

Eriophyoid mites from ferns: description of a new *Leipothrix* Keifer species (Eriophyidae: Phyllocoptinae) from the Arasbaran forests (Iran) and a key to the world species

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ABSTRACT — A survey of eriophyoid mites on ferns was carried out in the Arasbaran forests, East Azerbaijan province, Iran. A new species of the genus *Leipothrix* Keifer (Eriophyidae: Phyllocoptinae: Phyllocoptini) was collected on *Polypodium vulgare* L. (Polypodiaceae), named as *L. pterisfolii*, is described and illustrated. It is the first record of a mite of the tribe Phyllocoptini on a Polypodiaceae plant. This mite species was found also on a plant of the family Cystopteridaceae, namely *Gymnocarpium dryopteris* (L.) Newman, and this is the first record of an eriophyoid mite associated with a plant of this family, too. In addition, it is the first report of a fern-inhabiting eriophyoid mite in Iran. A key to the eriophyoid mite species collected on ferns worldwide and a table summarizing information on their type host, type locality and habitus are provided.

KEYWORDS — East Azerbaijan; Eriophyoidea; Cystopteridaceae; Phyllocoptini; Polypodiaceae; Middle East

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INTRODUCTION

The biosphere reserve of the Arasbaran forests constitutes the limited territory of Kaleybar, Ahar and Jolfa with an area of 160,000 ha on the Caucasus Iranian Highlands (Talebi *et al.*, 2014). Different climates and various physiographic conditions of these forests induced very variable plant diversity and fauna associated with those plants. Considering the relevance of eval-

uating mite faunas in highly biodiverse areas like Iran (de Lillo and Skoracka, 2010), eriophyoid mites of ferns were surveyed in the Arasbaran forests.

About 36 eriophyoids have been recorded on ferns worldwide (Amrine & de Lillo unpublished databases; table 1), including three *Leipothrix* species: *L. triquetra* [Meyer (Smith), 1990], *L. minidonta* [Meyer (Smith), 1990] and *L. serbiclus* (Petanović, 2001). The latter species was recently moved from *Epitrimerus* to *Leipothrix* (Petanović *et al.*, 2015) after a careful examination of the mor-

TABLE 1: Eriophyoid mite species collected on ferns worldwide and their type host, type locality and habitus. The list is sorted alphabetically.

Species	Type host (family)	Type locality	Habitus
<i>Aceria gersoni</i> Manson, 1984	<i>Dicksonia squarrosa</i> (G. Forst.) (Dicksoniaceae)	Sw Kaimai Range near Matamata, New Zealand	Under small areas of whitish webbing on lower surface of pinnae
<i>Aceria gleicheniae</i> Manson, 1984	<i>Gleichenia circinata</i> Sw. (Gleicheniaceae)	Tiwi Swamp, Bluff, New Zealand	Frond malformations and 3 mm galls on lower surface of pinnae
<i>Aceria pauropae</i> (Nalepa, 1909)	<i>Nephrolepis hirsutula</i> (G. Forst.) Presl (Nephrolepidaceae)	C. Near Malifa, Upolu Island, Samoa	Galls and erinea
<i>Aceria pteridii</i> Kuang & Gong, 1996	<i>Pteridium</i> sp. (Dennstaedtiaceae)	Guilin City, Guangxi Zhuang Autonomous Region, China	Erinea
<i>Acerimina pyrrhosiae</i> Manson, 1984	<i>Pyrrosia serpens</i> Ching (Polypodiaceae)	Rotorua, New Zealand	Brown witches' brooms
<i>Acerimina shuiensis</i> Huang, 1991	<i>Peranema cyatheoides</i> D. Don. (Dryopteridaceae)	Shuishe, Yuechih, Nantou, Taiwan, China	Vagrant on upper leaf surface
<i>Aculus beveroi</i> (Manson & Gerson, 1986)	<i>Gleichenia cunninghamii</i> Heward ex Hook (Gleicheniaceae)	Waitakere, Auckland, New Zealand	On the lower pinnae surface, under the broad scales along midrib
<i>Calacarus dicranopteris</i> Wei & Feng, 2002	<i>Dicranopteris linearis</i> (Burm. f.) Underw. (Gleicheniaceae)	Nanning City, Guangxi Zhuang Autonomous Region, China	Not stated
<i>Cosella pteridiae</i> Huang, 2001b	<i>Pteris wallichiana</i> J. Agardh (Pteridaceae)	Hualien, Walapi, Taiwan, China	Vagrant on lower leaf surface
<i>Cymeda zealandica</i> Manson & Gerson, 1986	<i>Cyathea medullaris</i> Sw. (Cyatheaceae)	Mt. Albert research Centre, Auckland, New Zealand	Vagrant on lower pinna surfaces
<i>Diclopodacus pterpterus</i> (Huang, 1991)	<i>Pteridium aquilinum</i> (L.) Kuhn (Dennstaedtiaceae)	Kuanshi, Hsinchu, Taiwan, China	Vagrant on upper leaf surface
<i>Diphytoptus nephrideus</i> Huang, 1991	<i>Nephrolepis hirsutula</i> (Forst.) Presl. (Nephrolepidaceae)	Shuishe, Nantou, Taiwan	Vagrant on upper leaf surface
<i>Eriophyes eckloniae</i> Meyer (Smith) & Ueckermann, 1989	<i>Cheilanthes eckloniana</i> Mett. (Pteridaceae)	Between Monks Cowl and Hlanyaka, Drakensberg Mountains, Natal, South Africa	Among dense hairs on leaves
<i>Eriophyes equiseti</i> (Farkas, 1960)	<i>Equisetum arvense</i> L. (Equisetaceae)	Borzsony-Gyongye, alongside a narrow gauge rail-line, Hungary	Found in the star-shaped sheath of the female sporulating structure
<i>Eriophyes helicanyx</i> Keifer, 1966a	<i>Pteridium aquilinum</i> (L.) Kuhn (Dennstaedtiaceae)	Millbury, Massachusetts, USA.	Rolling of leaf margins
<i>Eriophyes parapteridis</i> Livtshitz, Mitrofanov & Sharonov, 1983	<i>Pteridium tauricum</i> V.I. Krecz. (Dennstaedtiaceae)	Vicinity of Lake Karagol, Crimea, Ukraine	Not stated
<i>Eriophyes quadrifidus</i> Meyer (Smith) & Ueckermann, 1989	<i>Pteridium aquilinum</i> (L.) Kuhn (Dennstaedtiaceae)	Maanharrand, Traansval, South Africa	Thickening and curling of pinnule edges
<i>Esalqua centennaria</i> Flechtmann, 2002	<i>Thelypteris</i> sp. (Thelypteridaceae)	Cananeia, São Paulo, Brazil	Vagrant on lower leaf surface
<i>Floracarus biseratae</i> Huang, 2001a	<i>Nephrolepis biserrata</i> (Sw.) Schott (Nephrolepidaceae)	Taitung, Lanyu, Taiwan, China	Rolling of leaf edge
<i>Floracarus perrepae</i> Knihinicki & Boczek, 2002	<i>Lycopodium microphyllum</i> (Cav.) R. Br. (Lygodiacae)	Glasshouse, CSIRO, Long Pocket Laboratories, Brisbane, Queensland, Australia	Severe curling and rolling of leaf sub pinnae

