



FURTHER DESCRIPTIONS OF WESTERN NORTH AMERICAN *PODMOSTA* LARVAE AND THEIR SEPARATION FROM *OSTROCERCA* LARVAE (PLECOPTERA: NEMOURIDAE)

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ABSTRACT

Associated larvae of the four western North American species of *Podmosta* are comparatively described and illustrated. Three species, *Podmosta delicatula* (Claassen), *P. obscura* (Frison) and *P. weberi* (Ricker), are described in detail for the first time. A preliminary larval key to the five North American species is presented, based mainly on differences in pigment pattern and cercal setation. Separation of the larvae of non-gilled nemourid genera *Ostrocerca* and *Podmosta*, though difficult, is further clarified by comparative scanning electron micrographs of the four western Nearctic *Podmosta* species and larvae of *Ostrocerca dimicki* (Frison).

Keywords: Plecoptera, Nemouridae, Larval descriptions, *Podmosta*, *Ostrocerca*, Western Nearctic

INTRODUCTION

Stewart & Stark (1988, 2002) established a generic level benchmark for the taxonomy and biology of North American stonefly larvae that has stimulated increased interest in species level taxonomic resolution of larvae. Because larval characters for most polytypic genera are currently based on a limited number of congeners, additional species descriptions and keys within those genera will encourage continued evaluation of possible morphological variation, and allow species identification benefitting diversity, life history, and biomonitoring studies.

The lack of specific descriptions of Nemouridae larvae is generally typical for other families of Plecoptera. Only 30% (22) of the larvae of the currently recognized 74 North American species have been comprehensively described and illustrated, and only 25% (12) of the larvae of the 48 species of the

four largest genera, *Amphinemura*, *Malenka*, *Soyedina* and *Zapada* are well described. The most recent descriptions of associated Nemouridae larvae were: *Malenka bifurcata* (Claassen), *Ostrocerca dimicki* (Frison) and *Soyedina producta* (Claassen) (Stewart & Anderson 2008); *Malenka bifurcata* (larval generic character development, Stewart & Anderson 2009); *Soyedina producta* (early – mid-instars, Stewart & Anderson 2010), *Amphinemura alabama* (Stark & Harrison 2010); and *Soyedina carolinensis* (Claassen), *S. interrupta* (Claassen), and *S. nevadensis* (Claassen) (Stark & Stewart unpublished). Baumann & Kondratieff (2010a) included a preliminary written larval description of their new species, *Malenka murvoshi*, and Baumann & Kondratieff (2010b) provided brief written larval descriptions of their new *Lednia* species, *L. borealis* and *L. sierra*.

Larvae of three of the four western North American species of the genus *Podmosta* are poorly

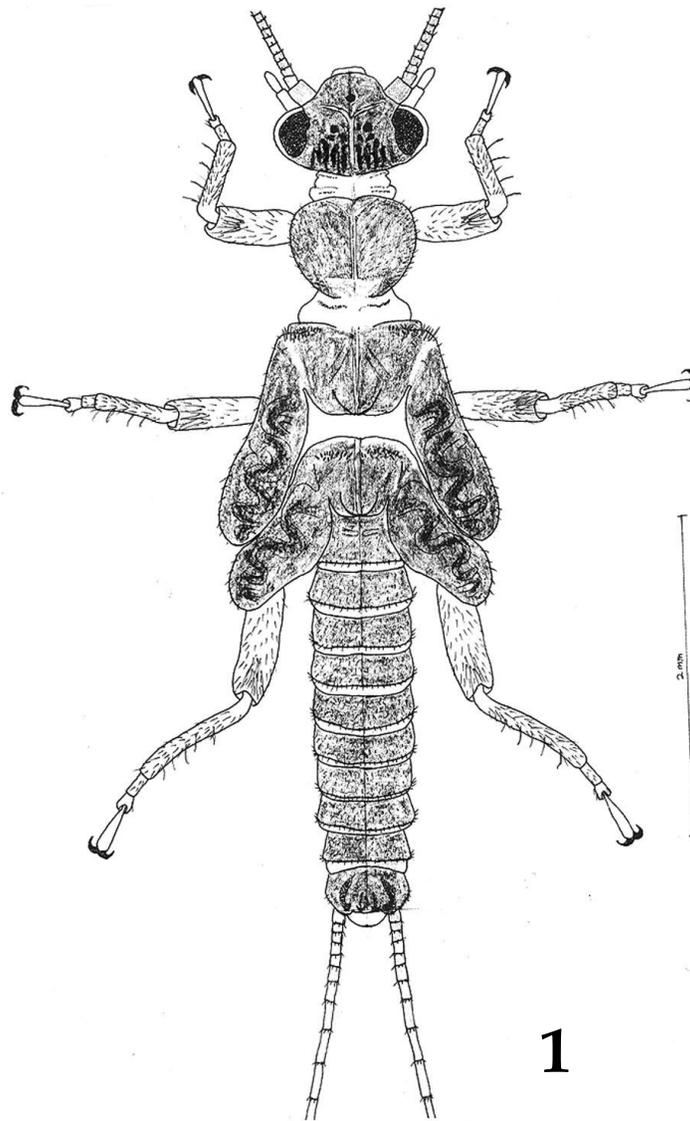
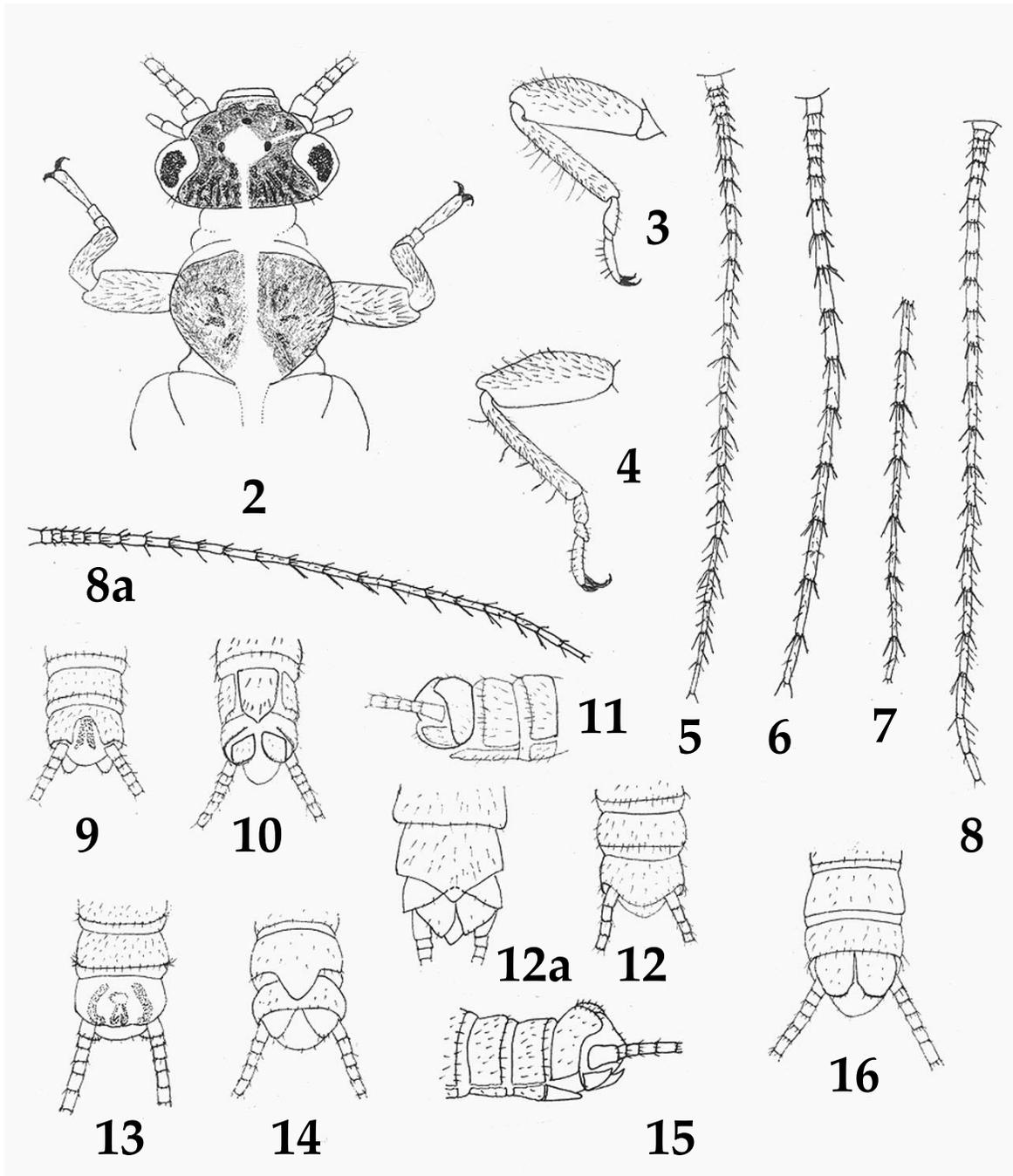


