

# Molecular and biometric assessment of *Myzodium mimulicola* (Hemiptera: Aphididae), with new synonymy and host and distributional data

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**Abstract**—A molecular and biometric assessment and redescription of *Myzodium mimulicola* (Drews and Sampson) are provided. New North American host and distributional data are presented, including the first record from Alaska. *Myzodium knowltoni* (Smith and Robinson) is a junior subjective synonym of *M. mimulicola*, based on molecular-sequence and morphological evidence. A key to the known *Myzodium* species (apterae and alatae) is included.

**Résumé**—Nous présentons une évaluation moléculaire et biométrique, ainsi qu'une redescription de *Myzodium mimulicola* (Drews et Sampson). De nouvelles données sur la répartition en Amérique du Nord et sur les hôtes sont fournies, dont une première mention pour l'Alaska. L'étude de la morphologie et des séquences moléculaires montre que *Myzodium knowltoni* (Smith et Robinson) est un synonyme subjectif plus récent de *M. mimulicola*. Un clé permet de reconnaître les espèces connues de *Myzodium* (aptères et ailées).

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## Introduction

The aphid fauna (Hemiptera: Aphididae) of western North America is represented by a broad spectrum of species (1000+ species; see Pike *et al.* 2003) utilizing a wide range of plants. Among aphids encountered on *Mimulus* L. and *Veronica* L. (Scrophulariaceae), *Rorippa* Scop. (Brassicaceae), and mosses in forest settings, wetlands, seeps, and slow-moving waterways are species of *Myzodium* Börner. Field collections from Alaska, Idaho, Montana, Oregon, Utah, and Washington reveal that two (*M. knowltoni* Smith and Robinson and *M. mimulicola* (Drews and Sampson)) of the three species of *Myzodium*

recognized in North America are morphologically indistinguishable.

*Myzodium mimulicola* collected from *Mimulus guttatus* DC was originally placed in *Kakimia* Hottes and Frison (now a subgenus of *Nasonovia* Mordvilko; Remaudière and Remaudière 1997) and then in *Ovatus* Van der Goot (Eastop and Hille Ris Lambers 1976). Because of its short, distinctly shaped cauda and certain other features, Eastop and Voegtlin (1990) classified it as a *Myzodium* species. At that time, whether *M. mimulicola* and *M. knowltoni* (described from moss) were separate species was unclear. Herein we place *M. knowltoni* as a subjective junior synonym of *M. mimulicola*, based on

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comparisons of molecular sequences and morphological characters, add new host and distributional information, and provide a diagnostic key to the species of *Myzodium*.

## Materials and methods

Our assessments of *M. mimulicola* are based on specimens from the authors' field collections taken from *Mimulus*, *Rorippa*, *Veronica*, and mosses from Alaska, Idaho, Montana, Oregon, Utah, and Washington, and from previously determined material in the Canadian National Collection, Ottawa (CNC); Essig Museum of Entomology, University of California, Berkeley (EMEC); University of Idaho, Moscow (UI); Utah State University, Logan (USU); the National Museum of Natural History Aphidoidea Collection, Beltsville, Maryland (USNM); and Washington State University (WSU). Field-collected specimens preserved in 70%–95% ethanol were cleared and slide-mounted in Canada balsam following Footitt and Maw (2000) or Hille Ris Lambers (1950) with modifications by D. Voegtlin (Illinois Natural History Survey) (Pike *et al.* 1991). We studied the holotype and paratypes of *M. knowltoni* and the syntypes of *M. mimulicola* and compared them with the original descriptions. For comparison, specimens of *Myzodium modestum* (Hottes) were also examined. Measurement data are based on the analysis of 58 apterae (24 specimens (including 10 syntypes) of *M. mimulicola*, 22 specimens (including the holotype and 10 paratypes) of *M. knowltoni*, and 9 specimens of *M. modestum*) and 9 alatae (including 2 syntypes) of *M. mimulicola*. Collection data for all specimens examined are presented in a standardized format organized by state and county (or borough). The following abbreviations are used for collection records: al, alate vivipara(e); ap, aptera vivipara(e); Boro., borough; CG, campground; coll., collector; Co., county; Cr., creek; ex, extracted or collected from; E, east; FR, forest road; Hwy, highway; im, immature; Jct., junction; mi., mile or miles; Mt, Mount; Mtn, mountain or mountains; N, north; ONP, Olympic National Park; Rd, road; S, south; W, west. Identifying letters in authors' collection codes (*e.g.*, 95G009) are as follows unless otherwise indicated: G, G.

Graf; K, K.S. Pike. Anatomical and other descriptive abbreviations are as follows: ABD, abdomen or abdominal; ANT, antenna; ASIII, ASIV, *etc.*, antennal segment 3, 4, *etc.*; BVI, base of ultimate antennal segment (part up to and including primary rhinarium); FT, frontal antennal tubercles; L/W, length/width ratio; PT, processus terminalis of the ultimate antennal segment (part beyond the primary rhinarium); SIPH, siphunculus; URS, ultimate rostral segment (penultimate and ultimate segments, 4+5). Morphological terminology follows Footitt and Richards (1993) and Pike *et al.* (2003).