TABLE 1: Continued.

Species	Type host (family)	Type locality	Habitus
<i>Jutarus plagiogyrus</i> Huang, 2001c	<i>Plagiogyria formosana</i> Christ (<i>Plagiogyriaceae</i>)	Kaohsiung, Tengchih, Taiwan, China	Vagrant on lower leaf surface
<i>Leipothrix minidonta</i> [Meyer (Smith), 1990]	<i>Cheilanthes viridis</i> (Forssk.) Swartz	Richmond, Natal, South Africa	Vagrant on slightly distorted leaflets
<i>Leipothrix pterisfolii</i> n. sp.	<i>Polypodium vulgare</i> L. (<i>Polypodiaceae</i>)	Arasbaran forests, Kaleybar, East Azerbaijan, Iran	Leaf vagrant
<i>Leipothrix serbicus</i> (Petanović, 2001)	<i>Dryopteris filix-mas</i> (L.) Schott (<i>Dryopteridaceae</i>)	Mt. Goc, Serbia	Vagrant on lower leaf surface
<i>Leipothrix triquetra</i> [Meyer (Smith), 1990]	<i>Cheilanthes</i> sp. (<i>Pteridaceae</i>)	Pretoria, Transvaal, South Africa	Vagrant, found amongst sporangia; slightly deformation on leaflets
<i>Litaculus acutus</i> Manson & Gerson, 1986	<i>Blechnum cordatum</i> (Desv.) Hieron (<i>Blechnaceae</i>)	Christian Rd., Waitakere, Auckland, New Zealand	Under scales or within continuous sori on fertile pinnae
<i>Litaculus antapicus</i> Manson & Gerson, 1986	<i>Cyathea smithii</i> Hook. f. (<i>Cyatheaceae</i>)	Waitakere, Auckland, New Zealand	Not stated
<i>Litaculus gilliana</i> Manson & Gerson, 1986	<i>Polystichum chilense</i> (H. Chr.) Diels (<i>Dryopteridaceae</i>)	Old Man Range near Alexandra, Central Otago, New Zealand	Browning of sori bases
<i>Litaculus kbandus</i> Manson & Gerson, 1986	Unidentified fern (<i>Polypodiaceae</i>)	Khandalla, Wellington, New Zealand	Vagrant on lower leaf surface
<i>Litaculus pennigerus</i> Manson & Gerson, 1986	<i>Pneumatopteris pennigera</i> Holttum (<i>Thelypteridaceae</i>)	Tongaporutu white cliffs walkway, Taranaki, New Zealand	Vagrant on pinnae
<i>Litaculus squarrus</i> Manson & Gerson, 1986	<i>Dicksonia squarrosa</i> Sw. (<i>Dicksoniaceae</i>)	Kaimai Rang, Waikato, New Zealand	Not stated
<i>Metaculus tanythrix</i> Flechtmann & De Queiroz, 2010	<i>Dicksonia sellowiana</i> Hook. (<i>Dicksoniaceae</i>)	Jardim Botânico, Curitiba, Paraná, Brazil	Leaf vagrant
<i>Nothopoda footei</i> (Keifer, 1969)	<i>Nephrolepis</i> sp. (<i>Nephrolepidaceae</i>)	The Philippine Islands; intercept n. 66-13435 (Honolulu, Hawaii)	Terminal galls on frond branches
<i>Phyllocoptes dimorphus</i> Keifer, 1940	<i>Pteridium aquilinum</i> var. <i>lanuginosum</i> (Bong.) Fernald (<i>Dennstaedtiaceae</i>)	On the highway near Crest Road Camp, Arrowhead Lake District, San Bernardino Co., California, USA	Vagrant on lower surface of fronds
<i>Phyllocoptes pteridi</i> Petanović, 2001	<i>Pteridium aquilinum</i> (L.) Kuhn (<i>Dennstaedtiaceae</i>)	Mt. Goc, Serbia	Vagrant on lower leaf surface
<i>Rhinophytopus plagiogyrus</i> Huang, 2001c	<i>Plagiogyria formosana</i> Christ (<i>Plagiogyriaceae</i>)	Kaohsiung, Tengchih, Taiwan, China	Vagrant on lower leaf surface
<i>Stenacis biserratae</i> Huang, 2001a	<i>Nephrolepis biserrata</i> (Sw.) Schott (<i>Nephrolepidaceae</i>)	Taitung, Lanyu, Taiwan, China	Vagrant on lower leaf surface

