Stewart, K.W. & B.C. Kondratieff. 2012. Larvae of the Nearctic species of the stonefly genus *Megarcys* Klapálek (Plecoptera: Perlodidae). *Illiesia*, 8(03):16-36. Available online: http://www2.pms-lj.si/illiesia/papers/Illiesia08-03.pdf

LARVAE OF THE NEARCTIC SPECIES OF THE STONEFLY GENUS *MEGARCYS* KLAPÁLEK (PLECOPTERA: PERLODIDAE)

Kenneth W. Stewart[1] and Boris C. Kondratieff[2]

[1] Department of Biological Sciences, P.O. Box 305220, University of North Texas, Denton, Texas, U.S.A.76203
E-mail: stewart@unt.edu

[2] Department of Bioagricultural Sciences and Pest Management, Colorado State University,
Fort Collins, Colorado, U.S.A. 80523
E-mail: Boris.Kondratieff@Colostate.edu

ABSTRACT

Associated larvae of the five Nearctic species of *Megarcys* are comparatively described and illustrated. Four of them, *Megarcys irregularis* Banks, *M. subtruncata* Hanson, *M. watertoni* (Ricker), and *M. yosemite* (Needham & Claassen) are described in detail for the first time. Body size and setation, wingpad macroptery/brachyptery, and gill size were variable between populations of some species. Diagnostic differences were not found in late instar larvae of the five species in color and pigment patterns, mouthparts, body and appendage setation, gill size and structure, and developing male and female genitalia. The detailed descriptions and measurements help expand the generic diagnosis, show morphological differences between populations of different habitats, and provide an atlas of illustrations for larvae of the five species.

Keywords: Plecoptera, stonefly larvae, *Megarcys*, Nearctic

INTRODUCTION

The stonefly genus *Megarcys* Klapálek 1912, comprises seven Palearctic and five Nearctic species (DeWalt et al. 2009). Teslenko (2009) reviewed distributions of three of the Eastern Palearctic species: *M. magnilobus* Zhiltzova 1988, *M. ochracea* Klapálek 1912, and *M. pseudochracea* Zhiltzova 1977, and presented additional descriptions for larvae of *M. ochracea* and *M. magnilobus*, first description of larvae of *M. pseudochracea* and a key to larvae of the three species. Larvae of the remaining three species, *M. bussoni* (Navas 1923), *M. sjostedti* (Navas 1930), and *M. teslenkonis* Zwick 2010, remain unknown.

VanWieren et.al. (2001) reviewed and presented new updated and detailed descriptions and illustrations of adults, eggs, keys to males, females, and eggs for the five Nearctic species: *Megarcys irregularis* (Banks 1900), *Megarcys signata* (Hagen 1874), *Megarcys subtruncata* Hanson 1942, *Megarcys watertoni* (Ricker 1952), and *Megarcys yosemite* (Needham & Claassen 1925). Larvae of *M. signata* are well known (Stewart & Stark 2002), but those of the other four species have surprisingly never been described (Stewart & Stark 2002).

Fig. 1. Brachypterous female *Megarcys yosemite*, Cold Creek, California.

As indicated by Teslenko (2009) for the Palearctic species, and Stewart & Stark (2002) for *M. signata*, *Megarcys* larvae are characterized by the following combination of features: 1) a pair of simple, finger-shaped gills located on the submentum, supracoxal on the prothorax, and anteriorly on both the meso- and metasternum, 2) body densely covered with dark clothing hairs, 3) a dorsomesal, longitudinal band of erect silky white hairs on the thorax and abdomen and behind arms of the ecdysial suture on the head, 4) Y-arms of the mesosternum meeting the anterior corners of the furcal pits, and 5) cercal segments with a dorsal fringe of silky hairs. In response to the pressing need to increase taxonomic resolution of Plecoptera larvae to the species level (Stewart & Stark 2002), we began in 2005 assembling associated larvae of the five Nearctic species of *Megarcys* from our own collections and those of colleagues for study to determine if species-level resolution is possible, that would be beneficial for diversity, life history, biomonitoring and other basic biological studies.

MATERIALS AND METHODS

Larvae were associated by rearing or field collection with adults from streams where no congeners were known from repeated collections. Specific material studied, measured, and drawn, using a Wild M-5 stereomicroscope with drawing attachment, is listed in the following species accounts. In anticipation that color-pigment patterns might prove diagnostic, comparative color photomicrographs were made of body structures of all five species using a Leica MZ125 microscope and Sony DXC-390 color video camera housed at the University of Wisconsin, Stevens Point.

Character differences of gill size, structure, and setation, body pigmentation and chaetotaxy, and head-pronotum widths, found in Palearctic larvae by Teslenko (2009), and used in her key, were a clue for our examination of the North American material for possible similar differences. Measurements of head capsule and pronotal widths, body length, and submental and anterior supracoxal gill lengths were made with a calibrated ocular micrometer. Numbers

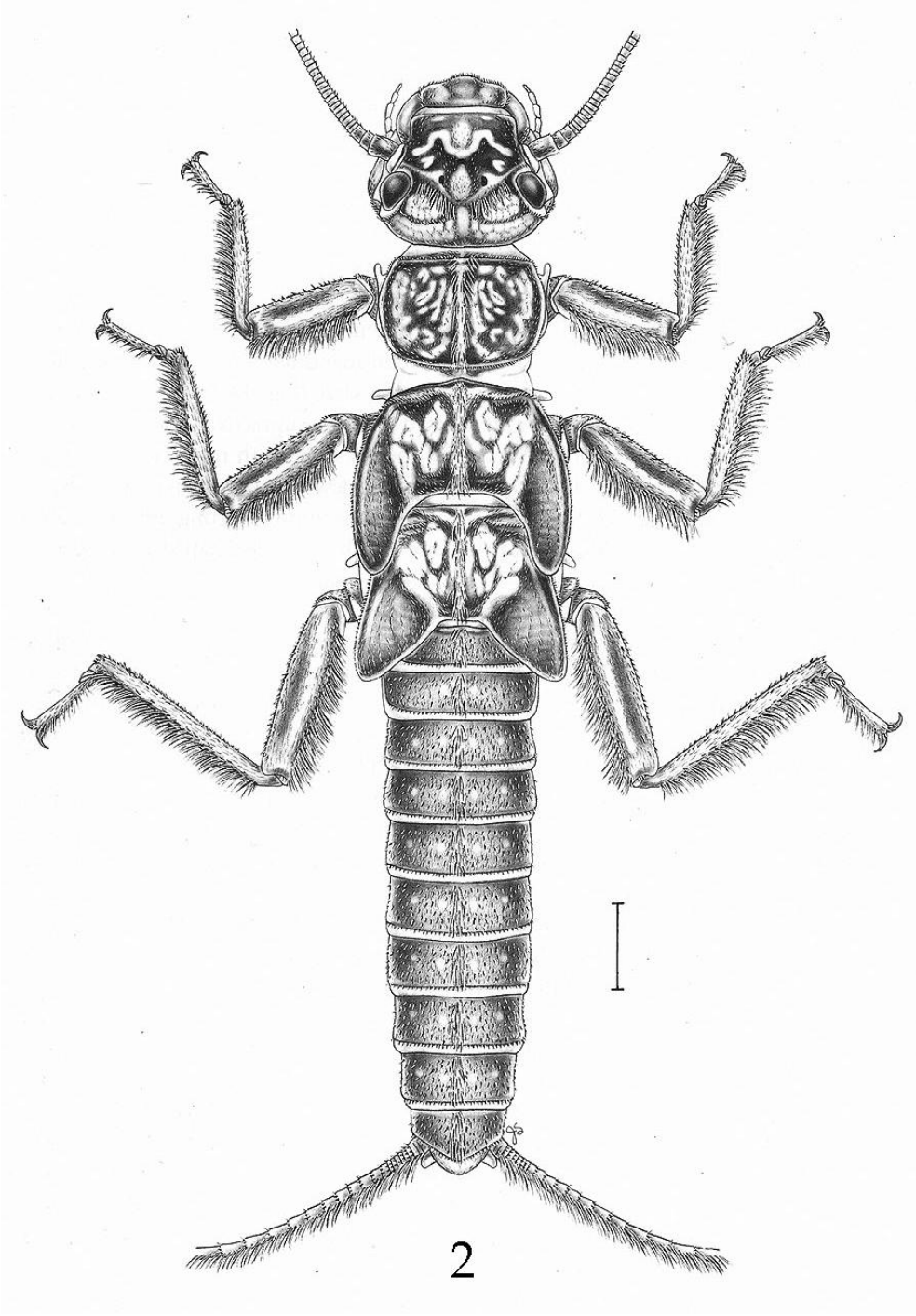


Fig. 2. *Megarcys signata* habitus, South Fork, American River, Utah (Stewart & Stark 2002, Fig. 14.35).

of cercal segments were counted and macroptery or brachyptery of wingpads of pre-emergent individuals was noted for the different populations studied. Material examined is deposited in the K. W. Stewart Collection, University of North Texas, C. P. Gillette Museum of Arthropod Diversity, Colorado State University, and Bill P. Stark Collection, Mississippi College, Clinton, Mississippi.

Table 1. Individual or range measurements (mm) and cercal segment numbers of pre-emergent *Megarcys* larvae from different localities.

	Megarcys irregularis			*Megarcys signata*	
	WA1	WA2	WA3	CO4	MT5
♂ wingpads	mac	mac	mac	mac	brac
Head capsule width	3.06-3.12	-	3.80	3.24-3.48	3.24
Pronotal width	**3.12**	-	2.88	2.76	2.64
Body length	18.3-19.5	-	18.72	16.20-18.48	17.40
SM gill length	0.12-0.45	-	0.30	0.36-0.48	0.36
ASC gill length	0.42	-	0.27-0.30	0.36-042	0.36
No. cercal segments	24-26	-	broken	26	26
♀ wingpads	mac	mac	mac	mac	mac
Head capsule width		4.62	3.90	4.14-4.20	4.20
Pronotal width		4.08	3.36-3.72	3.60-3.72	3.36-3.90
Body length		20.4-24.0	19.5	25.5	-
SM gill length		0.36-0.39	0.39-0.45	0.54-0.60	0.60
ASC gill length		0.36	0.36	0.48-0.60	0.45

	Megarcys subtruncata		*Megarcys watertoni*	*Megarcys yosemite*	
	CA6	OR7	MT8	MT9	CA10
♂ Wingpads	mac	brac	brac	mac	brac
Head capsule width	3.78-3.90	3.12-3.48	2.76-3.00	3.72	2.88-3.36
Pronotal width	3.36-3.48	2.94-3.12	2.58-2.64	3.00	2.76-3.30
Body length	17.94-21.6	15.6-16.0	16.08-17.28	20.4	17.64-20.2
SM gill length	0.39-0.54	0.27-0.30	0.24-0.27	0.54-0.57	0.27-0.36
ASC gill length	0.42-0.54	0.21-0.24	0.24-0.27	0.36	0.18-0.30
No. cercal segments	24-26	broken	26	26	24-26
♀ wingpads	mac	brac	mac	mac	brac
Head capsule width	4.68-4.74	4.20-4.22	3.48- 3.84	4.32-4.38	3.60-3.84
Pronotal width	4.20	4.02-4.26	3.36	3.90	3.54-3.66
Body length	22.2-25.5	19.5-21.2	20.9-22.2	24.30	22.4-22.9
SM gill length	0.54-0.66	0.34-0.36	0.36-0.39	0.66-0.72	0.33-0.45
ASC gill length	0.54-0.60	0.30-0.34	0.33-0.42	0.60-0.66	0.24-0.33

Localities listed in Material Examined for each species: WA1= Washington, Nisqually River, WA2= Washington, Fryingpan Creek, WA3= Washington, White River, CO4= Colorado, Mosquito Creek, MT5=Montana, Pine Creek, CA6= California Butte Creek, OR7=Oregon, Quinn Spring, MT8= Montana, Iceberg Creek, MT9== Montana, Bear Creek, CA10= California, Cold Creek. Brac= brachypterous specimens, mac=macropterous specimens.

