A New Species of *Leipothrix* (Acari: Prostigmata: Eriophyidae) on *Dipsacus* spp. in Europe and Reassignment of Two *Epitrimerus* spp. (Acari: Prostigmata: Eriophyidae) to the Genus *Leipothrix*

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ABSTRACT A new species of eriophyid mite, *Leipothrix dipsacivagus* n. sp. (Acari: Prostigmata: Eriophyidae), collected from *Dipsacus laciniatus* L. (Dipsacaceae) and *Dipsacus fullonum* L. in Serbia, Bulgaria, and France, is described and illustrated. Differential diagnosis is provided in comparison with *Leipothrix knautiae* (Liro) n. comb., and *Leipothrix succisae* (Roivainen) n. comb., two species that also are proposed here for reassignment from the genus *Epitrimerus* Nalepa to the genus *Leipothrix* Keifer, within the family Eriophyidae. *L. dipsacivagus* n. sp. is being investigated as a candidate for biological control of invasive *Dipsacus* spp. in the United States.

KEY WORDS Eriophyidae, *Leipothrix*, systematics, *Dipsacus*, biological control of weeds

Teasels (*Dipsacus* L. spp.), belong to the Dipsacaceae, a family of exclusively Old World plants. Two closely related teasel species of Eurasian origin, *Dipsacus fullonum* L. and *Dipsacus laciniatus* L. have become invasive weeds in the United States, with either or both species occurring 43 states and declared noxious in five states (Rector et al. 2006). Classical biological control is considered to be an important component of the overall management strategy of these weeds in the United States due to three main factors: the Dipsacaceae is known to be an exclusively Old World family with no important economic species, thus the risk of nontarget feeding by biological control candidates is reduced; invasive *Dipsacus* spp. are too prominent and widespread to make eradication feasible; and invasive teasels frequently occur in areas with little or no regular weed management, such as roadsides, wetlands, and parklands (Rector et al. 2006). Biological control candidates currently under study for host range and suitability for release include eriophyid mites, insects, and fungi. The new eriophyid mite species *Leipothrix dipsacivagus* n. sp. was collected during surveys conducted in Serbia, Bulgaria, and France in 2005 and is a candidate for biological control of invasive teasels.

According to Amrine and Stasny (1994) and De Lillo and Amrine (2006), only three eriophyid mite species are known to occur on dipsacaceous plants, including hosts in the genera *Cephalaria* Schrad. ex Roemer & J.A. Schultes, *Knautia* L., *Scabiosa* L., and *Succisa* Haller. These three mite species are *Aceria squalida* (Nal.), *Epitrimerus knautiae* Liro, and *E. succisae* Roivainen. Petanovic (1999) reported the presence of *Epitrimerus knautiae* in northern Serbia on *Dipsacus laciniatus.* However, after detailed revision of the material collected in Serbia in 1999, it was confirmed (R.U.P., unpublished data) that this mite, initially identified as *E. knautiae* (Petanovic 1999), should henceforth be known as a new species: *Leipothrix dipsacivagus.* Moreover, after careful study of the original and additional descriptions of *E. knautiae* (Liro 1942, Boczek 1964) and *E. succisae* (Roivainen 1947), it was determined that these species also should be transferred to the genus *Leipothrix.*

The genus *Leipothrix* was established by Keifer (1966) "to receive a species that has the central longitudinal ridge of *Epitrimerus,* but the legs lack the femoral setae." Later, Amrine (1996) and Amrine et al. (2003) synonymized *Flechtmannia* (described by Keifer 1979 as having a moderately long bifurcate antapical gnathosomal seta) with *Leipothrix* on the basis that all *Leipothrix* species, including the type species have "antapical seta moderately long and bifurcate, branch may be minute and indicated by sharp bend in seta." Subsequently Chetverikov (2005), in describing one new species of *Leipothrix,* briefly discussed the systematics of the genus. He stated in the diagnosis of the genus "setae s. apic. bifurcate or angled, usually consisting of basic and accessory branches" and emphasized that "the main distinctive feature of the genus *Leipothrix* spp. is the bifurcate setae s. apic. of the gnathosoma." He also mentioned that in some species the distal part of the basic branch is very short and setae s. apic. have an "angled" form and stated that 11 more *Epitrimerus* species "probably belong to the genus *Leipothrix.*" Furthermore, four species of the genus *Leipothrix* are considered as species *incerte sedis*

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because the structure of the setae apicales has not been described (Chetverikov 2005).

