Acarologia
Open Science in Acarology

The eriophyid mite *Aculops ailanthi* Lin, Jin, & Kuang, 1997 (Acariformes: Prostigmata: Eriophyidae) from tree-of-heaven in the United States – new state records and morphological observations

Michael J. Skvarla[a] , Ron Ochoa[b] , Andrew Ulsamer[b] , James Amrine[c]

[a] Department of Entomology; 501 Agricultural Science and Industries Building, University Park, PA, 16802, USA.
[b] USDA-ARS Systematic Entomology Laboratory, 10300 Baltimore Ave, Building 005, BARC-West, Beltsville, MD, 20705, USA.
[c] West Virginia University, Division of Plant and Soil Sciences, P.O.Box 6108, Morgantown, WV 26506-6108, USA

Original research

ABSTRACT

We report *Aculops ailanthi* Lin, Jin, & Kuang, 1997 (Acariformes: Trombidiformes: Prostigmata: Eriophyidae) from Pennsylvania and West Virginia, USA; present the first scanning electron micrographs of the species in North America and discuss morphological observations that clarify features observed in slide-mounted specimens, such as the number ridges on female genital flaps; and briefly discuss symptoms and control of an *A. ailanthi* infestation on greenhouse-grown tree-of-heaven, *Ailanthus altissima* (Mill.) Swingle (Sapindales: Simaroubaceae).

Keywords *Aculops ailanthi*; *Ailanthus altissima*; tree-of-heaven; invasive pest; new state record

Introduction

Tree-of-heaven, *Ailanthus altissima* (Mill.) Swingle (Sapindales: Simaroubaceae), which is native to China, was first introduced to North America in 1784 and was widely planted in urban industrial centers in the mid-1800's; it is now found across most of the United States and adjacent areas of Canada and Mexico (Hu 1979, Fryer 2010, Ripka & Érsek 2014). *Ailanthus altissima* is commonly found in disturbed habitats (e.g., forest edges, along railway and road cuts, and even sidewalk cracks) and occasionally in undisturbed habitats. It is considered an invasive, noxious weed by many state and federal agencies due to its ability to outcompete native species and form dense, monoclonal stands, which is in part due to the production of allelopathic chemicals that inhibit the growth of native plants (Fryer 2010, Ding et al 2006, iNaturalist 2019, USDA NRCS 2019). In addition to these direct effects, *Ai. altissima* is a preferred host for spotted lanternfly (*Lycorma delicatula* (White, 1845)), an invasive fulgorid planthopper first detected in Pennsylvania in 2014 that is expected to have significant impacts on various agricultural industries (e.g., tree fruit and viticulture production), forest health and timber production, and private homeowners (PSU n.d.).

Ding *et al.* (2006) reported 46 species of phytophagous arthropods that feed on *Ai. altissima* in its native range, seven of which have been introduced to North America (*Atteva*

Received 03 September 2019
Accepted 01 September 2020
Published 12 February 2021

Corresponding author
Michael J. Skvarla:
mxs1578@psu.edu

Academic editor
Navia, Denise

DOI
10.24349/acarologia/20214421

ISSN 0044-586X (print)
ISSN 2107-7207 (electronic)

Copyright
Skvarla M. J. *et al.*

Distributed under
Creative Commons CC-BY 4.0

OPEN ACCESS

How to cite this article Skvarla M. J. *et al.* (2021), The eriophyid mite *Aculops ailanthi* Lin, Jin, & Kuang, 1997 (Acariformes: Prostigmata: Eriophyidae) from tree-of-heaven in the United States – new state records and morphological observations. **Acarologia 61(1): 121-127; DOI 10.24349/acarologia/20214421**

aurea (Cramer, 1781), the ailanthus webworm moth, a native North American species, also feeds on *Ai. altissima*) . Included in the *Ailanthus*-feeding arthropods are four species of eriophyid mites – *Aculops ailanthi* Lin, Jin, & Kuang, 1997, *Ac. mosoniensis* Ripka & Ersek, 2014, *Ac. taihangensis* Hong & Xue, 2005, and *Aculus altissimae* Xue & Hong, 2005. Of these species, only *Ac. ailanthi* have been reported from the US, in a single state (Maryland) (Gardener, 2008).

