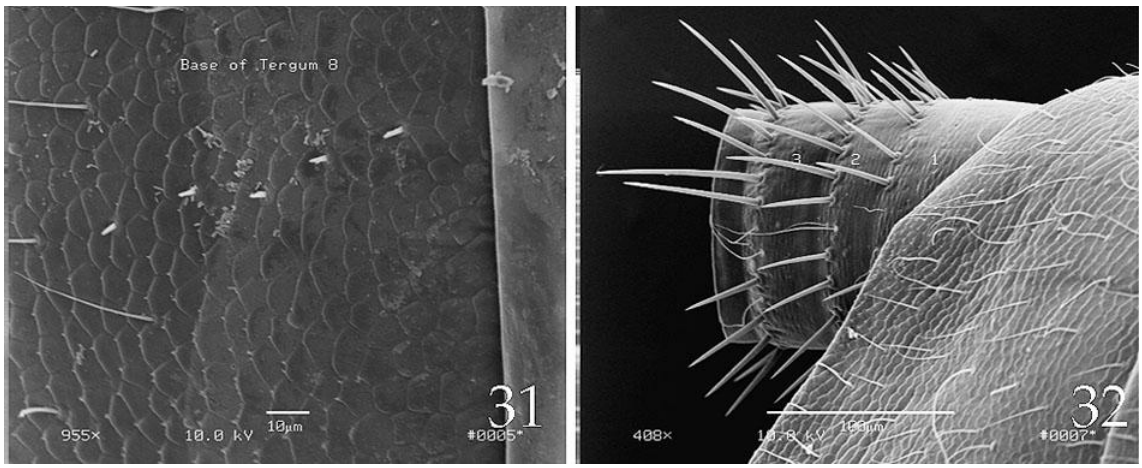


Figs. 21-24. *Calileuctra dobryi* larval characters. 21. Habitus (from Stewart & Drake, 2007); scale line = 2mm. 22. Right foreleg. 23. Abdomen, left lateral (from Stewart & Drake, 2007). 24. Basal 16 cercal segments, dorsal (from Stewart & Drake, 2007).

(Fig. 28; cup of the 1 larva sacrificed for SEM was well worn, in poor condition). Mesosternum with a double stem of its Y-ridge. Foreleg femoral and tibial surface with sparse hairs and with variable number of fine fringe hairs; apex of tibia with 2 heavy apical spines (Fig. 22). Tarsal segments 1, 2 with double vental row of short thick setae. Abdominal terga with long, fine appressed surface clothing hairs; terga 7-9 without thick setae (Fig. 29), especially laterally, as are present in *C. ephemera* (Figs. 16-18). Terga 7-8



Figs. 25-30. *Calileuctra dobryi* larval characters. 25. Right lacinia, ventral. 26. Right mandibular molar cup, outer margin. 27. Ridges of right mandibular molar cup. 28. Worn left mandibular molar cup. 29. Abdominal tergum 7, left side, arrow = sensilla row. 30. Abdominal tergum 8, diverging rows of short, thick sensillae.



Figs.31-32. *Calileuctra dobryi* larval characters. 31. Abdominal tergum 8, right side. 32. Basal cercal segments, dorsal.

with 2 diverging basal, sublateral rows of short, thick sensillae (Figs. 30-31), not present in *C. ephemera.* Cercal segments 20-22, each with apical circlet of more than 15 stiff hairs, except few apical and preapical cercomeres (Fig. 16); basal segments with some hairs longer than the following segment (Fig. 32).

Key to Mature *Calileuctra* larvae

1 Abdominal terga 7-10 with thick setae, especially laterally Figs. 16-18); terga 7, 8 without diverging sublateral rows of short, thick sensillae (Fig. 17). Apical hair circlet on basal 3 cercal segments mostly about 0.5-0.75 the length of following segment (Fig. 19) ……..……. *ephemera*

1′ Abdominal terga 7-10 without thick setae (Fig. 29); terga 7, 8 with diverging sublateral rows of short, thick sensillae (Figs. 30, 31). Some apical circlet hairs on basal 3 cercal segments longer than following segment (Fig. 33) ..... *dobryi*

GENERAL DISCUSSION

The now clarified structure of the molar cup of the right mandible, with its stalked ridges forming a masticating pad in *C. dobryi* (Fig. 27), and mentioned in the written description of *C. ephemera* larvae by Shepard & Baumann (1995), probably acts like a "mortar" against the opposing, ridged molar cup face (smooth and worn?, Fig. 13) of the left mandible as a "pestle". The long, curved comb-like teeth of the outer edge of the left cup probably act to hold food particles in the cup during mastication. Shepard & Baumann (1995) indicated these molar areas of the mandibles are similar to those of beetle larvae that feed on fungal tissues with high protein content, particularly of spores, that would aid in the fast growth and development of larvae.

The original side-only views of the right larval mandibles of leuctrid and capniid genera, drawn from SEM's by Stewart & Stark (2002), and described by them as "scraping ridges" are now clarified in *Calileuctra*, and in two species of *Capnia* (Stewart et al. 2011) more as masticating structures. The stalked ridges of the right mandible of *Calileuctra*, and the different, raised, bristly pads of *Capnia umpqua* Frison 1942 and *C. ventura* Nelson & Baumann 1987 (see Figs. 46-47, 52-53 in Stewart et al. 2011) suggest that further SEM study of larvae of additional genera and species of these families may provide an additional diagnostic character in the difficult separation of their larvae. Current keys to larvae of these two families use: 1) the difficult to observe extent of the pleural fold on abdominal segments and extent of coverage of the bases of the maxilla by the mentum, and 2) inconsistent shapes of the abdominal terga, length relationships of the wingpads, and

Figs. 33-34. Intermittent headwater habitats of *Calileuctra.* 33. Capell Creek, type locality of *C. ephemera*. 34. Arroyo Sequit, habitat of *C. dobryi*. No larvae found in rainwater pools, February 2000.

inconsistent (for different leuctrid genera) presence or absence of a posterior setal fringe on abdominal terga (Stewart & Stark 2002, 2008).

The collections of adult *Calileuctra* of both species indicate that, upon emergence, they remain in low lying herbaceous vegetation, or objects close to the stream. Good numbers of larvae have only been collected by disturbing sand or sand-cobble substrates within shallow pools, or slow current reaches, of headwater tributaries in hills at elevations near 130-140 meters.

ACKNOWLEDGEMENTS

This study was supported in part during earlier years by grants from the University of North Texas Faculty Research Fund. Bill Shepard, Cheryl Barr, and Keith Dobry helped in collection attempts in 2000, and Eugene Drake helped with, and made numerous collections of *C. dobryi* in Silverado Canyon Creek, California, 2004-2006. We also thank the Conservation Fund for their role in protecting the Garcia River Forest, and for their gracious cooperation with this and other scientific studies conducted on their property. We also acknowledge the long term efforts of the North Coast Regional Water Quality Control Board to improve water quality throughout the Garcia River watershed.

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Received 22 December 2012, Accepted 31 December 2012, Published 9 January 2013