phology with scanning electron microscopy which clarified the bifurcated shape of the palp seta *d* (R. Petanović, unpublished micrographs and pers. comm., on 18 Sept. 2015).

Two *Leipothrix* species are known from Iran: *L. retidorsi* Lotfollahi, Haddad & de Lillo, 2014 from *Rubia tinctorum* L. (Rubiaceae) in Azarshahr, East Azerbaijan province (Lotfollahi *et al.*, 2014), and *L. liroi* (Rovainen, 1947) from *Primula* sp. (Primulaceae), Aliabad-eKatul, Golestan province (Gol *et al.*, 2015). *Leipothrix liroi* was moved from *Epitrimerus* to *Neoleipothrix* by Soika and Labanovki (2009) and, later, to *Leipothrix* by Jočić and Petanović (2012). The synonymy of *L. liroi* with *L. jaceae* (Liro) proposed by Chetverikov (2005) was a typographic mistake (P.E. Chetverikov, pers. comm., on 17 Aug. 2016).

In the current study a new *Leipothrix* species was collected and described on *Polyodium vulgare* L. (common polypody) and *Gymnocarpium dryopteris* (L.) Newman (common oak fern). This is the third *Leipothrix* species found in Iran, and the fourth from ferns worldwide.

MATERIALS AND METHODS

In order to start a survey on the mite fauna of ferns, plants of the families Polypodiaceae and Cystopteridaceae were sampled during September 2010 in the Arasbaran forests (East Azerbaijan, Iran). Eriophyoid mites were recovered from the plant material by means of a modified washing method developed by Monfreda *et al.* (2007). The mites were slide mounted according to Baker *et al.* (1996).

The terminology and the setal notation in the morphological description of the mite follow mainly Lindquist (1996). All morphological measurements were taken by means of a phase contrast microscope Olympus BX50 according to Amrine and Manson (1996) as modified by de Lillo *et al.* (2010),

and are given in micrometers. Slight clarifications should be added as follows: ventral semiannuli were counted from the first entire annulus behind the prodorsal shield; coxigenital semiannuli were counted medially from the coxal region to the anterior margin of the external genitalia and were not included in the ventral semiannuli count.

Measurements and means are rounded off to the nearest integer when required. Measurements refer to the length of the morphological trait unless otherwise specified. The holotype measurements are followed by range values, in parentheses, of the studied population (*i.e.* holotype and paratypes). The mean values of the paratypes are reported in the few cases in which the measurements of the holotype could not be taken, due to the slide mounting position of the specimens.

Line drawings were hand-drawn through a *camera lucida* according to de Lillo *et al.* (2010) and the abbreviations labelling schematic drawings in figure 1 follow mainly Amrine *et al.* (2003). The generic classification follows Amrine *et al.* (2003) and comparisons were also made with new genera described since that publication. Host plant names and their synonymies are in accordance with "The Plant List on-line database" (2013).

Type materials are deposited at the Acarology Laboratory, Department of Plant Protection, Faculty of Agriculture, Azarbaijan Shahid Madani University, Tabriz (Iran), and at the Department of Soil, Plant and Food Sciences (Di.S.S.P.A.), section of Entomology and Zoology, University of Bari Aldo Moro (Italy).