De Lillo *et al.* (2017) suggested that *Ac. taihangensis* and *Ac. mosoniensis* are likely synonymous. Author JA agrees and additionally suggests that *Ac. altissimae* are junior synonyms of *Ac. ailanthi* as the variations between the species are slight and may be the result of various factors, including over-clearing specimens prior to slide mounting, differences in interpretation of characters of slide-mounted specimens, and poorly made illustrations . However, such taxonomic changes have not been officially proposed following ICZN rules, so we list them as distinct species herein.

Aculops ailanthi are vagrant eriophyids that live on the surface of leaves (as opposed to forming galls or seeking other forms of protection) and can build up large populations on *Ailanthus* that cause leaf deformation, yellowing, necrosis, premature leaf drop, and death in young, container-grown trees (Lin *et al.* 1997, Gardener 2008). Ripka & Érsek (2014) and de Lillo *et al.* (2017) also showed *Ac. mosoniensis* can cause similar symptoms on *Ailanthus* in Hungary and Italy, respectively. The majority of the mites are found on the underside of leaflets but are occasionally found on the upper side of leaflets and even on the stem when mite populations are large (Ripka & Érsek 2014, de Lillo *et al.* 2017).

Herein we report *Ac. ailanthi* from Pennsylvania and West Virginia for the first time, describe an infestation on and damage to 1.5 m, greenhouse-grown containerized trees, report successful control efforts of the mites, and provide the first scanning electron micrograph (SEM) images of specimens from North America with comments on external morphology.

Materials and methods

Wild 1–1.5 m *Ai. altissima* trees were collected in State College, Pennsylvania and containerized before budbreak in the spring of 2019; those wild-collected trees were comingled in a greenhouse with similarly sized two-year-old seed-grown containerized trees. On 10 July 2019, the trees appeared sickly (see Results for description of symptoms) and leaf samples were collected for analysis.

The *Ailanthus* leaves were examined using a Nikon SMZ18 stereomicroscope and large infestations of eriophyid mites were immediately apparent on every leaf, which the lead author suspected to be *Ac. ailanthi*. Specimens were sent to the USDA-ARS Systematic Entomology Laboratory for examination and species confirmation.

At the USDA-ARS-SEL, the leaves were sectioned into small (approximately 1 × 0.5 cm) pieces and placed onto a sticky carbon pad, which was mounted on to a steel viewing stub at room temperature. The steel stub was placed into the mounting ring of a Hitachi TM3030Plus tabletop scanning electron microscope (SEM), which was cooled to -25 °C with a Deben Standard SEM Coolstage (Suffolk, UK). The specimens were then imaged without further manipulation. Species identification was confirmed by J. Amrine based on the resulting scanning electron micrographs.

Photographs of the *Ailanthus* leaves and mite infestations were taken using a Samsung Galaxy S6 cell phone and stereomicrographs taken using the cell phone in combination with the SMZ18. After the eriophyid infestation was discovered, the trees were treated with a 2% solution of M-Pede insecticidal soap (active ingredient: Potassium salts of fatty acids) (Gowan USA, Yuma, Arizona, USA).

On 18 August 2018, eriophyid mites were collected from new shoots of wild *Ai. altissima* along Morgan's Run Trail, Morgantown, West Virginia. Specimens were cleared in KOH, slide mounted in Hoyer's and Berlese medium, and identified as *Ac. ailanthi*. Stereomicrographs of slide mounted specimens were taken using a Zeiss Axioskop microscope.