To the best of our knowledge, movement of *Epitrimerus knautiae* Liro and *Epitrimerus succissae* Roivainen to the genus *Leipothrix* has not been specifically proposed until now. We propose here that these two species be reassigned to the genus *Leipothrix* due to the absence of femoral setae, following Keifer (1966).

Leipothrix dipsacivagus n. sp. is the first species of eriophyid mite recorded from hosts in the genus *Dipsacus.* Morphology of *L. dipsacivagus* n. sp. is described here in addition to notes on its distribution and effect on host plant morphology and development. Differences between *L. dipsacivagus* n. sp. and both *L. knautiae* (Liro) n. comb. and *L. succisae* (Roivainen) n. comb. are summarized and discussed.

Materials and Methods

The morphology of *L. dipsacivagus* n. sp. was investigated using a phase-contrast microscope (Leica DMLS) and with scanning electron microscopy (JEOL-JSM 6460LV). Before light microscopy, the mites were cleared in lactic acid for several days and then mounted in Keifer's F or Heinze's medium. The measurements presented here are based on study of 10 females and four males as well as one larva and one nymph. Morphometry was performed using the software package IM 1000 (Leica, Wetzlar, Germany).

The terminology and setal notation in the description follow the terminology of Lindquist (1996) and Baker et al. (1996). Measurements of the holotype and the range of paratypres (in parentheses) are given in micrometers and refer to the length of the structure, unless otherwise stated. Body length is measured from the anterior edge of the prodorsal shield to the end of the anal lobe. The length of legs is taken from the posterior margin of the apodeme between coxae I and II to the apical margin of the tarsus (excluding empodium and solenidion).

Description

Genus Leipothrix Keifer, 1966.
Leipothrix Keifer 1966: 9; Amrine et al. 2003: 88.
Flechtmannia Keifer 1979: 10.
Type species: *Leipothrix solidaginis* Keifer, 1966, by monotypy.

Leipothrix dipsacivagus n. sp.
(Figs. 1–22)

Females ($n = 10$). Body fusiform, 236 (193–289), 80 (77–85) wide, light to bright orange. Gnathosoma: 21 (19–25), downcurved. Coxal setae (*ep*) three (3–4); dorsal genual setae (*d*) angled consisting of basic and accessory branches, 16; basic branch, six (4–6), accessory branch 10 μm (10–13); apical papila (*v*) two (1–2); cheliceral stylet 16 (17–20). Prodorsal shield: 62 (54–68). Plicate tubercles of scapular setae set ahead of rear margin of prodorsal shield; basal axes longitudinal; scapular setae (*sc*) four (3–6), 17 (16–21) apart, directed centrad convergently. Prodorsal shield with a lobe over gnathosoma, 12 (11–13); with two admedian lines beginning from the base of the shield reaching the end of the lobe; two submedian lines shorter than admedians, diverging anteriorly; two transversal lines cross anterior central part; median field with numerous dashes. Legs: With all usual segments and setae except setae femorales I and II. Legs I 37 (33–41), femora 10 (9–14), femoral setae (*bv*) absent; genua six (5–6), genual setae (*l*") 27 (27–30); tibiae nine (7–10), tibial setae (*l*') four (4–7); tarsi six (4–7); inner fastigial setae (*ft*') 16 (16–22), outer fastigal setae (*ft*") 20 (20–23); ventromesal setae (*u*') three (2–3); solenidia six (5–8), knobbed; empodia five (4–6), 4-rayed. Legs II: 36 (30–37); femora 11 (9–13), femoral setae (*bv*) absent; genua six (5–7), genual setae (*l*") 14 (14–18); tibiae eight (6–9); tarsi seven (6–7); inner fastigial setae (*ft*') five (4–5), outer fastigal setae (*ft*") 21 (21–23); ventromesal setae (*u*') four (3–4); solenidia six (6–7), knobbed; empodia length five (4–6), 4-rayed. Coxae: Coxae I with numerous dotted lines, coxae II with fewer lines. Sternal line 10 (6–10), unforked; coxal setae *1b* 16 (9–17), 19 (15–20) apart; coxal setae *1a* 21 (17–37), 11 (7–11) apart; coxal setae *2a* 31 (23–53), 33 (21–33) apart. Coxisternal area with 13 (11–14) microtuberculated annuli. Genitalia: 20 (20–25), 25 (22–28) wide, with 12 (12–15) uneven longitudinal ridges on anterior field of coverflap. Coxal setae *3a* nine (11–17) and 13 (13–17) apart. Opiosthosoma: Opisthosoma with longitudinal middorsal ridge fading above setae *f*. Setae *c2* 10 (10–17), 63 (57–68) apart, on annulus 17 (15–23); setae *d* 15 (15–30), 39 (31–46) apart, on annulus 35 (33–39); setae *e* seven (7–18), 19 (16–21) apart, on annulus 53 (53–71); setae *f* 30 (27–33), 26 (23–31) apart, on annulus 74 (74–89). Total dorsal annuli 47 (47–55). Dorsal annuli smooth. Total ventral annuli 79 (79–94) with round microtubercles on the edges of annuli; five terminal annuli striated. Setae *h2* 30 (30–65), eight (7–10) apart; setae *h1* two (1–2), five (5–6) apart.