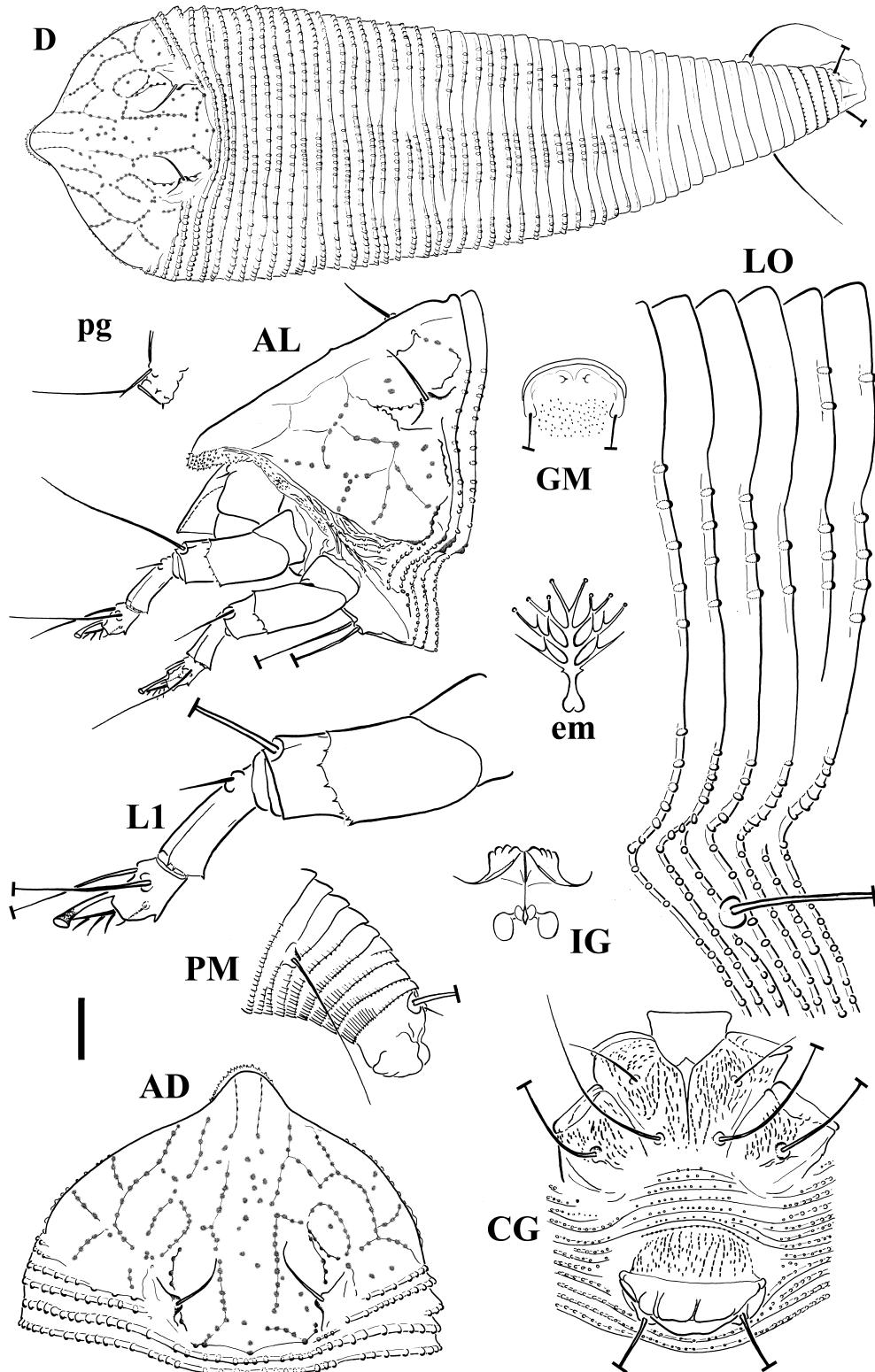


FIGURE 1: Schematic drawings of *Leipothrix pterisfolii* n. sp.: AD – Prodorsal shield; AL – Lateral view of anterior body region; CG – Female coxigenital region; D – Dorsal view; em – Empodium; GM – Genital region, Male; IG – Internal female genitalia; LO – Lateral view of annuli; L1 – Leg I; pg – palp genua; PM – Lateral view of posterior opisthosoma. Scale bar: 15.5 μ m for D; 10 μ m for AD, AL, CG, GM, IG, pg, PM; 5 μ m for LO, L1; 2.5 μ m for em.

DESCRIPTION

Subfamily Phyllocoptinae

Tribe Phyllocoptini

Leipothrix pterisfolii n. sp. (Figure 1)

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Diagnosis — Prodorsal shield with granulated lines forming a cell-like network; coverflap ornamented only on the basal part with 1-2 transverse rows of dashes in vertical lines.

Female (measured specimens n: 10)

Body — fusiform, 223 (216 – 235, excluding gnathosoma), 67 (62 – 73) thick, 72 (70 – 76) wide.

Gnathosoma — 25 (25 – 26) projecting obliquely downwards, chelicerae 20 (18 – 21), palp coxal setae *ep* 3 (2 – 4), palp genual setae *d* 21 (it is the average value of the measured population; 18 – 23), branched; branch 1 (no variation), at 5 (4 – 6) from the base of setae *d*.

Prodorsal shield — 54 (48 – 54) including frontal lobe, 61 (60 – 70) wide, subsemicircular; with a broad-based frontal lobe, 13 (10 – 14), over gnathosomal base; frontal lobe with numerous very short and spiny protuberances. Shield pattern distinct, consisting of granulate lines forming a cell-like network; sparse granules on median shield area; complete admedian lines, short first submedian lines, extended $\frac{1}{4}$ ahead of tubercles of *sc* setae, complete second submedian lines; cell pattern of lateral and transverse lines on lateral shield areas. Tubercles of *sc* setae 5 (5 – 6) ahead of rear shield margin, 27 (23 – 27) apart, setae *sc* 13 (10 – 14), directed anteromedially.

Leg I — 40 (36 – 41), femur 11 (10 – 12), genu 5 (5 – 6), tibia 10 (9-11), tarsus 8 (8 – 9), ω 5 (no variation) distally funnel shaped, empodium simple, 6 (5 – 6.5), 4-rayed; femoral setae *bv* absent, genual setae *l''* 30 (28 – 31),

tibial setae *l'* 5 (3 – 5), tarsal setae *ft'* 18 (15 – 19), *ft''* 22 (19 – 24).

