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Aceria species associated with Solanaceae worldwide with description of a new species

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Original research

ABSTRACT

During the study on the eriophyoid mite fauna of Ajabshir region in East Azerbaijan province (Iran), a new species was found on \textit{Lycium ruthenicum} Murray (Solanaceae). It was described, named as \textit{Aceria ajabshiriensis} \textbf{n. sp.} and compared with 18 other \textit{Aceria} species associated with plants of the family Solanaceae. \textit{Aceria ajabshiriensis} \textbf{n. sp.} strongly resembles \textit{Aceria eucricotes} (Nalepa). \textit{Aceria ajabshiriensis} \textbf{n. sp.} is the third eriophyoid species collected on \textit{L. ruthenicum} in Iran. A list of \textit{Aceria} species associated with Solanaceae plants worldwide, their type hosts, type localities, habitats and a key for identification are provided. In addition, a new combination was proposed: \textit{Aceria dunaliae} (Boczek \& Oleczek, 1988) \textbf{n. comb.}

Keywords  Ajabshir; habitus; identification key; \textit{Lycium ruthenicum}

Zoobank  http://zoobank.org/5F62B54F-AC4C-40AD-BF42-B3647A44D239

Introduction

The family Solanaceae is one of the largest and economically important families of flowering plants, including fruit, spice, and drug plants representing 8,400 scientific plant names of species (2,678 species names are accepted) within 115 plant genera (The Plant List on-line database 2013). This family includes evolutionarily successful and advanced taxa and shows high level of diversity reflected by the variety of life forms of its members, ranging from ephemeral herbs to large trees. They are cosmopolitan plants found throughout tropical and temperate regions, but with more focus in Australia and Latin America (Majaz Ganaie \textit{et al.} 2018).

Due to the high host specificity of the eriophyoid mites, it seems that a large number of these mites must be found on Solanaceae. However, about 46 eriophyoid species have been collected on this plant family until now and 18 of them belong to the genus \textit{Aceria} (Amrine and de Lillo unpublished database; Table 1). Six eriophyoid mite species are reported in Iran from Solanaceae including \textit{Aceria eucricotes} (Nalepa), \textit{A. melongena} (Zaher \& Abou-Awad), \textit{A. paramacrodonis} Kuang, \textit{Aculops lycopersici} (Tryon), \textit{Teta lycopersici} Xue \& Hong and \textit{Echinacrus ruthenicus} Lotfollahi, de Lillo \& Haddad (Sepasgozarian 1973; Baradaran-Anaraki and Daneshvar 1992; Ramazani \textit{et al.} 2006; Jalilian \textit{et al.} 2010; Kamali 2011; Xue and Hong, 2005, \textit{Xue et al.} 2011; Lotfollahi \textit{et al.} 2014, 2017; Delfan \textit{et al.} 2015; Honarmand and Sadeghi 2016).

The seventh species from Solanaceae was collected from \textit{Lycium ruthenicum} Murray in Iran. It is described and illustrated herein and a key to the \textit{Aceria} species associated with Solanaceae plant species is given in order to assist species identification.
Table 1 *Aceria* species collected on Solanaceae plants, worldwide and their type host, type locality and habitus. The list is sorted according to the key sequence. The name of the host species is consistent with the current nomenclature available in The Plant List (2013).