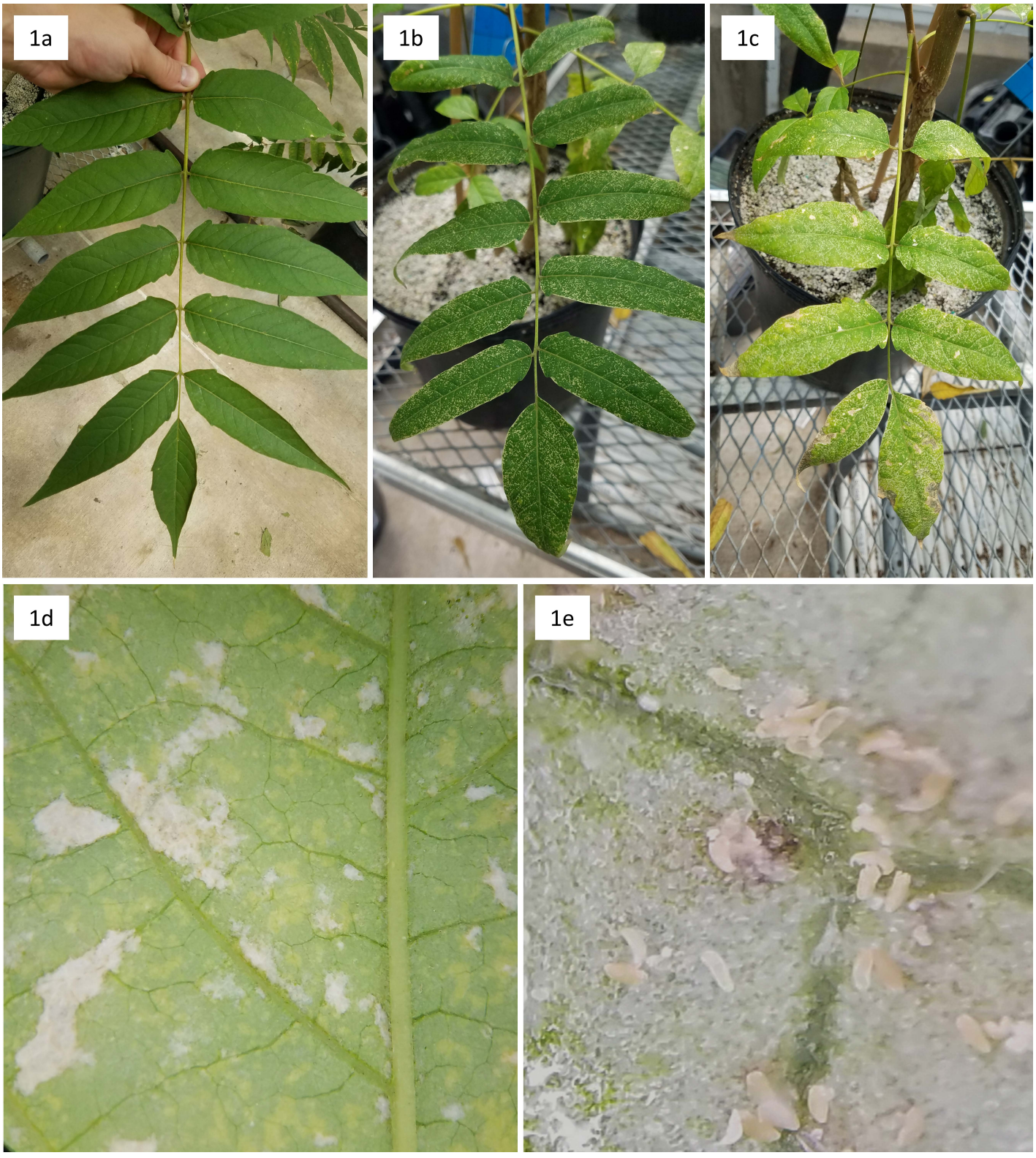


Figure 1 Tree-of-heaven damaged by *Aculops ailanthi* Lin, Jin, & Kuang feeding: 1a – healthy leaf without mite infestation; 1b – leaf showing severe stippling; 1c – leaf showing yellowing, stippling, and necrosis; 1d – leaf necrosis; 1e – mites on leaf surface after an application of a 2% solution of M-Pede insecticidal soap.

Results and discussion

The *Ac. ailanthi* reported here represent the first records of the species in Pennsylvania and West Virginia and the second and third records of them in the United States – Gardener (2008) had previously reported it from Maryland. While it is likely that *Ac. ailanthi* is present in North America wherever tree-of-heaven is found given the tree has been established on the continent for more than 200 years, all three reports of it are from a limited region in the Mid-Atlantic. Additional surveys should be taken to establish its range in North America given its potential as a biological control agent of *Ailanthus* (see Smith *et al.* (2010) for a review of eriophyids that have been proposed or released as biocontrol agents of weeds).

The greenhouse-grown *Ai. altissima* exhibited similar symptoms to heavily infested wild tree-of-heaven, namely leaf yellowing, leaf deformation and edge curling, stippling, and small necrotic lesions (Figure 1). Because the trees were grown for experiments with spotted lanternfly, they were treated to control the eriophyid infestation before more severe symptoms could develop. The application of 2% insecticidal soap effectively eliminated the mites after one application: two weeks post treatment, MS could not locate a single living mite despite examining more than a dozen leaves from trees that had previously hosted heavy infestations. While tree-of-heaven are not often grown in greenhouses as ornamentals, there may be an increasing need for *Ailanthus* IPM as the North American spotted lanternfly infestation grows and research to combat it increases.