Fig. 1. Male *Podmosta obscura* larva. Scale line = 2 mm.

known. The larvae of *P. delicatula* (Claassen) and *P. weberi* (Ricker) have been incompletely described by Dossdall & Lehmkuhl (1979) and Stewart & Stark (1988, 2002) respectively, and the larva of *P. obscura* (Frison) is undescribed. Larvae of *Podmosta decepta* (Frison) were described in detail by Stewart & Stark (1988, 2002). Larvae of the only eastern North American species, *Podmosta macdunnoughi* (Ricker), has only been partially described (Ricker 1947).

Studies of Nemouridae in temporary streams of Oregon (Stewart & Anderson 2008, 2009, 2010a,b), Alaska and western Canada (Stewart & Oswood 2006), and collections by us and colleagues R. W. Baumann and B. C. Kondratieff, have enabled us to assemble small samples of associated larvae of the four western *Podmosta* species for comparative study. The non-gilled larvae of *Podmosta* and *Ostrocerca* are morphologically similar to an extent that they



Figs. 2-16. *Podmosta* larval characters. *P. delicatula*. 2. head, thorax, dorsal. 3. right front leg, dorsal. 5. cercus, lateral. 9. male terminalia, dorsal. 10. male terminalia, ventral. 11. male terminalia, lateral. 12. female terminalia, dorsal. *P. obscura*. 4. right front leg, dorsal. 6. right cercus proximal segments, dorsal. 7. left cercus apical segments, lateral. 13. male terminalia, dorsal. 14. male terminalia, ventral. 15. male terminalia, lateral. 16. female terminalia, ventral. *P. weberi*. 8. right cercus, lateral (exuvium of reared male). 12a. male terminalia, ventral (exuvium of reared male).

represent one of the more difficult pairs of stonefly genera for non-specialist taxonomists to separate. The long term study of intermittent headwater streams near Corvallis, Oregon (Stewart & Anderson 2009, 2010b) afforded the opportunity to obtain associated nymphs of *Ostrocerca dimicki* (Frison) and *O. foersteri* (Ricker) for further study and clarification of diagnostic characters separating them from *Podmosta* larvae.

MATERIAL AND METHODS

Late instar and pharate larvae and larval exuvia of reared and field associated *Podmosta* and *Ostrocerca* species were examined with a Wild M5 dissecting microscope with drawing attachment and an Amray 1810D scanning electron microscope (SEM). Setal patterns and other characters were documented with drawings and SEM, and compared with other specimens in the samples to check for variation. Because of the small sample size of the associated larvae, descriptions and keys will need to be further tested for individual and geographic (i.e. population) variation when additional associated specimens become available. The specimens studied are deposited in the K.W. Stewart Collection, University of North Texas, Denton, Texas and the B.P. Stark Collection, Mississippi College, Clinton, Mississippi.

RESULTS AND DISCUSSION

Species Accounts of Larvae

The following accounts include: (1) known distribution, (2) larval, exuvial and adult material examined and method of association, and (3) description of characters that offer potential diagnosis. Particular attention was given to characters addressed in the generic descriptions of Stewart & Stark (2002) and head capsule widths (HCW), body lengths, and counts of antennal and cercal segments.

Podmosta decepta (Frison)