Males ($n = 4$). Smaller than female, 156 (146–164), 59 (56–65) wide. Gnathosoma: 13 (12–13), downcurved. Coxal setae (*ep*) two (2); dorsal genual setae (*d*) angled, consisting of basic and accessory branches, 17; basic branch four (3–6), accessory branch 13 (11–13); apical papila (*v*) two (1–2), cheliceral stylet 15 (14–17). Prodorsal shield: 46 (44–54), 49 (49–55) wide. Frontal lobe eight (8–10). Scapular setae (*sc*) five (3–5), 16 (15–16) apart, directed centrad convergently. Legs I: 35 (35–39), femora 10 (19–14), femoral setae absent; genua five (5–6), genual setae (*l*") 26 (25–26); tibiae seven (7–8), tibial setae (*l*') three (3–5); tarsi five (5–6); inner fastigial setae (*ft*') 19 (19–22), outer fastigal setae (*ft*") 18 (18–22); ventromesal setae (*u*') three (3–4); solenidia six (6–7), knobbed; empodia five (4–6), 4-rayed. Legs II: 32 (32–34); femora 10 (10–12), femoral setae absent; genua five (4–5), genual setae (*l*") 13 (13–16); tibiae six (6–7); tarsi five (5–6); inner fastigial setae (*ft*') four (4–5), outer fastigal setae (*ft*") 24 (17–24); ventromesal setae (*u*') two (2–3); solenidia seven (6–7), knobbed; empodia five (3–5), 4-rayed. Coxae: Sternal line nine (6–9), unforked; coxal setae *1b* 12 (11–14), 13 (7–13)