RESULTS AND DISCUSSION

Species Accounts of Larvae

The following accounts include: 1) known distribution (Stark et al. 2009), 2) larval, exuvial and adult material examined, 3) description of characters, particularly any that offers definitive or potential population or specific diagnosis, and 4) comments. Particular attention is given to characters studied by Teslenko (2009), and similarities and any differences of proposed generic characters based on study of *M. signata* by Stewart & Stark (2002). The descriptions and referenced illustrations are based on typical individuals of the single or few populations that were successfully associated and studied; therefore they do not address possible additional individual or population variation.

Megarcys signata (Hagen 1874)

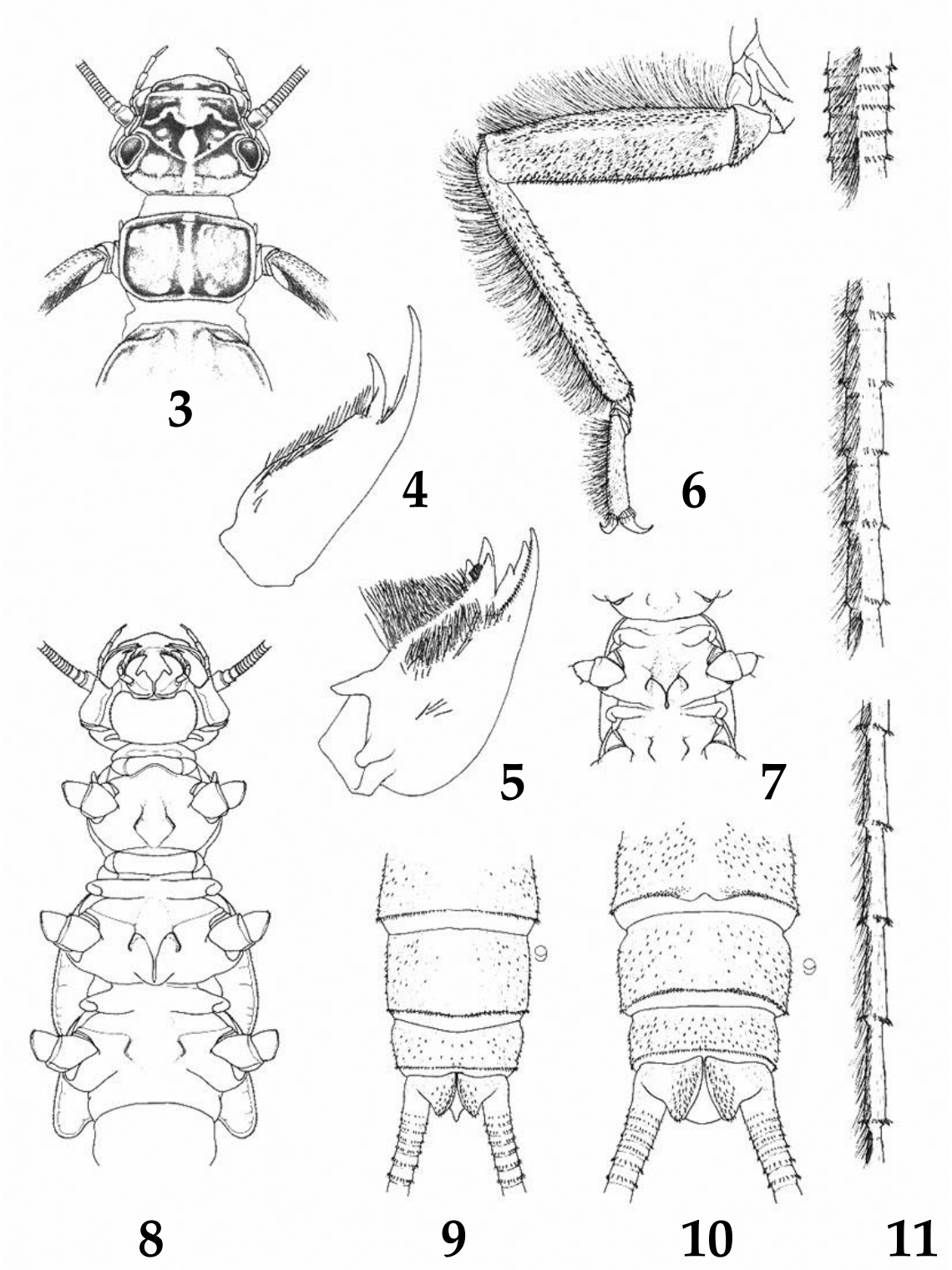
(Figs. 2-11, 13, 18, 19, 25, 31, 37, 43, 50, 61, 71, 80, 85 a-b, Table 1)

Distribution. Rocky Mountains, New Mexico-Nevada northward to British Columbia and Alaska.
Material examined. Colorado: Boulder Co., South Boulder Creek, 3.2 km west of Tolland, 7-VII-1991, B. Kondratieff, R. Durfee, 11♂ (both macropterous and brachypterous), 6♀, 11♀ larvae, 2♂ exuviae; Middle St. Vrain Creek, FR 14 west of Peaceful Valley, 17-VII-1993, B. Kondratieff, B. Painter, 1♂, 2♀ larvae; Gunnison Co., Mosquito Creek/confluence Quartz Creek, Colorado Rd. 76 north of Pitkin, 9-VII-2008, K. Stewart, reared series: 2 reared ♂ with exuviae, 1 reared ♀ with exuvium, 8♂ larvae, 14♀ larvae; Larimer Co., outlet stream of Chasm Lake, Rocky Mountain National Park, El. 3536m, 16-VII-1994, B. Kondratieff, R. Durfee, 2 brachypterous ♂ larvae, 1♀ brachypterous larva. Montana: Gallatin Co., 5.63 km off Trail Creek Rd., 10-6-1987, B. Kondratieff, 2♂, 2♂ larvae, 3♀ larvae, 3♂ exuviae, 2♀ exuviae. Wyoming: Teton Co., Granite Creek, Granite Falls, 8-VII-2001, B. VanWieren, 1♀, 2♀ larvae. Yukon Territory: Alaska Hwy., stream crossing between Watson Lake and Whitehorse, V-1997, P. Niblett, 4♂ larvae, 3♀ larvae.
Characters. Head capsule width ♂ 3.24-3.48mm, ♀ 4.14-4.20mm; pronotal width ♂ 2.64-2.76mm, ♀ 3.36-3.90mm; body length ♂ 16.2-18.5mm, ♀ 25-26mm (Table 1). Color and pigmentation (Figs. 2, 3, 13, 19, 25, 43, 50), lacinia (Fig. 21), and dorsomesal band of erect silky white hairs (Figs. 18, 19) typical of genus and as described by Stewart & Stark (1988, 2002). Wingpads of ♂ and ♀ (Figs. 2, 25) macropterous (or brachypterous in high elevation streams). Gill number and arrangement typical of genus (Fig. 61). Submental gill length ♂ 0.36-0.48mm, ♀ 0.54-0.60mm; anterior supracoxal gill length ♂ 0.36-0.42mm, ♀ 0.45-0.0.60mm (shorter in high elevation Chasm Lake outlet stream in Rocky Mountain National Park) (Table 1). Legs (Figs. 6, 31) with setation typical of genus as described by Stewart & Stark (2002).Y-arms of mesosternum meet anterior corners of furcal pits (Figs. 7, 8, 37), typical of genus. Cercal segments ♂ 26 (Table 1), as described by Stewart & Stark (2002) with apical whorl of short setae on cercomeres and dorsal fringe of silky white hairs (Fig. 11). Developing membranous, windsock-like posterior process of male epiproct (Fig.71) evident in late instar individuals, and pointed posteroventrally in lateral view (Fig. 80). Developing female subgenital plate of 8th sternum (Figs. 50, 85) shallowly notched mesally.
Comments. The generic characters proposed by Stewart & Stark (1988, 2002) were further confirmed in these additional larvae examined. Color and pigmentation (Figs. 2, 3, 13, 19, 25, 31, 43, 50) were of a generic pattern that was similar in the other four species examined. The measured gill lengths, and shapes, were variable between left and right sides, individuals, and populations, therefore difficult to compare with the generalized terms "short" and "long" as used by Teslenko (2009) in her descriptions and keys to Palearctic species. Submental (SM) gills (Figs. 8, 61) are not visible from dorsal view; anterior supracoxal (ASC) gills and anterior mesothoracic and anterior metathoracic (AT_2, AT_3) gills (Figs. 8, 61) are "long" and usually visible in dorsal view.