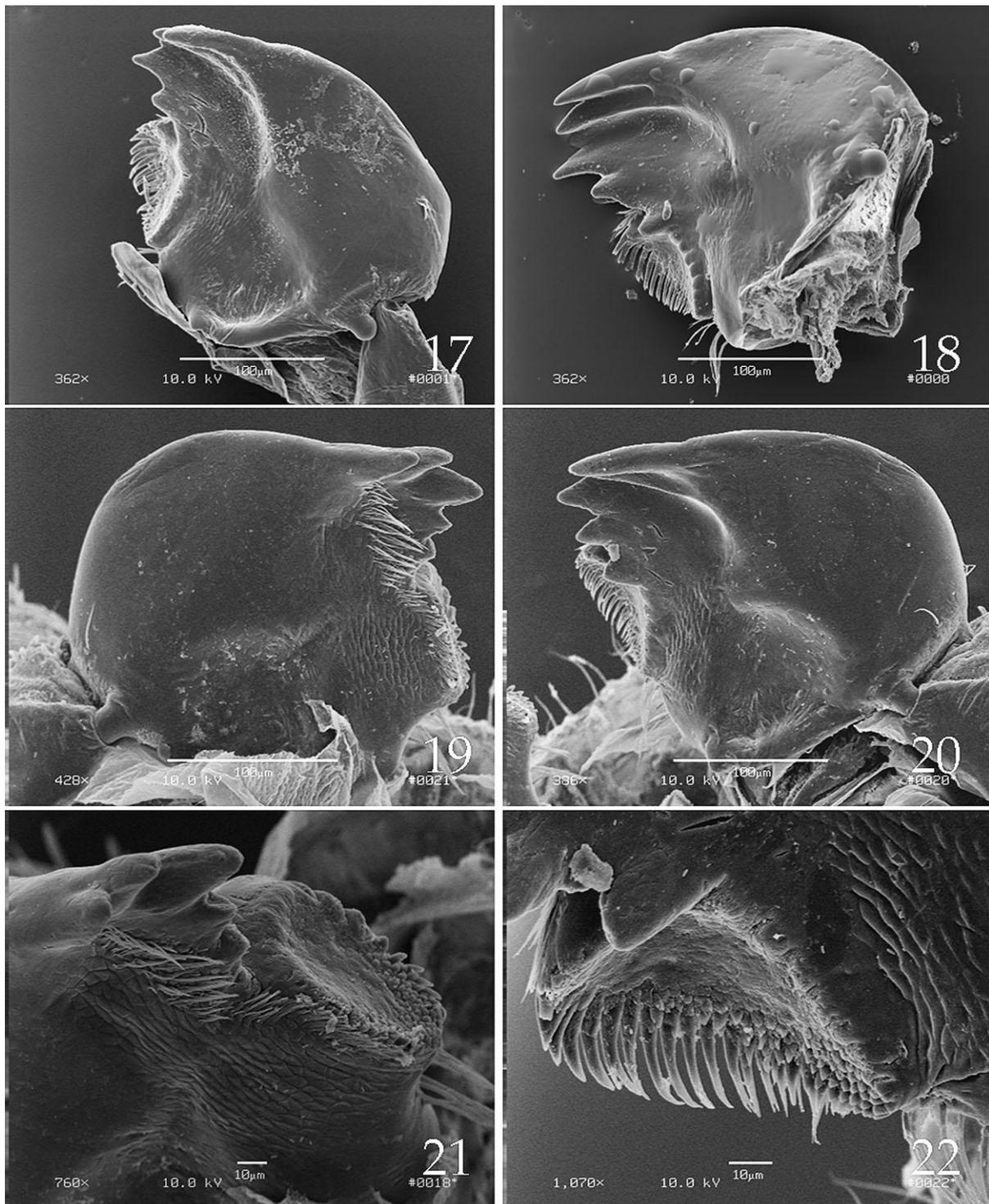
(Figs. 8a, 25, 29, 35, 40, 43, 44)

Distribution. Widespread. Rocky Mountains and Pacific Northwest (Colorado-Utah and northwestward to Alaska).

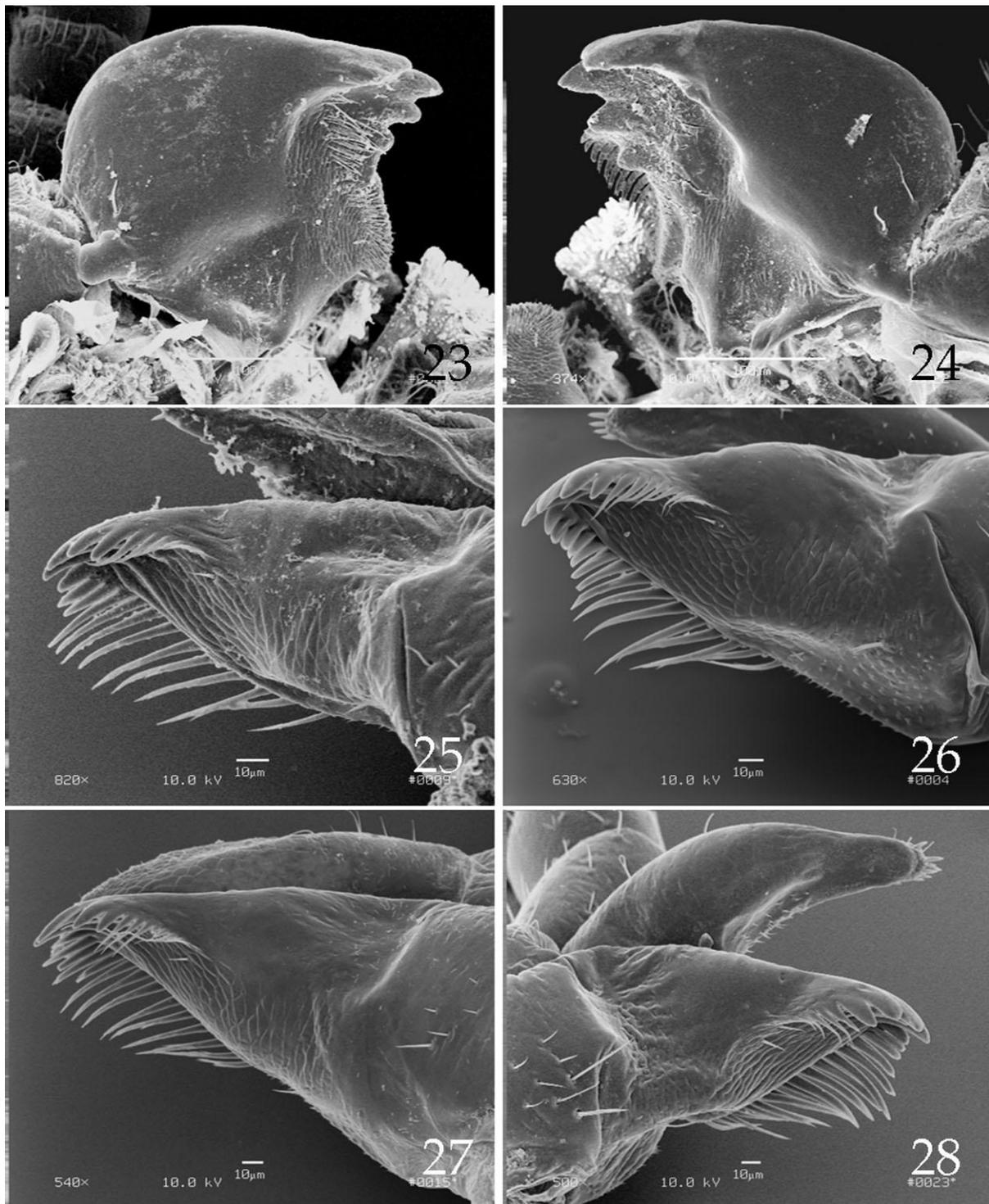
Material examined. Colorado: Grand Co., Tonahata

Creek, Big Meadows of Rocky Mountain National Park, 5-VII-1988, B.C. Kondratieff, 12♂ 14♀, 1♀ larva. Oregon: Union Co. Whiskey Creek, approximately 32 km southwest of LaGrande, 18-VI-1976, O. Dunster, 3♀ larvae. Montana: Gallatin Co. stream crossing Forest Service Road 3163 just upstream from Hyalite Youth Camp, 6-VI-1997, D.E. Ruiter, 9♂, 4♀, 3♀ larvae; Missoula Co., North Fork Elk Creek, 5-III-1969, M. Miner, 2 vials adults, 1♂ larva, 1♀ larva (described by Stewart & Stark 1988, 2002; reexamined larvae in poor condition from manipulation for drawings and SEM of mouthparts).