Illustrations are hand-drawn from images taken with a DEC13M digital eyepiece camera through a Zeiss Axiolab compound microscope; morphological measurements (all recorded in millimetres, with segment length measured unless otherwise indicated) and character ratios are derived using image-measuring software (Pike *et al.* 2005).

Sequence data for mitochondrial cytochrome *c* oxidase subunit I (COI), 5' end ("DNA barcoding" region), of exemplar specimens (Table 1) selected from the authors' collections were compared to provide an indication of molecular coherence and distinctness of species. Details of specimen processing and primers follow Footitt *et al.* (2008). Information on sequences, collections, and taxonomy for each specimen was entered in the Barcode of Life Data System (BOLD) (Ratnasingham and Hebert 2007). All sequences obtained in this study are deposited in GenBank (Table 1). Where available, voucher specimens from the same collection sequenced are deposited in WSU or CNC. Pairwise nucleotide sequence divergences were calculated using the Kimura 2–76 parameter model of base substitution (Kimura 1980).

### Specimens examined (in WSU collections unless otherwise indicated)

#### *Myzodium mimulicola* (Drews and Sampson, 1937)

*Kakimia mimulicola* Drews and Sampson 1937: 29; Heie 1979: 7.

*Myzodium knowltoni* Smith and Robinson 1975: 482. **New synonymy.**

**Table 1.** Material of *Myzodium* taxa used for comparing DNA (COI) sequences.

	Plant host*	Collection code†	BOLD specimen ID No.	GenBank Accession No.
<i>Myzodium mimulicola</i> (Drews and Sampson)	Mg	A5K024	CNC HEM113538	EU701773
	Mg	A9K186	CNC HEM063970	GU224131
<i>Myzodium knowltoni</i> Smith and Robinson	Moss	A7A162	CNC HEM061718	GU224127
	Moss	A7G055	CNC HEM058031	GU224129
	Moss	A7G315	CNC HEM058063	GU224128
	Moss	A9G196	CNC HEM064056	GU224130
	Moss	A9G243	CNC HEM063917	GU224133
	Moss	A9K185	CNC HEM063968	GU224132
<i>Myzodium modestum</i> (Hottes)	Moss	A5G045	CNC HEM113125	EU701775
	Moss	A5G129	CNC HEM113216	EU701774
	Moss	A5G215	CNC HEM113286	EU701781
	Moss	A5K042	CNC HEM113546	EU701777
	Moss	A5K323	CNC HEM113758	EU701780
	Moss	A6K204	CNC HEM114025	GU224146
	Moss	A7A125	CNC HEM061702	GU224145
	Moss	A7A181	CNC HEM061733	GU224144
	Moss	A7G098	CNC HEM058044	GU224138
	Moss	A7G242	CNC HEM058056	GU224137
	Moss	A7G288	CNC HEM058059	GU224136
	Moss	A7G309	CNC HEM058062	GU224135
	Moss	A7K136	CNC HEM058088	GU224134
	Moss	A8G148	CNC HEM061740	GU224143
	Moss	A8G236	CNC HEM061744	GU224142
	Moss	A8G241	CNC HEM061745	GU224141
	Moss	A8K021	CNC HEM061755	GU224140
	Moss	A8K100	CNC HEM061759	GU224139
	Moss	A9A004	CNC HEM063882	GU224150
	Moss	A9A008	CNC HEM063884	GU224149
	Moss	A9G013	CNC HEM063997	GU224147
	Moss	A9G269	CNC HEM063927	GU224148

\*Mg, *Mimulus guttatus*.

†Correspond to collection numbers given in the text for the specimens examined. Full collection data for all samples are available on the Barcoding of Life Database (BOLD; <http://www.barcodinglife.org>, "Barcoding the Aphididae" and "*Myzodium* (Aphididae)" projects). Sequence data are available on BOLD and in GenBank.

*Ovatus mimulicola*: Eastop and Hille Ris Lambers 1976: 329.

*Myzodium mimulicola*: Remaudière and Remaudière 1997: 124.