| Species | Type host | Type locality | Ecological class/plant symptoms |
|---------|-----------|---------------|---------------------------------|
| A. eucricotes (Nalepa, 1892) | *Lycium europaeum* L. | South Europe, and Algiers, Algeria | Blister galls in leaves |
| A. pallida Keifer, 1964 | *Lycium pallidum* Miers | 11.3 km E. Tombstone, Arizona, USA | Leaf galls |
| A. kendalli Baker et al., 1996 | *Lycium barbarum* L. | Arnold Arboretum, Forest Hills, Norfolk Co., Massachusetts, USA | Leaf galls |
| A. kuko (Kishida, 1927) | *Lycium chinense* Mill. | Japan | Blister galls in leaves |
| A. paramacrononis Kuang, 1988 | *Lycium sp.* | Zhongning County, Ningxia Hui Autonomous Region, China | Pockets galls on leaf undersurface |
| A. bicorns (Trotter, 1900) | *Solanum elaeagnifolium* Cav. | La Plata, Argentina | Leaf galls |
| A. sodomaei (Keifer, 1976) | *Solanum sodoaeae* Drege in DC | The Ark, Aberdare National Park, Kenya | Collected in bud hairs but no specific symptoms were recorded |
| A. melongena (Zaher & Abou-Awad, 1979) | *Solanum melongena* L. | Alexandria, Egypt | Vagrant |
| A. daturae (Soliman & Abou-Awad, 1978) | *Datura stramonium* L. | Gyza, Egypt | Vagrant |
| A. balites (Nalepa, 1921) | *Solanum indicum* L. | Bandoeng, Java, Indonesia | Yellow spots on leaf undersurface |
| A. lycopersici (Wolffenstein, 1879) | *Lycopersicon lycopersicum* (L.) H.Karst. | Southern Spain | Leaf and stem erinea, curling and shrinkage |
| A. acnisti Keifer, 1953 | *Acanthospermum arborescens* (L.) Schltdl. | Ouro Preto, Minas Gerais, Brazil | Conspicuous blister galls in leaves |
| A. dunaliae (Boczek & Oleczek, 1988) n. comb. | *Acanthospermum arborescens* (L.) Schltdl. | Pueblo Hondo, Venezuela | Small galls on the leaves |
| A. annui (Keifer, 1977) | *Capsicum annuum* L. | Guarne, Antioquia, Columbia | Erinea on buds, stems and leaves |
| A. wagnoni (Keifer, 1977) | *Lycium cooperi* A. Gray | Valecito Creek box canyon, NW of Vallecito, Laguna Mts., San Diego Co., California, USA | Large, central, blister galls with lower surface, spout-like openings |
| A. macrodonois Keifer, 1965 | *Lycium macrodon* A. Gray | Along highway in Kit Peak District, South of Tucson, Arizona, USA | Blister galls in leaves |
| A. caulicecis (Keifer, 1972) | *Lycium andersonii* A. Gray | San Felipe, San Diego Co., California, USA | Irregular hollow galls along stems and on spines, especially at the leaf bases |
Material and Methods

Plant samples of Russian Box Thorn, *L. ruthenicum*, were collected in Ajabshir region of East Azerbaijan province (Iran), on July 2016. Eriophyoid mites were recovered from the plant samples by means of a modified washing method developed by Monfreda et al. (2007). The mites were slide mounted according to Baker et al. (1996) with some changes: specimens were directly placed in modified Hoyer’s medium without previous clearing and fibers were interposed between slide and coverslip. Mounted specimens were cleared at 90°C for a few minutes. Then, the slides were dried for about four weeks in an oven at 47°C. The terminology and the setal notation in the morphological description of the mite follow mainly Lindquist (1996) and terminology of the internal female genital apparatus follows Chetverikov (2014) and Chetverikov et al. (2014). All morphological measurements were taken by means of a phase contrast microscope Olympus BX53, at 1,000 magnification (oil immersion), 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: dorsal semiannuli were counted from the first semiannulus behind the rear margin of the prodorsal shield; ventral semiannuli were counted from the first complete annulus after coxae II; 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 except of the minute characters. Measurements refer to the length of the morphological trait unless otherwise specified and are given in micrometers. In the female description, the holotype measurements are followed by range values, in parentheses, of the studied population (i.e. holotype and paratypes) and for males only the range values are given. The mean values of the paratypes are reported in the cases in which the measurements of the holotype could not be taken, due to the slide mounting position of the specimens and were marked by an asterisk (*) in the description. Line drawings were hand-drawn with a camera lucida according to de Lillo et al. (2010) and the abbreviations labelling schematic drawings follow mainly Amrine et al. (2003). The genus classification follows Amrine et al. (2003) but new genera described after 2003 were also considered. 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).

Family Eriophyidae
Subfamily Eriophyinae
Tribe Acerini

*Aceria ajabshiriensis* n. sp.

Zoobank: 714B12BB-BC8E-43DA-BA85-BB6E61A48939

Description — FEMALE (Figure 1; measured specimens n = 10).

Body vermiform, 190 (173–205, excluding gnathosoma), 53* (52–54) thick, 55 (50–58) wide.

Gnathosoma projecting obliquely downwards, chelicerae 26 (26–30), palp 28 (26–35), palp coxal setae ep 3.5* (3–3.5), dorsal palp genual setae d 8 (7–10), unbranched.