Characters. Body length 3.6-5.0 mm, light brown above with indistinct mottled darker pattern on occiput and light mesal stripe on thorax (Stewart & Stark 2002 Figs. 9.15, 9.16A). Antennal segments 36-38, head capsule width 0.81-0.90 mm; eyes large, head wider than pronotum. Gills absent. Mandibles with 5 or 6 apical teeth; right mandible with raised molar pad that grinds against opposing depressed molar cup of left mandible as in "mortar-pestle" action, molar cup with outer (dorsal) comb of curved teeth (similar to *P. weberi*, Figs. 21, 22). Lacinia triangular, palmate, with scalloped palm surface, 7 or 8 fingerlike apical teeth, apicodorsal comb of about 10 long, acute-pointed bristles and apicoventral comb of fewer short, acute-pointed bristles (Fig. 25). Pronotum bearing scattered short bristles and sensillae over surface and lacking a distinct lateral fringe (Fig. 29). Mesothoracic wingpads bearing scattered short bristles over surface and tuft of short bristles on anterolateral corners (Fig. 35). Femora bearing scattered short bristles and hairs over dorsal surface, longer bristles apicodorsally (similar to *P. weberi* Fig. 38, and Stewart & Stark 2002 Fig. 9.16D). Tibiae bearing scattered short bristles and few (5 or 6) posterior silky fringe hairs (Fig. 38 and Stewart & Stark 2002, Fig. 9.16D). Mesosternal Y-ridge faint, closed anteriorly by ridge forming rectangular area (Stewart & Stark 2002 Fig. 9.16E). Abdominal terga bearing microtrichia and socketed macrotrichia scattered over intercalary surface and forming a posterior fringe (Fig. 40). Sexual dimorphism evident; males with developing hypoproct on sternum 9, and in pharate individuals evidence of developing dorsal genitalia on tergum 10 (Stewart & Stark 2002 Figs. F, G). Cercal segments 24-26; cercomeres 1-10 bearing apical whorls of stout



Figs. 17-22. *Podmosta* mandibles. 17. *P. delicatula* left mandible, ventral. 18. *P. obscura* left mandible, ventral. 19. *P. weberi* right mandible, ventral. 20. *P. weberi* left mandible, ventral. 21. *P. weberi* right molar pad. 22. *P. weberi* left molar cup.



Figs. 23-28. *Ostrocerca* and *Podmosta* mandibles and laciniae. 23. *O. dimicki* right mandible, ventral. 24. *O. dimicki* left mandible, ventral. 25. *P. decepta* lacinia, ventral. 26. *P. obscura* lacinia, ventral. 27. *P. weberi* lacinia, ventral. 28. *O. dimicki* lacinia, galea, ventral.

bristles, fine hairs and sensillae, bristles up to 0.40 times length of their segment (Fig. 43). Middle and anteapical cercomeres bearing whorl bristles up to 0.20 times segment length, a single long ventral bristle up to 0.75 times segment length, and 2-3 fine intercalary hairs about 0.25 times length of their segment, all as seen laterally (Figs. 8a, 44). *Diagnostic characters*: Cercal setation as described (Figs. 8a, 43, 44).

***Podmosta delicatula* (Claassen)**

(Figs. 2, 3, 5, 9-12, 17, 30, 45, 46)

Distribution. Widespread in Rocky Mountains, Great Basin, Pacific Northwest (New Mexico, Nevada and California, northwestward to Alaska).

Material examined. Colorado: Larimer Co., Buckhorn Creek, 32 km north of Masonville, 31-V-1986, B.C. Kondratieff, 2♂, 2♀, 1♂ larva, 3♀ larvae, 1 exuvium. Oregon: Umatilla Co., Meachum Creek and tributaries at and upstream of Hwy. 84 and adjacent railroad bridges, 26-IV-2004, K.W. Stewart, B.J. Armitage, 12♂ larvae, 17♀ larvae (121 adults, all *P. delicatula*, in Monte L. Bean Life Science Museum, Brigham Young University, collected at this site).

Characters. Body length ♂ 4.2-4.5 mm, ♀ 4.3-5.5 mm, light brown above, with mottled dark head pattern, distinct light interocellar spot and light mesal stripe on thorax (Fig. 2). Antennal segments approximately 38, head capsule width ♂ 0.78-0.88 mm, ♀ 0.84-0.96 mm; eyes large, head wider than pronotum (Fig. 2). Gills absent. Mandibles with 5 or 6 apical teeth; right mandible with raised molar pad (as in other species) that grinds against opposing, depressed molar cup of left mandible (Fig. 17) as in a "mortar-pestle" action, molar cup with outer (dorsal) comb of curved teeth (Fig. 17). Lacinia triangular, palmate, with scalloped palm surface, similar to other species. Pronotum bearing short bristles and sensillae scattered over surface and lacking distinct lateral fringe (Fig. 30). Metathoracic wingpads bearing short bristles scattered over surface, and tuft of short bristles on anterolateral corners. Femora bearing short bristles and hairs scattered over dorsal surface, longer bristles apicodorsally (Fig. 3). Tibiae bearing scattered short bristles and few (5-8) posterior silky fringe hairs (Fig. 3). Mesosternal Y-ridge faint, closed by an anterior ridge forming a rectangular area.

Abdominal terga bearing microtrichia and socketed macrotrichia scattered over intercalary surface and forming a posterior fringe. Sexual dimorphism evident; males with developing hypoproct on sternum 9 (Fig. 10) and in pharate individuals evidence of developing dorsal genitalia (Figs. 9, 11). Cercal segments 22-24; cercomeres 1-10 bearing apical whorls of stout bristles, fine hairs and sensillae, bristles up to same length as their segment (Fig. 45). Middle and anteapical cercomeres bearing long whorl bristles up to 0.60 times length of their segment, and 3-6 fine intercalary hairs up to 0.30 times length of their segment, (Fig. 46) all as seen laterally. *Diagnostic characters*: light interocellar spot (Fig. 2), and cercal setation as described (Figs. 45, 46).

