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**THREE NEW SPECIES OF GALL-FORMING ERIOPHYID MITES
(ACARI: ERIOPHYIDAE) ON THE PAINTED MAPLE
(ACER PICTUM THUNB.) FROM JAPAN**

By YUKI YOSHINO, SHIN-ICHI AKIMOTO, FUJIO KADONO

Abstract

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Three eriophyid mites, *Aceria circularis* Yoshino & Kadono sp. nov., *Aceria acutiuscula* Yoshino & Kadono sp. nov., and *Aculops vallecularis* Yoshino & Kadono sp. nov., are described from Hokkaido, northern Japan. These species induce galls on the leaves of the painted maple, *Acer pictum*. *Aceria circularis* and *A. acutiuscula* induce granular-shaped galls on the adaxial and abaxial sides of the leaves, respectively, and *A. vallecularis* induces groove-shaped galls on both sides of the leaves. *Aceria* galls on the adaxial and abaxial sides are remarkably similar, thus species status was tested by comparing the morphology and DNA sequences of the mitochondrial Cytochrome oxidase subunit I. *Aceria* mites from the adaxial and abaxial granular shaped-galls are morphologically distinct and phylogenetically separated, confirming that they constitute different species, which are herein formally described.

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INTRODUCTION

The maple genus *Acer* (Aceraceae) is composed of 129 known species that are widespread in both the temperate and tropical regions of northern Africa, Asia, Europe, and Central and North America (Xu *et al.* 2008). More than 130 species of eriophyoid mites inhabiting on the leaves of *Acer* plants have been described from around the world, and of these mites, 30 species belong to the genus *Aceria* (Table 1) and 10 species belong to the genus *Aculops* (Table 2). In Japan, 26 *Acer* species have been reported (Iwatsuki *et al.* 1999). Although leaf galls and erineum induced by eriophyoid mites have been recorded from seven *Acer* species in Japan (Monzen 1922, 1930, 1932; Ito 1974; Yukawa and Masuda 1996), only two gall-inducing eriophyoid species, *Aceria macrorhynchus* (Nalepa, 1889) on *A. pictum* and *Aceria aceris* (Hodgkiss, 1930) on *A. rufinerve*, have been described (Monzen 1922; Ito 1974). However, the Japanese eriophyoid mites from *Acer* have not been taxonomically reviewed.

We found that remarkably similar galls were induced on the adaxial and abaxial sides of the leaves of *Acer pictum* Thunb.. The gall inhabitants belonged to *Aceria* but did not correspond to any known species. To clarify whether the difference in the gall positions reflects taxonomic difference or phenotypic plasticity, we compared the morphology and DNA sequences of the mitochondrial Cytochrome oxidase subunit I (mtCOI) of the gall inhabitants from the two gall types. Our results showed that the eriophyoids within the two gall types were morphologically and phylogenetically separated into two species. In addition, through the course of the study, we also found an additional eryophyoids species that forms apparently different-shaped galls on *Acer*.

In the present study, we newly describe three species of gall-inducing eriophyoid mites, *Aceria circularis* Yoshino & Kadono sp. nov., *A. acutiuscula* Yoshino & Kadono sp. nov., and *Aculops vallearularis* Yoshino & Kadono sp. nov. associated with the painted maple, *Acer pictum* Thunb..

MATERIALS AND METHODS

Collection and measurements of morphological characters

Galls (Figure 1) were collected from the leaves of the painted maple *A. pictum* in Hokkaido, northern Japan, from May to July 2021. Mites were picked up from the galls after dissection using an insect pin with a pig's eyelash in the laboratory. The mite specimens were mounted on glass slides using a modified Berlese solution (Amrine & Manson, 1996) and heated on a hot plate at 100 °C for at least 3 h. All type specimens of the new species described herein are deposited in Hokkaido University Insect Collection (SEHU), Sapporo, Japan. The mites were examined using a phase-contrast or bright-field microscope (Zeiss Axiophot[®] or Leica TCS SP5). Photo images were captured using a digital microscope camera (Zeiss Axiocam ERc 5s[®] or Leica TCS SP5[®]). The images were stacked using a Zerene Stacker (Zerene Systems, LLC, Richland, WA, USA), and schematic drawings were created by tracing the photo images with a drawing tool in CLIP STUDIO PAINT (clipstudio.net). The measurement methods followed Lindquist (1996) and de Lillo *et al.* (2010). In the descriptions, we provided the measurements of the holotype only. The average and range of measurements of the holotype and paratype were shown in the Table 4, 6 and 8. Because males and immatures were not collected,

Table 1 List of *Aceria* recorded from *Acer* spp.

Species	Type host	Type locality	Other locality	Habitus
<i>Aceria aceris</i> (Hodgkiss, 1930)	<i>Acer saccharum</i>	Geneva, New York, USA	-	leaf reddish erineum, undersurface of leaf
<i>Aceria aceriscampestris</i> (Nalepa, 1922)	<i>Acer campestre</i>	?, Austria?	Europe	leaf spherical galls
<i>Aceria antonimus</i> (Keifer, 1962)	<i>Acer negundo californicum</i>	Sacramento, California, USA	-	bud
<i>Aceria calaceris</i> Keifer, 1952	<i>Acer glabrum</i>	California, USA	Turkey	purplish-red erineum on the leaf tops
<i>Aceria cephaloneus</i> (Nalepa, 1922)	<i>Acer pseudoplatanus</i>	?, Austria?	Europe (Hungary, Latvia, Poland), North America	tiny bead leaf galls
<i>Aceria crassipunctatus</i> (Nalepa, 1909)	<i>Acer campestre</i>	?, Austria?	Europe (Czech)	galls
<i>Aceria elongatus</i> (Hodgkiss, 1913)	<i>Acer saccharum</i>	New York?, USA	Canada	erineum
<i>Aceria eriobius</i> (Nalepa, 1922)	<i>Acer pseudoplatanus</i>	?, Austria?	Italy, Czech, UK	erineum
<i>Aceria heteronyx</i> (Nalepa, 1891)	<i>Acer campestre</i>	?, Europe	Europe (Czech, Italy, France, Hungary)	bark galls
<i>Aceria lophophyes</i> (Nalepa, 1922)	<i>Acer campestre</i>	?, Austria?	-	abnormal erineum
<i>Aceria macrochelus</i> (Nalepa, 1891)	<i>Acer campestre</i>	?, Austria?	Europe ?	leaf spherical galls
<i>Aceria macrocheluserinea</i> (Trotter, 1902)	<i>Acer campestre</i>	?, Italy	Europe (Poland)	leaf erineum
<i>Aceria macrorhynchus</i> (Nalepa, 1889)	<i>Acer pseudoplatanus</i>	?, Austria?	Europe (Czech, Denmark, France, UK, Hungary, Iran, Italy, Krim (Ukraine), Montenegro, Poland)	elongate leaf gall
<i>Aceria major</i> (Hodgkiss, 1913)	<i>Acer rubrum</i>	New York, USA	-	leaf erineum
<i>Aceria marshalli</i> (Keifer, 1972)	<i>Acer macrophyllum</i>	Beacon Hill, Victoria, Vancouver Isl., Br. Colombia, Canada	Europe (Hungary)	tiny bead galls on the surface of leaf
<i>Aceria modestus</i> (Hodgkiss, 1913)	<i>Acer saccharum</i>	Bug Lake, Adirondack, Mts., New York, USA	Canada	green erineum on the undersurface of the leaf
<i>Aceria monspessulani</i> (Cecconi, 1902)	<i>Acer monspessulanum</i>	Sardinia, Italy	Europe (Montenegro)	leaf read erineum
<i>Aceria monspessulinerineus</i> (Nalepa, 1922)	<i>Acer monspessulanum</i>	?, Austria?	-	erineum
<i>Aceria negundi</i> (Hodgkiss, 1913)	<i>Acer negundo</i>	Bug Lake, Adirondack, Mts., New York, USA	Canada	wart-like swelling leaf galls
<i>Aceria opulifoliae</i> (Nalepa, 1922)	<i>Acer opalus</i>	?, Austria?	-	galls
<i>Aceria ornatae</i> (Hodgkiss, 1913)	<i>Acer rubrum</i>	New York?, USA	-	pinkish erineum on the undersurface of the leaf
<i>Aceria parallelus</i> (Hodgkiss, 1913)	<i>Acer spicatum</i>	New York, USA	-	whitish erineum on the undersurface of the leaf
<i>Aceria phyllerites</i> (Nalepa, 1922)	<i>Acer pseudoplatanus</i>	not listed, Austria?	-	erineum
<i>Aceria platanoideus</i> (Nalepa, 1922)	<i>Acer platanooides</i>	?, Austria?	Finland, Czech, Latvia	erineum
<i>Aceria pseudoplataneus</i> (Nalepa, 1922)	<i>Acer pseudoplatanus</i>	?, Austria?	Europe (Montenegro)	?
<i>Aceria pseudoplatani</i> (Corti, 1905)	<i>Acer pseudoplatanus</i>	Lanzada, Val Malenco (Valtellina), Italy	Europe (Czech, Denmark/Faroe Is.), UK, Latvia, Poland)	leaf erineum
<i>Aceria psilomerus</i> (Nalepa, 1922)	<i>Acer pseudoplatanus</i>	?, Austria?	-	erineum
<i>Aceria regulus</i> (Hodgkiss, 1913)	<i>Acer platanooides</i>	New York, USA	Canada	red erineum on the uppersurface of the leaf
<i>Aceria spicati</i> (Stebbins, 1909)	<i>Acer spicatum</i>	Springfield, Massachusetts, USA	North America ?, China	hairy whitish leaf galls
<i>Aceria vermicularis</i> (Nalepa, 1902)	<i>Acer obtusatum</i>	Botanical Garden in Vienna, Austria	Europe (Czech)	bud swelling

Table 2 List of *Aculops* recorded from *Acer* spp.