#### ex *Mimulus guttatus* DC

**UNITED STATES OF AMERICA. California:** Alameda Co., Berkeley, 4.x.1937, coll. E.A. Drews and W.W. Sampson (syntypes 49 al, 44 ap, 1 im, EMEC); Marin Co., Inverness, 13.iv.1936, coll. E.A. Drews and W.W. Sampson

(syntypes 14 ap, 4 im, EMEC); **Oregon:** Umatilla Co., I-84 exit, 4 mi. E of Emigrant Springs State Park, 2.v.2005 (no mounts, barcode verified, A5K024); **Washington:** Columbia Co., Table Rock, 28.vii.2005 (1 al, 4 ap, A5G126); Grant Co., Lake Lenore, 1.xi.2005 (4 ap, A5K237); Kittitas Co., Manastash Rd, mi. marker 6, 27.viii.2002 (2 ap, A2G287); Klickitat Co., Newell Rd, 11.iii.2002 (1 ap, A2K007), 5 mi. E of Maryhill, 11.iii.2002 (1 ap, A2K020) near BZ Corners, Rattlesnake Cr., 2.v.2003 (3 ap,

A3G139), Lyle-Snowden Rd, 8 mi. N of Lyle, 9.vi.2003 (2 ap, A3G175); Yakima Co., near Trout Lake 0.5 mi. W of Mirror Lake, 6.viii.2007 (2ap, A7G124), FR1500 first creek N of Cash Prairie Jct., 16.vii.2009 (3 ap, A9K186); Whitman Co., Hwy 26, 0.7 mi. SW of Fleming Rd, 19.ii.2004 (5 ap, A4K005), near La Cross, 6.vi.2006 (3 ap, 1 im, A6K094).

**ex *Rorippa nasturtium-aquaticum* (L.) Hayek (new host record)**

**UNITED STATES OF AMERICA. Montana:** Lake Co., near Ronan, 28.vi.2002 (1 ap, A2K099); **Washington:** Benton Co., Whitstran, 17.xii.2001 (2 ap, A1G405); Kittitas Co., Lower Taneum, 3.x.2002 (2 ap, A2K278); Lincoln Co., Hanson Harbor Rd, 13.xi.2003 (1 al, 1 ap, 1 im, A3G566).

**ex *Veronica anagallis-aquatica* L. (new host record)**

**UNITED STATES OF AMERICA. Washington:** Benton Co., Whitstran, 17.xii.2001 (1 al, 1 ap, A1G406); Franklin Co., W Sagemore Rd, 8.i.2002 (1 ap, A2G016), Sagemore Rd, 1 mi. W of Taylor Flats, 13.ii.2002 (3 ap, A2G039); Klickitat Co., near Goldendale, Dot Rd, 13.xii.2001 (1 ap, A1G393), John Day Dam, near aluminum plant, 28.iv.1995 (2 al, 1 ap, 95G009), 5 mi. E of Maryhill, 11.iii.2002 (1 ap, A2G021); Whitman Co., Hwy 26, near Fleming Rd, 19.ii.2004 (5 ap, A4K004).

**ex moss (specific mosses are listed if known)**

**UNITED STATES OF AMERICA. Alaska** (new distribution records): Juneau Boro., Juneau, Montana Cr., Area B, 28.viii.2007, ex *Calliergon stramineum* (Dicks. ex Brid.) Kindb. (**new host record**), coll. B. Kunibe (1 im, barcode verified, A7A162); **Idaho:** Franklin Co., Cub River Canyon, 8.ix.1959, coll. G.F. Knowlton (1 ap, UI), and 7.ix.1963 (1 ap, 2 im, UI; 1 al, 1ap, USNM); **Montana:** Mineral Co., I-90, Saltese exit, 12.viii.09, ex *Sanionia uncinata* (Hedw.) Loeske (**new host record**) (1 ap, A9G379); **Oregon:** Umatilla Co., near Lehman Hot Springs, 13.vi.2007, ex *Brachythecium* Schimp. in B.S.G. (3 ap, A7K069); **Utah** (coll. G.F. Knowlton unless otherwise indicated): Cache Co., Logan Canyon, 7.ix.1960 (1 al, 1 ap, USNM), 3.viii.1962

(paratype 1 ap, USNM), 12.viii.1962 (holotype 1 ap, USNM), 20.ix.1974 (paratype 1 al, USU), 16.ix.1975 (1 al, USU), 14.x.1977 (1 al, 1 ap, USU), Logan Cave, 9.ix.1974 (paratypes 2 ap, 1 im, UI; 1 ap, USNM; 1 ap, 1 im, USU); Middle Spring, 9.ix.1974 (paratype 1 ap, USNM), 21.viii.1975 (1 ap, USNM); Spring Hollow (1 al, USU), 27–28.viii.1975 (paratypes 1 ap, USNM; 1 ap, USU), Tony Grove, 12.viii.1972 (paratype 1 ap, USNM) and 21.viii.1974, coll. G.F. Knowlton and C.F. Smith (paratype 1 ap, USU); **Washington:** Kittitas Co., Manastash Rd, 19.vii.2007, ex *Brachythecium frigidum* (Müll. Hal.) Besch. (**new host record**) (no mounts, barcode verified, A7G055), 1 mi. E of Quartz Mtn, 6.ix.2007 (1 ap, A1K034), FR3111, road to Tamarack Springs, 11.ix.2008, ex *Philonotis fontana* (Hedw.) Brid. (**new host record**) (1 ap, A8G304); Klickitat Co., Glenwood-Trout Lake Rd, 24.vi.2009 (1 ap, A9G093); Skamania Co., near Trout Lake, FR30 E of FR24 junction, 25.vi.2009 (1 ap, A9G142); Yakima Co., Bethel Ridge, Cash Prairie, 8.vii.2009 (no mounts, barcode verified, A9G196), 16.vii.2009, ex *Philonotis fontana* (3 ap, A9G243, A9G246, A9K185), near Trout Lake 0.5 mi. W of Mirror Lake, 6.viii.2007 ex *Aulacomnium palustre* (Hedw.) Schwägr. (**new host record**) (2 ap, A7G123), Umtanum Falls, 2.ix.2004, ex *Brachythecium rivulare* Schimp. (**new host record**) (1 ap, A4K099), near White Pass, Dog Lake, 20.ix.2007, ex mix of *Brachythecium frigidum* and *Philonotis fontana* (1 im, DNA barcode verified, A7G315).