The SEM images presented here are the first such images of *Ac. ailanthi* in North America. We were able to capture the eriophyids feeding on the ventral side of the leaf and congregating around the trichomes (Figure 2c). Several individual mites were imaged while feeding directly from the lateral surface of the trichome (Figure 2d). Eggs were located in small groups of 3-6 and larvae were encountered near the eggs (Figure 2e). Spermatophores were randomly distributed across the surface of the leaf.

The SEM images provide an undistorted view of how morphological structures appear on uncleared specimens that are not slide-mounted. The anterior lobe over the gnathosoma is acuminate (which is characteristic of *Aculops*) (Figures 2a, 2f) but may appear rounded in some specimens (which is characteristic of *Aculus*) due to specimen orientation on the slides or because the lobes are slightly declivous (Figure 2b). The prodorsal shield is subtriangular with a network pattern with broad cells medially, laterally with granules. The ridges that create the cells are obvious in the SEMs (Figure 2f) but may be obscured or destroyed during clearing and slide mounting (Figure 2a); some of the ridges are absent in nymphs (Figure 2e). Dorsal tubercles are present on rear margin. Dorsal annuli 37–42, ventral annuli 77–87. The female genital flap has 10–12 longitudinal ridges (Figures 3b–d), which may be difficult to observe or destroyed in slide mounted specimens (Figure 3a). The number of rays on the empodia has been used to differentiate species of *Ailanthus*-feeding *Aculops* (4 in *Ac. altissimae*, 5 in the other 3 species); unfortunately, we were unable to crisply image the empodia and cannot at this time determine how many rays the specimens we collected possess.

These images confirm the species present in North America is *Ac. ailanthi* and may inform the discussion of whether *Ac. ailanthi*, *Ac. taihangensis, Aculus altissimae*, and *Ac. mosoniensis* are synonymous.

Acknowledgements

We thank Dana Roberts, David Long, Scott DiLoretto, and Julie Urban for bringing the mite infestation to our attention, allowing us to photograph their trees, and providing information about the trees and control measures implemented against the eriophyids; and Dr. Cheryle O′Donnell and Mr. Armando Rosario-Lebron (APHIS-USDA) for the use of the Tabletop SEM. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA; USDA is an equal opportunity provider and employer.