Leg II — 38 (36 – 40), femur 12 (10 – 13), genu 5 (5 – 7), tibia 9 (9 – 10), tarsus 8 (8 – 10), ω 5 (5 – 5.5) distally funnel shaped, empodium simple, 4 (no variation), 4-rayed; femoral setae *bv* absent, genual setae *l''* 7 (7 – 13), tarsal setae *ft'* 3 (3 – 5), *ft''* 20 (18 – 22). Coxae with distinct dashes arranged in lines; setae *1b* 12 (10 – 15), tubercles *1b* 15 (14 – 16) apart, setae *1a* 26 (24 – 36), tubercles *1a* 8 (no variation) apart, setae *2a* 51 (48 – 68), tubercles *2a* 27 (26 – 30) apart. Prosternal apodeme 11 (9 – 12).

Opisthosoma — with 53 (52 – 59) dorsal semiannuli, 78 (65 – 81) ventral semiannuli (counted from first complete annulus after coxae II); dorsal median ridge, extended on the anterior 37 (35 – 37) dorsal semiannuli, flanked by two lateral ridges; 7 (5 – 7) semiannuli between coxae and genital coverflap.

Microtubercles — elliptical, on posterior margin of dorsal semiannuli, more distinct on ridges and faint on the space between median and lateral ridges of 15 – 17 anterior dorsal semiannuli, no microtubercles visible on the space between median and lateral ridges of remaining posterior dorsal semiannuli; circular, on posterior margin of ventral semiannuli; spiny on the rear margin of the last 4 dorsal semiannuli and elongated and linear on last five ventral semiannuli. Setae *c2* 25 (20 – 26) on ventral semiannulus 13 (11 – 15), setae *d* 47 (43 – 49) on ventral semiannulus 27 (27 – 32); setae *e* 17 (12 – 18) on ventral semiannulus 46 (46 – 55); setae *f* 30 (25 – 33) on ventral semiannulus 69 (66 – 74); 5 annuli posterior to setae *f*. Setae *h2* 75 (65 – 75) apically very fine, *h1* 5 (4 – 5). Genital coverflap 16 (15 – 20), 26 (20 – 28) wide, basal part ornamented with 1-2 transverse rows of dashes arranged in vertical lines, distal part smooth and apparently soft with a few folds on the edge; setae *3a* 15 (13 – 17), 17 (16 – 18) apart.

Male (n = 1)

Similar in shape and prodorsal shield arrangement to female. Body 125, 51 wide; palp genual setae d 11; prodorsal shield 43, 40 wide; setae sc 13, 16 apart. Opisthosoma with 47 dorsal semiannuli and 51 ventral semiannuli (counted from first complete annulus after coxae II). Setae: $1b$ 7, $1a$ 16, $2a$ 35, $c2$ 12.5, d 22, e 10, f 19, $h2$ 60, $h1$ 3. Male genitalia 12 wide, setae $3a$ 10, 14 apart.

Type host plant — *Polypodium vulgare* L. (Polypodiaceae), common polypody.

Type locality — Arasbaran forests, Kaleybar, East Azerbaijan, Iran ($38^{\circ}50'44.9''N$, $47^{\circ}00'27.8''E$), 1,616 m above sea level, coll. P. Lotfollahi, late September 2010.

Type material — Holotype: single female on a microscope slide (PV-IEA-AN10L-1). Paratypes: 33 females, 1 male and 1 nymph mounted singly on separate microscope slides.

Other host plant — 38 females and 2 nymphs mounted singly on separate microscope slides, collected from *Gymnocarpium dryopteris* (L.) Newman (Cystopteridaceae), oak fern, Western oak fern, common oak fern or Northern oak fern in the same localities and on the same dates, as mentioned above.

Other material — Mites preserved in Oudemans' fluid (Walter & Krantz, 2009) as extracted from the same sample as the type specimens.

Relation to the host plant — Vagrant on leaves, in high density. The protocol applied for the mite extraction did not allow establishing the side of leaves colonized by the mite population. No apparent damage was observed.

Etymology — The specific epithet, *pterisfolii*, is the genitive case of a combined name composed from the Greek *pteris*, meaning fern, and the Latin *folii*, meaning leaf.

Differential diagnosis — The new species herein described was compared with all *Leipothrix* species currently known and similarities were observed only with those species known on other ferns: *L. minidonta*, *L. triquetra* and *L. sericus*.

The new species differs from *L. triquetra* in the prodorsal shield pattern (complete median line in *L. triquetra* vs no median line in *L. pterisfolii*), frontal lobe (shorter and smooth in *L. triquetra* vs larger and with numerous spiny protuberances in *L. pterisfolii*), ornamentation of the female coverflap (seven slightly diagonal lines on distal part in *L. triquetra* vs smooth distal part in *L. pterisfolii*), number of the empodial rays, length of palp genual setae d , and setae $1a$, e , f , $h1$ and $3a$, number of dorsal and ventral semiannuli, and of semiannuli between coxae and genital coverflap (Fig. 2A, Table 2).

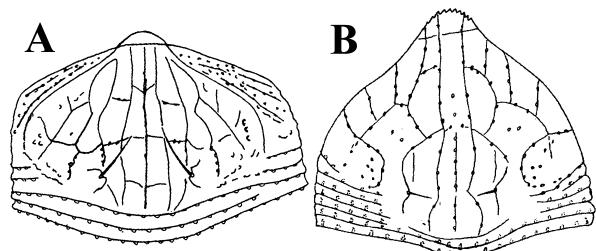


FIGURE 2: Schematic drawings of the prodorsal shields of other *Leipothrix* species found on ferns: A – *Leipothrix triquetra* (Meyer, 1990); B – *Leipothrix minidonta* (Meyer, 1990). Redrawn from Meyer (Smith), 1990.