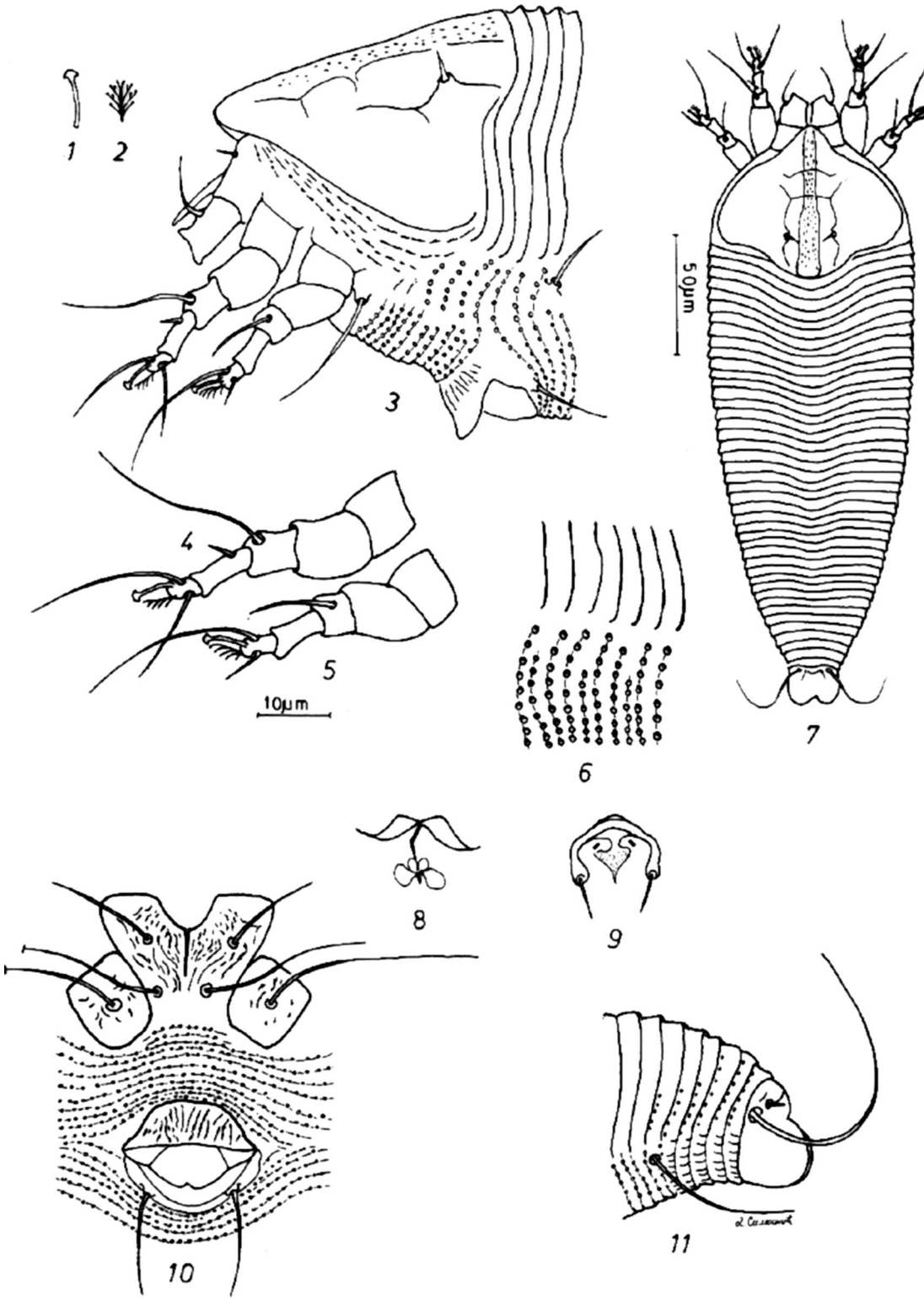

Fig. 1–11. (1) Solenidion, detail. (2) Empodium, detail. (3) Antero-lateral view. (4) Leg I. (5) Leg II. (6) Detail of microtubercles on lateral surface. (7) Dorsal view. (8) Female internal genitalia. (9) Male internal genitalia. (10) Coxigenital region of female. (11) Postero-lateral view.

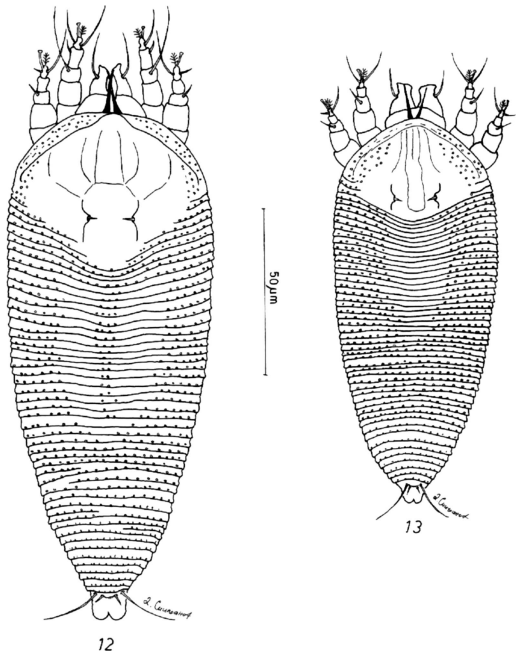

Fig. 12–13. (12) Nymph, dorsal view. (13) Larva, dorsal view.