Species	Type host	Type locality	Other locality	Habitus
<i>Aculops abloppurpureus</i> (Huang, 2001) comb. nov.	<i>Acer abloppurpureus</i>	Hualien, W Taipei, China	-	vagrant
<i>Aculops acericola</i> (Nalepa, 1894)	<i>Acer pseudoplatanus</i>	? , Austria?	Europe (Denmark, Montenegro)	vagrant
<i>Aculops aceris</i> (Nalepa, 1894)	<i>Acer campestre</i>	China, Henan Province, Hui County, Baligou	Czech, Italy, Poland	erineum galls
<i>Aculops baligouis</i> Xue, Song and Hong, 2007	<i>Acer</i> sp.	Fallen Leaf Lake, El Dorado Co., California, USA	-	vagrant
<i>Aculops glabri</i> (Keifer, 1952)	<i>Acer glabri</i>	Shengningjia, Hubei Province, China	-	erineum
<i>Aculops longispinosus</i> Kuang and Hong, 1989	<i>Acer</i> sp.		-	vagrant
<i>Aculops macilata</i> (Hodgkiss, 1913)	<i>Acer saccharum</i>	New York?, USA	Canada	red erineum on the under surface of the leaf
<i>Aculops mononis</i> (Xue and Hong, 2008) comb. nov.	<i>Acer pictum</i>	Guan'e Gou, Dangechang County, Gansu Province, China	-	vagrant
<i>Aculops paraglabri</i> (Keifer, 1952)	<i>Acer glabrum</i>	Fallen Leaf Lake, El Dorado Co., California, USA	Iran	erineum
<i>Aculops spinithius</i> (Keifer, 1966)	<i>Acer saccharinum</i>	Ludlow, Vermont, USA	-	erineum

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Table 3 List of samples used for DNA extraction.

No.	Collect date	Locality	Species	Assetion number
1	6/1/21	Yūbari, Hokkaidō, Japan. 42.8818N,142.0331E	<i>Aceria acutiuscula</i>	LC669553
2	6/1/21	Yūbari, Hokkaidō, Japan. 42.8818N,142.0331E	<i>Aceria acutiuscula</i>	LC669553
3	6/1/21	Yūbari, Hokkaidō, Japan. 42.8818N,142.0331E	<i>Aceria acutiuscula</i>	LC669553
4	6/10/21	Masike, Hokkaidō, Japan. 43.7947N,141.5248E	<i>Aceria circularis</i>	LC669558
5	6/10/21	Masike, Hokkaidō, Japan. 43.7947N,141.5248E	<i>Aceria acutiuscula</i>	LC669554
6	6/23/21	Ishikari, Hokkaidō, Japan. 43.6916N,141.3434E	<i>Aceria acutiuscula</i>	LC669555
7	6/23/21	Masike, Hokkaidō, Japan. 43.7947N,141.5248E	<i>Aceria circularis</i>	LC669559
8	6/23/21	Masike, Hokkaidō, Japan. 43.7947N,141.5248E	<i>Aceria circularis</i>	LC669559
9	6/23/21	Masike, Hokkaidō, Japan. 43.7947N,141.5248E	<i>Aceria acutiuscula</i>	LC669556
10	7/4/21	Hirafū, Hokkaidō, Japan. 42.8463N,140.7230E	<i>Aceria circularis</i>	LC669557

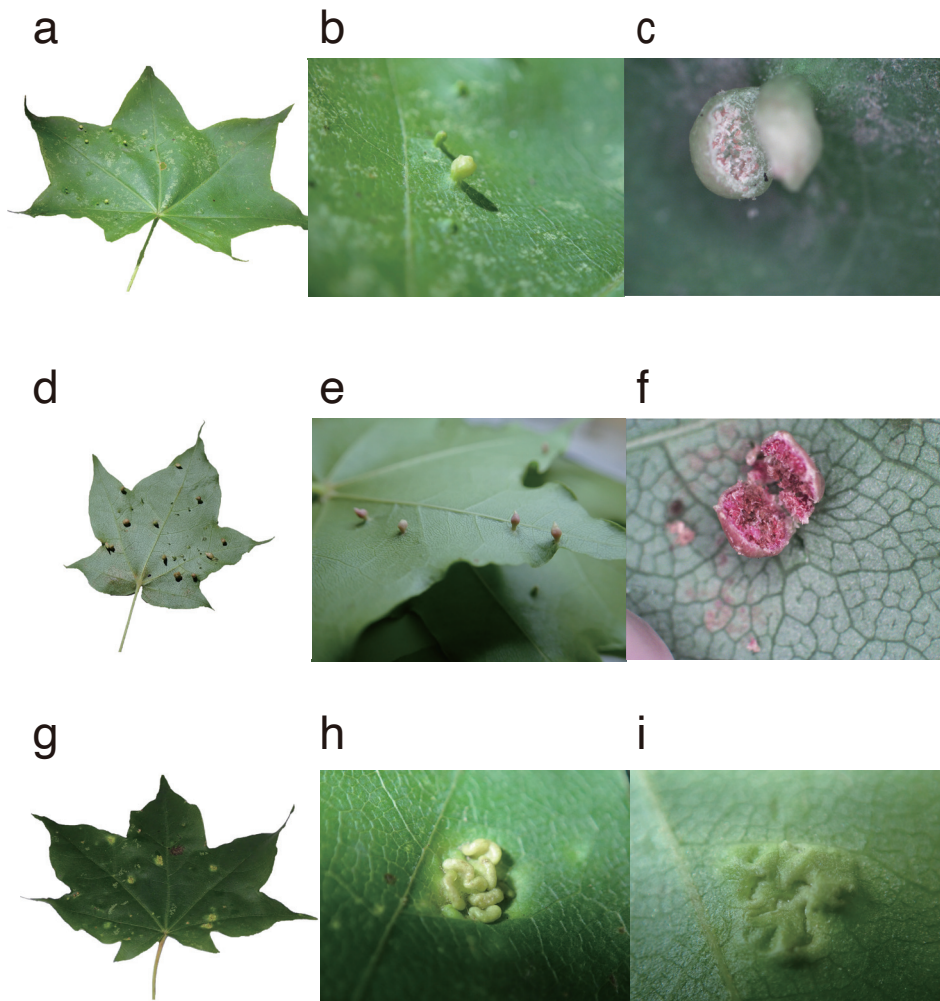


Figure 1 Galls on the leaves of *Acer pictum*. *Aceria circularis* sp. nov. a – galls on the adaxial side of leaf, b – galls caused by *A. circularis*, c – inner side of a gall. *Aceria acutiuscula* sp. nov. d – galls on the abaxial side of the leaf, e – galls caused by *A. acutiuscula*, f – inner side of a gall. *Aculops vallecularis* sp. nov. g – galls on the both side of leaf, h – a gall caused by *A. vallecularis*, i – inner side of a gall.

they were not included in the types. All host plant names and their synonyms were based on “The Plant List on-line database” (2013).

DNA extraction, amplification, and sequencing

Whole DNA was extracted from four specimens from adaxial galls and six specimens from abaxial gall (Table 3). One mite was soaked in 10 μ L of protease K solution, to which 200 μ L of 10% Chelex-EDTA solution was added. The whole solution

was incubated at 56 °C for at least 6 h, followed by incubation at 95 °C for 5 min to inactivate protease K. The solution was centrifuged at 13,000 rpm for 10 min and the resin and water layers were separated. Only the water layer was absorbed and transferred into a 1.5 mL tube, to which 10 µL of 3 M sodium acetate solution (pH 7.0), 1 µL of glycogen, and 277.5 µL of 99.5% EtOH were added. After centrifugation at 13,000 rpm for 15 min, the precipitate was washed twice with 70% EtOH, and the supernatant was decanted. After complete evaporation of the EtOH, 20 µL of distilled water was added to dissolve the DNA. The extracted DNA was stored at -12 °C.