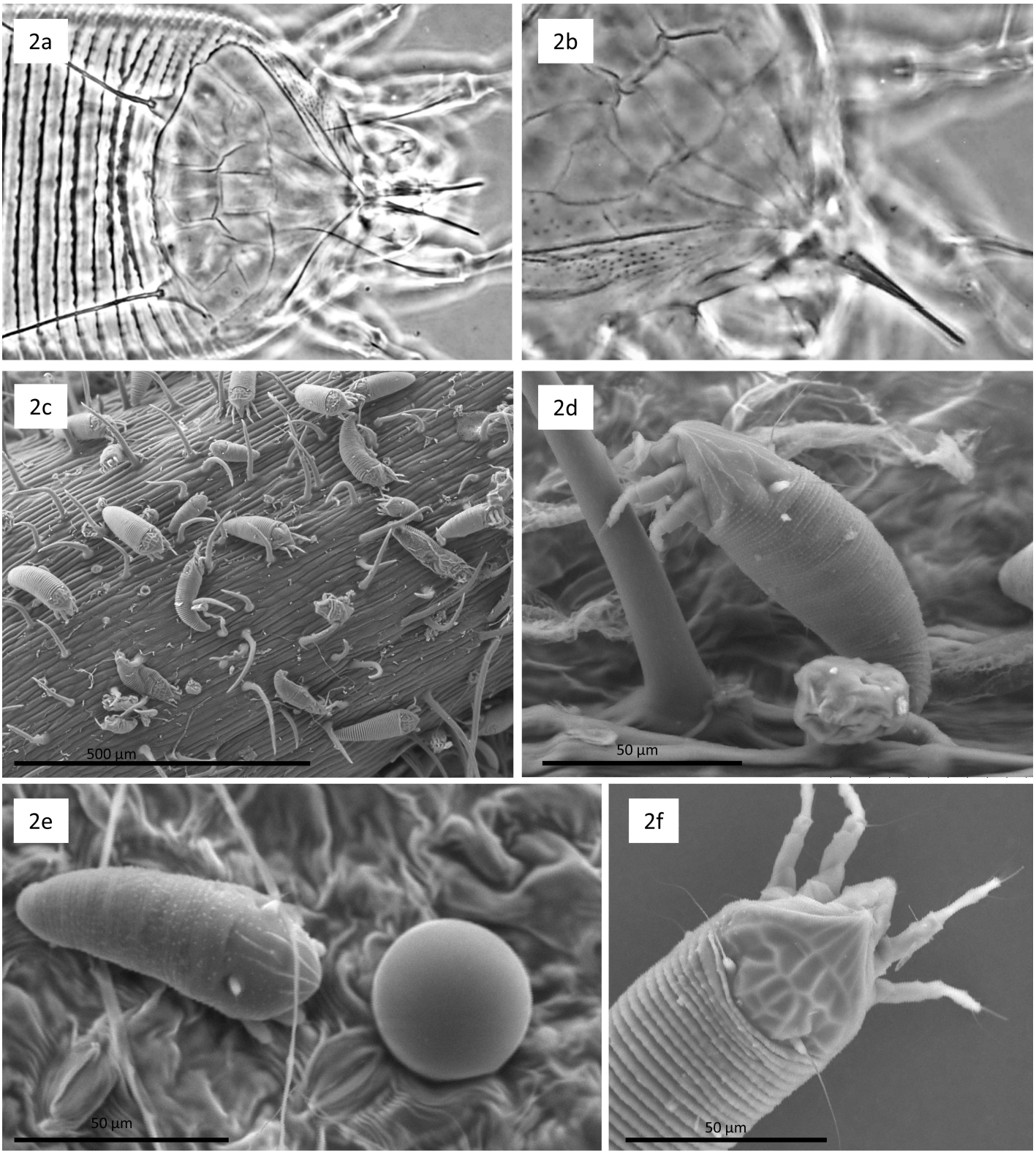


Figure 2 Stereomicrographs (2a–b) and SEMs (2c–f) of *Aculops ailanthi*: General aspect of colonies on leaves and morphological traits:** 2a–b – prodorsal shield; 3c – mite infestation of a leaf; 2d – mite feeding on a trichome; 2e – nymph next to an egg, note the lack of reticulate cells on the prodorsal shield; 2f – dorsum.