***Myzodium modestum* (Hottes, 1926)**

*Carolinaia modestus* Hottes 1926: 117.

*Myzodes* (*Myzodium*) *rabeleri* Börner 1950:

11; Remaudière and Remaudière 1997: 124.

*Myzodium modestum*: Eastop and Hille Ris

Lambers 1976: 294; Heie 1992: 172; Remau-

dière and Remaudière 1997: 124.

**ex moss (specific mosses are listed if known)**

**UNITED STATES OF AMERICA. Alaska** (**new distribution records**): Juneau Boro., Juneau, Dredge Lake Rd, Trail (Area B), 22.viii.2007, coll. E. Knube (3 ap, 1 im, A7A125); Fairbanks North Star Boro., Fairbanks, Rosie Cr. Farms,



5.ix.2007, coll. A. Hagerty (1 im, DNA barcode verified, A7A181), near Fairbanks, Calypso Farm, 30.vii.2007, ex mix of *Polytrichum juniperinum* Hedw., *Dicranella crispa* (Hedw.) Schimp. (**new host record**) and *Pogonatum dentatum* (Menzies ex Brid.) Brid. (**new host record**) (3 ap, A7K136), Murphy Dome, 1.viii.2007, ex *Sphagnum rubellum* Wilson (**new host record**) (1 ap, A7K201), Steese Hwy, 22.vi.2009, ex mix of *Polytrichum juniperinum* and *Sanionia uncinata* (Hedw.) Loeske (**new host record**), coll. R. Pampell (4 ap, A9A004, A9A008, A9A020), and 14.ix.2009, ex *Pleurozium schreberi* (Brid.) Mitt. (**new host record**), coll. D. Fleming (1 ap, A9A092); Yukon—Koyukuk Boro., Greyling Lake Rest Area, 16.viii.2007, ex *Polytrichum juniperinum*, coll. S. Emmert (2 ap, A7A120); **Idaho**: Clearwater Co., 7 mi. S Bovill, 1 mi. N of Hwy 8, 7.vi.2009, coll. W.J. Turner (2 ap, A9K189); **Oregon**: Umatilla Co., Mill Cr. Rd, mi. marker 14, 19.iv.2005, ex *Polytrichum* sp. (11 ap, A5G023) and 17.v.2005, ex mix of *Polytrichum juniperinum* and *Racomitrium* sp. (**new host record**) (2 ap, A5G045), FR64, 17.v.2005, ex *Polytrichum* Hedw. (2 ap, 1 im, A5K039); **Montana**: Mineral Co., I-90 Saltese exit, 12.viii.2009 (1 ap, A9G379); **Washington**: Clallam Co., ONP, Deer Park Rd, 14.ix.2006, ex *Dicranum* Hedw. (**new host record**) (1 ap, A6K204), near Port Angeles, Little River Rd, 3.vi.2008, *Polytrichum juniperinum* (2 ap, A8K021); Columbia Co., FR46, 29.vii.2005, ex *Polytrichum* sp. (1 al, 2 ap, A5G129), FR 64, 5 mi. E of Jct. 64, 1.viii.2007, ex *Polytrichum formosum* Hedw. (9 ap, A7G098); Jefferson Co., ONP, Quinault River, N shore Rd, ex *Polytrichum* sp., 15.xii.2005 (1 ap, A5K323), 21.iii.2006 (1 ap, A6K026), ex *Polytrichum juniperinum*, 5.vi.2008 (4 ap, A8K100), Quinault River, S side, 21.iii.2006 (1 ap, A6K010); Kittitas Co., FR236, and Quartz Mtn Rd, 30.vii.2007, ex *Polytrichum longisetum* Sw. ex Brid. (**new host record**) (1 im, DNA barcode verified, A7G071), Salmon La Sac, FR 4315, end of road, 5.viii.08, ex *Polytrichum formosum* (3 ap, A8G148); Lewis Co., Sand Lake Rd near White Pass, 1.viii.2008, ex *Polytrichastrum alpinum* (Hedw.) G.L. Sm. (**new host record**) (1 ap, A8K157); Skamania Co., FR 24, 2.5 mi. S of FR 8851 near Big Mosquito Lake, 12.ix.2005, ex *Polytrichum* sp. (8 ap, A5G215), Trout Lake,