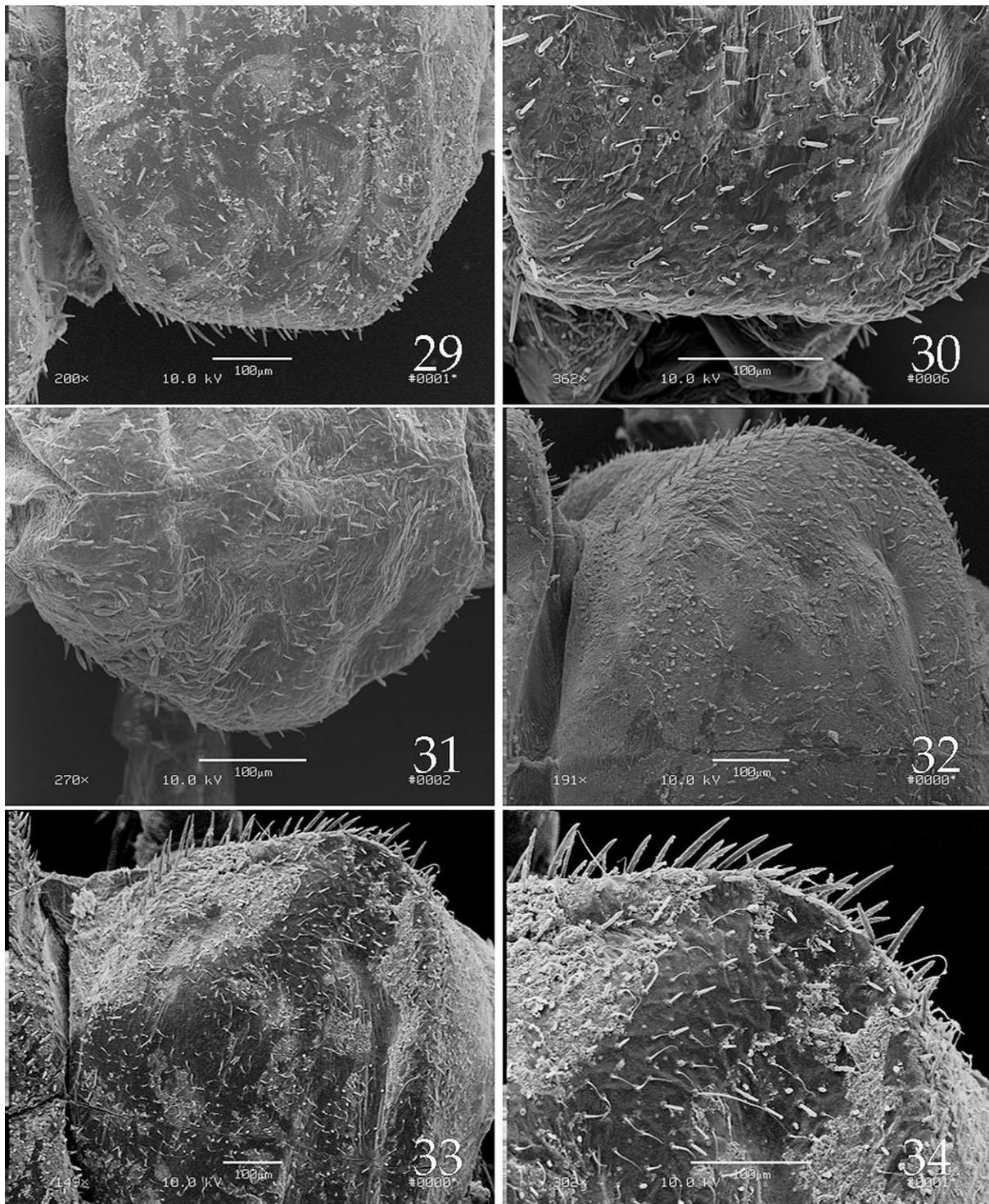
***Podmosta obscura* (Frison)**

(Figs. 1, 4, 6, 7, 13-16, 18, 26, 31, 47, 48)

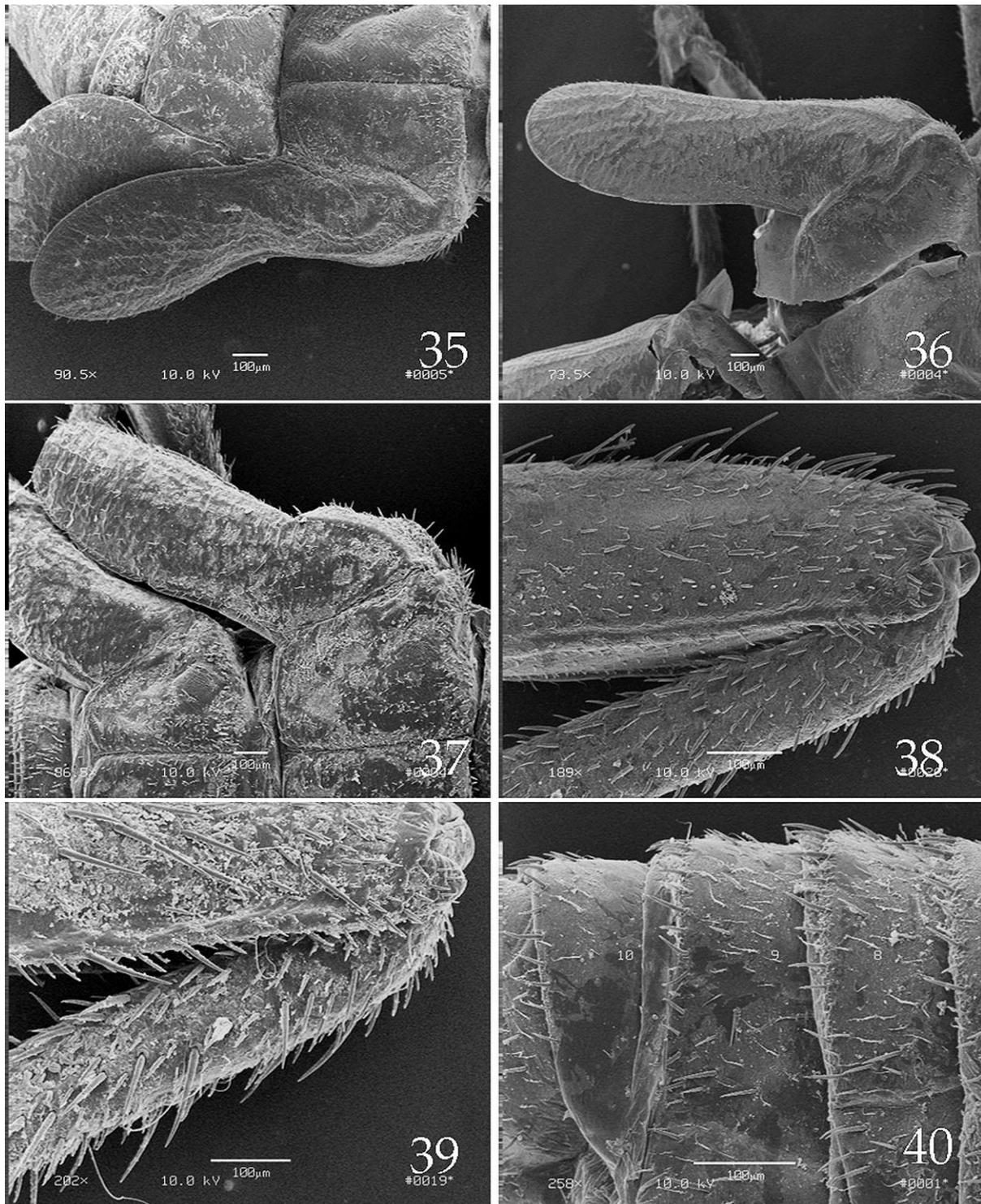
Distribution. Pacific Northwest (Oregon, Washington).