The new species differs from *L. minidonta* in the prodorsal shield pattern (incomplete and broken median line of *L. minidonta* vs no median line for *L. pterisfolii*; different arrangement for admedian lines and lines on the lateral sides), ornamentation of the female coverflap (8 inconspicuous slightly diagonal lines on the distal part in *L. minidonta* vs smooth distal part in *L. pterisfolii*), length of setae sc , $c2$ and d , number of dorsal semiannuli and of semiannuli between coxae and genital coverflap (Fig. 2B, Table 2).

TABLE 2: Gross comparison of some traits among four *Leipothrix* species inhabiting ferns.

Morphological details	<i>L. triquetra</i> [Meyer (Smith), 1990]	<i>L. minidonta</i> [Meyer (Smith), 1990]	<i>L. serbicus</i> (Petanović, 2001)	<i>L. pterisfolii</i> Lotfollahi & de Lillo
palm genual setae (<i>d</i>) length	9	18	15	18-23
setae <i>sc</i> length	13	5-6	5	10-14
empodium rays number	5	4	4	4
coxal setae <i>1b</i> length	13	9-13	8	10-15
coxal setae <i>1a</i> length	25-32	-	10	24-36
dorsal semiannuli number	62-69	54-60	about 50	52-59
ventral semiannuli number	62-69	71-85	about 76	65-81
semiannuli number between coxae and female coverflap	7	9	6	5-7
setae <i>c2</i> length	28-35	16	9	20-26
setae <i>d</i> length	41-47	32-35	18	43-49
setae <i>e</i> length	35-38	16-19	5	43435
setae <i>f</i> length	32-33	28-32	23	25-33
setae <i>b1</i> length	5	3	2	4-5
setae <i>3a</i> length	16-19	9-16	6	13-17
ornamentation of the distal part of the female coverflap	-	8 inconspicuous slightly diagonal striae	with about 6-7 striae	smooth and with a few folds

The new species differs from *L. serbicus* in the prodorsal shield pattern (the published line drawing of the prodorsal shield does not fit perfectly with SEM pictures taken by R. Petanović, pers. comm., on 18 Sept. 2015); according to the new data (unpublished) also the prodorsal shield of *L. serbicus* is provided of a net-like ornamentation made by granulated lines and it differs from the prodorsal shield of the Iranian species on a complete median line which cannot be seen on *L. pterisfolii*. Other differences concern the length of palp genual setae *d*, scapular setae *sc*, setae *1a*, *c2*, *d*, *e* and *3a* (all of them are longer in *L. pterisfolii*) (Table 2).

Remarks — This is the first record of a species belonging to the tribe Phyllocoptini on a Polypodiaceae plant species, the first record of an eriophyoid mite from ferns of the family Cystopteridaceae and the first record

of an eriophyoid mite from ferns in Iran. The mites (38 females) found on *G. dryopteris* showed highly similar morphometric details and variability in respect to the mites (34 females) found on *P. vulgare*. This latter fern was selected as type host plant because of the collection of male and nymphs within the collected mite population. The close cohabitation of the two host plant species does not allow to understand if *G. dryopteris* is an alternative or accidental host species due to mite dispersal or if they refer to two populations of a complex of species. DNA and biological studies are needed to determine the host plant range of this new mite species. In addition, a multifactorial morphometric analysis should be done on the two populations in order to give evidences of minor differences which could be caused by the plant genotype.

KEY OF THE SPECIES ASSOCIATED TO THE FERNS

A key of the eriophyoid mite species collected on ferns worldwide is proposed on the base of the most detailed published descriptions and including a previous species key of the genus *Litaculus* (Manson & Gerson, 1986).

1. Gnathosoma large in comparison to the body; chelicerae abruptly curved and bent down near their base; prodorsal shield with a net-like pattern: median and admedian lines well distinct on the posterior half, admedian and submedian lines delimit 11 cells on the anterior half along with a pair of transverse lines; femoral setae *bv* present on both legs; empodium entire; opisthosoma with subequal dorsoventrally annuli
..... Diptilomiopidae Keifer, 1944 – Rhyncaphytoptinae Roivainen, 1953 – *Rhinophytoptus plagiogyrus* Huang, 2001c
- Gnathosoma small in comparison to the body; chelicerae straight or slightly curved down.....
..... Eriophyidae Nalepa 1898 – 2
2. Coxae I often fused with sternal line faint or absent; tibiae reduced or completely fused with tarsi; tibial setae *l'* absent.....
..... Nothopodinae Keifer, 1956 – 3
- Combination of characters not as above .. 7
3. Prodorsal shield with blunt frontal lobe and lobes at each anterolateral angles; tubercles *sc* ahead of the rear margin of the prodorsal shield; coxal setae *1b* present; coxae I usually weakly divided; tibiae I completely fused with tarsi; empodium divided; opisthosoma with broad dorsal semiannuli and a dorsal median ridge; female coverflap with two rows of longitudinal striae.....
..... Colopodacini Mohanasundaram, 1984 – *Dicolopodacus pterpterurus* (Huang, 1991)

Note: this species was described without mentioning the leg arrangement and drawn with distinct leg tarsi and tibiae; later, it was moved to the new genus *Dicolopodacus* pointing out "leg segment tibiae fused with tarsi" (Huang, 2001b).