Fragments of mitochondrial Cytochrome oxidase subunit I (*mtCOI*) were amplified for species identification based on the barcoding region and to construct molecular phylogenies. A universal primer set, LCO1490 (5'- GGT CAA CAA ATC ATA AAG ATA TTG G -3') and HCO2198 (5'- TAA ACT TCA GGG TGA CCA AAA AAT CA -3') (Folmer *et al.* 1994), was used to amplify ca. 650 bp fragments of partial *mtCOI*. Amplification was performed using a thermal cycler (BioRad T100™) in a 20 µL system (7.3 µL D.W., 4 µL kapa, 2 µL MgCl₂, 0.6 µL dNTPs, 1 µL forward primer, 1 µL reverse primer R, 0.1 µL Taq, and 4 µL DNA). Thermocycles consisted of an initial denaturation step at 94 °C for 2 min, followed by 20 cycles of denaturation at 94 °C for 15 s, annealing at 40 °C for 40 s, and extension at 68 °C for 1 min. After 1st cycle, 2nd cycle followed by 25 cycles of denaturation at 94 °C for 15 s, annealing at 45 °C for 40 s, and extension at 68 °C for 1 min. The final extension was at 68 °C for 10 min. After confirming the PCR amplification on a 1.5% agarose gel, the amplified products were purified and sequenced using a Sanger sequencer (Beckman Coulter CEQ2000XL).

Phylogenetics

To clarify the phylogenetic relationships between mites in granular-shaped galls induced on the adaxial and abaxial sides of the leaf, we constructed a phylogenetic tree using the maximum likelihood (ML) method based on the *mtCOI* sequences. *Aceria fennica* (Lindroth, 1899) associated with *Betula nana* was selected as an outgroup taxon, whose sequence was obtained from GenBank (KU315234.1). All sequences were aligned using ClustalW (Higgins *et al.* 1994) in MEGAX (Kumar *et al.* 2018). The aligned sequences were trimmed to 527 bp. and deposited to GenBank (see Table 3 for the accession numbers). For the ML method, partitioning and nucleotide substitution models for each partition were selected using PartitionFinder2 (Lanfear *et al.* 2017). The F81 model was adopted for the second codon position, and the HKY model for the first and the third codon positions. ML tree was estimated by using MEGAX. The bootstrap values of each branch of the constructed ML tree was calculated using IQ-TREE (Nguyen *et al.* 2015), with 1,000 replicates of an ultrafast likelihood bootstrap. The pairwise distances (*p*-distances) among the samples were examined using MEGAX. The number of segregating sites and nucleotide diversity were calculated by DnaSP 6 (Julio *et al.* 2017).

RESULTS AND DISCUSSION

Phylogenetics

The number of segregating sites and nucleotide diversity were 155 and 0.15, respectively. The GC composition ranged from 33.4% to 35.5%. The p -distances between adaxial and abaxial gall mites ranged from 20.3% to 22.6%, which were larger than the p -distances observed within adaxial and abaxial gall mites, 9.11% and 12.9%, respectively.

There were only one or two base substitutions in the DNA sequence among samples 1, 5, 6, and 9 (*A. acutiuscula* Yoshino & Kadono sp. nov.) and among samples 4, 7, and 10 (*A. circularis* Yoshino & Kadono sp. nov.) (Figure 2). *Aceria* mites inhabiting galls on the adaxial and abaxial sides of *A. pictum* leaves each formed a monophyletic group with bootstrap supports of 80 and 99, respectively (Figure 2). Additionally, we recognized morphological differences between these two mites as discussed below. We conclude that they belong to separate species, and the positional difference of galls represents species status. Below, those two mites are formally described as *A. circularis* (adaxial side galls) and *A. acutiuscula* (abaxial side galls).

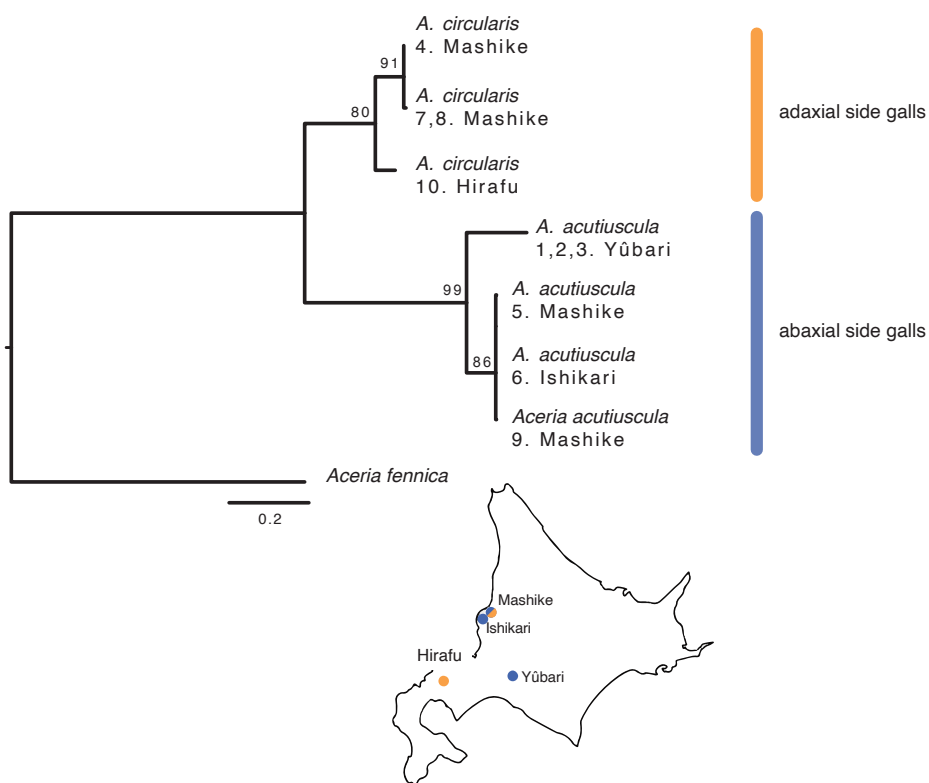


Figure 2 Phylogenetic tree of *Aceria circularis* sp. nov. and *Aceria acutiuscula* sp. nov.

Descriptions

Family Eriophyidae Nalepa, 1898
Subfamily Eriophyinae Nalepa, 1898
Tribe Aceriini Amrine & Stasny, 1994
Genus *Aceria* Keifer, 1944

Aceria circularis Yoshino & Kadono sp. nov.

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(Figures 3, 4 and Tables 4, 5)

Diagnosis

Prodorsal shield median line absent; admedian lines complete and divergent to rear; submedian line complete and running along side; shield projection absent. Setae *c2* shorter than *d*. Setae on coxisternum I *1b* normal in length. Tarsal solenidion longer than empodium.

Female holotype.

Body vermiform, 138 long, 44 wide.

Gnathosoma projecting obliquely downwards. Dorsal pedipalp genual setae *d 2* unbranched. Prodorsal shield 20, 24 wide, semicircular sometimes with a very short median line on the posterior end; admedian lines complete and divergent to the rear; submedian lines complete and running along the side; scapular tubercles trapezoid, 22 apart; scapular setae *sc 25*, directed divergently backward.

Legs with all usual segments and setae. Tarsal solenidion distally rounded; tarsal empodium simple.

Coxisternal plates smooth; prosternal apodeme entire, distinct 6; lateral setae on coxisternum I *1b 7*, 8 apart; setae on coxisternum I *1a 26*, 10 apart; proximal setae on coxisternum II *2a 35*, 17 apart. External genitalia 7, 17 wide; coverflap subtriangular, with 8 longitudinal striae; setae *3a 4*, 13 apart. Coxigenital region with 4 semiannuli, microtubercles.

Opisthosoma with subequal annuli: 53 dorsal semiannuli, with microtubercles, which gradually disappear from about 40th annulus to anal lobe; 48 ventral annuli with hemispherical microtubercles (counted from first complete annulus after coxae II); setae *c2 14*, 44 apart, on 4th ventral annulus; setae *d 34*, 32 apart, on 13th ventral annulus; setae *e 7*, 18 apart, on ventral annulus 24; setae *f 15*, 15 apart, on 42nd ventral annulus, on 5th ventral annulus from rear; setae *h2 53*; 12 apart; setae *h1 3*, 7 apart.

Host plant. *Acer pictum* Thunb.

Type material. Holotype female: JAPAN: Hokkaidō, Sapporo-shi, Minami-ku, Shirakawa, Kannonzawa, 42.58076N 141.15557E, alt. 15 m, 19.V.2021, Yuki Yoshino leg. Paratypes: 5 females, ditto; 6 females, JAPAN: Hokkaidō, Yūbari-shi, near the Takinoue Station, Forest road, 42.914793N 141.964224E, alt. 119.5 m, 1.VI.2021, Yuki Yoshino leg.

Relation to host. Living in globular-shaped galls with a rounded tip on the adaxial side of the leaf (Figure 1a–c).

Etymology. The species epithet comes from a Latin singular feminine adjective *circularis*, meaning rounded, with reference to the globular-shaped galls with a rounded tip.