Material Examined. Oregon: Benton Co., Outgate Beck intermittent stream, 60th Street, outskirts of Corvallis, Feb. 1997-1999 benthos and emergence trap samples, numerous individuals of all stages, specifically 6♂, 10♀, 8♂ larvae, 3♀ larvae (only adults of this species collected in emergence traps in this stream over several years by N.H. Anderson).

Characters. Body length ♂ 4.5-5.2 mm, ♀ 5.4-5.6 mm, light brown above with mottled dark head pattern and light mesal stripe on thorax (Fig. 1). Antennal segments approximately 46, head capsule width ♂ 0.90-0.96 mm, ♀ 0.96-1.02 mm; eyes large, head wider than pronotum (Fig. 1). Gills absent. Mandibles with 5 or 6 apical teeth; right mandible as described herein for *P. weberi*, with raised molar pad that grinds against the opposing depressed molar cup of left mandible (Figs. 21, 22), molar cup with outer (dorsal) comb of curved teeth (Figs. 20, 22). Laciniae triangular, palmate, with scalloped palm surface, 7-9 fingerlike apical teeth, apicodorsal comb of about 10 long, acute-pointed bristles and apicoventral comb of about 8 short, acute-pointed bristles (Fig. 26). Pronotum bearing scattered short bristles and sensillae on disc, distinct lateral fringe lacking (Fig. 31). Wingpads bearing scattered short bristles over surface, and tuft of short bristles on anterolateral corners (Fig. 1). Femora bearing scattered short bristles and hairs over dorsal surface, longer bristles



Figs. 29-34. *Podmosta* and *Ostrocerca* pronota. 29. *P. decepta*, right disc. 30. *P. delicatula*, right disc. 31. *P. obscura* right disc. 32. *P. weberi* left disc. 33. *O. dimicki* left disc. 34. *O. dimicki* left anterolateral disc margin.



Figs. 35-40. *Podmosta* and *Ostrocerca* wingpads, legs, abdominal terga. 35. *P. decepta* right mesothoracic wingpad. 36. *P. weberi* left mesothoracic wingpad. 37. *O. dimicki* left mesothoracic wingpad. 38. *P. weberi* hind femur and tibia. 39. *O. dimicki* hind femur and tibia. 40. *P. decepta* left abdominal terga 8,9.

apicodorsally (Fig. 1). Tibiae bearing scattered short bristles and few (5-7) posterior silky fringe hairs (Figs. 1, 4). Mesosternal Y-ridge faint, closed by anterior ridge forming a rectangular area as in Stewart & Stark (2002, Fig. 9.16E). Abdominal terga bearing scattered microtrichia and macrotrichia scattered on intercalary surface, and forming a posterior fringe. Sexual dimorphism evident; males with developing hypoproct on sternum 9 (Fig. 14) and in pharate individuals evidence of developing external genitalia (Fig. 13) and raised tergum 10 (Fig. 15). Cercal segments 22-24; cercomerites 1-10 bearing apical whorls of stout bristles, fine hairs and sensillae, bristles about 0.65 times length of their segment (Fig. 47). Middle and anteapical cercomerites bearing whorl bristles 0.35-0.46 times length of their segment, and 3-7 fine intercalary hairs about 0.32 times length of their segment, all as seen laterally (Fig. 48). *Diagnostic characters:* cercal setation as described (Figs. 47, 48).

Podmosta weberi (Ricker)

(Figs. 8, 12a, 19-22, 27, 32, 36, 38, 41, 49, 50)

Distribution. Alaska and Yukon Territory.

Material Examined. Alaska: Stampede Creek, Kantishna Hills of Denali National Park, 25-VII-1981 (emerged 26-VII-1981), M. Oswood and B. Brown, 1♂ reared; 27-VII-1981 (emerged 29-VII-1981) 1♂ reared; same locality, 1-VII-1984 (emerged 20-VII-1984), D. Volsen, 1♂ reared, 1♀ reared, 7♀ larvae; same locality, 22-VII-1984, D. Volsen, 5♂, 11♀, 1♀ with attached exuvium, 4 exuvia.