Prodorsal shield 35 (24–35) including frontal lobe, 43* (40–45) wide, sub-circular; with a short flexible distally acuminate frontal lobe, 7 (5–7), over gnathosomal base, completely smooth. Tubercles of scapular setae sc on rear shield margin, 29 (27–29) apart, setae sc 30 (26–35), directed backward divergently.

Legs with all usual segments and setae. Leg I 31 (26–33), trochanter 6 (6–7), femur 8 (8–10), genu 6 (5–6), tibia 8 (6–9), tarsus 9 (7–9), tarsal solenidion o6 (6–8) distally enlarged and tapered, empodium simple, 7.5 (6.5–9), 6-rayed; femoral setae bv 14* (12–16), genual setae l” 29 (25–33), paraxial tibial setae l’ 8 (6–10), located in basal third of tibia, paraxial fastigial
Figure 1 Schematic drawings of *Aceria ajabshiriensis* n. sp.: AD – Prodorsal shield; AL – Lateral view of anterior body region; CG – Female coxigenital region; em – Empodium; GM – Male genital region; IG – Internal female genitalia; LO – Lateral view of annuli; L1 – Leg I; PM – Lateral view of posterior opisthosoma. Scale bar: 10 μm for AD, AL, CG, GM, IG, PM; 5 μm for LO, L1; 2.5 μm for em.
tarsal setae ft’ 15 (10–19), antaxial fastigial tarsal setae ft” 26 (23–30), paraxial unguinal tarsal setae u’ 4 (3–4.5). Leg II 31 (26–33), trochanter 5 (5–7), femur 10 (9–10), genu 5 (4–5), tibia 7 (5–8), tarsus 7 (7–8), tarsal solenidion o8 (7–8.5) distally tapered, empodium simple, 6 (5.5–8), 6-rayed; femoral setae bv 12 (12–15), genual setae l” 11 (9–15), paraxial fastigial tarsal setae ft’ 6 (6–9), antaxial fastigial tarsal setae ft” 24 (21–27), paraxial unguinal tarsal setae u’ 4.5 (3.5–5.5).

Coxisternal region. Prosternal apodeme 5 (5–6.5), anterior setae on coxisternum I 1b 12* (10–19), 11 (9–11) apart; proximal setae on coxisternum I 1a 34 (27–41), 10 (7–10) apart; proximal setae on coxisternum II 2a 48 (44–54), 23 (18–23) apart; 7 (6–8) microtuberculate semiannuli between coxae and genital cover flap plus 3 (2–3) transversal rows of lined granules at the base of the cover flap. Coxae ornamented with numerous dots and dashes.

External genitalia 11 (10–15), 21 (21–22) wide, cover flap with 9 (9–10) longitudinal striae; setae 3a 22 (20–27), 14 (11–14) apart.

Internal genitalia: spermathecae ovoid, oriented posterolateral; spermathecal tubes relatively short; transverse genital apodeme trapezoidal, distally folded.

Opisthosoma dorsally arched, with 48 (39–53) dorsal semiannuli, 64 (46–64) ventral semiannuli. Microtubercles: subelliptical, on posterior margin of dorsal semiannuli, bigger on last 17–20th dorsal semiannuli and minute spiny on last 3 (no variation) dorsal semiannuli; circular, on posterior margin of ventral semiannuli, elongated and linear on last 5 (5–7) ventral semiannuli. Setae c2 55 (37–57) on ventral semiannulus 11 (9–11), setae d 69 (69–86) on ventral semiannulus 23 (18–23); setae e 53 (47–72) on ventral semiannulus 40 (27–40); setae f 33 (28–36) on ventral semiannulus 59 (42–59); 5 (4–5) annuli posterior to setae f. Setae h2 110 (87–115) apically very fine, h1 3 (3–5).

MALE (measured specimens n = 3). Similar in shape and prodorsal shield arrangement to female. Body smaller than female, 125–150, 47–52 wide, 42 thick; palp genual setae d 7–8; prodorsal shield 24–32, 40–42 wide; setae sc 25–26, 20–25 apart. Opisthosoma with 35–41 dorsal semiannuli and 53–50 ventral semiannuli; 8 semiannuli between coxae and genitalia, with microtubercles similar to those of female. Setae: 1b 8.5–9, 1a 20–27, 2a 32–43, c2 37–47, d 42–44, e 33–41, f 22–29, h1 3, h2 55–67). Male genitalia 15–20 wide, setae 3a 15–21, 12 apart.