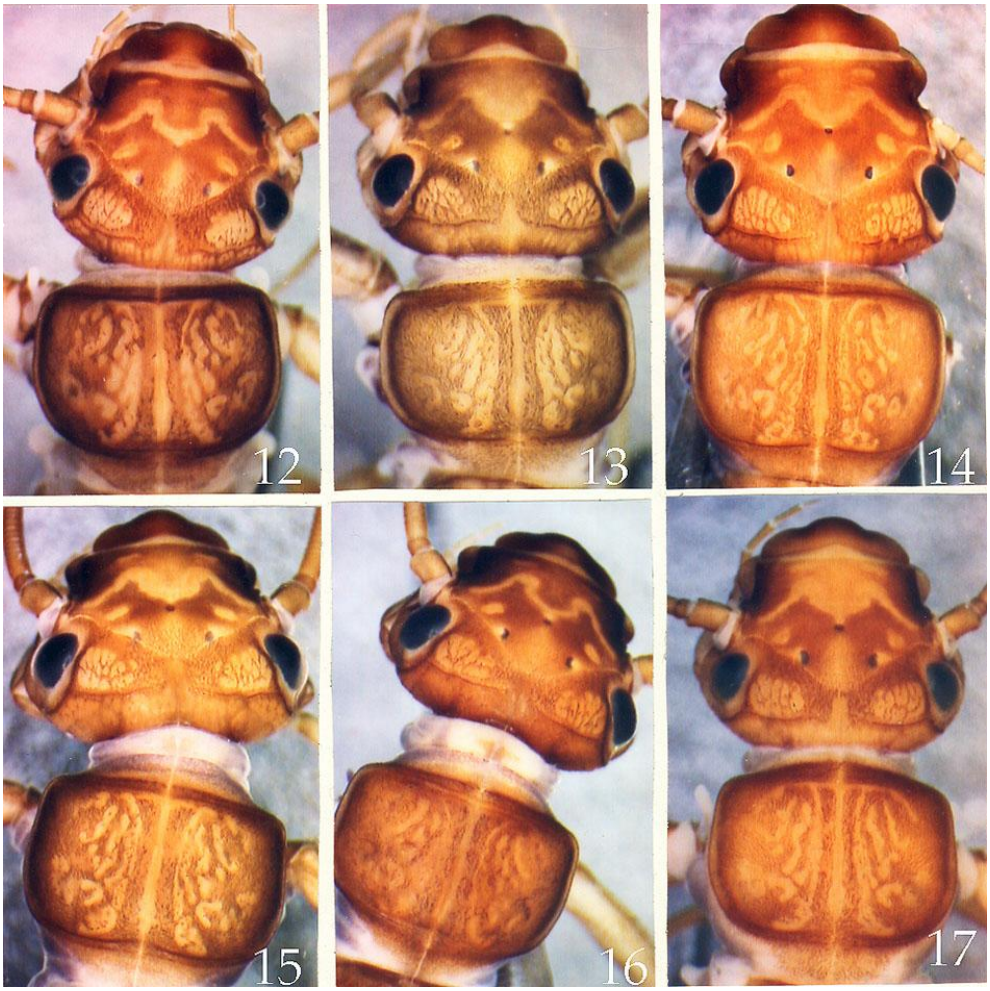
Megarcys irregularis (Banks 1900)

(Figs. 12, 24, 30, 36, 42, 48, 60, 70, 84a-b, Table 1)

Distribution. Pacific Northwest; Coastal and Cascade Mountains of Washington, British Columbia.
Material examined. Washington: Pierce Co., Fryingpan Creek, Sunrise Road, Mount Rainier National Park, 13-VII-2003, B. Kondratieff, J. Schmidt, 1♂, 2♀ larvae; 14-VII-2004, B. Kondratieff,



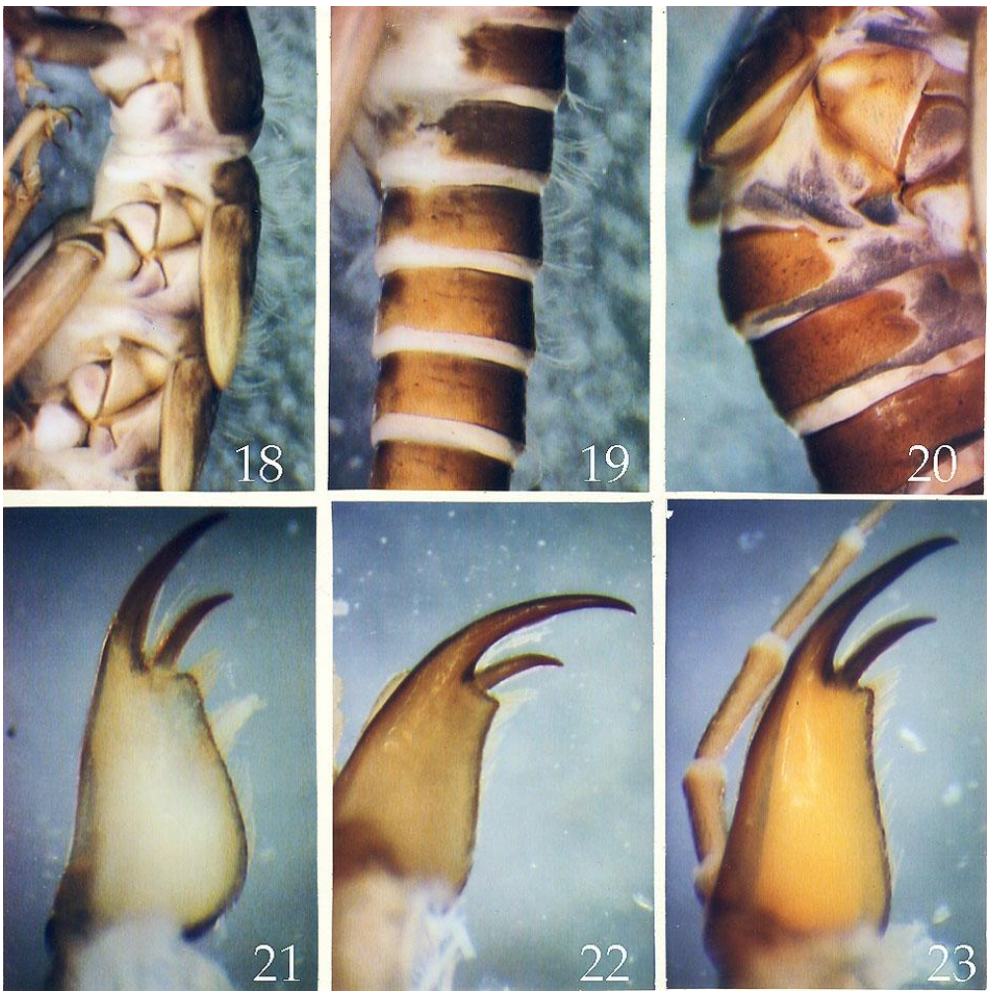
Figs. 3-11. *Megarcys signata* larval characters. 3. Head-pronotum. 4. Left lacinia, ventral. 5. Left mandible, ventral. 6. Right front leg, dorsal. 7. Mesosternum. 8. Gill arrangement, ventral. 9. Male abdomen, ventral. 10. Female abdomen, ventral. 11. Basal-mid-apical cercomeres, dorsal. (Stewart & Stark 2002, Figs. 14.36 a-i).



Figs. 12-17. *Megarcys* larval head-pronotal pattern. 12. *M. irregularis*, White River, Washington. 13. *M. signata,* Mosquito Creek, Colorado. 14. *M. subtruncata,* Ohanopecosh River, Washington. 15. *M. subtruncata*, Butte Creek, California. 16. *M. subtruncata,* Quinn Spring, Oregon. 17. *M. watertoni*, Iceberg Creek, Montana.

5♀; Nisqually River, Longmire, Mount Rainier National Park, 28-V-1997, B. Kondratieff, 2♂, 1♀, 2♂ larvae; White River, Hwy. 410, Mount Rainier National Park, B. Kondratieff, 8♂, 1♀, 3♂ larvae, 3♀ larvae, 1♂ exuvium, 2♀ exuviae; 20-VI-2003, B. Kondratieff, R. Zuellig, J. Schmidt, 2♀.

Characters. Head capsule width ♂ 3.06-3.30mm, ♀ 3.90-4.62mm; pronotal width ♂ 2.88-3.12mm, ♀ 3.36-4.08mm; body length ♂ 18.3-19.5mm, ♀ 19.5-24.0mm (Table 1). Color and pigmentation (Figs. 12, 24, 30, 36, 42, 48), lacinia, and dorsomesal band of erect silky white hairs typical of genus. Wingpads of ♂ and ♀ macropterous. Gill number and arrangement typical of genus (Fig. 70). Submental gill length ♂ 0.12-0.42mm, ♀ 0.36-0.45mm; anterior supracoxal gill length ♂ 0.27-0.42mm, ♀ 0.36mm (Table 1). Legs (Fig. 30) with setation typical of genus as described by Stewart & Stark (2002).Y-arms of mesosternum (Fig. 36) typical of genus. Cercal segments ♂ 24-26 (Table 1), with setation typical of genus. Developing membranous , windsocklike process of male epiproct (Figs. 42, 48, 70) evident in late instar individuals, and pointed posteroventrally in lateral view (Fig. 79).Developing female subgenital plate of 8th sternum



Figs. 18-23. *Megarcys* larval characters. 18. *M. signata,* thorax, lateral, Mosquito Creek, Colorado. 19. *M. signata,* abdomen, lateral, Mosquito Creek, Colorado 20. *M. subtruncata,* thorax-abdomen, lateral, Quinn Spring, Oregon. 21. *M. signata,* right lacinia, ventral, Mosquito Creek, Colorado. 22. *M. subtruncata,* right lacinia, ventral, Ohanapecosh River, Washington. 23. *M. watertoni,* right lacinia, ventral, Iceberg Creek, Montana.

(Figs. 49, 84a, b) shallowly notched mesally.