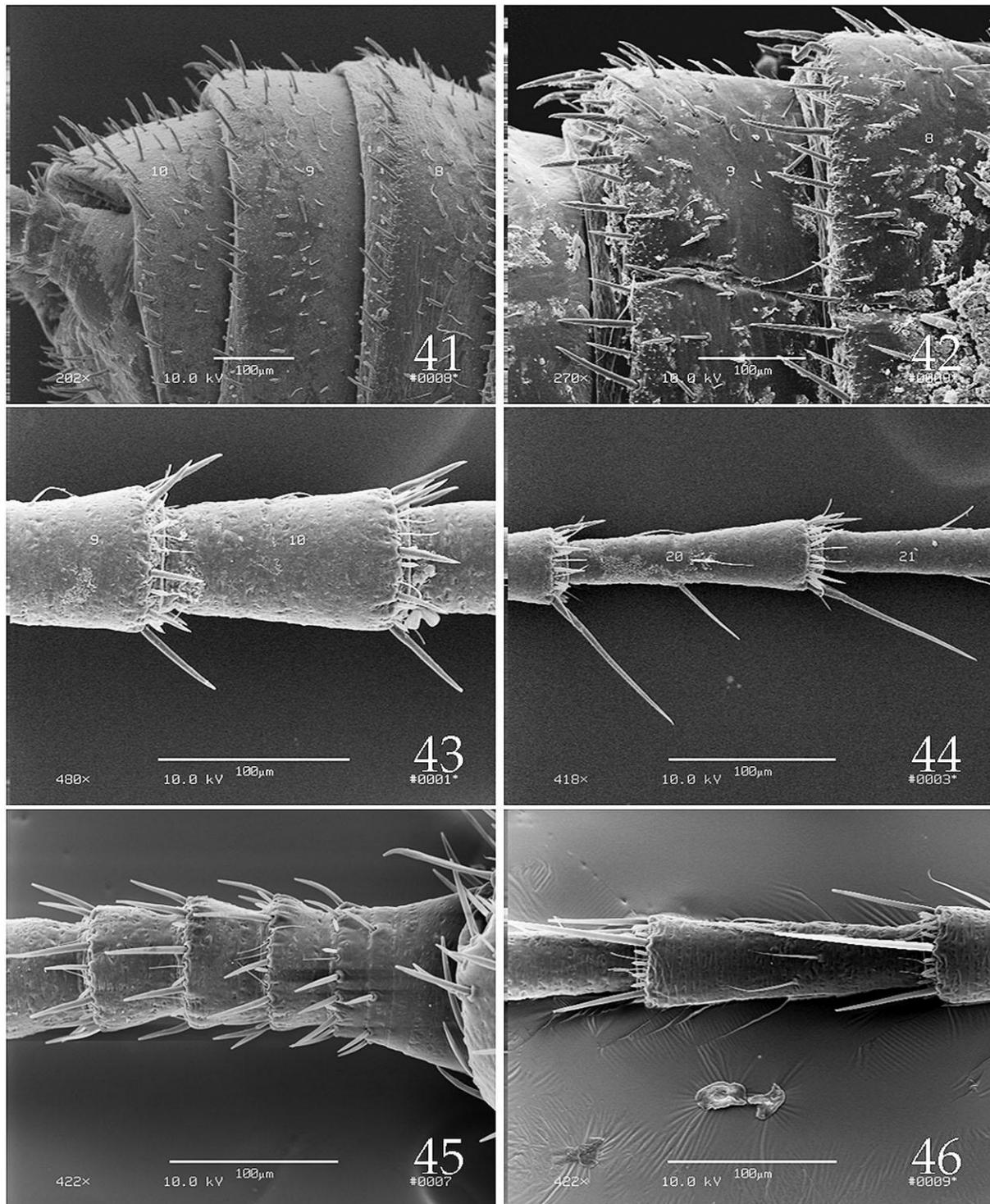
Characters. Body length ♂ 4.2-4.5 mm, ♀ 4.5-5.5 mm, light brown with indistinct dark mottled pattern on occiput. Antennal segments approximately 42, head capsule width 0.80-0.90mm; eyes large, head wider than pronotum. Gills absent. Mandibles with 5 or 6 apical teeth; right mandible with raised molar pad (Figs. 19, 21) that grinds against the opposing depressed molar cup of left mandible (Figs. 20, 22), molar cup with outer (dorsal) comb of curved teeth (Figs. 20, 22). Laciniae triangular, typical of genus, palmate, with scalloped palm surface, 7-9 fingerlike apical teeth, apicodorsal comb of about 10 long, acute-pointed bristles and apicoventral comb of about 8 short, acute-pointed bristles (Fig. 27). Pronotum bearing scattered short bristles and

sensillae on disc surface and lacking distinct lateral fringe (Fig. 32). Wingpads bearing scattered, short bristles and tuft of short bristles on anterolateral corners (Fig. 36). Femora bearing scattered short bristles and hairs over dorsal surface, longer bristles apicodorsally (Fig. 38). Tibiae bearing scattered short bristles (Fig. 38) and few (5-7) posterior silky fringe hairs. Mesosternal Y-ridge closed anteriorly as in Stewart & Stark (2002; Fig. 9.16E). Abdominal terga bearing macrotrichia and microtrichia scattered on intercalary surface and forming a posterior fringe (Fig. 41). Sexual dimorphism evident; males with raised tergum 10 in lateral view, and developing hypoproct on sternum 9 (Fig. 12a). Cercal segments 22-24, cercomerites 1-10 bearing apical whorls of stout bristles, fine hairs and sensillae, bristles about 0.25 times length of their segment (Fig. 49). Middle and anteapical cercomerites bearing whorl bristles 0.35-0.60 times length of their segment, with anteapical ones longest ventrally, and with 2-4 intercalary bristles and/or fine hairs about 0.25 times length of their segment, all as seen laterally 9 (Fig. 50). *Diagnostic characters:* cercal setation as described (Figs. 49, 50).

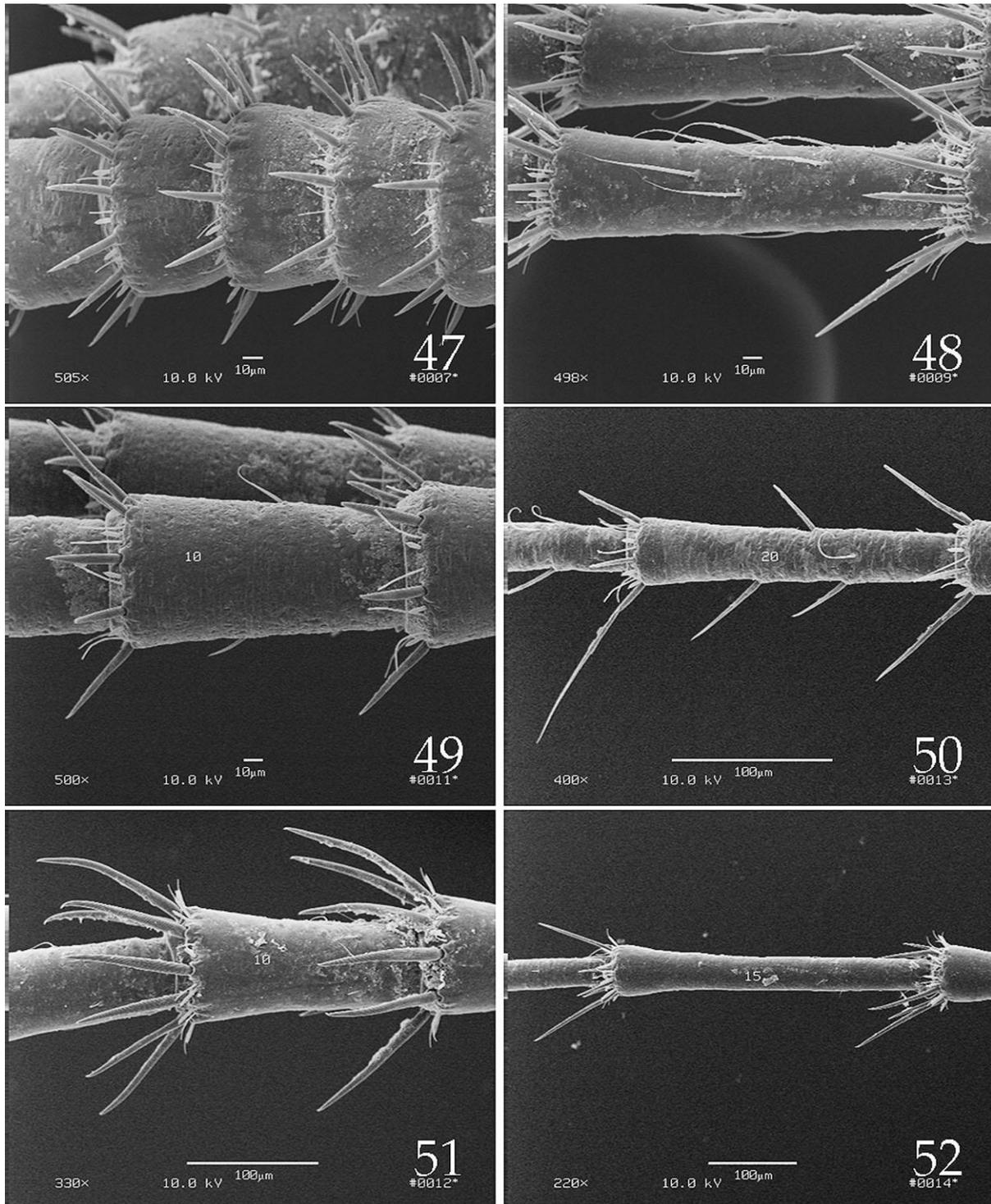
Provisional Key to North American *Podmosta* Larvae