apart; coxal setae *1a* 23 (20–25), six (6–8) apart; coxal setae *2a* 25 (25–26), 23 (21–26) apart. Coxisternal area with 13 (13–15) microtuberculated annuli. Genitalia: 11 (9–11), 17 (14–18) wide. Coxal setae *3a* 13 (13–14) and 12 (11–13) apart. Opiosthosoma: Setae *c2* 11 (7–12), 47 (47–49) apart, on annuulus 13 (11–13); setae *d* 19 (16–20), 29 (29–34) apart, on annulus 20 (20–26); setae *e* 12 (9–12), 14 (13–16) apart, on annulus 38 (38–44); setae *f* 21 (20–23), 21 (17–24) apart, on annulus 58 (54–66). Total dorsal annuli 49 (43–52), total ventral annuli 62 (59–70). Setae *h2* 29 (28–44), eight (8–10) apart; setae *h1* two (1–2), five (5–6) apart.

Nymph (n = 1). 172, 69 wide. Gnathosoma: 13, downcurved. Coxal setae (*ep*) two (2); dorsal genual setae (*d*) angled, consisting of basic and accessory branches, 15; basic branch 4, accessory branch 11; apical papila (*v*) 1; cheliceral stylet 15. Prodorsal shield: 46, 49 wide. Frontal lobe 4. Scapular setae (*sc*) 3, 16 apart, directed centrad convergently. Legs I: 24; femora 6, femoral setae absent; genua 4, genual setae (*l*") 24; tibiae 5; tibial setae (*l*') 3; tarsi 4; inner fastigial setae (*ft*') 19, outer fastigal setae (*ft*") 12; ventromesal setae (*u*') 3; solenidia 4, knobbed; empodia 3, 4-rayed. Legs II: 22; femora 6, femoral setae absent; genua 3, genual setae (*l*") 5; tibiae 3; tarsi 2; inner fastigial setae (*ft*') 3, outer fastigal setae (*ft*") 15; ventromesal setae (*u*') 2; solenidia 5, knobbed; empodia 4, 4-rayed. Coxae: Sternal line 6, unforked; coxal setae *1b* 8, 13 apart; coxal setae *1a* 16, eight apart; coxal setae *2a* 12, 23 apart. Coxisternal area with 16 microtuberculated annuli. Coxal setae *3a* 5, 11 apart. Opiosthosoma: Setae *c2* 9, 43 apart, on annuulus 19; setae *d* 13, 35 apart, on annulus 34; setae *e* 7, 19 apart, on annulus 48; setae *f* 19, 18 apart, on annulus 66. Total dorsal annuli 44, total ventral annuli 70. Setae *h2* 9, three apart, setae *h1* 2, six apart.

Larva (n = 1). 124, 60 wide. Gnathosoma: 13, downcurved. Coxal setae (*ep*); dorsal genual setae (*d*) 8; cheliceral stylet 13. Prodorsal shield: 35, 48 wide. Frontal lobe absent. Prodorsal shield with median line on

Fig. 15. Larva, dorsal view.

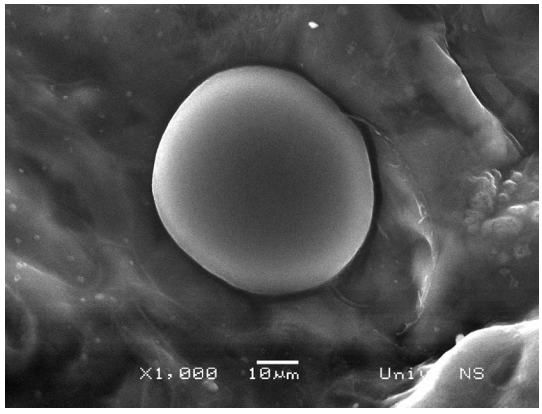

Fig. 14. Egg.

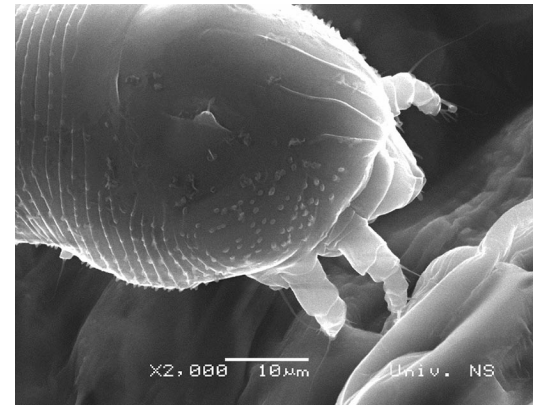

Fig. 16. Larva, antero-lateral view.