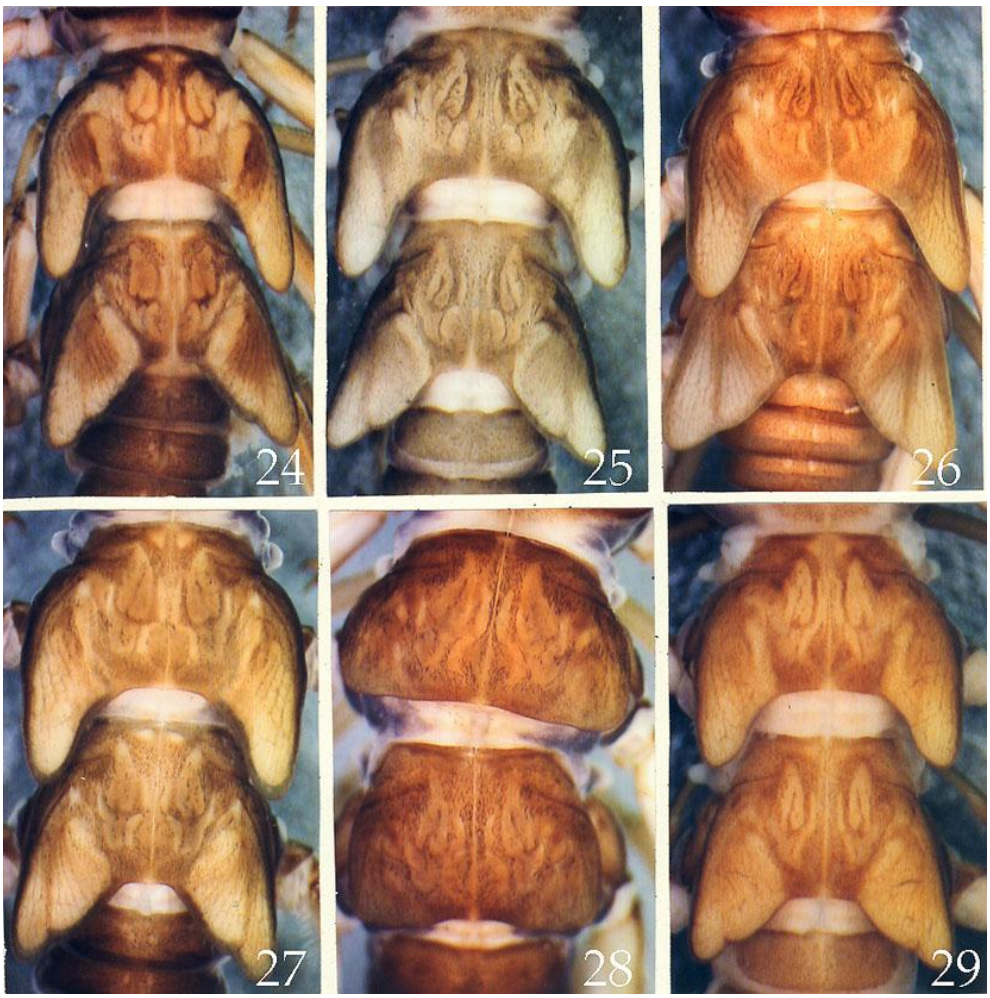
Comments. The generic characters proposed by Stewart & Stark (2002), based solely on *M. signata* , are reaffirmed in this species, and color and pigmentation fit the generic pattern illustrated herein for *M. signata.* The measured gill lengths and shapes were greatly variable in this species (Table 1), and otherwise similar to *M. signata.*

***Megarcys subtruncata* Hanson 1942**

(Figs. 14-16, 20, 22, 26-28, 32-34, 38-40, 44-46, 51, 52, 62-64, 72, 81, 86, Table 1)

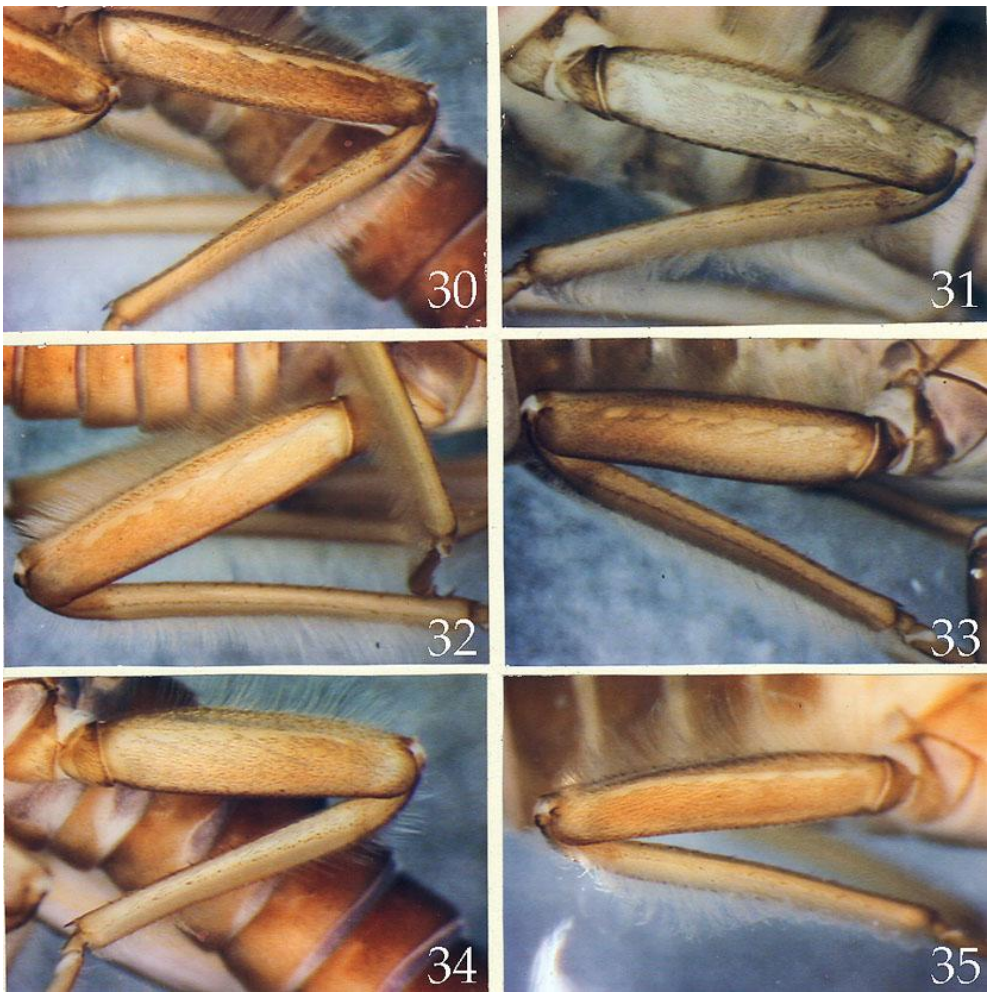
Distribution. California, Pacific Northwest (Oregon, Washington, British Columbia), and Northern Rocky Mountains (Idaho, Montana).

Material examined. California: Butte Co., Butte Creek, Cherry Hill Campground, 12-V-2007, J. Sandberg, 1♂, 5 ♂ larvae, 5♀ larvae. Shasta Co., Hat Creek at Hat Creek Lake, Lassen-Volcanic National Park, 6-VII-1979, K. Stewart, B. Stark, 1 reared ♀, 1 pharate ♂ larva (cleared genitalia), 1♀ larva; Hat



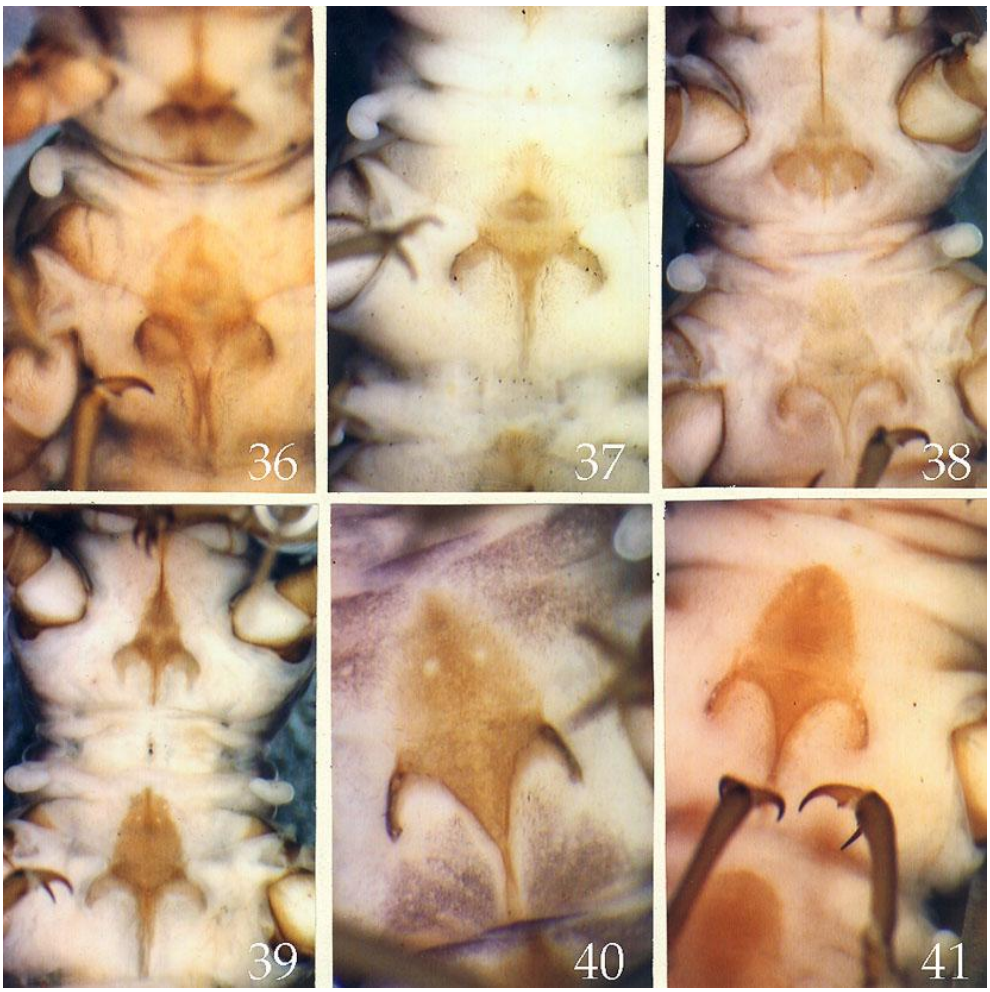
Figs. 24-29. *Megarcys* wingpads. 24. *M. irregularis* male, White River, Washington. 25. *M. signata* male, Mosquito Creek, Colorado. 26. *M. subtruncata,* Ohanopecosh River, Washington. 27. *M. subtruncata,* Butte Creek, California. 28. *M. subtruncata,* Quinn Spring, Oregon. 29. *M. watertoni,* Iceberg Creek, Montana.

Creek, Big Pine Camp, 26-IV-1987, B. Stark, R. Baumann, C. Nelson, 1♂ larva. Oregon: Deschutes Co., Quinn River Spring, Quinn River Campground, 10-VI-2004, B. Stark, R. Baumann, 20♂, 13♀, 8♂ larvae, 8♀ larvae. Washington: Lewis Co., Ohanapecosh River, Grove of the Patriarchs, Mount Rainier National Park, 28-V-1997, B. Kondratieff, 1 reared ♂ with exuvium; Ohanapecosh River, Hwy. 123, North Silver Falls, Mount Rainier National Park, 23-V-2003, B. Kondratieff, J. Schmidt, R. Evans, 2♂ larvae, 4♀ larvae; Ohanapecosh River, Hwy. 123, Paradise River above Narada Falls, Mount Rainier National Park, 16-VIII-1999, B. Kondratieff, R. Lechleitner, 1♀, 2 reared ♀ with exuviae, 5 exuviae; Pierce Co., Fish Creek, Westside Road Bridge, Mount Rainier National Park, 21-VI-2003, B. Kondratieff, R. Zuellig, J. Schmidt, 2♂, 1♀, 1♂ exuvium, 2♀ exuviae; Fryingpan Creek, Sunrise Road, Mount Rainier National Park, 16-VIII-1999, B. Kondratieff, 1♂ with exuvium, 1♀ with 2 exuviae; Ipsut Creek at bridge, Mount Rainier National Park, 6-VI-1997, R. Lechleitner, 2♀, 1 exuvium.