Natural Brides near ice cave, 25.v.2005, ex *Polytrichum* sp. (4 ap, A5K042, A5K043), FR60, 1.6 mi. SW of Peterson CG, 25.v.2005 (2 ap, A5K045), FR24 near Big Mosquito Lake, 29.viii.2006, ex *Polytrichum* sp., coll. J. Fulbright (2 al, 10 ap, A6K184), FR23, near Takalak Lake, 23.ix.2006 (1 ap, A6K279), FR24 near Cultus Cr. CG, ex *Polytrichum commune* (4 ap, A8G241), near Mt St. Helens, FR99, Bear Meadows, 20.ix.2007, ex *Polytrichum juniperinum* (1 im, barcode verified, A7G309), FR24 near Smoky Cr. CG, 12.viii.2008 (1 im, barcode verified, A8G236); Yakima Co., near Chinook Pass, Morse Cr. Rd, 4.ix.2007, *Oligotrichum aligerum* Mitt. (**new host record**) (2 ap, A7G242), and 10.vi.2009 (2 ap, A9G013), Raven's Roost trailhead, 18.ix.2007, ex *Roellia roellii* Broth. (**new host record**) (1 ap, A7G288), Bethel Ridge, FR1500 2 mi. N of Hwy 12, 8.vii.2009 (1 ap, A9G174).

## Results

### Character comparisons

Biometric comparisons of *M. mimulicola* and *M. knowltoni* (Table 2) show that the latter, sourcing from moss, was, on average, smaller than *M. mimulicola*, but with confidence intervals that overlapped those of *M. mimulicola* for a majority of characters measured and ratios compared. *Myzodium mimulicola* and *M. knowltoni* are also alike in coloration and pigmentation (adult apterae, mounted: ABD mainly pale (Fig. 3), head and appendages (ANT, URS, legs, tarsi, SIPH, cauda) light brown to brown) and shape of the cauda (Fig. 5). *Myzodium modestum*, though similar in size to *M. mimulicola* (Table 2), differs in coloration and pigmentation (adult apterae, mounted: ABD dorsum with large pigmented brown to dark-brown patch (Fig. 7), head and appendages brown to dark brown) and shape of the cauda (Figs. 8, 9).

### Molecular sequence comparisons

Results of the comparison of COI DNA sequences for samples of the three nominal North American *Myzodium* species (Remaudière and Remaudière 1997) are given in Table 3. *Myzodium mimulicola* from *Mimulus* sp. formed a tight cluster with *M. knowltoni* from moss, with

**Table 2.** Biometric summary (measurements and comparisons of features) of aptera vivipara *Myzodium mimulicola*, *M. knowltoni*, and *M. modestum*.