Podmosta macdunnoughi (Ricker) was partially described by Ricker (1947) and Harper & Hynes (1971). Details of the cercal intercalaries are difficult to see at 50X with a dissecting light microscope, and therefore require SEM.

- 1 Distribution east of 90th meridian ... *macdunnoughi*
- 1' Distribution west of 100th meridian 2
- 2 Head with distinct, light interocellar spot (Fig. 2) *delicatula*
- 2' Head without interocellar spot (Fig.1) 3
- 3 Whorl bristles of middle and anteapical cercal segments short, at most, ca. 0.20X the length of their segment, and bearing 2-3 intercalary hairs as seen laterally (Fig. 44); widespread, Alaska south to Colorado *decepta*
- 3' Whorl bristles of middle and anteapical cercal segments long, 0.35-0.80X the length of their segment, and bearing variable number of intercalaries up to 7 (Figs. 48, 50); Alaska-Yukon and south to Oregon 4



Figs. 41-46. *Podmosta* and *Ostrocerca* abdomens and cerci. 41. *P. weberi* left abdominal terga 8-10. 42. *O. dimicki* left abdominal terga 8,9. 43. *P. decepta* cercomeres 9,10, lateral. 44. *P. decepta* cercomeres 20, 21, lateral. 45. *P. delicatula* proximal 7 cercomeres. 46. *P. delicatula* subapical cercomeres.



Figs. 47-52. *Podmosta* and *Ostrocerca* cerci. 47. *P. obscura* proximal cercomeres. 48. *P. obscura* subapical cercomeres. 49. *P. weberi* cercomere 10. 50. *P. weberi* cercomere 20. 51. *O. dimicki* cercomeres 10, 11. 52. *O. dimicki* cercomere 15.

- 4 Whorl bristles of proximal 10 cercal segments short, ca. 0.25X length of their segment (Fig. 49); middle and apical cercal segments bearing 2-4 intercalary bristles and/or fine hairs (Fig. 50); Alaska and Yukon *weberi*
- 4' Whorl bristles of proximal 10 cercal segments long, about 0.67X the length of their segment (Fig. 47); middle and apical cercal segments bearing 3-7 fine intercalary hairs (Fig. 48); Oregon and Washington *obscura*

Separation of *Podmosta* from *Ostrocerca*

Table 1 is provided to further clarify the difficult generic separation of non-gilled *Podmosta* and *Ostrocerca* larvae. Descriptions used are those of *O. truncata* (Claassen) by Stewart & Stark (1988, 2002), *O. dimicki* (Frison) and *P. decepta* by Stewart & Anderson (2008), and descriptions and selected SEM's of *O. dimicki* and the four western *Podmosta* species from the current study.

Table 1. Comparison of diagnostic generic characters of North American *Podmosta* and *Ostrocerca* larvae.

Character	<i>Ostrocerca</i>	<i>Podmosta</i>
1. Size	6-7 mm	3.6-5.5 mm
2. Pronotal setation	scattered short bristles, hairs and sensillae over surface and lateral fringe of longer bristles (Figs. 33-34)	scattered short hairs and sensillae over surface and no definitive lateral fringe of bristles (Figs. 30-32)
3. Tibia	prominent row(s) of long outer spines (Fig. 39)	scattered bristles over surface, no prominent long outer spines (Fig. 38)
4. Posterior fringe of abdominal bristles	longest bristles up to 0.5 times length of their segment (Fig. 42)	longest bristles up to 0.33 times length of their segment (Figs. 1, 41)
5. Cerci	18-20 segments; few short intercalary hairs present on basal segments, mostly absent on apical segments (Figs. 51, 52)	22-26 segments; 2-7 intercalary hairs present, mostly beyond cercomere 10 (Figs. 5-8a, 44, 46, 48, 50)
6. Pharate male characters	<p>a) developing dorsal genitalia variable, projecting and truncate in <i>O. truncata</i> (Stewart & Stark 2002, Figs. 9.12 G, H), lobate in <i>O. dimicki</i> (Stewart & Anderson 2008, Fig. 2C)</p> <p>b) developing hypoproct truncate (Stewart & Stark 2002, Fig. 9.12H, Stewart & Anderson, 2008, Fig. 2C)</p> <p>c) paraprocts elongate with pointed apex (Stewart & Stark 2002, Fig. 9.12H; Stewart & Anderson 2008, Fig. 2C)</p>	<p>a) developing dorsal genitalia not projecting posteriorly, visible only subcutaneously (Figs. 9, 13)</p> <p>b) developing hypoproct triangulate with pointed apex (Stewart & Stark 2002, Fig. 9.16H; Figs. 10, 12a, 14)</p> <p>c) paraprocts short (Stewart & Stark 2002, Fig. 9.16H; Figs. 10, 12a, 14)</p>

GENERAL DISCUSSION

Closer examination of associated larvae of the four western *Podmosta* species with light microscopy and SEM revealed: 1) presence of intercalary hairs on at least some cercomeres beyond segment nine (Figs.

44, 46, 48, 50); these are often fine hairs that are difficult to see at 50X magnification under a dissecting microscope, and 2) presence of a molar pad of right mandible and molar cup of left mandible, that presumably act in apposition to grind

food particles in a “mortar and pestle-like” action. These newly discovered characters require correction of the generic description by Stewart & Stark (1988, 2002) who indicated that intercalary cercal hairs are absent, and described the molar surfaces of mandibles as “serrated scraping ridges”; that interpretation was based on drawings of the right mandible of *P. decepta* from SEM side views of the raised molar pad. These, and additional counts of antennal and cercal segments, pattern differences and sexual differences of males, provide an update of the generic description. Also, Stewart & Anderson (2008) indicated that, based on dissecting scope examination, *O. dimicki* appeared to have no intercalary cercal hairs, but SEM reveals some very short intercalaries on some segments (Fig. 51) as in *O. truncata* (Stark & Stewart 2002).

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