Type host plant — Lycium ruthenicum Murray (Solanaceae), Russian Box Thorn.

Type locality — Rahmanloo village, Ajabshir region, East Azerbaijan province, Iran (37°18’39.8”N, 45°28’50.3”E), 1,290 m above sea level, coll. S. Tajaddod, late July 2016.

Type material — Holotype: single female on a microscope slide (LR-IEA-RO16T-1). Paratypes: 5 females and 3 males mounted singly on separate microscope slides (LR-IEA-RO16T-2–8).

Other material — Mites preserved in a vial (LR-IEA-RO16T) of Oudemans’ fluid (Walter and Krantz, 2009) as extracted from the same sample as the type specimens.

Relation to the host plant — Vagrant; no apparent symptom was observed.

Etymology — This species is named after Ajabshir, the region where it was collected.

Differential diagnosis — The new species was compared with 18 Aceria species associated with the plants of family Solanaceae known to date. The new species closely resembles Aceria eucricotes (Nalepa) collected on Lycium europaeum L. from Algeria and, previously, also on L. ruthenicum from Iran (Lotfollahi et al. 2017). Both species have completely smooth prodorsal shields, similar number of empodial rays and body setal length. But these two species differ in number of dorsal semiannuli (39–53 in the new species versus 51–73 in A. eucricotes), number of semiannuli between coxae and genital cover flap (6–8 in the new species versus 3–5 in A. eucricotes). In addition, A. ajabshiriensis n. sp. has a short flexible distally acuminate frontal lobe, while A. eucricotes doesn’t have a frontal lobe. Finally, the female genital cover flap of the new species is ornamented with 9–10 longitudinal striae, whereas A. eucricotes has a smooth cover flap.
**Remarks** — This is the third eriophyoid species collected on *L. ruthenicum* and all three species were collected from this host plant in Iran (Lotfollahi *et al.* 2014, 2017).

**Key of the *Aceria* species associated to the Solanaceae plants**

A key of the *Aceria* mite species collected on Solanaceae worldwide is proposed on the base of the most detailed published descriptions:

| Step | Description | Species | References |
|------|-------------|---------|------------|
| 1.   | Female genitalia cover flap smooth | ... | ... |
|      | — Female genitalia cover flap with ornamentations | ... | ... |
| 2.   | Empodium 6-rayed | ... | ... |
|      | — Empodium 5-rayed | ... | ... |
| 3.   | Predorsal shield completely smooth | *A. eucricotes* (Figure 2A) (from Lotfollahi *et al.* 2017) | ... |
|      | — Predorsal shield with design almost absent, with very short median and admedian lines near rear predorsal shield margin as short curved lines converging posteriorly, and surrounded outwardly by some granules | *A. pallida* (Figure 2B) (from Keifer 1964) | ... |
| 4.   | Predorsal shield without distinct lines | ... | ... |
|      | — Predorsal shield with distinct design posteromedially | ... | ... |
| 5.   | Predorsal shield very small, triangular, smooth or with obscure design | *A. kendalli* (no Figure available) (from Kendall 1929) | ... |
|      | — Predorsal shield with granules between setae *sc* tubercles near rear margin | *A. kuko* (Figure 2D) (from Ripka and Sanchez 2017) | ... |
| 6.   | Median line very short near rear predorsal shield margin | *A. parawagnoni* (Figure 2E) (from Kuang 1983) | ... |
|      | — Predorsal shield with very short admedian lines and without median lines | *A. paramacrodonis* (Figure 2F) (from Kuang 1988) | ... |
| 7.   | With two long horn-shaped projections anteriorly on predorsal shield | *A. bicornis* (Figure 2C) (from Trotter 1900) | ... |
|      | — Without the projections; frontal lobe normal if present | ... | ... |
| 8.   | Predorsal shield completely smooth | *A. ajabshiriensis* n. sp. (Figure 1AD) | ... |
|      | — Predorsal shield with ornamentations | ... | ... |
| 9.   | Empodium 4-rayed | ... | ... |
|      | — Empodium with more than 4 rays | ... | ... |
| 10.  | Setae *e* 4 and setae *3a 6* | *A. sodomaei* (Figure 2G) (from Keifer 1976) | ... |
|      | — Without this combination for setae *e* and length | ... | ... |
| 11.  | With more than 70 dorsal semiannuli | ... | ... |
|      | — With less than 70 dorsal semiannuli | ... | ... |
| 12.  | Predorsal shield with complete median line and first submedian lines in the middle of shield, quite close to admedian lines | *A. melongena* (Figure 2H) (from Zaher and Abou-Awad 1979) | ... |
|      | — Predorsal shield with incomplete median line (on posterior 2/3 of shield) and without first... | ... | ... |
Figure 2  Schematic drawings of the prodorsal shield of: A – *A. eucricotes* (Nalepa, 1892) (from Lotfollahi et al. 2017); B – *A. pallida* Keifer, 1964 (redrawn from Keifer 1964); C – *A. bicornis* (Trotter, 1900) (redrawn from Trotter 1900); D – *A. kuko* (Kishida, 1927) (from Ripka and Sanchez 2017); E – *A. parawagnoni* (Kuang, 1983) (redrawn from Kuang 1983); F – *A. paramacrodonis* Kuang, 1988 (from Kuang 1988); G – *A. sodomaei* (Keifer, 1976) (redrawn from Keifer 1976); H – *A. melongena* (Zaher & Abou-Awad, 1979) (from Zaher and Abou-Awad 1979).
submedian lines .................. \textit{A. daturae} (Figure 3A) (from Soliman and Abou-Awad 1978)