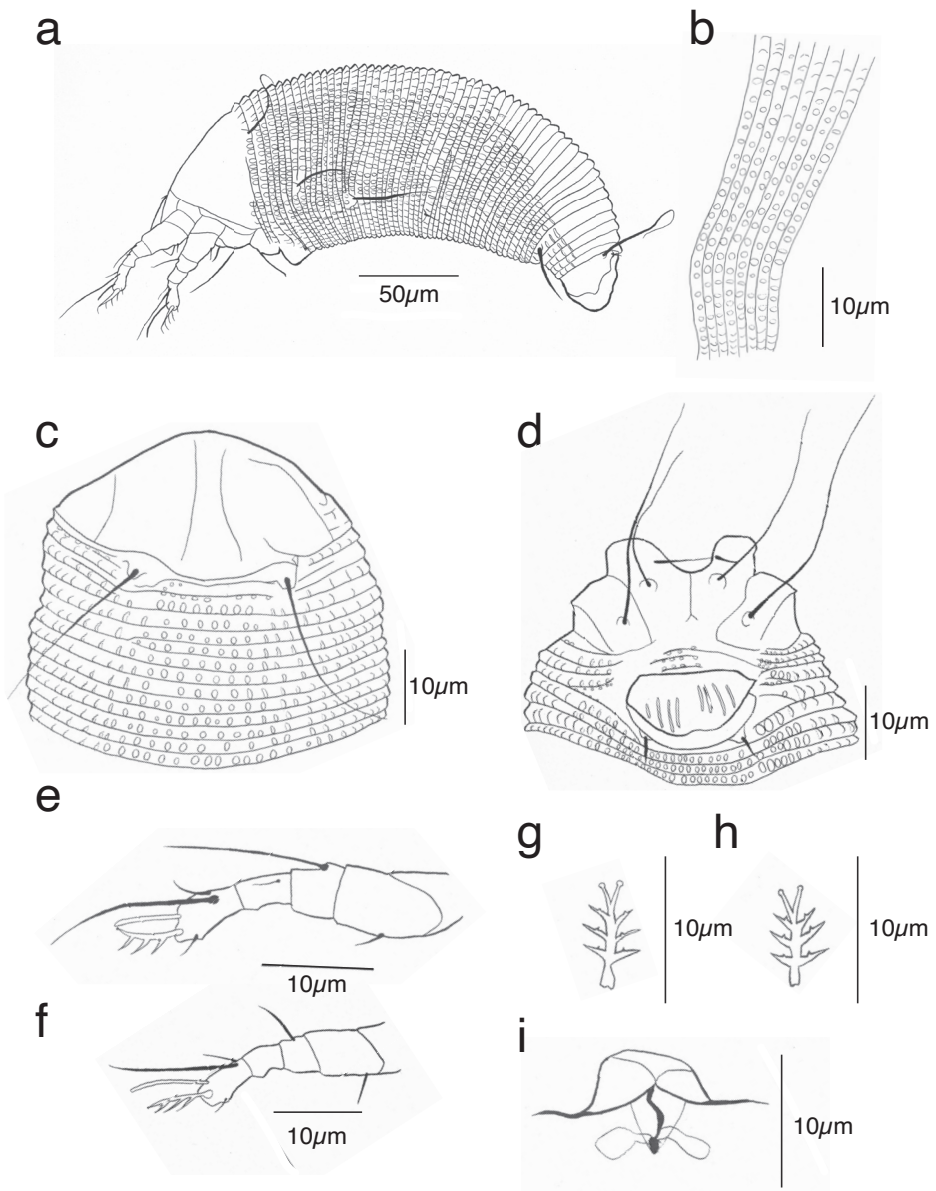


Figure 3 Drawings of *Aceria circularis* sp. nov. a – lateral view of the body, b – lateral view of the abdomen, c – prodorsal shield, d – coxigenital region of female, e – leg I, f – leg II, g – empodium I, h – empodium II, i – internal genitalia of female.

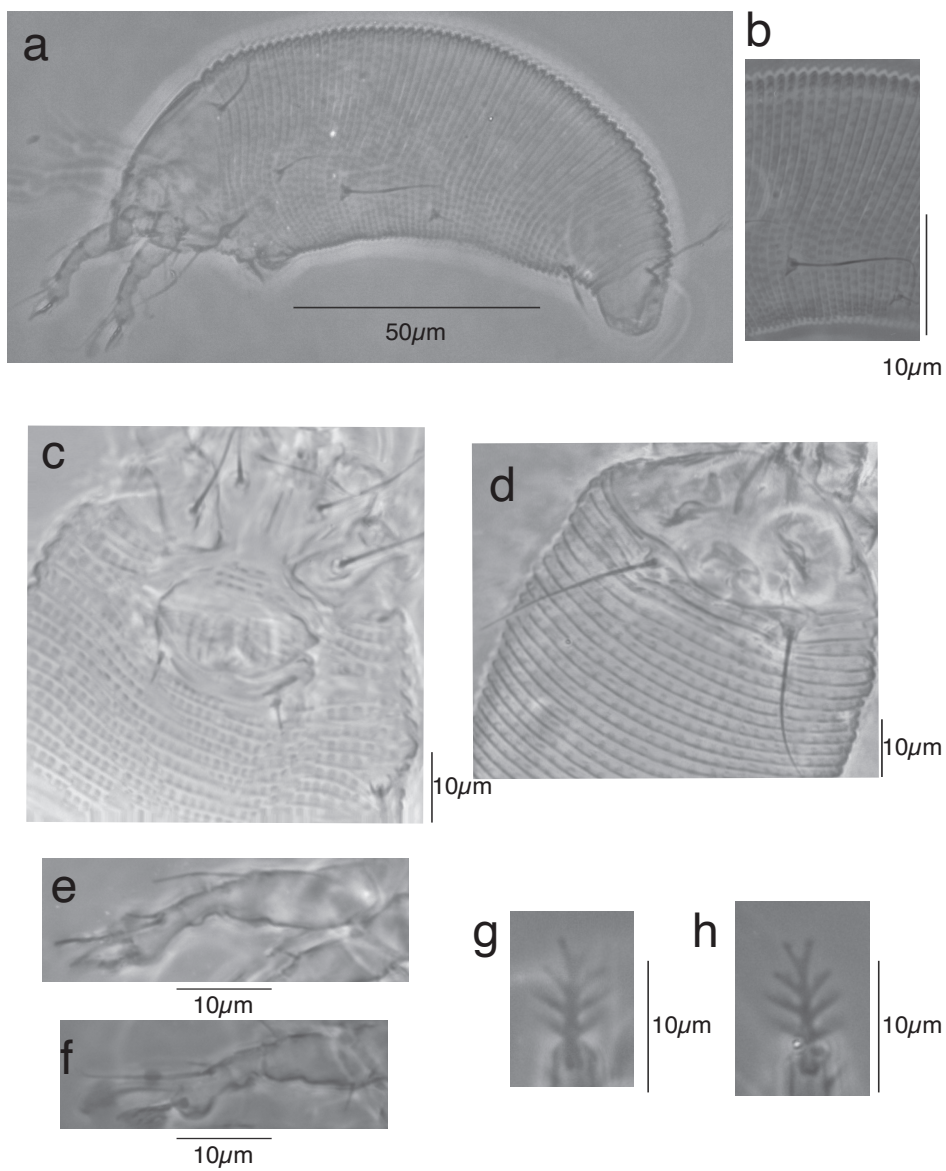


Figure 4 Phase-contrast light microscope images of *Aceria circularis* sp. nov. a – lateral view of the body, b – lateral view of the abdomen, c – prodorsal shield, d – coxigenital region of female, e – leg I, f – leg II, g – empodium I, h – empodium II.

Remarks. *A. circularis* is similar to *A. macrorhyncha* (Nalepa, 1889), *A. negundi* (Hodgkiss, 1913) and *A. regulus* (Hodgkiss, 1913) in the prodorsal shield pattern of lines but differs from them by having the setae *c2* shorter than setae *d* (*c2* as long as *d* in *A. macrorhyncha*), by the absence of an anterior prodorsal shield projection (present in *A. macrorhyncha*), by having the setae on coxisternum I *1b* of normal length (*1b* very short in *A. negundi*), and by having the solenidion longer than the tarsal empodium (the solenidion shorter than the tarsal empodium in *A. regulus*).