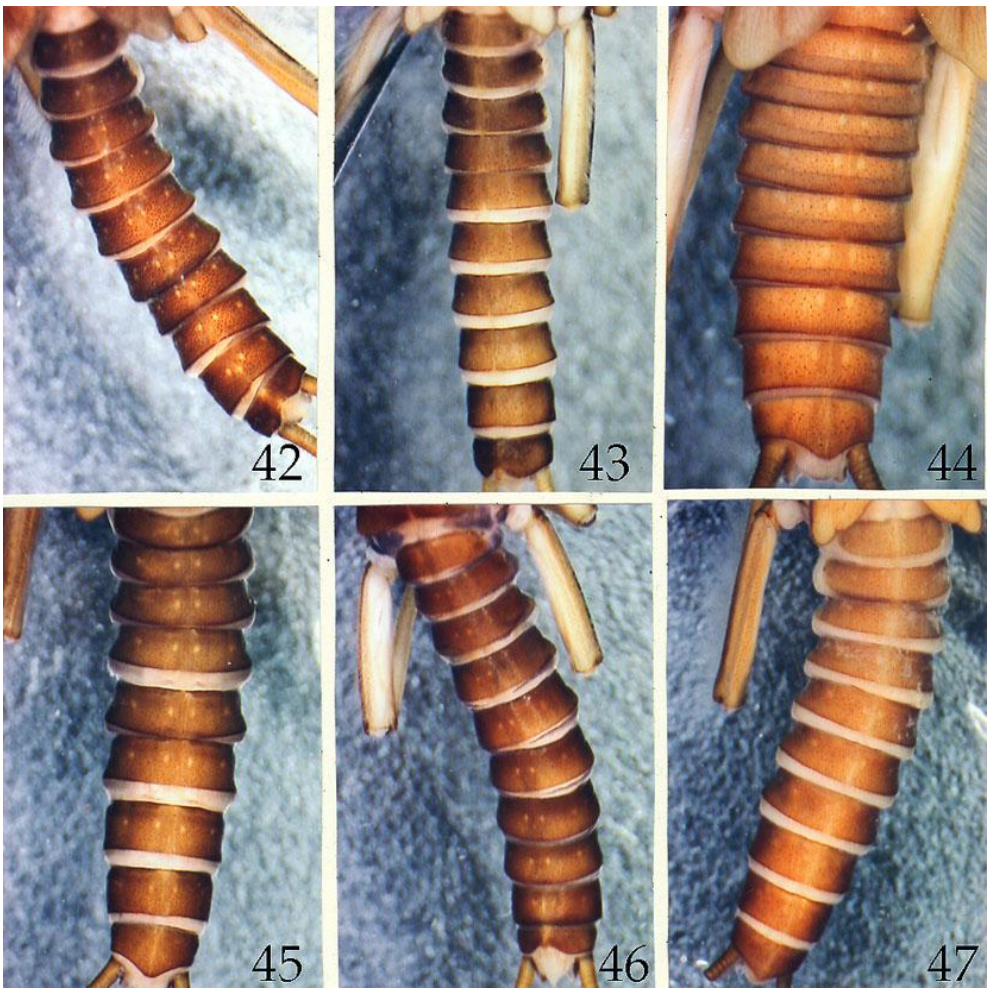
Figs. 30-35. *Megarcys* larval legs. 30. *M. irregularis,* left rear, White River, Washington. 31. *M. signata,* left rear, Mosquito Creek, Colorado. 32. *M. subtruncata*, right rear, Ohanopecosh River, Washington. 33. *M. subtruncata*, right rear, Butte Creek, California. 34. *M. subtruncata,* left rear, Quinn Spring, Oregon. 35. *M. watertoni,* right rear, Iceberg Creek, Montana.

Characters. Butte Creek, California, macropterous population: Head capsule width ♂ 3.78-3.90mm, ♀ 4.68-4.74mm; pronotal width ♂ 3.36-4.48mm, ♀ 4.20mm; body length ♂ 17.9-21.6mm, ♀ 22.2-25.5mm (Table 1). Color and pigmentation (Figs. 15, 27, 33, 39, 45, 51), lacinia (like Ohanapecosh River, Washington population Fig. 28), and dorsomesal band of erect silky white hairs typical of genus. Wingpads of ♂ (Fig. 27) and ♀ macropterous. Gill number and arrangement typical of genus (Fig. 62). Submental gill length ♂ 0.39-0.54mm, ♀ 0.54-0.66mm; anterior supracoxal gill length ♂ 0.42-0.54mm, ♀ 0.54-0.66mm (Table 1). Legs (Fig. 33) with typical setation of genus as described by Stewart & Stark (2002). Y-arms of mesosternum (Fig. 39) typical of genus. Cercal segments ♂ 24-26 (Table 1), with setation typical of genus. Developing membranous windsock-like process of male epiproct (Fig. 72) evident in late instar individuals, and pointed posteroventrally in lateral view (Fig. 81). Developing female subgenital plate of 8th sternum (Figs. 51, 86) shallowly notched mesally.



Figs. 36-41. *Megarcys* larval thoracic sterna. 36. *M. irregularis,* pro-and metasterna, White River, Washington. 37. *M. signata,* mesosternum, Mosquito Creek, Colorado. 38. *M. subtruncata,* meso- and metasterna, Ohanopecosh River, Washington. 39. *M. subtruncata,* meso- and metasterna, Butte Creek, California. 40. *M. subtruncata,* mesosternum, Quinn Spring, Oregon. 41. *M. watertoni,* mesosternum, Iceberg Creek, Montana.

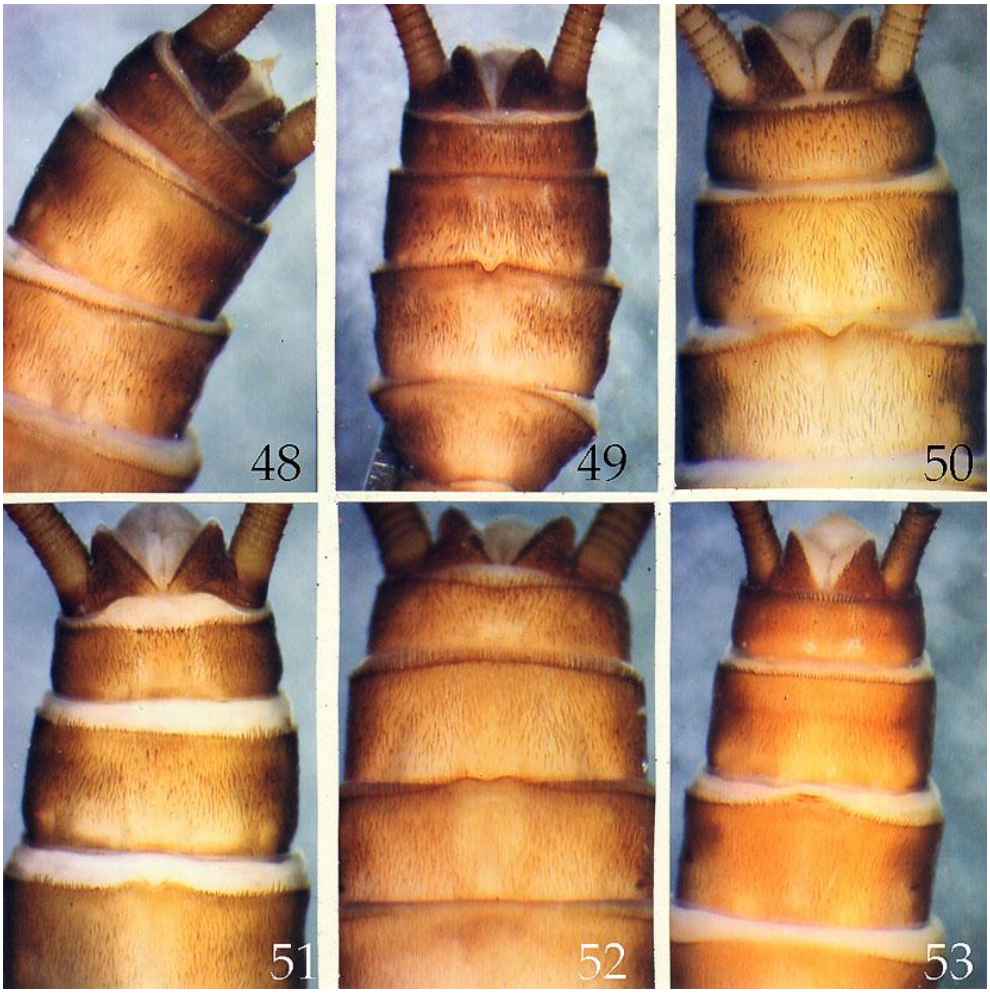
Quinn Spring, Oregon, brachypterous population: As indicated by Stark & Baumann (2005), larvae of this population, that they did not describe in detail, "agree in most respects" with the generic description in Stewart & Stark (2002). Head capsule width ♂ 3.12-3.48mm, ♀ 4.20-4.22mm; pronotal width ♂ 2.94-3.12mm, ♀ 4.02-4.26mm; body length ♂ 15.6-16.0mm, ♀ 19.5-21.2mm. Color and pigmentation (Figs. 16, 28, 34, 40, 46), lacinia typical of genus. Dorsomesal band of erect silky white hairs and those along the ecdysial suture of the head absent. Wingpads ♂ (Fig. 28) and female brachypterous. Gill number and arrangement typical of genus. Submental gill (Fig. 63) length ♂ 0.27-0.30mm, ♀ (Fig. 64) 0.34-0.36mm; anterior supracoxal gill length ♂ 0.21-0.24mm, ♀ 0.30-0.34mm (Table 1). Legs (Fig. 34) with typical setation of genus. Y-arms of mesosternum (Fig. 40) typical of genus. Cercal segments of ♂ 22+ (all broken), dorsal silky fringe (typical of the other four species) absent or with a few obscure setae on basal segments. Developing membranous, windsock-like process of male epiproct evident in late instar individuals, and



Figs. 42-47. *Megarcys* dorsal larval abdomen. 42. *M. irregularis* male, White River, Washington. 43. *M. signata* male, Mosquito Creek, Colorado. 44. *M. subtruncata* female, Ohanopecosh River, Washington. 45. *M. subtruncata* female, Butte Creek, California. 46. *M. subtruncata* male, Quinn Spring, Oregon. 47. *M. watertoni* female, Iceberg Creek, Montana.

pointed posteroventrally in lateral view like the Butte Creek, California, population (Fig. 81). Developing female subgenital plate of 8th sternum shallowly notched mesally like the Butte Creek, California, population (Figs. 51, 86).