13. Opisthosoma with about 58 annuli and \textit{sc} setae almost one and half the prodorsal shield length ......................... \textit{A. baliotes} (no Figure available) (from Nalepa 1921)
— Opisthosoma with about 70 annuli and \textit{sc} setae almost twice the prodorsal shield length . . . . . . \textit{A. lycopersici} (Figure 3B) (from Farkas 1965)

14. Empodium 5-rayed .............................................................. 15
— Empodium with more than 5 rays ........................................ 16

15. Prodorsal shield with numerous short dashes, obscuring the shield design ................
\textit{A. acnistii} (Figure 3C) (from Keifer 1953)
— Prodorsal shield mostly smooth, with just a few dotted transverse lines near rear margin . . \textit{Aceria dunaliae} (Boczek & Oleczek, 1988) \textbf{n. comb.} (Figure 3D) (from Boczek and Oleczek 1988)

\textbf{Note} Boczek and Oleczek (1988) assigned this species to the genus \textit{Paraphytoptus}. According to Amrine et al. (2003), members of this genus are characterized by wider annuli on the posterior opisthosoma. But in this species annuli of posterior opistosoma are continuous and subequal dorsoventrally and this species morphologically fits the diagnosis of the genus \textit{Aceria}, and therefore we propose a new combination, \textit{Aceria dunaliae} (Boczek and Oleczek, 1988) \textbf{n. comb.}

16. Prodorsal shield with submedian lines connected to admedian lines ........................
\textit{A. annui} (Figure 3E) (from Keifer 1977)
— Prodorsal shield without submedian lines ................................ 17

17. Median and admedian lines very short near rear prodorsal shield margin; spiny microtubercles ........................................ \textit{A. wagnoni} (Figure 3F) (from Keifer 1977)
— Without median lines, only short admedian lines present near rear prodorsal margin . . . 18

18. Prodorsal shield design close to the rear margin, consisting of short admedian lines subparallel, outwardly convex, surrounded laterally and posteriadly with granules; opisthosoma with about 70 annuli . . . \textit{A. macrodonis} (Figure 3G) (from Keifer 1965)
— Prodorsal shield design weak and close to the rear margin, admedian lines represented by short centrally curved lines on rear 1/4; opisthosoma with 60 rings ................................. \textit{A. caudicecis} (Figure 3H) (from Keifer 1972)

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Figure 3 Schematic drawings of the prodorsal shield of: A – *A. daturae* (Soliman & Abou-Awad, 1978) (from Soliman and Abou-Awad 1978); B – *A. lycopersici* (Wolffenstein, 1879) (redrawn from Farkas 1965); C – *A. acnistii* Keifer, 1953 (redrawn from Keifer 1953); D – *A. dunaliae* (Boczek & Oleczek, 1988) (redrawn from Boczek and Oleczek 1988); E – *A. annui* (Keifer, 1977) (redrawn from Keifer 1977); F – *A. wagnoni* (Keifer, 1977) (redrawn from Keifer 1977); G – *A. macrodonis* Keifer, 1965 (redrawn from Keifer 1965); H – *A. caulicecis* (Keifer, 1972) (redrawn from Keifer 1972).
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