Table 4 Measurements of *Aceria circularis* n. sp. (n=12)

Characters	Avarage	Range	Characters	Avarage	Range
Length of body	141	126–161	Length of tarsal empodium (legII)	5	5–6
Thick of body	43	34–47	Number of tarsal empodium ray (legII)	4	4–4
Width of body	40	36–44	Length of prosternal apodeme	6	5–7
Length of chrlcerae	11	9–14	Length of anterior setae <i>1b</i>	9	7–10
Length of palp	16	15–18	Distance between anterior setae <i>1b</i>	8	8–9
Length of dorsal pedipalp coxal setae <i>ep</i>	3	3–3	Length of proximal setae <i>1a</i>	25	20–26
Length of dorsal pedipalp genual setae <i>d</i>	2	1–2	Distance between proximal setae <i>1a</i>	10	9–10
Length of prodorsal shield	23	19–24	Length of proximal setae <i>2a</i>	39	33–43
Width of prodorsal shield	26	24–27	Distance between proximal setae <i>2a</i>	19	17–20
Distance between scapular tubercles	21	20–22	Length of external genitalia	7	7–8
Length of scapular setae <i>sc</i>	26	24–27	Width of external genitalia	17	17–18
Length of leg I	27	25–31	Number of longitudinal striae	9	8–9
Length of femur (legI)	9	7–10	Length of genital setae <i>3a</i>	4	3–5
Length of basiventral femoral setae <i>bv</i> (legI)	3	3–3	Distance between genital setae <i>3a</i>	13	13–14
Length of genu (legI)	4	3–5	Number of coxigenital region semiannuli	3	3–4
Length of antaxial genual setae <i>1''</i> (legI)	19	17–20	Number of dorsal semiannuli	53	52–54
Length of tibia (legI)	5	5–6	Number of ventral semiannuli	50	45–57
Length of paraxial tibial setae <i>1'</i> (legI)	2	2–3	Length of opisthosomal setae <i>c2</i>	15	13–17
Length of tarsus (legI)	7	6–8	Distance between opisthosomal setae <i>c2</i>	40	36–44
Length of paraxial, fastigial, tarsal setae <i>f1'</i> (legI)	6	5–8	Number of semiannuli on opisthosomal setae <i>c2</i>	4	3–5
Length of antaxial, fastigial, tarsal setae <i>f1''</i> (legI)	17	15–19	Length of opisthosomal setae <i>d2</i>	37	30–44
Length of tarsal solenidion (legI)	7	6–8	Distance between opisthosomal setae <i>d2</i>	32	31–34
Length of tarsal empodium (legI)	6	5–6	Number of semiannuli on opisthosomal setae <i>d2</i>	14	13–15
Number of tarsal empodium ray (legI)	4	4–4	Length of opisthosomal setae <i>f</i>	8	6–10
Length of legII	23	21–25	Distance between opisthosomal setae <i>e</i>	18	18–19
Length of femur (legII)	8	7–10	Number of semiannuli on opisthosomal setae <i>e</i>	26	24–29
Length of basiventral femoral setae <i>bv</i> (legII)	3	3–3	Length of opisthosomal setae <i>f</i>	13	12–15
Length of genu (legII)	4	3–4	Distance between opisthosomal setae <i>f</i>	14	14–15
Length of antaxial genual setae <i>1''</i> (legII)	8	5–11	Number of semiannuli on opisthosomal setae <i>f</i>	46	42–49
Length of tibia (legII)	4	3–4	Number of semiannuli on opisthosomal setae <i>f</i> from rear	5	5–6
Length of tarsus (legII)	6	6–7	Length of setae <i>h1</i>	3	3–4
Length of paraxial, fastigial tarsal setae <i>f1'</i> (legII)	3	3–4	Distance between setae <i>h1</i>	8	7–9
Length of antaxial, fastigial, tarsal setae <i>f1''</i> (legII)	19	15–22	Length of setae <i>h2</i>	46	32–53
Length of tarsal solenidion (legII)	9	8–10	Distance between setae <i>h2</i>	12	12–12

Table 5 Difference between *Aceria circularis* and other species

Species	median line	admedian line	submedian line	prodorsal shield projection	setae c2	setae 1b	solenidion
<i>Aceria circularis</i> sp. nov.	absent	complete, divergent to the rear	complete, running along side	none	c2 shorter than d	normal length	solenidion longer than empodium
<i>Aceria macrorhyncha</i> (Nalepa, 1889)	present	complete, divergent to the rear	complete, running along side	present	c2 as long as d	normal length	solenidion longer than empodium
<i>Aceria negundi</i> (Hodgkiss, 1913)	absent	complete, divergent to the rear	4 lines complete, divergent to the rear	none	c2 shorter than d	very short	solenidion longer than empodium
<i>Aceria regulus</i> (Hodgkiss, 1913)	absent	complete, divergent to the rear	4 lines complete, divergent to the rear	none	c2 shorter than d	normal length	solenidion shorter than empodium

Aceria acutiuscula Yoshino & Kadono sp. nov.

Zoobank: urn:lsid:zoobank.org:act:FC9B195F-2D17-4EAC-A160-53CCEA44C992

(Figures 5, 6 and Tables 6, 7)

Diagnosis

Prodorsal shield median line present and short; submedian lines present and short, slightly longer than median line; 2–3 longitudinal submedian lines present on the side; setae *sc* as long as prodorsal shield. Microtubercles hemispherical in shape. Tarsal empodium 4-rayed.

Female holotype.

Body vermiform, 126 long, 36 wide.

Gnathosoma projecting obliquely downwards; dorsal pedipalp genual setae *d* 2 unbranched.

Prodorsal shield 18, 24 wide, semicircular; shield pattern composed of a very short median line and admedian lines on the posterior end; admedian lines slightly longer than median line and 2–3 longitudinal submedian lines on the side, one of which is almost complete and the rest are on anterior part only; tubercles of *sc* setae trapezoid, 17 apart; setae *sc* 24, directed divergently backward.

Legs with all usual segments and setae. Tarsal solenidion distally rounded; tarsal empodium simple.

Coxisternal plates smooth; prosternal apodeme entire, distinct, 6; setae on coxisternum I *lb* 1, 7 apart; setae on coxisternum I *la* 16, 8 apart; setae on coxisternum II *2a* 28, 17 apart.

External genitalia 5, 14 wide, 8 longitudinal line on coverflap; setae *3a* 2, 12 apart. Coxigenital region with 6 semiannuli, microtubercles.

Opisthosoma with subequal annuli; 59 dorsal semiannuli with hemispherical microtubercles, which gradually disappear on last 5 annuli; 54 ventral semiannuli with hemispherical microtubercles (counted from first complete annulus after coxae II); setae *c* 2 12, 36 apart, on 3rd ventral annulus; setae *d* 31, 30 apart, on 12th ventral annulus; setae *e* 5, 16 apart, on 26th ventral annulus; setae *f* 10, 15 apart, on 50th ventral annulus, on 5th ventral annulus from rear; setae *h* 2 50, 11 apart; setae *h* 1 3, 9 apart.

Host plant. *Acer pictum* Thunb.

Type material. Holotype female: JAPAN: Hokkaidō, Sapporo-shi, Minami-ku, Shirakawa, Kannonzawa, 42.58076N 141.15557E, alt. 15 m, 19.V.2021, Yuki Yoshino leg. Paratypes: JAPAN: 8 females, Hokkaidō, Sapporo-shi, Minami-ku, Shirakawa, Kannonzawa, 42.58076N 141.15557E, alt. 15 m, 19.V.2021 Yuki Yoshino leg.; 3 females, JAPAN: Hokkaidō, Yūbari-shi, Tyobotunai river, Forest road, 42.881882N 142.033171E, alt. 225 m, 1.VI.2021, Yuki Yoshino leg.

Relation to host. Living in globular-shaped galls with a pointed tip on the abaxial side of the leaf (Figure 1d–f).

Etymology. The species epithet comes from a Latin feminine adjective *acutiuscula*, meaning pointed, with reference to the globular-shaped galls with a pointed tip.

Remarks. *A. acutiuscula* is similar to *A. clerodendronis* (Farkas, 1960), *A. ligustri* (Keifer, 1943), *A. macrotuberculata* (Nalepa, 1895), *A. pallida* Keifer, 1964, and *A. squalida* (Nalepa, 1892) in having the prodorsal shield with short median and admedian lines near the rear shield margin but differs from them by having the four-rayed tarsal empodium (five-rayed in *A. clerodendronis*, *A. ligustri* and *A. pallida*), by having median