Comments. The Quinn Spring, Oregon, brachypterous population exhibited these substantial character differences from generic and the Butte Creek, California, and Ohanapecosh River, Washington macropterous populations examined: 1) the dorsomesal band of erect silky white hairs and those along the ecdysial suture of the head were absent, 2) the dorsal silky fringe of basal cercal segments was absent or with only a few obscure setae present, 3) the body size (length) of pre-emergent males was on average 20% shorter, and females about 15% shorter (Table 1), 4) submental and anterior supracoxal gills of males (Fig. 63) were on average about 39% and 53% shorter, respectively (Table 1). The gills of the Quinn Spring population could therefore generally be described as "short" in comparison with "long" in the other two populations



Figs. 48-53. *Megarcys* ventral larval abdomen, 48. *M. irregularis* male, White River, Washington. 49. *M. irregularis* female, White River, Washington. 50. *M. signata* female, Mosquito Creek, Colorado. 51. *M. subtruncata* female, Butte Creek, California. 52. *M. subtruncata* female, Ohanopecosh River, Washington. 53. *M. watertoni* female, Iceberg Creek, Montana.

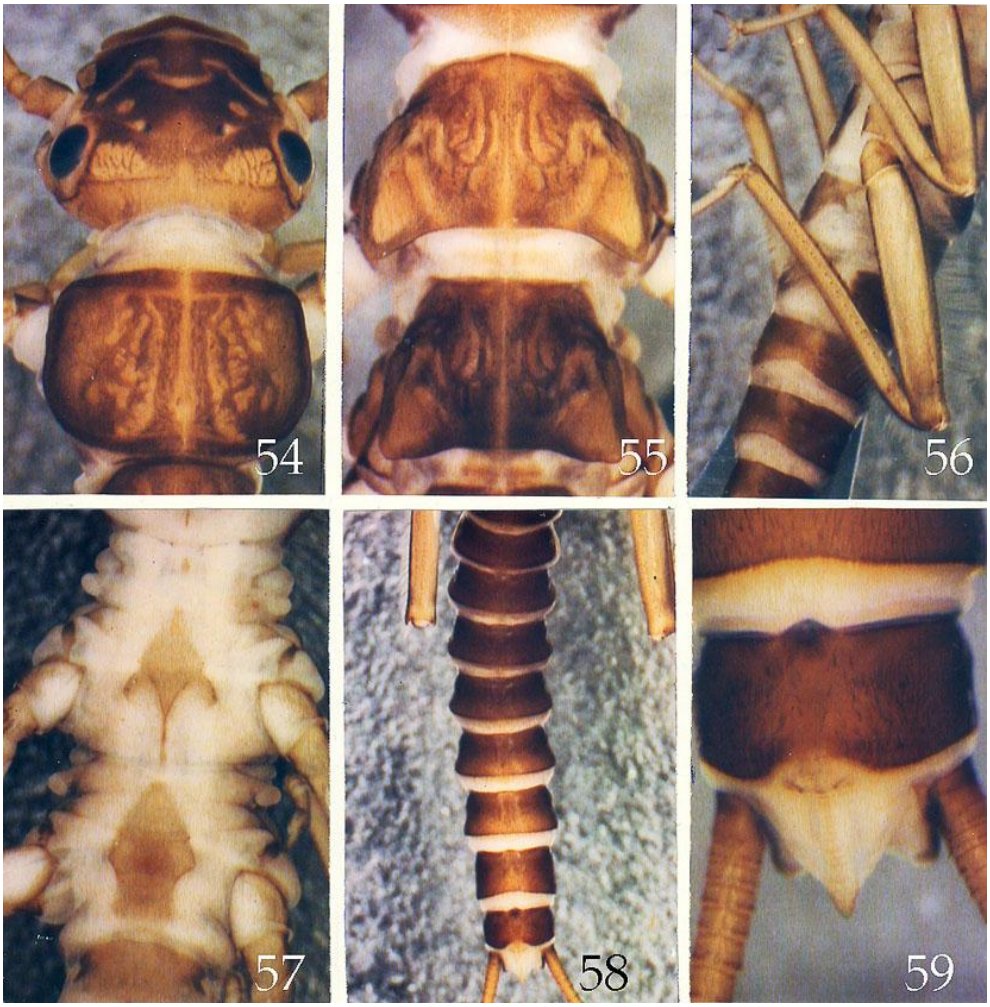
studied. This suggests that populations of this species in ecotypes may vary in wing length, body and gill size, and setation, but still conform to the diagnostic generic characters of gill arrangement and Y-arms extending to anterior corners of the furcal pits (Stewart & Stark 2002).

Megarcys watertoni (Ricker 1952)

(Figs. 17, 23, 29, 35, 41, 47, 53, 65-68, 73, 75-77, 82, 87, Table 1)

Distribution. Northern Rocky Mountains; Idaho, Montana, Alberta, British Columbia.

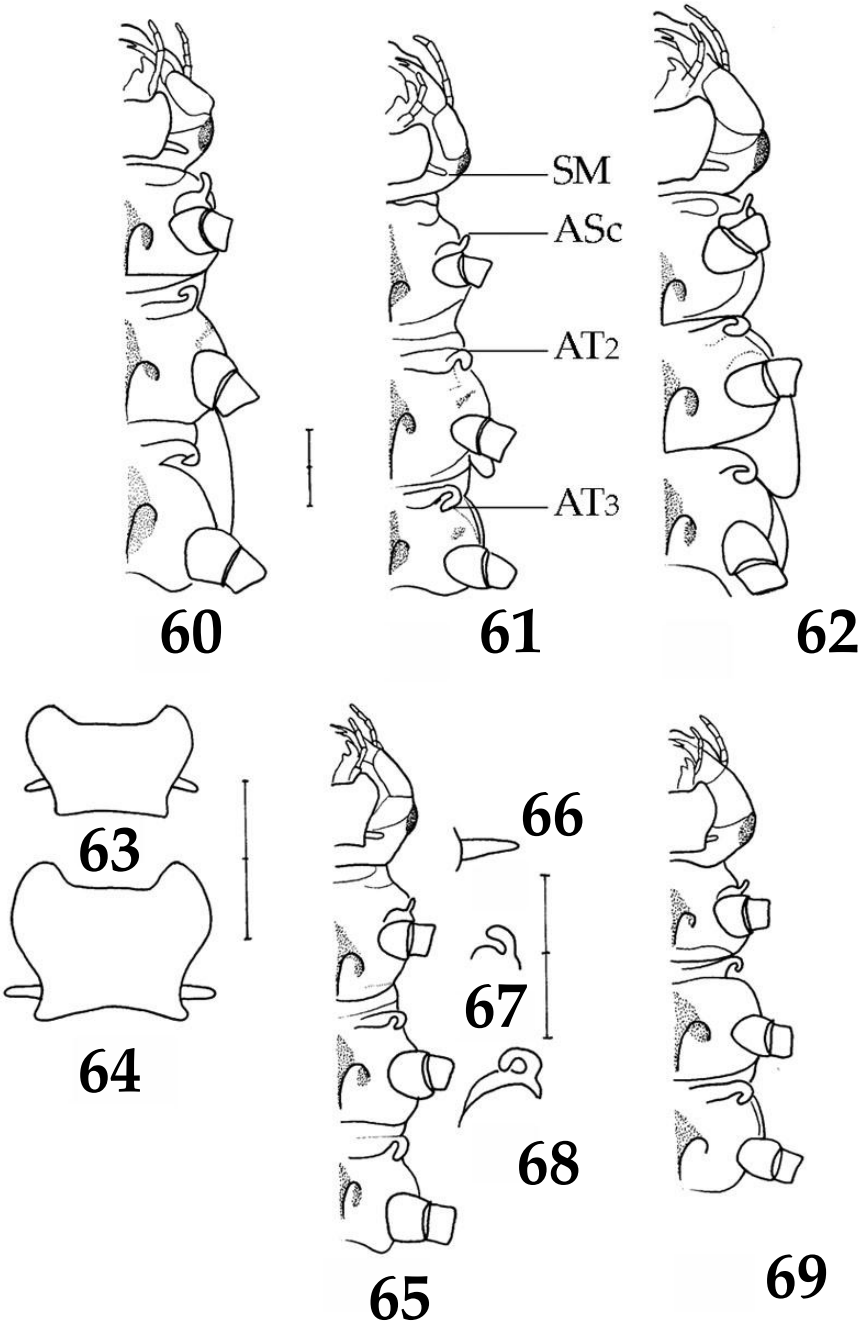
Material examined. British Columbia: Kooteny National Park, 8-VII-1985, 2♂, 2♀, many exuviae. Montana: Carbon Co., Baring Falls, 28-VII-1989, B. Stark et al., 1♀ larva; Rock Creek, 0.8 km below Glacier Lake Trailhead, 22-VII-1989, B. Stark, 1 brachypterous ♂ (to Ab9), 1 brachypterous ♂ (to Ab5), 4♀, 1♀ larva; Glacier Co., Baring Creek, Sunrift Gorge, Glacier National Park, 22-VII-1979, K. Stewart, R. Baumann, B. Stark, 4♂ larvae, 5♀ larvae;