	<i>Myzodium mimulicola</i> <sup>a</sup>		<i>Myzodium knowltoni</i> <sup>b</sup>		<i>Myzodium modestum</i> <sup>b,c</sup>
	Syntypes (n = 10) <sup>d</sup>	Mean (n = 24) <sup>e</sup>	Holotype	Mean (n = 22) <sup>e</sup>	Mean (n = 9) <sup>e</sup>
<b>Measurement (mm)<sup>f</sup></b>					
Body length	1.86	1.75 (1.65–1.86)	1.16	1.44 (1.32–1.56)	1.58 (1.49–1.68)
Head (width)	0.47	0.46 (0.44–0.48)	0.41	0.41 (0.39–0.44)	0.48 (0.47–0.50)
ASI–ASVI	1.22	1.21 (1.15–1.27)	0.91	1.05 (0.97–1.13)	1.11 (1.05–1.17)
ASIII	0.30	0.30 (0.28–0.31)	0.21	0.25 (0.23–0.28)	0.25 (0.21–0.30)
ASIV	0.21	0.20 (0.19–0.22)	0.15	0.17 (0.15–0.19)	0.15 (0.15–0.16)
ASV	0.16	0.17 (0.16–0.18)	0.12	0.14 (0.13–0.15)	0.16 (0.15–0.16)
BVI	0.11	0.12 (0.11–0.12)	0.09	0.10 (0.10–0.11)	0.11 (0.11–0.12)
PT	0.32	0.30 (0.29–0.32)	0.24	0.27 (0.25–0.29)	0.31 (0.30–0.32)
ASIII (width) <sup>f</sup> × 10	0.26	0.26 (0.24–0.27)	0.22	0.23 (0.21–0.25)	0.27 (0.26–0.29)
ASIII longest seta × 10	0.07	0.07 (0.06–0.07)	0.07	0.06 (0.06–0.07)	0.08 (0.07–0.09)
URS	0.15	0.14 (0.14–0.15)	0.12	0.13 (0.13–0.14)	0.15 (0.15–0.16)
URS (basal width) × 10	0.48	0.52 (0.49–0.54)	0.47	0.50 (0.48–0.53)	0.60 (0.58–0.65)
<b>Thorax</b>					
Hind femur	0.49	0.47 (0.44–0.50)	0.35	0.37 (0.34–0.40)	0.45 (0.41–0.48)
Hind tibia	0.82	0.80 (0.76–0.85)	0.55	0.65 (0.60–0.70)	0.77 (0.69–0.85)
Hind tarsus II	0.1	0.10 (0.09–0.10)	0.08	0.09 (0.09–0.10)	0.10 (0.10–0.10)
Hind tarsus II (width) <sup>g</sup> × 10	0.22	0.22 (0.22–0.23)	0.22	0.21 (0.20–0.22)	0.22 (0.21–0.23)
<b>Abdomen</b>					
SIPH	0.35	0.33 (0.31–0.35)	0.25	0.28 (0.26–0.30)	0.33 (0.32–0.35)
SIPH (basal width)	0.1	0.10 (0.06–0.13)	0.08	0.08 (0.08–0.09)	0.09 (0.09–0.09)
Flange diameter × 10	0.58	0.57 (0.42–0.62)	0.52	0.54 (0.51–0.57)	0.54 (0.51–0.57)
Cauda	0.12	0.12 (0.07–0.16)	0.09	0.10 (0.09–0.10)	0.09 (0.08–0.09)
Cauda (width)	0.12	0.11 (0.06–0.15)	0.09	0.10 (0.09–0.10)	0.08 (0.08–0.09)
<b>Comparison</b>					
Cauda L/W	1.02	1.09 (1.05–1.14)	1.05	1.03 (1.00–1.08)	1.03 (0.96–1.11)
Head width/ASIII	1.6	1.60 (1.55–1.66)	1.95	1.69 (1.59–1.78)	2.00 (1.76–2.24)
PT/ASIII	1.07	1.03 (0.99–1.08)	1.14	1.08 (1.03–1.12)	1.28 (1.11–1.44)
PT/BVI	2.81	2.61 (2.49–2.73)	2.67	2.57 (2.46–2.67)	2.76 (2.62–2.90)
SIPH/ASIII	1.17	1.11 (1.07–1.15)	1.19	1.10 (1.07–1.13)	1.38 (1.21–1.55)
SIPH/body	0.19	0.19 (0.18–0.19)	0.22	0.19 (0.19–0.20)	0.21 (0.21–0.22)
SIPH/cauda	2.82	2.88 (2.75–3.01)	2.78	2.95 (2.84–3.06)	3.83 (3.59–4.08)
SIPH L/W	3.6	3.43 (3.26–3.59)	3.29	3.40 (3.18–3.61)	3.71 (3.55–3.88)
Hind tarsus II L/W	4.51	4.48 (4.35–4.62)	3.41	4.29 (4.06–4.52)	4.55 (4.23–4.87)
Hind tarsus II/URS	0.68	0.68 (0.67–0.70)	0.63	0.68 (0.66–0.70)	0.66 (0.62–0.69)
URS L/W	3.13	2.86 (2.72–2.99)	2.55	2.66 (2.52–2.79)	2.49 (2.35–2.63)

**Note:** Values in parentheses are 95% confidence intervals.

<sup>a</sup>From *Mimulus guttatus*, *Rorippa nasturtium-aquaticum*, and *Veronica anagallis-aquatica*.

<sup>b</sup>From moss.

<sup>c</sup>For a redescription of the species see Smith and Robinson (1975) and Heie (1992).