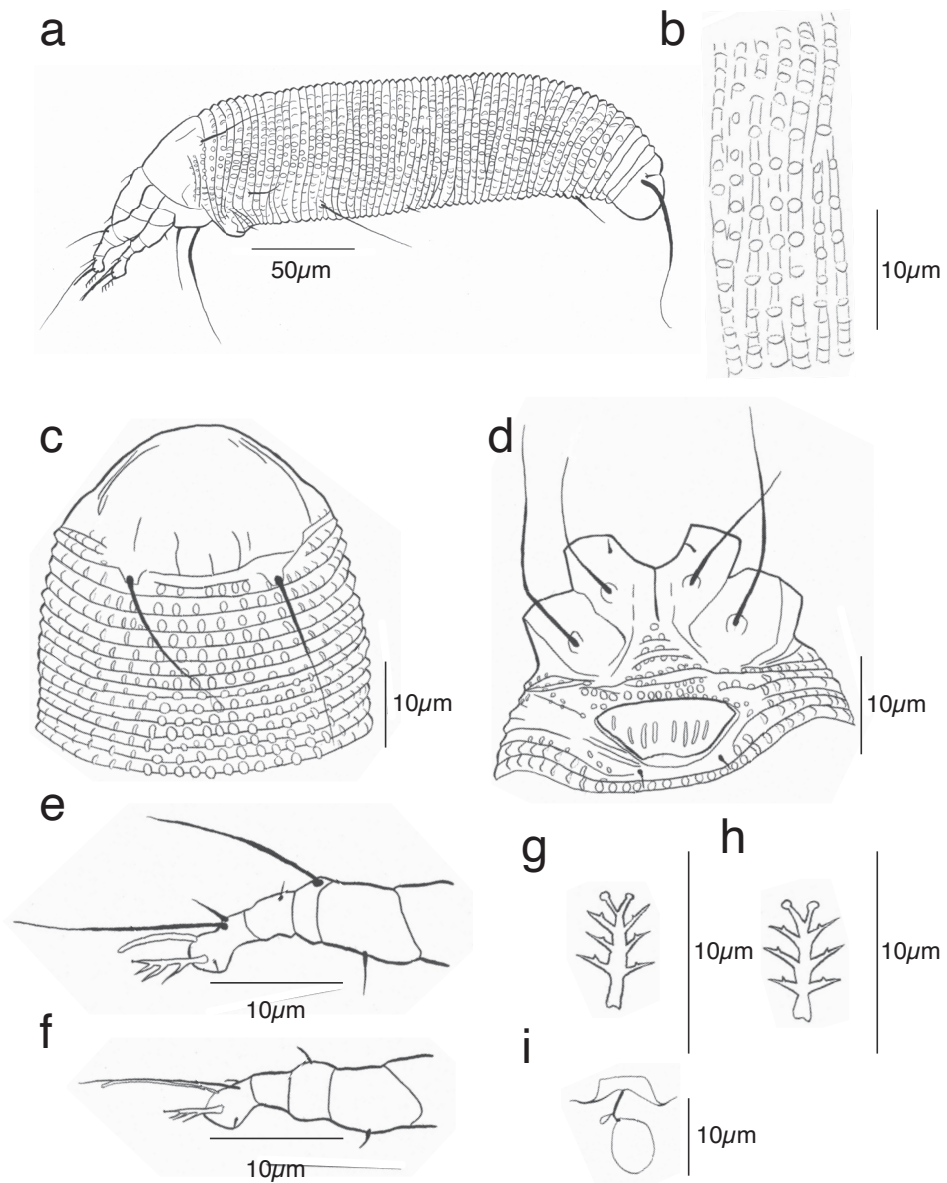


Figure 5 Drawings of *Aceria acutiuscula* sp. nov. a – lateral view of the body, b – lateral view of the abdomen, c – prodorsal shield, d – coxigenital region of female, e – leg I, f – leg II, g – empodium I, h – empodium II, i – internal genitalia of female.

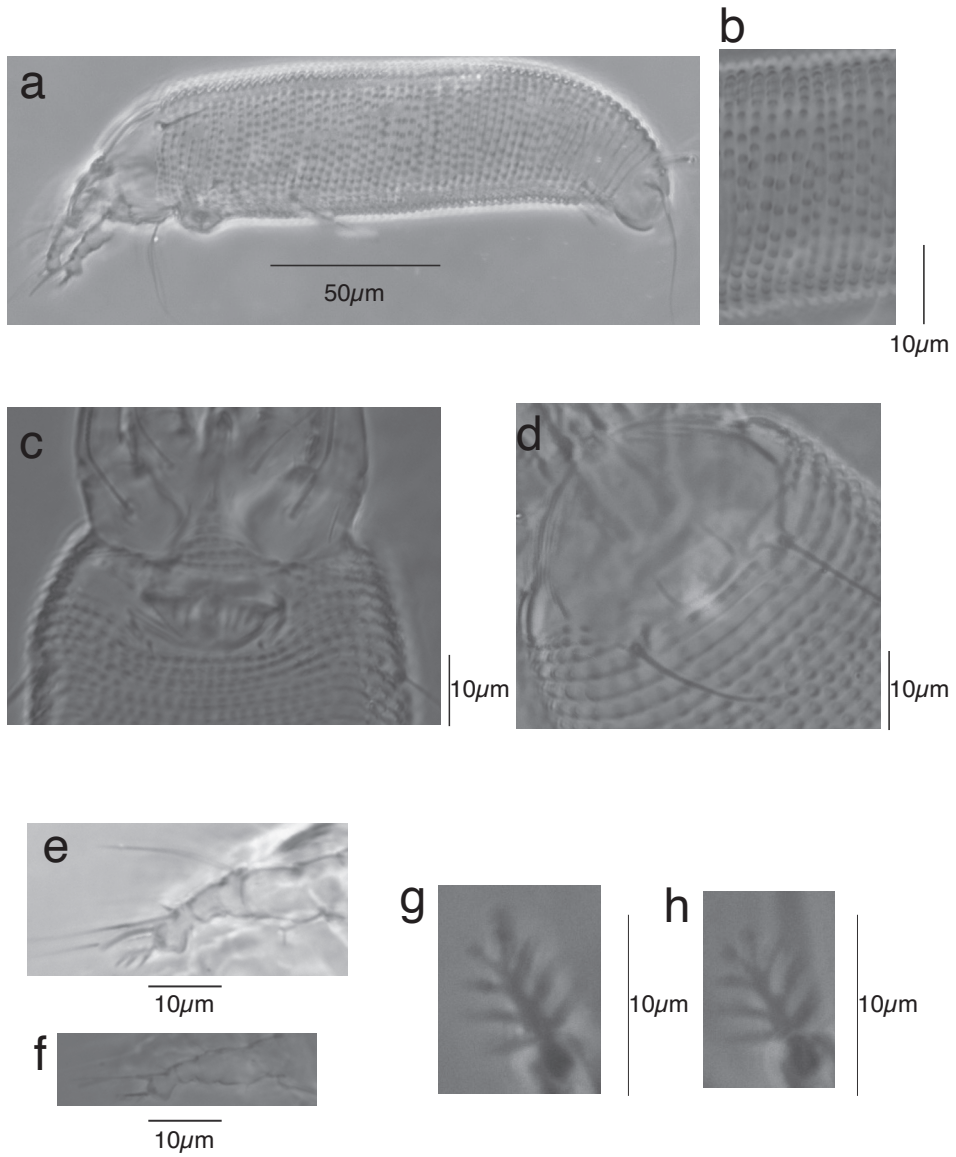


Figure 6 Phase-contrast light microscope images of *Aceria acutiuscula* sp. nov. a – lateral view of the body, b – lateral view of the abdomen, c – prodorsal shield, d – coxigenital region of female, e – leg I, f – leg II, g – empodium I, h – empodium II.

Table 6 Measurements of *Aceria acutiuscula* n. sp. (n=12)

Characters	Avarage	Range	Characters	Avarage	Range
Length of body	171	126–201	Length of tarsal empodium (legII)	4	4–5
Thick of body	37	31–46	Number of tarsal empodium ray (legII)	4	4–4
Width of body	37	34–43	Length of prosternal apodeme	7	5–7
Length of chrlcraeae	12	11–14	Length of anterior setae <i>1b</i>	2	1–2
Length of palp	16	14–18	Distance between anterior setae <i>1b</i>	8	7–8
Length of dorsal pedipalp coxal setae <i>ep</i>	3	2–4	Length of proximal setae <i>1a</i>	12	8–17
Length of dorsal pedipalp genual setae <i>d</i>	2	1–2	Distance between proximal setae <i>1a</i>	8	7–8
Length of prodorsal shield	20	18–21	Length of proximal setae <i>2a</i>	24	20–28
Width of prodorsal shield	23	21–24	Distance between proximal setae <i>2a</i>	16	11–17
Distance between scaplar tubercles	18	17–18	Length of external genitalia	6	5–7
Length of scapular setae <i>sc</i>	24	23–25	Width of external genitalia	14	13–14
Length of leg I	22	20–28	Number of longitudinal striae	8	5–8
Length of femur (legI)	8	6–9	Length of genital setae <i>3a</i>	2	2–4
Length of basiventral femoral setae <i>bv</i> (legI)	2	2–3	Distance between genital setae <i>3a</i>	11	11–12
Length of genu (legI)	3	3–4	Number of coxigenital region semiannuli	5	4–6
Length of antaxial genual setae <i>l'</i> (legI)	15	13–17	Number of dorsal semiannuli	60	56–63
Length of tibia (legI)	4	3–4	Number of ventral semiannuli	57	54–62
Length of paraxial tibial setae <i>l''</i> (legI)	2	1–3	Length of opisthosomal setae <i>c2</i>	13	12–13
Length of tarsus (legI)	5	5–6	Distance between opisthosomal setae <i>c2</i>	37	34–43
Length of paraxial, fastigial, tarsal setae <i>ft'</i> (legI)	5	4–6	Number of semiannuli on opisthosomal setae <i>c2</i>	3	3–4
Length of antaxial, fastigial, tarsal setae <i>ft''</i> (legI)	17	15–18	Length of opisthosomal setae <i>d2</i>	31	24–39
Length of tarsal solenidion (legI)	6	6–7	Distance between opisthosomal setae <i>d2</i>	30	30–31
Length of tarsal empodium (legI)	5	4–5	Number of semiannuli on opisthosomal setae <i>d2</i>	14	11–15
Number of tarsal empodium ray (legI)	4	4–4	Length of opisthosomal setae <i>e</i>	4	2–6
Length of legII	21	20–25	Distance between opisthosomal setae <i>e</i>	16	16–16
Length of femur (legII)	7	6–8	Number of semiannuli on opisthosomal setae <i>e</i>	28	25–30
Length of basiventral femoral setae <i>bv</i> (legII)	2	2–3	Length of opisthosomal setae <i>f</i>	9	6–10
Length of genu (legII)	3	3–4	Distance between opisthosomal setae <i>f</i>	14	14–15
Length of antaxial genual setae <i>l''</i> (legII)	4	3–5	Number of semiannuli on opisthosomal setae <i>f</i>	51	48–53
Length of tibia (legII)	3	2–4	Number of semiannuli on opisthosomal setae <i>f</i> from rear	5	5–6
Length of tarsus (legII)	5	4–6	Length of setae <i>h1</i>	3	3–4
Length of paraxial, fastigial tarsal setae <i>ft'</i> (legII)	4	2–4	Distance between setae <i>h1</i>	8	8–9
Length of antaxial, fastigial, tarsal setae <i>ft''</i> (legII)	18	14–22	Length of setae <i>h2</i>	42	34–50
Length of tarsal solenidion (legII)	11	10–12	Distance between setae <i>h2</i>	12	11–12