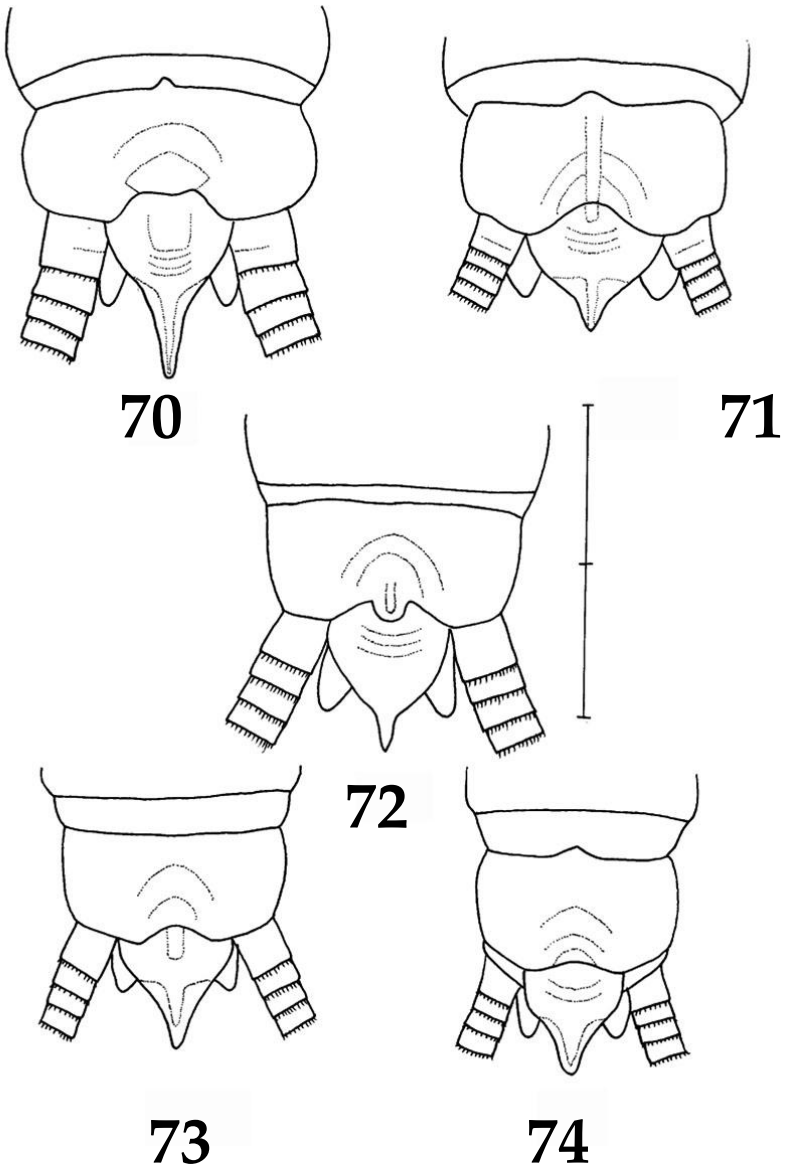
Figs. 54-59. *Megarcys yosemite* larval male characters, Cold Water Creek, California. 54. Head-pronotum. 55. Wingpads. 56. Left middle and hind legs. 57. Meso-metasterna. 58. Dorsal abdomen. 59. Developing genitalia, dorsal.

Iceberg Creek at Iceberg Lake, Glacier National Park, 29-VII-1969, R. Haick, 2 brachypterous ♂, 1♀; 3-VII-1972, J. Stanford, 3♂ larvae, 1♀ larva; 21-VII-1979, K. Stewart, R. Baumann, B. Stark, 1♂ larva, 1♀ larva; Roes Creek, Rising Sun Campground, Glacier National Park, 6-VII-1963, coll.?, 3♂, 3♀; Flathead Co., Bear Creek/ jct. Middle Fork Flathead River, Hwy. 2, 7-VI-1996, R. Hansen, B. Ward (C. Nelson # 6347), 1♂ larva, 1♀ larva; Juliet Creek, Bob Marshall Wilderness, 19-VII-1981, J. Stanford, 1♀ ; Lion Creek, 14-VII-1985, K. Stewart, 4♂ larvae, 4♀ larvae; Logan Creek at Logan Pass, Glacier National Park, 11-VII-1987, K. Stewart, 1♂ larva; 2100 m, 10-X-1991, J. Giersch, 5 small larvae; Logan Creek/confluence McDonald Creek, Glacier National Park, 29-VI-1995, J. Giersch, 2♂, 1♀; Spotted Bear River at Pentagon, Bob Marshall Wilderness, 21-VII-1981, J. Stanford, 1♂ larva.

Characters. Bear Creek, Montana, macropterous population: Head capsule width ♂ 3.72mm, ♀ 4.32-4.38mm; pronotal width ♂ 3.00mm, ♀ 3.90mm; body length ♂ 20.4, ♀ 24.3mm (Table 1). Color and pigmentation, lacinia, and dorsomesal band of erect white hairs similar to Iceberg Creek, Montana,

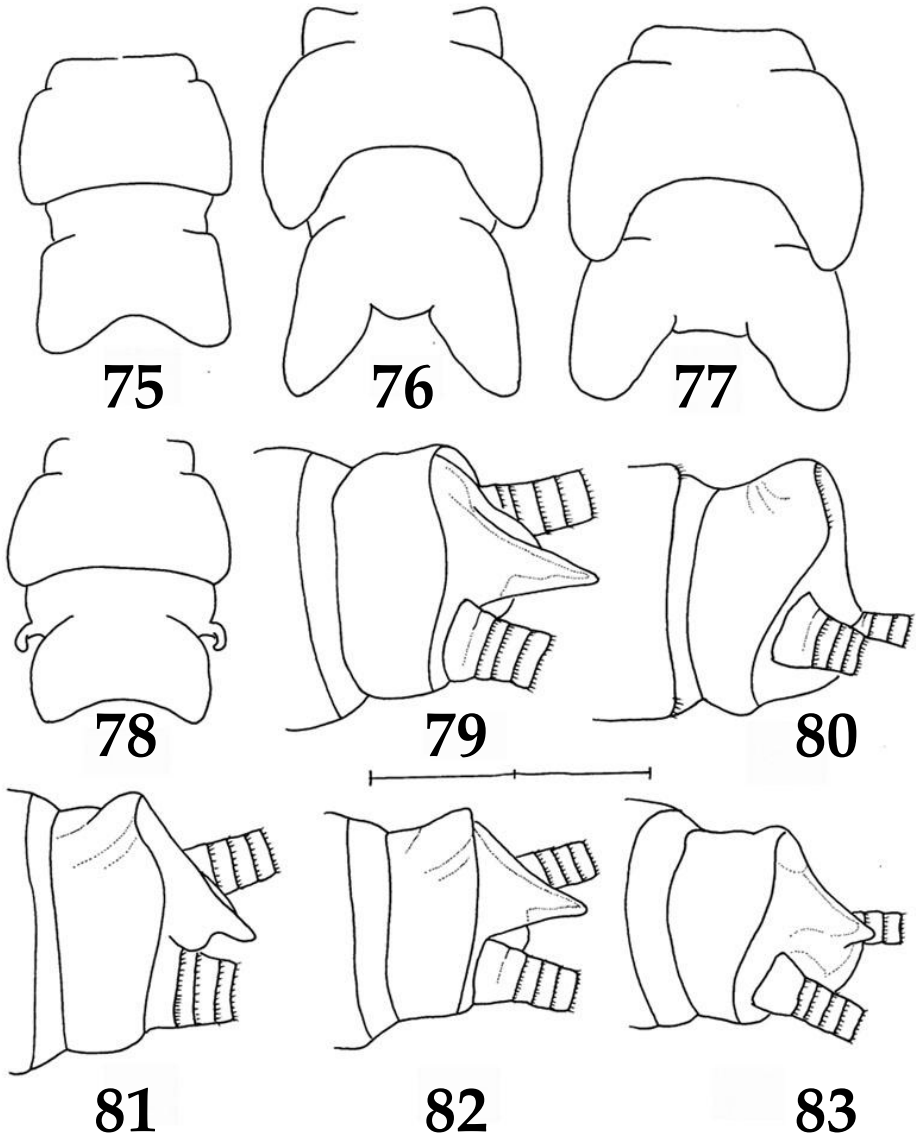


Figs. 60-69. *Megarcys* larval characters. 60. *M. irregularis* gills, male, Nisqually River, Washington. 61. *M. signata* gills, male, Mosquito Creek, Colorado. (SM = submental gill, ASc = anterior supracoxal gill, AT_2 = anterior mesothoracic gill, AT_3 = anterior metathoracic gill). 62. *M. subtruncata* male gills, Butte Creek, California. 63. *M. subtruncata* submentum and gills, male, Quinn Spring, Oregon. 64. *M. subtruncata* submentum and gills, female, Quinn Spring, Oregon. 65. *M. watertoni* gills, male, Iceberg Creek, Montana. 66. *M. watertoni* submental gill, male, Bear Creek/confl. Flathead River, Montana. 67. *M. watertoni* anterior supracoxal gill, male, Bear Creek/confl. Flathead River, Montana. 68. *M. watertoni* anterior supracoxal gill, female, Bear Creek/confluence Flathead River, Montana. 69. *M. yosemite* gills, male, Cold Creek, California. Scale lines = 2 mm.



Figs. 70-74. *Megarcys* larval characters. 70. *M. irregularis* developing male genitalia, dorsal, Nisqually River, Washington 71. *M. signata* developing male genitalia, Mosquito Creek, Colorado. 72. *M. subtruncata* developing male genitalia, dorsal, Butte Creek, California. 73. *M. watertoni* developing male genitalia, dorsal, Iceberg Creek, Montana. 74. *M. yosemite* developing male genitalia, dorsal, Cold Water Creek, California. Scale line= 2mm.

population (described below) (Figs. 17, 23, 29, 35, 41, 47, 53). Wingpads of ♂ (Fig. 76) and ♀ macropterous. Gill number and arrangement typical of genus. Submental gill (Fig. 66) length ♂ 0.54-0.57mm, ♀ 0.66-0.72mm; anterior supracoxal gill (Fig. 67) length ♂ 0.36mm, ♀ (Fig. 68) 0.60-0.66mm (Table 1). Legs with typical setation of genus as described by Stewart & Stark (2002). Y-arms of mesosternum



Figs. 75-83. *Megarcys* larval characters. 75. *M. watertoni* wingpads, male, Iceberg Creek, Montana. 76. *M. watertoni* wingpads, male, Bear Creek confl. Flathead River, Montana. 77. *M. watertoni* female wingpads, Iceberg Creek, Mt. 78. *M. yosemite* wingpads, male Cold Creek, California. 79. *M. irregularis* developing male genitalia, oblique view, Nisqually River, Washington. 80. *M. signata* developing male genitalia, lateral, Mosquito Creek, Colorado. 81. *M. subtruncata* developing male genitalia, oblique view, Butte Creek, California. 82. *M. watertoni* developing male genitalia, oblique view, Iceberg Creek, Montana. 83. *M. yosemite* developing male genitalia, oblique view, Cold Water Creek, California. Scale line = 2 mm.

typical of genus. Cercal segments ♂ 26 (Table 1), with setation typical of genus. Developing membranous windsock-like process of male epiproct evident in late instar individuals , and pointed posteroventrally in lateral view like the Iceberg Creek, Montana, population below (Figs. 73, 82). Developing female subgenital plate of 8th sternum shallowly notched mesally like Glacier Creek population below (Fig. 87).