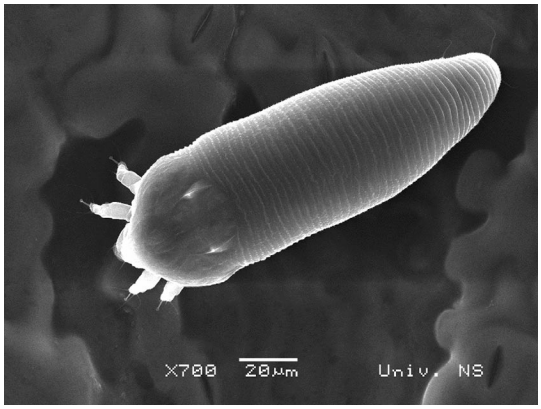

Fig. 17. Nymph, dorsal view.

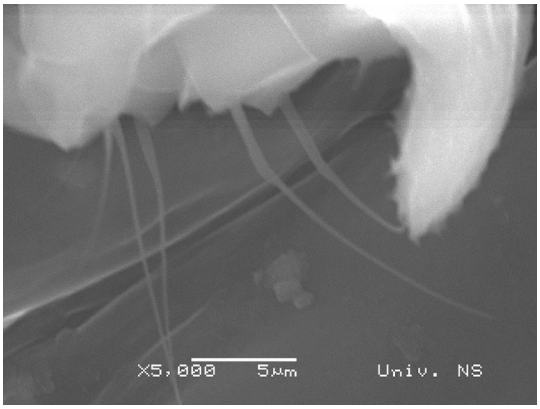

Fig. 19. Adult, gnathosomal genual seta (*d*).

anterior third, two median lines reaching dorsal tubercles, and two submedian lines on anterior half of the shield; lateral fields of the shield punctate. Scapular setae (*sc*) 2, 14 apart, directed centrad convergently. Legs I: 18; femora 4, femoral setae absent; genua 3, genual setae (*l*") 6; tibiae 3; tarsi 3; inner fastigial setae (*ft'*) 10, outer fastigal setae (*ft*") 11; solenidia 4, knobbed; empodia 3, 4-rayed. Legs II: 16; femora 6, femoral setae absent; genua 2, genual setae (*l*") 5; tibiae 3; tarsi 3; inner fastigial setae (*ft'*) 3, outer fastigal setae (*ft*") 8; solenidia 3, knobbed; empodia 3, 4-rayed. Coxae: Sternal line 4, unforked; coxal setae *1b* 4, 10 apart; coxal setae *1a* 12, five apart; coxal setae *2a* 12, 19 apart. Coxisternal area with 16 microtuberculated annuli. Coxal setae *3a* four and six apart. Opiosthosoma: Setae *c* 4, 36 apart, on annulus 11; setae *d* 19, 20 apart, on annulus 18; setae *e* 4, 14 apart, on annulus 25; setae *f* 16, 16 apart, on annulus 37. Total dorsal annuli 40, total ventral annuli 47. Setae *h2* 12, three apart; setae *h1* 2, seven apart.

Taxonomic Notes, Diagnosis, and Discussion

To the best of our knowledge, movement of *E. knautiae* Liro and *E. succissae* Roivainen to the genus *Leipothrix* has not been specifically proposed until now. We propose here that these two species be reassigned to the genus *Leipothrix* due to the absence of femoral setae, following Keifer (1966), and deducing from the drawings of subapical genual setae that are sharply bent, in original descriptions by Liro (1942) and Roivainen (1947). We support this proposal based on observations of specimens recently collected form *Knautia arvensis* L., in Serbia (R.U.P., unpublished data).

L. dipsacivagus sp. nov. is similar to *L. knautiae* (Liro) n. comb., found on *Knautia arvensis* (L.), and *L. succisae* (Roiv.) n. comb., found on *Succisa pratensis* Moench. A comparison of key characters of these three species is presented in Table 1. It should be stressed that the prodorsal shield patterns depicted and described for *L. knautiae* by Liro (1942) and Boczek (1964) are obviously different (Table 1). One possible explanation could be that different seasonal forms exist and were collected by these authors. Morphological differences between distant populations are also possible. *L. dipsacivagus* sp. nov. is the first eriophyid species recorded from *Dipsacus* spp.