Table 7 Difference between *Aceria acutiuscula* and other species

Species	median line	admedian line	submedian line	microtubcles	setae <i>sc</i>	empodium
<i>Aceria acutiuscula</i> sp. nov.	short line present on the posterior end	short line present on the posterior end	2 short lines on the posterior end	hemisphere	sc as long as the prodorsal shield	4-rayed
<i>Aceria clerodendronis</i> (Farkas, 1960)	short line present on the posterior end	short line present on the posterior end	many short lines on the anterior	-	sc longer than prodorsal shield	5-rayed
<i>Aceria ligustri</i> (Keifer, 1943)	short line present on the posterior end	short line present on the posterior end	many short lines on the anterior	hemisphere	sc shorter than prodorsal shield	5-rayed
<i>Aceria macrotuberculata</i> (Nalepa, 1895)	short line present on the posterior end	half length of prodorsal shield line present on the posterior end	absent	-	sc 1.5 times longer than the prodorsal shield	4-rayed
<i>Aceria pallida</i> Keifer, 1943	short line present on the posterior end	short line present on the posterior end	absent	like short spinules	sc longer than prodorsal shield	5 or 6-rayed
<i>Aceria squalida</i> (Nalepa, 1892)	short line present on the posterior end	short line present on the posterior end	half length of prodorsal shield running along side	-	sc 1.5 times longer than the prodorsal shield	-
<i>Aceria circularis</i> sp. nov.	absent	complete, divergent to the rear	complete, running along side	hemisphere	sc as long as the prodorsal shield	4-rayed

and admedian lines on the prodorsal shield connected to the rear shield margin (median and admedian lines separated from the rear shield margin in *A. clerodendronis*), by having the prodorsal setae *sc* as long as the prodorsal shield (*sc* 1.5 times longer than the prodorsal shield in *A. macrotuberculata* and *A. squalida*), and by having normal microtubercles on abdominal annuli (microtubercles projecting like short spinules on abdominal annuli in *A. pallida*).

Subfamily Phyllocoptinae Nalepa, 1892
Tribe Anthocoptini Amrine & Stasny, 1994
Genus *Aculops* Keifer, 1966

Aculops vallearis Yoshino & Kadono sp. nov.

Zoobank: urn:lsid:zoobank.org:act:E269BB79-2EFC-48E6-AF98-9D6E3492F9DD
(Figures 7, 8 and Table8)

Diagnosis

Prodorsal shield pattern net-like; median line present and incomplete, on posterior 2/3 of the prodorsal shield. Coxa with granules. Tibia very long.

Female holotype.

Body fusiform, 159 long, 56 wide.

Gnathosoma projecting obliquely downwards; dorsal palp genual setae unbranched.

Prodorsal shield 32, 33 wide, subtriangular; The shield pattern network like. Median line present on the 2/3 posterior end and partially broken at midpoint, median line and the admedian line connected by a transverse line; admedian lines partially broken, running from the anterior margin of the shield to the rear margin; 1st submedian line branched in front of tubercles of *sc*; some granules on mid field; short longitudinal line on side; scapular tubercles ellipsoidal, 25 apart; setae *sc* 23, directed divergently backward.

Legs with all usual segments and setae. Tarsal solenidion knobbed at the tip; tarsal empodium simple.

Coxisternal plates granules; prosternal apodeme entire, distinct, 8; lateral setae on coxisternum I *lb* 10, 11 apart; setae on coxisternum I *la* 25, 8 apart; setae on coxisternum II *2a* 49, 27 apart.

External genitalia 11, 23 wide, 11 longitudinal line on coverflap; setae *3a* 19, 18 apart; coxigenital region with 8 semiannuli, microtubercles.

Opisthosoma with subequal annuli; 62 dorsal semiannuli; 71 ventral semiannuli (counted from first complete annulus after coxae II); setae *c2* 37 on 8th ventral annulus, 56 apart; setae *d* 47 on 22nd ventral annulus, 37 apart; setae *e* 14 on 43rd ventral annulus, 21 apart; setae *f* 19, on 67th ventral annulus, on 5th ventral annulus from rear, 21 apart; setae *h2* 54, 12 apart; setae *h1* 2, 7 apart.

Host plant. *Acer pictum* Thunb.

Type material. Holotype female: JAPAN: Hokkaidō, Yūbari-shi, Chōbotsunai river, Forest road, 42.881882N 142.033171E, alt. 225 m, 1.VI.2021, Ryōichi Satō leg. Paratypes: 3 females, JAPAN: Hokkaidō, Yūbari-shi, Tyobotunai river, Forest road, 42.881882N 142.033171E, alt. 225 m, 1.VI.2021, Ryōichi Satō leg.; 1 female, JAPAN: Hokkaidō, Sapporo-shi, Minami-ku, Shirakawa, Kannonzawa, 42.58076N 141.15557E, alt. 15 m, 23.VI.2021, Yuki Yoshino leg.

Relation to host. Living in leaf grooved galls. (Figure 1g–i).

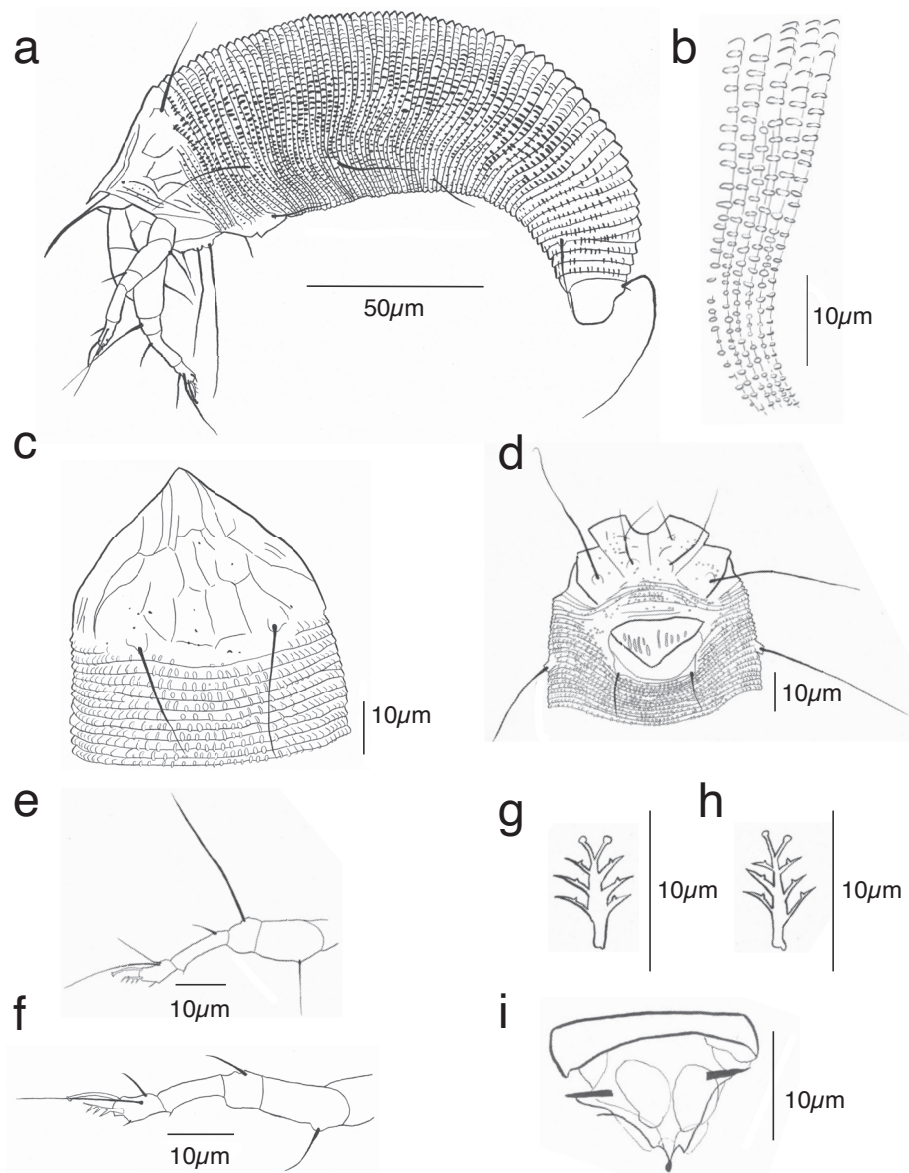


Figure 7 Drawings of *Aculops vallecularis* sp. nov. a – lateral view of the body, b – lateral view of the abdomen, c – prodorsal shield, d: coxigenital region of female, e – leg I, f – leg II, g – empodium I, h – empodium II, i – internal genitalia of female.