Iceberg Creek, Montana, male brachypterous (female macropterous) population: Head capsule width ♂ 2.76-3.00mm, ♀ 3.48-3.84mm; pronotal width ♂ 2.58-2.64mm, ♀ 3.36mm; body length ♂ 16.08-17.28mm, ♀ 20.9-22.2mm (Table 1). Color and pigmentation (Figs, 17, 29, 35, 41, 47, 53), lacinia, (Fig. 23), and dorsomesal band of erect silky white hairs typical of genus. Wingpads ♂ (Fig. 75) brachypterous, ♀ (Fig. 29) macropterous. Gill number and arrangement (Fig. 65) typical of genus. Submental gill length ♂ 0.24-0.27mm, ♀ 0.36-0.39mm; anterior supracoxal gill length ♂ 0.24-0.27mm, ♀ 0.33-0.42mm (Table 1. Legs (Fig. 35) with typical setation of genus. Y-arms of mesosternum (Fig. 41) typical of genus. Cercal segments ♂ 26 (Table 1), with setation typical of genus. Developing membranous windsock-like process of male epiproct (Fig. 73) evident in late instar individuals, and pointed posteroventrally in lateral view (Fig. 82). Developing female subgenital plate of 8th sternum (Fig. 87) shallowly notched mesally.

Comments. The high elevation Iceberg Creek population was similar in color and pigmentation, and other generic characters, to the lower elevation Bear Creek population, except for male brachyptery and smaller body and gill sizes. Head capsule widths of males and females were on average 21.4% and 17.8%, respectively, smaller; pronotal widths of males and females were on average 13.0% and 13.8% smaller, and body lengths were on average 10.0% and 11.4% smaller (Table 1). Gill lengths were substantially smaller; submental gills of males and females were on average 54.1% and 45.7% shorter; anterior supracoxal gills of males and females were on average 29.2% and 40.5% shorter, respectively (Table 1).

Megarcys yosemite (Needham & Claassen 1925)

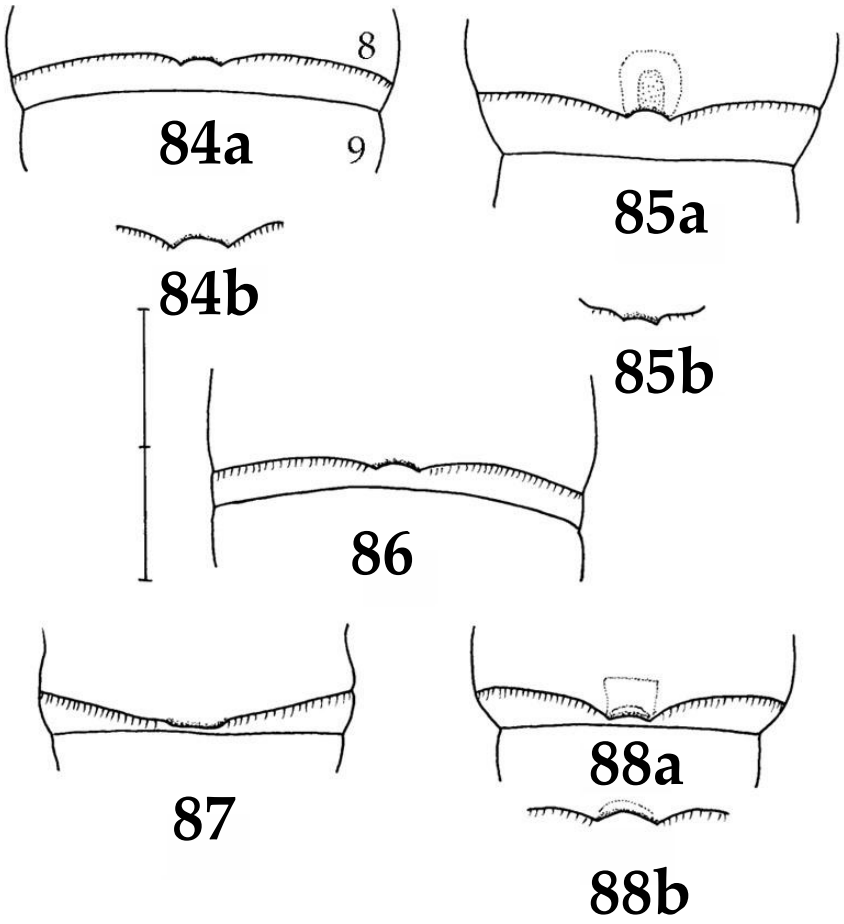
(Figs. 1, 54-59, 69, 74, 78, 83, 88a-b, Table 1)

Distribution. California, Washington (high elevation streams).

Material examined. California: Inyo Co., Ruby Creek, about 56.33km from the Mt. Lyell Type Locality, El. 3444m, water temp. 12.2°C, 20-VIII-2010, L. Serpa, 1 pre-emergent ♂ larva (died in rearing), 4 early instar larvae (on a previous date in 2008, 1♂ determined by R. Baumann, and 1♀ larva, were collected by L. Serpa at this site; personal correspondence); Mono Co., Coldwater Creek, 37°34′27.4″N 118° 59′ 16.7″W, El. 3063m, water temp. 4.44°C, 19-VIII-2010, L. Serpa, 2 reared brachypterous ♂ (one ♂ determined by R.W. Baumann), 2 brachypterous ♂ larvae, 4 brachypterous ♀ larvae, 6 early instar larvae with average head capsule width of 1.14mm, and average body length of 5.64mm; Coldwater Creek, Sky Meadow, 2.7km above Coldwater Creek Campground , El. 3067m, water temp. 4.49°C, 2 reared ♂, 1 reared ♀ (Fig. 1), 6 larvae (5 died in rearing: 07-IX-2010 collection date, 17-IX-2010 emergence date) (personal correspondence, J. Sandberg).

Characters. Head capsule width ♂ 2.88-3.36mm, ♀ 3.60-3.84mm; pronotal width ♂ 2.76-3.30mm, ♀ 3.54-3.66mm; body length ♂ 17.64-20.2mm, ♀ 22.4-22.9mm (Table 1). Color and pigmentation (Figs. 54-59), lacinia, and dorsomesal band of erect silky white hairs typical of genus. Wingpads of ♂ (Figs. 55, 78) and ♀ brachypterous, reflective of adults. Gill number and arrangement typical of genus (Fig. 69). Submental gill length ♂ 0.27-0.36mm, ♀ 0.33-0.45mm; anterior supracoxal gill length ♂ 0.18-0.30mm, ♀ 0.24-0.33mm (Table 1). Legs (Fig. 56) with setation typical of genus. Y-arms of mesosternum (Fig. 57) typical of genus. Cercal segments ♂ 24-26 (Table 1), with setation typical of genus. Developing membranous windsock-like process of male epiproct (Figs. 59, 74) evident in late instar individuals, and pointed posteroventrally in lateral view (Fig. 83). Developing female subgenital plate of 8th sternum (Fig. 88a, b) shallowly notched mesally.

Comments. Males and females (Fig. 1) of this high elevation California population are brachypterous, reflected by the very short wingpads of pre-emergent larvae. The submental and anterior supracoxal gill lengths of both sexes of larvae, like the brachypterous male larvae of *M. subtruncata* larvae of Quinn Spring, Oregon, and brachypterous male and macropterous female larvae of *M. watertoni* from Iceberg Creek, Montana, were substantially shorter than those of the macropterous populations studied (Table 1). Otherwise, coloration and pigmentation, generic, and other specific characters of larvae were not separable from the other four species.



Figs. 84-88. *Megarcys* larval characters. 84a. *M. irregularis* larval female 8th sternum, Nisqually River, Washington. 84b. *M. irregularis*, larval female 8th sternum, same specimen, 2X. 85a. *M. signata* larval female 8th sternum, Mosquito Creek, Colorado. 85b. *M. signata* larval female 8th sternum, Pine Creek, Montana. 86. *M. subtruncata* larval female 8th sternum, Butte Creek, California. 87. *M. watertoni* larval female 8th sternum, Iceberg Creek, Montana. 88a. *M. yosemite* larval female 8th sternum, Cold Water Creek, California. 88b. *M. yosemite*, larval female 8th sternum same specimen, 2X. Scale line = 2 mm.

GENERAL DISCUSSION

Zwick (2004) predicted that since many stonefly adults can be identified to species only by genital characters, often relatively subtle, less taxonomic resolution can be anticipated in some immatures, suggesting that species level resolution of larvae might have variable success in different genera. Larval studies of North American genera and regional species groups: *Strophopteryx, Taenionema, Taeniopteryx* (Taeniopterygidae), *Acroneuria, Neoperla, Perlesta* (Perlidae), *Sweltsa* (Chloroperlidae), *Isogenoides, Isoperla, Setvena* (Perlodidae), reviewed by Stewart (2009), have achieved useful morphological species diagnosis for construction of provisional keys. Further such success has been reported for western *Podmosta* (Stewart & Stark 2011), eastern *Sweltsa* (Stark et al. 2011), and California *Capnia* (Stewart et al. 2011). This has not been the case in our current study of *Megarcys* where sufficient differences were not found in the characters studied: 1) color and pigment patterns, 2) mouthparts, 3) body and appendage setation, 4) gill size and structure, 5) developing male and female genitalia, and 6) other generic characters, to diagnose late

instar larvae of the five Nearctic species. We were surprised at the lack of differences in pigment patterns. Therefore, we have not attempted to present a key to larvae of Nearctic species as Teslenko (2009) presented for three Palearctic species.

We could not characterize gills as simply "short" or "long" as done for Palearctic species by Teslenko (2009) in her key, because of variation in actual gill lengths and curvatures between left and right sides, individuals, and populations, reflected by ranges of measurements in Table 1. Another potential problem in using soft structures like gills for species diagnosis is lack of knowledge of the progression of gill size with ontogenic development in *Megarcys* and other gilled stoneflies as shown for *Malenka bifurcata* (Claassen, 1923) by Stewart & Anderson (2009). Generally, measurements of body and gill size of larvae were substantially smaller in the brachypterous, crenon-dwelling Quinn Spring population of *M. subtruncata,* and high elevation, cold stream brachypterous populations of *M. watertoni* and *M. yosemite,* than in macropterous populations in lower elevation streams and rivers (Table 1). These first detailed descriptions and measurements of *M. irregularis, M. subtruncata, M. watertoni,* and *M. yosemite* larvae help expand the generic diagnosis, show morphological differences in populations of different habitats, and provide an atlas of illustrations for larvae of the five species.

ACKNOWLEDGEMENTS

We thank Stanley Szczytko for providing the color photos of larvae, and John Sandberg for use of the color photo of a female adult of *M. yosemite*. We thank Richard Baumann, Robert Newell, John Sandberg, Larry Serpa, and Bill Stark for providing additional associated specimens of various species for study.

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Received 6 January 2012, Accepted 21 February 2012, Published 6 March 2012