General Discussion. Regarding the structure of antapical seta as the "key" character of the genus *Lei-*

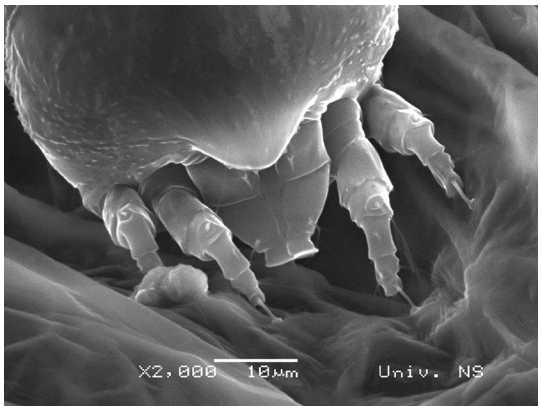

Fig. 18. Nymph, gnathosomal region.

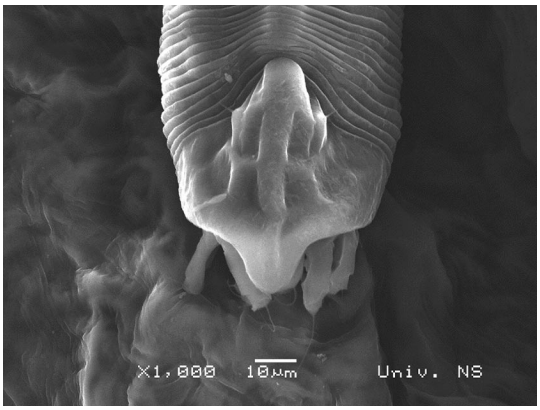

Fig. 20. Adult, prodorsal shield.

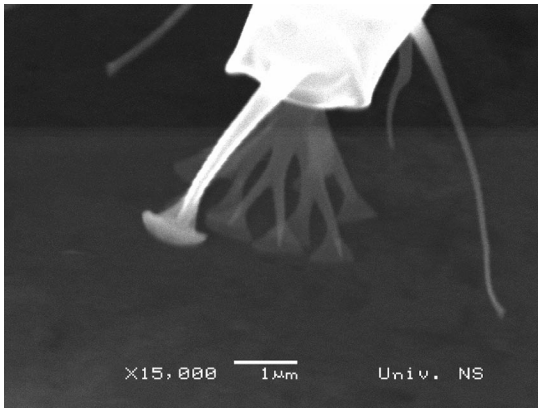

Fig. 21. Solenidion and empodium.

pothrix, it should be stressed that bifurcation is hardly visible on all slides by using phase-contrast microscopy and depends on the position and length of the bifurcate part of the basic branch. Even on scanning electron microscope (SEM) photographs bifurcation is not obvious.

In our opinion the statement "branch may be minute and indicated by sharp bend in seta" contained in an earlier generic key (Amrine 1996) and omitted in a more recent generic key (Amrine et al. 2003) should be returned. The presence of a bend in the dorsal genual seta or an "angled" dorsal genual seta is obvious on each slide and more precisely reflects the real situation.

Type Material. Holotype female (slide 967/4), 25 paratypes (19 females, four males and two nymphs), and allotype male of *L. dipsacivagus* sp. nov., were collected from *Dipsacus laciniatus* in a wetland at Bojcinska suma, in northern Serbia, ≈30 km west of Belgrade (global positioning system [GPS]: N 44° 47.765′ E 20° 05.955′) on 3 July 2005, 3 August 2005, 9 September 2005, and 8 October 2005. Five female paratypes also were collected from *D. laciniatus* along a roadside ditch in New Belgrade (suburb of Belgrade; GPS: N 44° 46.873′ E 20° 21.617′) on 17

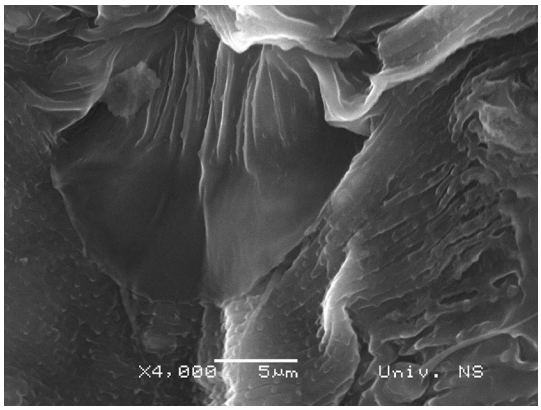

Fig. 22. Female genital cover flap.