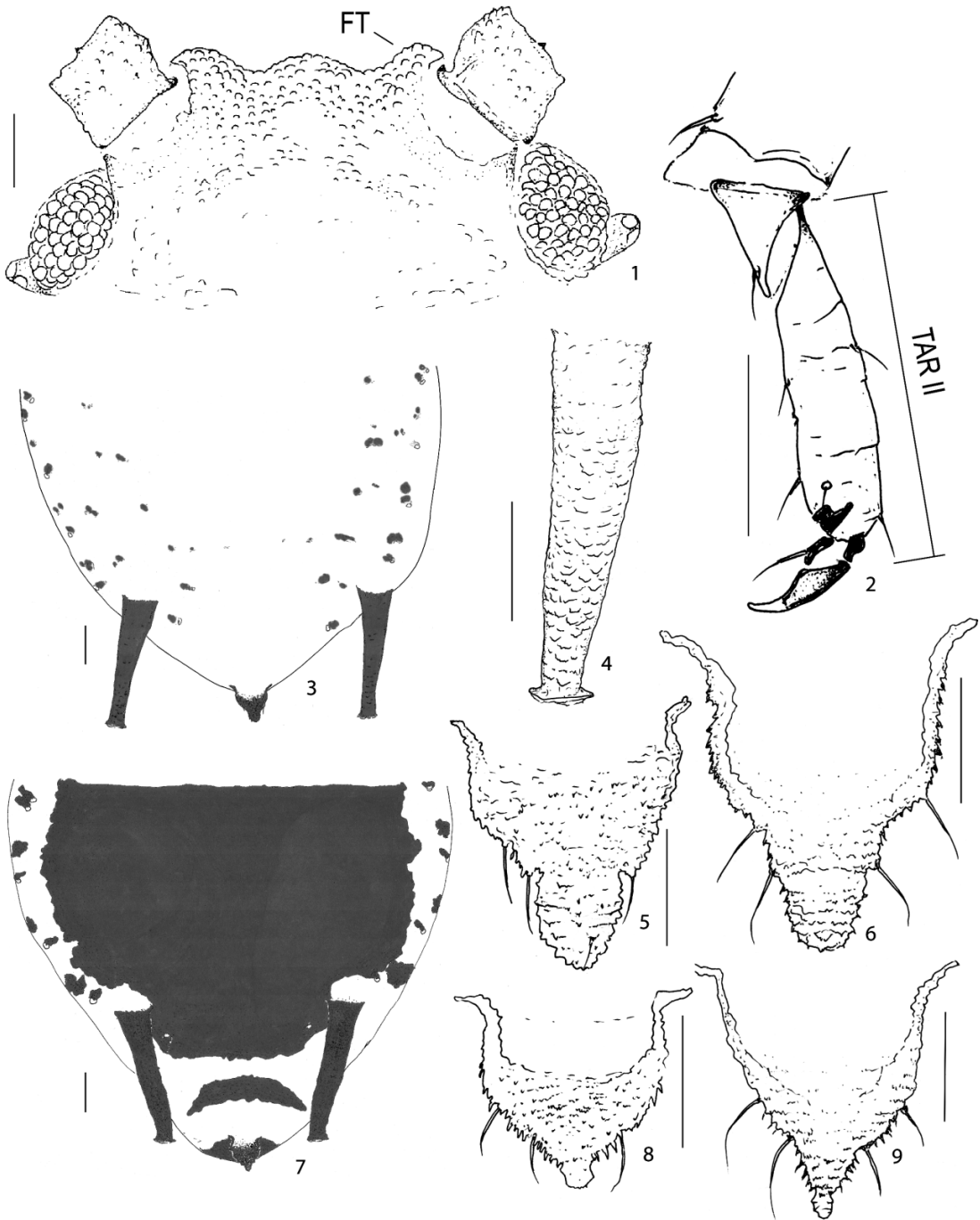
<sup>d</sup>Values represent the mean of 10 syntypes (designated cotypes on the original slides).

<sup>e</sup>Population means are expected (with 95% confidence) to lie within the intervals shown.

<sup>f</sup>Segment lengths were measured, unless otherwise indicated (AS, antennal segment; BVI, base of antennal segment VI; L/W, length/width ratio; PT, processus terminalis; SIPH, siphunculus; URS, ultimate rostral segment).

<sup>g</sup>Measured at the midpoint of the segment.

**Figs. 1–9.** *Myzodium* spp. 1–6, *Myzodium mimulicola*, aptera vivipara: 1, head; 2, hind tarsus; 3, abdomen with minimal dorsal pigmentation; 4, siphunculus; 5, cauda; alate vivipara: 6, cauda. 7–9, *Myzodium modestum*, aptera vivipara: 7, abdomen with extensive dorsal pigmentation; 8, cauda; alate vivipara: 9, cauda. Scale bars: 0.10 mm for Figs. 1, 3, 4, 7; 0.05 mm for Figs. 2, 5, 6, 8, 9.



**Table 3.** Summary of distances (percent sequence difference) among *Myzodium* taxa.

	<i>Myzodium knowltoni</i>	<i>Myzodium mimulicola</i>	<i>Myzodium modestum</i>
<i>Myzodium knowltoni</i> (n = 6)	0.46	0–0.46	6.25–7.14
<i>Myzodium mimulicola</i> (n = 2)		0.15	6.25–6.78
<i>Myzodium modestum</i> (n = 22)			0.31

**Note:** The range of divergences between specimens of nominal taxa is given above the diagonal, and maximum observed divergences within nominal taxa are given on the diagonal.

a maximum pairwise divergence among samples of 0.46%, typical of within-species variation observed in other aphid species (Footitt et al. 2008). *Myzodium modestum* is clearly differentiated; the mean pairwise distance between the *M. mimulicola*–*knowltoni* group and *M. modestum* was 6.67% (range 6.25%–7.14%).

### New synonymy

*Myzodium mimulicola* and *M. knowltoni* have virtually identical morphology, and COI sequences of each sample from *Mimulus* are identical with those of samples from moss. We therefore consider the samples from moss and those from vascular plants to belong to a single species. Because the original description of *M. mimulicola* (Drews and Sampson 1937) predates that of *M. knowltoni* (Smith and Robinson 1975), we propose *M. knowltoni* as a subjective junior synonym of *M. mimulicola*. Presently, there are three species in the genus: *M. lutescens* (Zhang and Qiao) from China (Zhang and Qiao 1998; Eastop and Blackman 2005) and *M. mimulicola* and *M. modestum* from North America (*M. modestum* also occurs in Europe).