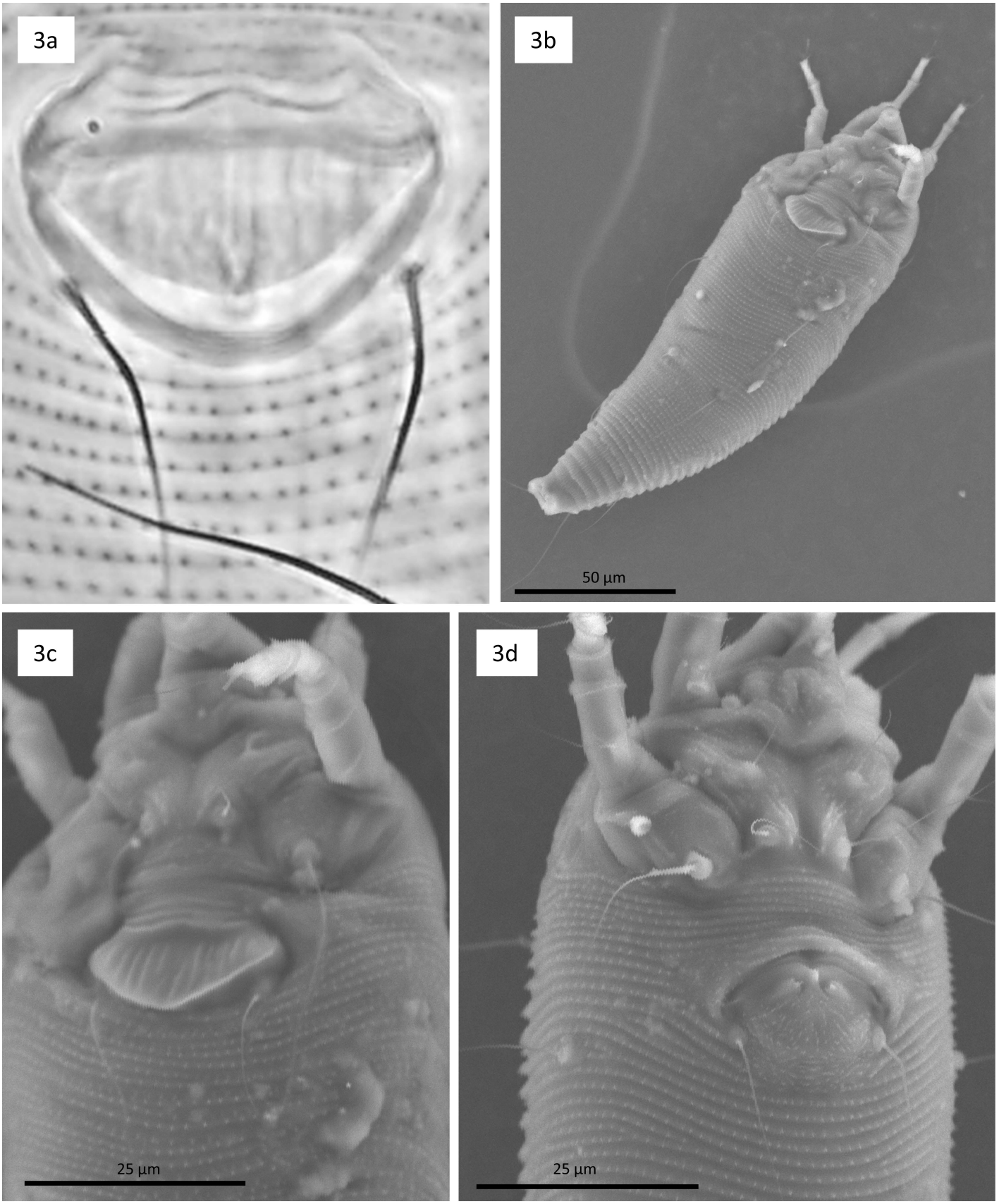


Figure 3 Stereomicrograph (3a) and SEMs (3b–3d) of *Aculops ailanthi*: 3a – female genital flap; 3b – female venter; 3c – female genital flap; 3d – male genital flap.

References

Ding J., Wu Y., Zheng H., Fu W., Reardon R., Liu M. 2006. Assessing potential biocontrol of the invasive plant, tree-of-heaven, *Ailanthus altissima*. Biocontr. Sci. Tech. 16(5/6): 547-566. doi:10.1080/09583150500531909

Fryer J.L. 2010. Ailanthus altissima. In: Fire Effects Information System [Online]. Ft. Collins, CO: USDA, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory; [30 July 2019]. Available from: https://www.fs.fed.us/database/feis/plants/tree/ailalt/all.html

Gardener R.T. 2008. Native and indigenous biocontrols for *Ailanthus altissima* [M.S. thesis]. College Park, University of Maryland. pp. 140.

Hu S.Y. 1979. Ailantus. Arnoldia, 39(2): 29-50. doi:10.5834/jdh.29.39

iNaturalist. 2019. Tree-of-Heaven (*Ailanthus altissima*). [30 August 2019]. Available from: https://www.inaturalist.org/taxa/57278-Ailanthus-altissima

de Lillo E., Panzarino O., Loverre P., Valenzano D., Mattia C., Marini F., Augé M., Cristofaro M. 2017. New eriophyid mites from Italy. IV. Mites associated with weed plants. Sys. Appl. Acarol., 22(12): 2256-2272. doi:10.11158/saa.22.12.15

Lin F.-P., Jin C., Kuang H.-Y. 1997. A new genus and six new species of Eriophyidae from China (Acari: Eriophyoidea). Acta Entomol. Sin., 40(1): 86-93

[PSU] Penn State University Extension. n.d. Spotted lanternfly [Online]. University Park, PA: Penn State Extension; [30 July 2019]. Available from: https://extension.psu.edu/spotted-lanternfly

Smith L., de Lillo E., Amrine JW Jr. 2010. Effectiveness of eriophyid mites for biological control of weedy plants and challenges for future research. Exp. Appl. Acarol. 51(1-3): 115-149. doi:10.1007/s10493-009-9299-2

Ripka G., Érsek L. 2014. A new *Aculops* species (Acari: Prostigmata: Eriophyoidea) on *Ailanthus altissima* from Hungary. Acta Phytopathologica Entomologica Hungarica, 49(1): 49-56. doi: 10.1556/APhyt.49.2014.1.5

USDA NRCS. 2019. The PLANTS Database: *Ailanthus altissima* (Mill.) Swingle