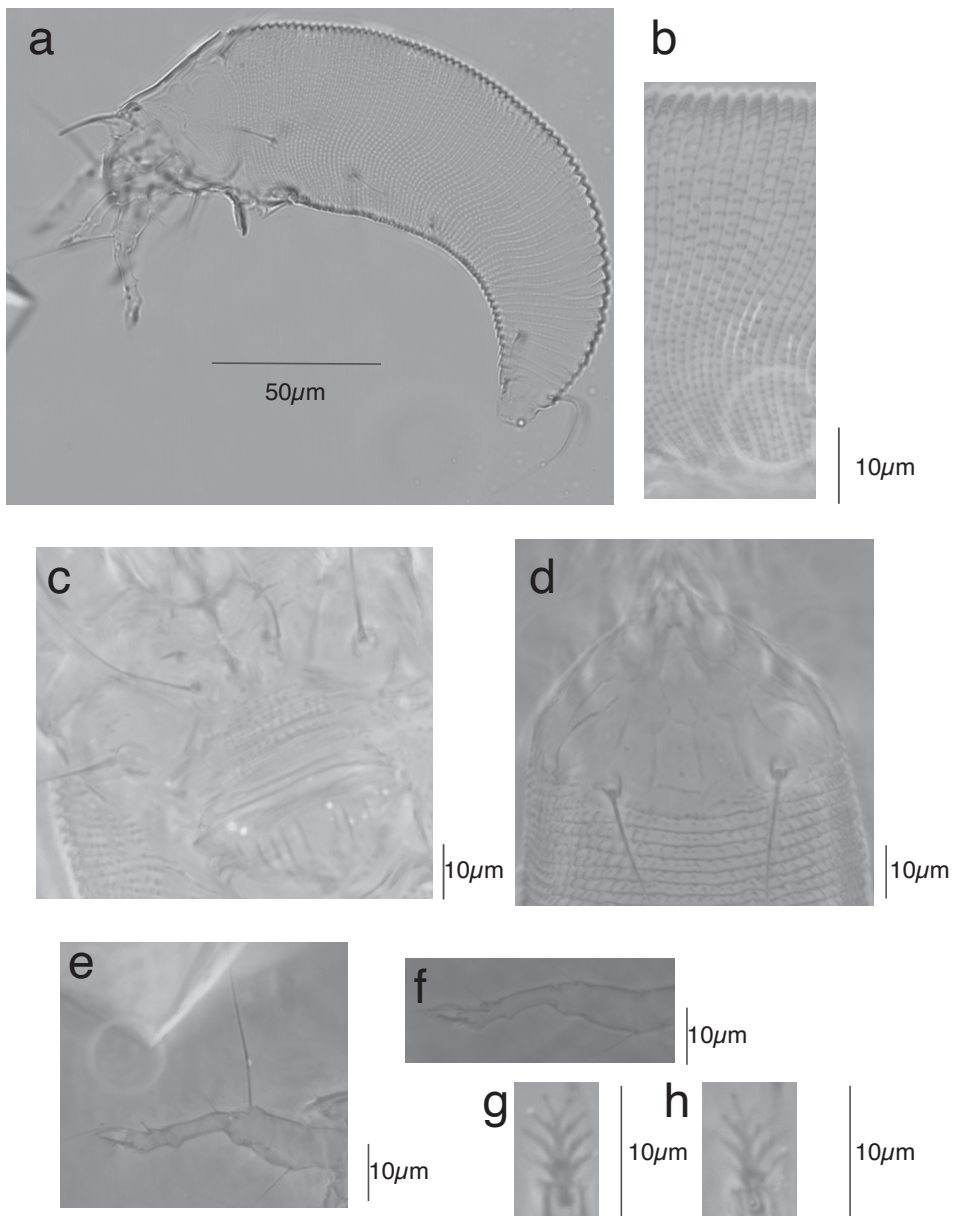


Figure 8 Phase-contrast light or bright-field microscope images of *Aculops vallecularis* sp. nov. a – lateral view of the body, b – lateral view of the abdomen, c – prodorsal shield, d – coxigenital region of female, e – leg I, f – leg II, g – empodium I, h – empodium II.

Etymology. The species epithet comes from a Latin singular masculine adjective *vallecularis*, meaning grooved, with reference to the leaf grooved galls.

Remarks. *A. vallecularis* is similar to *A. baligouis* Xue, Song & Hong, 2007 in the shield net-like pattern, coxa granules, and very long tibia, but differs from it by having incomplete median line present on posterior 2/3 of the prodorsal shield (median line complete in *A. baligouis*).

ACKNOWLEDGEMENTS

We would like to thank: Mr. Ryōichi Satō for providing the samples; Dr. Masahiro Ohara and Dr. Kazunori Yoshizawa for reviewing this paper.

Table 8 Measurements of *Aculops vallecularis* n. sp. (n=5)

Characters	Avarage	Range	Characters	Avarage	Range
Length of body	159	159–159	Length of tarsal empodium (legII)	5	4–6
Thick of body	57	48–61	Number of tarsal empodium ray (legII)	4	4–4
Width of body	56	56–56	Length of prosternal apodeme	8	8–8
Length of chelicerae	19	17–22	Length of anterior setae <i>1b</i>	10	10–10
Length of palp	3	3–3	Distance between anterior setae <i>1b</i>	11	11–11
Length of dorsal pedipalp coxal setae <i>ep</i>	3	3–3	Length of proximal setae <i>1a</i>	25	25–25
Length of dorsal pedipalp genual setae <i>d</i>	6	4–7	Distance between proximal setae <i>1a</i>	8	8–8
Length of prodorsal shield	33	29–38	Length of proximal setae <i>2a</i>	49	49–49
Width of prodorsal shield	33	33–33	Distance between proximal setae <i>2a</i>	27	27–27
Distance between scapular tubercles	25	25–25	Length of external genitalia	11	11–11
Length of scapular setae <i>sc</i>	23	21–23	Width of external genitalia	23	23–23
Length of leg I	37	34–39	Number of longitudinal striae	11	11–11
Length of femur (legI)	12	10–13	Length of genital setae <i>3a</i>	21	15–26
Length of basiventral femoral setae <i>bv</i> (legI)	11	9–12	Distance between genital setae <i>3a</i>	18	18–18
Length of genu (legI)	6	4–7	Number of coxigenital region semiannuli	8	8–8
Length of antaxial genual setae <i>l''</i> (legI)	27	21–31	Number of dorsal semiannuli	62	62–62
Length of tibia (legI)	11	9–13	Number of ventral semiannuli	71	71–71
Length of paraxial tibial setae <i>l'</i> (legI)	6	4–7	Length of opisthosomal setae <i>c2</i>	31	25–37
Length of tarsus (legI)	7	7–8	Distance between opisthosomal setae <i>c2</i>	56	56–56
Length of paraxial, fastigial, tarsal setae <i>ft'</i> (legI)	10	7–11	Number of semiannuli on opisthosomal setae <i>c2</i>	8	8–9
Length of antaxial, fastigial, tarsal setae <i>ft''</i> (legI)	22	21–23	Length of opisthosomal setae <i>d2</i>	40	33–47
Length of tarsal solenidion (legI)	8	6–8	Distance between opisthosomal setae <i>d2</i>	37	37–37
Length of tarsal empodium (legI)	5	4–5	Number of semiannuli on opisthosomal setae <i>d2</i>	23	22–23
Number of tarsal empodium ray (legI)	4	4–4	Length of opisthosomal setae <i>e</i>	15	14–16
Length of legII	37	34–39	Distance between opisthosomal setae <i>e</i>	21	21–21
Length of femur (legII)	12	11–14	Number of semiannuli on opisthosomal setae <i>e</i>	43	42–43
Length of basiventral femoral setae <i>bv</i> (legII)	9	7–11	Length of opisthosomal setae <i>f</i>	19	16–21
Length of genu (legII)	5	4–5	Distance between opisthosomal setae <i>f</i>	21	21–21
Length of antaxial genual setae <i>l''</i> (legII)	9	8–11	Number of semiannuli on opisthosomal setae <i>f</i>	67	66–67
Length of tibia (legII)	9	8–10	Number of semiannuli on opisthosomal setae <i>f</i> from rear	5	4–5
Length of tarsus (legII)	8	6–8	Length of setae <i>h1</i>	2	1–2
Length of paraxial, fastigial tarsal setae <i>ft'</i> (legII)	5	4–6	Distance between setae <i>h1</i>	7	7–7
Length of antaxial, fastigial, tarsal setae <i>ft''</i> (legII)	22	20–24	Length of setae <i>h2</i>	54	50–58
Length of tarsal solenidion (legII)	7	6–8	Distance between setae <i>h2</i>	12	12–12

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