- Coxal setae *1b* absent; coxae and tibiae I variable.....
..... *Nothopodini* Keifer, 1956 – 4
- 4. Setae *sc* directed up and converging
..... *Nothopoda footei* (Keifer, 1969)
- Setae *sc* directed posteriorly 5
- 5. Tubercles *sc* cylindrical, near the rear margin of the prodorsal shield 6
- Tubercles *sc* plicate, ahead of the rear margin of the prodorsal shield; smooth dorsal semiannuli
..... *Cosella pteridiae* Huang, 2001b
- 6. Median line complete and connected to the admedian lines by two transverse lines on basal 1/3 and 1/2 of the prodorsal shield; dorsal semiannuli fully microtuberculated...
..... *Floracarus biseratae* Huang, 2001a
- Median line on 2/3 of the prodorsal shield and not connected to the admedian lines; dorsal semiannuli with sparse spinulated microtubercles.....
..... *Floracarus perrepae* Knihinicki & Boczek, 2002
- 7. Female genital apodeme bent up and shortened, usually appearing as a heavy transverse line in ventral view; female coverflap appressed to coxae II and often with ridges typically in 2 uneven ranks; coxae I usually narrowly connate with a short sternal line; coxae often with curved lines outlining tubercles of setae *1a*; prodorsal shield with two large tuberosity, medially contiguous, extending from the rear margin anteriorly to cover an half; tubercles *sc* well ahead of

- the rear margin of the prodorsal shield; empodium divided; opisthosoma with broad dorsal semiannuli, narrow ventral semianuli, a middorsal furrow and two subdorsal rounded ridges.....
..... *Cecidophyinae* Keifer, 1966b – *Esalquia centennaria* Fletchmann, 2002
- Female genital apodeme extending moderate distance forward and not appearing as a heavy transverse bar in ventral view; female coverflap well far from coxae II, variably sculptured and striae rarely occurring in 2 ranks; sternal line usually evident; coxae usually without curved lines outlining setal tubercles 8
8. Body vermiform, opisthosoma with annuli subequal dorsoventrally, at least on anterior 1/2 to 2/3; prodorsal shield lacking a frontal lobe or if frontal lobe present, it is narrow, basally flexible, and combined with narrow annuli.....
..... *Eriophyinae* Nalepa, 1898 – 9
- Body usually fusiform; prodorsal shield usually with a broad-based and rigid frontal lobe; opisthosoma typically with broad dorsal semiannuli and narrow microtuberculate ventral ones; if frontal lobe absent or only a slight one present, then semiannuli differ dorsoventrally, at least in broader dorsal ones.....
..... *Phyllocoptinae* Nalepa, 1892 – 21
9. Empodium divided, 4-rayed
..... *Diphytoptini* Amrine & Stasny, 1994 – *Diphytoptus nephroideus* Huang, 1991
- Empodium entire 10
10. Tuberles and coxal setae 1b absent..... 11
— Tuberles and setae coxal 1b present..... 12
11. Prodorsal shield unornamented except for a few basal granules and faint, short lines on posterior half; coxae smooth; female coverflap sometimes with few faint markings on the distal part and granules on the proximal part
..... *Acerimina pyrrosiae* Manson, 1984
- Prodorsal shield design obscure, with many short dash-like lines, particularly near to the posterior margin; coxae with few granules; female coverflap with short distal striae and proximal granules
..... *Acerimina shuishensis* Huang, 1991
12. Setae sc directed posteriorly; tibial setae l' present 13
— Setae sc directed upwards and centrad or laterad 16
13. Prodorsal shield unornamented except for a weak longitudinal, dash-like line directed anteriorly from each tubercle sc, and marks close to the rear margin of the prodorsal shield at the base between tubercles sc....
..... *Aceria gersoni* Manson, 1984
- Prodorsal shield ornamented by distinct lines and granules 14
14. Median and admedian lines complete and broken
..... *Aceria pteridii* Kuang & Gong, 1996
- Median line shorter than the anterior half of the prodorsal shield, admedian lines complete or broken 15
15. Median line short on the anterior half of the prodorsal shield, admedian lines running about 2/3 length of shield, 3-4 submedian lines; sc setae longer than prodorsal shield; with about 94-104 microtuberculated annuli .
..... *Aceria gleicheniae* Manson, 1984
- Median line short and broken, admedian lines as long as prodorsal shield length; sc setae shorter than prodorsal shield; with about 68 microtuberculated rings

..... *Aceria pauropa* (Nalepa, 1909)

Note: *Aceria nalepae* (Giesenhenken, 1919) is its junior synonym.

16. Setae *sc* directed upwards and laterad; frontal lobe distinctly large and weak

..... *Stenacis biserratae* Huang, 2001a

— Setae *sc* directed upwards and centrad; frontal lobe absent or very short..... 17

17. Prodorsal shield design made up of continuous lines..... 18

— Prodorsal shield design made up of lined short dashes and granules..... 19

18. Coxae I fused; setae *bv* absent; empodium 5-rayed *Eriophyes eckloniae* Meyer (Smith) & Ueckermann, 1989

— Coxae I not fused; setae *bv* present; empodium 4-rayed *Eriophyes parapteridis* Livshits, Mitrofanov & Sharonov, 1983

19. Both coxae completely granulated..... 20

— Coxae I granulated and coxae II almost completely smooth; empodium 3-rayed

..... *Eriophyes helicantyx* Keifer, 1966a
Note: Amrine & Stasny (1994) listed also *Eriophyes? pteridis* (Molliard, 1898). The author described the fern deformations but gave a very generic and useless description of the mite. It was never collected and described. Currently, it is a valid name species but it requires to be found and re-described in order to check its systematic position in relation to *E. helicantyx* which was found on the same host species in the USA and induced quite similar symptoms.