### Redescription

#### *Myzodium mimulicola* (Drews and Sampson)

(Figs. 1–6)

**Syntypes** of *Kakimia mimulicola* (female apterae and alatae): **UNITED STATES OF AMERICA. California:** Alameda Co., Berkeley, 4.x.1937, coll. E.A. Drews and W.W. Sampson; Marin Co. (EMEC) and Inverness, 13.iv.1936, coll. E.A. Drews and W.W. Sampson (EMEC); **Holotype** of *Myzodium knowltoni* (female aptera):

**UNITED STATES OF AMERICA. Utah:** Cache Co., Logan Canyon, 12.viii.1962 (USNM).

### Description

Female aptera.

**Color:** Live, brownish green with some orange color between SIPH; mounted, body mainly pale, head and appendages (ANT, URS, legs, tarsi, SIPH, cauda) light brown to brown.

**Body:** 0.81–2.04 mm.

**Head:** Surface conspicuously nodulose; head width = 1.34–2.10 × ASIII; median tubercle developed; FT developed, rounded, divergent; ANT < body length (0.60–0.95 × body length) and without secondary rhinaria, ASI–ASII rough, nodulose to spiculose, ASIII–ASBIV imbricated, with sparse setae, very short and stout, <0.4 × ASIII midwidth; PT > 2 × BVI; URS elongate, 2.18–3.46 × basal width, with 2–4 accessory setae; rostrum reaching to or slightly beyond metacoxae.

**Thorax and ABD:** dorsal surface reticulate; marginal tubercles lacking; hind tarsus II < URS (0.60–0.75 × URS); tarsal I chaetotaxy 3-3-2; claws simple; empodial setae acuminate, reaching to tip of claws; SIPH strongly imbricated, gradually tapering (narrowing) from base to preapex; flange distinctive, 1.31–1.66 × narrowest part of SIPH; cauda with 4–6 setae (usually 2 lateral pairs, 1 preapical).

### Description

Female alate.

**Body:** 1.80–2.10 mm.

**Head:** Head width = 0.42–0.49 mm; ANT < body length (0.78–0.85 × body length); ASIII = 0.37–0.44 mm; ASIV = 0.26–0.34 mm; ASV = 0.20–0.26 mm; PT = 2.52–2.80 × BVI; secondary rhinaria = ASIII (21–32), ASIV (8–11), and ASV (0–6); URS L/W = 2.60–3.42.



*Thorax and ABD*: hind femur = 0.47–0.61 mm; hind tibia = 0.87–1.11 mm; hind tarsus II = 0.05–0.11 mm, and 0.34–0.76 × URS; tarsal I chaetotaxy 3-3-2; SIPH = 0.27–0.33 mm, L/W = 3.20–4.15, and 2.41–3.05 × cauda; ABD dorsum with dark pigmented patch, or patch partially separating into transverse bars; cauda shape comparable to that of aptera, with 4 or 5 setae, length = 0.10–0.13 mm, L/W = 0.95–1.20.

#### Ovipara and male

Not examined.

#### Host plants

The species occurs on vascular plants (*Mimulus guttatus* (seep monkeyflower), *M. floribundus* Douglas ex Lindl. (manyflowered monkey-

flower) (Blackman and Eastop 2006), *Rorippa nasturtium-aquaticum* (watercress), and *Veronica anagallis-aquatica* (water speedwell)) and non-vascular plants (six new moss associations reported; see records of specimens examined). It is occasionally abundant on *Mimulus* and *Veronica*, but always sparse on other hosts.

#### Distribution

The species has a broad western Nearctic distribution, ranging from central California east to Utah, and north to southeastern Alaska (new record). The species was previously known in California, Idaho, Montana, Oregon, Utah, Washington, and British Columbia (Smith and Parron 1978; Pike *et al.* 2003).

### Key to *Myzodium* (alate and aptera viviparae)

1	Tarsal segment I chaetotaxy 2-2-2; China, on <i>Carissa spinarum</i> L. (Apocynaceae) . . . . .	<i>M. lutescens</i>
—	Tarsal segment I chaetotaxy 3-3-2; North America, not on <i>C. spinarum</i> . . . . .	2
2(1)	Aptera . . . . .	3
—	Alate . . . . .	4
3(2)	ABD dorsum with a large pigmented patch (Fig. 7); cauda apex with a small, narrow digitate projection (Fig. 8). . . . .	<i>M. modestum</i>
—	ABD dorsum without a large pigmented patch, mainly membranous (Fig. 3); cauda apex without a small, narrow digitate projection (Fig. 5) . . . . .	<i>M. mimulicola</i>
4(2)	Cauda apex with a very small, narrow digitate projection (Fig. 9). . . . .	<i>M. modestum</i>
—	Cauda apex without a small, narrow digitate projection (Fig. 6) . . . . .	<i>M. mimulicola</i>

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