Table 1. Key differences between females of *L. dipsacivagus* n. sp.; *L. knautiae*, n. comb. (Liro 1942); *L. knautiae*, n. comb. (sensu Boczek 1964); and *L. succisae*, n. comb. (Roivainen 1947)

Character	*L. dipsacivagus* sp. nov.	*L. knautiae* (Liro, 1942)	*L. knautiae* (Boczek, 1964)	*L. succisae* (Roivainen, 1947)
Length of body	236 μm (193–289)	210–240 μm	230 μm	220–250 μm
Length of scapular setae	4 μm (3–6)	10 μm	7–8 μm	9 μm
Prodorsal shield pattern	Two admedian lines from the base reaching the lobe; two submedian lines, shorter than admedians, diverging anteriorly; two transversal lines on anterior central part; central field with numerous dashes	One median and two admedian lines: complete, weakly diverging; two submedian lines bifurcate posteriorly; two lines on lateral field	Two longitudinal lines in the middle part and some indistinct lines laterally to dorsal setae	In posterior part of middle field three indistinct longitudinal lines
Shape of shield lobe	Blunt	Blunt with rounded apiculus	Blunt with rounded apiculus	Rounded
Shape of solenidion	Distinctly knobbed	Weakly knobbed	Slightly knobbed	Distinctly knobbed
No. of dorsal annuli	47 (47–55)	32–35	38–42	39–42
Shape and pattern of epigynium	Female genital cover flap divided into two fields; anterior field with 12–15 uneven ridges		Epigynium of one part; anterior field with 10 furrows	Cover flap indistinct, 10-striate
Host plant	*Dipsacus laciniatus* L., *D. fullonum* L.	*Knautia arvensis* (L.)	*K. arvensis* (L.)	*Succisa pratensis* Moench

Holotype measurements are presented for *L. dipsacivagus* with range of paratype measurements present in parentheses in the same units.

May 2005. Four female paratypes, one male, one nymph, and two larvae were collected from *D. fullonum* at Montferrier-sur-Lez, France (GPS: N 43° 41.032′ E 03° 52.473′) on 21 November 2005. Three female paratypes and one larva were collected from *D. laciniatus* at Klokotnitsa, Bulgaria, (GPS: N 42° 00.43′ E 25° 27.41′) on 31 August 2005. Holotyope, allotype and 11 paratype slides are deposited in the Acari Collection, Department of Entomology, Faculty of Agriculture, University of Belgrade, Serbia. Two paratype slides are deposited at the Department of Entomology, Faculty of Plant Protection, Agricultural University, Plovdiv, Bulgaria. Eight paratype slides are deposited at USDA–ARS, European Biological Control Laboratory, Montpellier, France. One female paratype slide each has been deposited at the British Museum, London, England, and the National Museum, Washington, DC.

Additional Material. More than 150 paratypes from type locality as well as 25 paratypes from Klokotnitsa, Bulgaria, and 55 paratypes from Montferrier-sur-Lez, France, mostly females; although also including males, nymphs, and larvae.

Relation to Host Plant. *L. dipsacivagus* sp. nov. was found on both upper and lower leaf surfaces of *D. laciniatus* and *D. fullonum* as a vagrant, causing rust-like symptoms and wrinkles on the longitudinal folds of the leaves. Experimentally reared *L. dipsacivagus* caused severe russeting and drying of the leaves of young plants. "Witches broom" of the plant itself (i.e., reduced internode lengths and deformed leaves), stunted development, delayed flowering, and galls of the flower heads were observed in the abandoned fields of dense populations of *D. laciniatus* infested with *L. dipsacivagus.* Deformations of flower heads were observed in autumn on new small flower heads, when the rest of the plant was dry. Dense colonies of mites aggregate on these parts and provoke such symptoms.

Etymology. The specific designation is derived from the genus of the type host plant + Latin *vagus* for roaming, wandering.

Acknowledgments

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