20. Setae *sc* longer than half of the prodorsal shield length; empodium 4-rayed

..... *Eriophyes quadrifidus* Meyer (Smith) & Ueckermann, 1989

— Setae *sc* less long than half of the prodorsal shield; empodium 5-rayed

..... *Eriophyes equiseti* (Farkas, 1960)

21. Empodium divided

..... *Acaricalini* Amrine & Stasny, 1994 – 22

— Empodium entire

22. Femur two-segmented and setae *bv* on the basal one; tibial setae *l'* absent; opisthosoma with alternate dorsal annuli bearing longitudinal scorings laterally and small punctures centrally; intervening annuli smooth; wax plates laterally and around the shield

.... *Cymeda zealandica* Manson & Gerson, 1986

— Tibial setae *l'* present; femur and opisthosoma annuli not as above..... 23

23. Frontal lobe of the prodorsal shield acutely pointed, triangular; opisthosoma with 34 – 42 dorsal semiannuli

.... *Litaculus acutus* Manson & Gerson, 1986

— Frontal lobe of the prodorsal shield rounded or truncate..... 24

24. Genital coverflap with two rows of striae; prominent protuberance at the base of genua I setae *l''*; opisthosoma with at most 30 dorsal semiannuli

... *Litaculus squarrosus* Manson & Gerson, 1986

— Not as above

25. Palp genual setae *d* with an abrupt right angle bend ('flag-shaped'); opisthosoma with at most 25 dorsal semiannuli

... *Litaculus antapicus* Manson & Gerson, 1986

— Palp genual setae *d* normal

26. All dorsal semiannuli (except the first three) with a rectangular or diamond shaped pattern at the mid lateral position; opisthosoma with at most 30 dorsal semiannuli

- *Litaculus khandus* Manson & Gerson, 1986
— Dorsal semiannuli not as above 27
27. Frontal lobe bluntly rounded; opisthosoma with more than 40 dorsal semiannuli and with a weak middorsal ridge
.... *Litaculus gilliana* Manson & Gerson, 1986
— Frontal lobe truncate, with a jagged anterior margin; opisthosoma with at most 30 dorsal semiannuli and without a ridge
. *Litaculus pennigerus* Manson & Gerson, 1986
28. Setae and tubercles *sc* absent
..... *Calacarini* Amrine & Stasny, 1994 – 29
— Setae and tubercles *sc* present 30
29. Prodorsal shield without median line; dorsal semiannuli evenly rounded; empodium 3-rayed
..... *Jutarus plagiogyrus* Huang, 2001c
— Prodorsal shield with median line on the rear 1/4 of shield; dorsal semiannuli with three equal ridges; empodium 6-rayed
..... *Calacarus dicranopteris* Wei & Feng, 2002
30. Tubercles *sc* on or very near the rear margin of the prodorsal shield, directing setae to rear, usually divergently; tubercles *sc* either subcylindrical or the alignment of their bases is transverse to the body
..... *Anthocoptini* Amrine & Stasny, 1994 – 31
— Tubercles *sc* usually well formed, often plicate and placed ahead of the rear margin of the prodorsal shield, directing setae *sc* forward, up or centrad; if tubercles *sc* are near the rear margin of the prodorsal shield, then tubercles are subcylindrical and bent forward or the alignment of their bases is longitudinal or diagonal to the body
..... *Phyllocoptini* Nalepa, 1892 – 32
31. Tubercles and coxal setae *1b* absent
..... *Metaculus tanythrix* Flechtmann & De Queiroz, 2010
— Tubercles and coxal setae *1b* present; prodorsal shield smooth; empodium 5-rayed
.... *Aculus beevori* (Manson & Gerson, 1986)
32. Palp genual setae *d* unbranched 33
— Palp genual setae *d* bifurcate 34
33. Prodorsal shield pattern distinct, with strongly granulated and complete median, admedian and two pairs of submedian lines; female coverflap with granules on the proximal part and striae on the distal part
..... *Phyllocoptes pteridii* Petanović, 2001
— Prodorsal shield pattern with finely granulated lines, median line incomplete, joint by a transverse line to the admedian line close to the rear margin of the prodorsal shield, admedian lines complete forming cells along with the first pair of submedian lines; female coverflap with a double row of striae
..... *Phyllocoptes dimorphus* Keifer, 1940
34. Median line complete; empodium 5-rayed
.... *Leipothrix triquetra* [Meyer (Smith), 1990]
— Median line incomplete or absent; empodium 4-rayed 35
35. Distal part of the female coverflap smooth and with a few folds
..... *Leipothrix pterisfolii* n. sp.
— Distal part of the female coverflap ornamented by striae 36
36. Median line short, on the posterior half, made by lined granules; distal part of the female coverflap with 8 inconspicuous slightly diagonal striae
... *Leipothrix minidonta* [Meyer (Smith), 1990]
— Median line replaced by lined granules; distal part of the female coverflap with about

6-7 striae.....
.....*Leipothrix serbicus* (Petanović, 2001)*

*Note: see comments in the "Differential diagnosis" paragraph for updates on the morphology of this species.

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