THE FIRST REPORT OF THE APHIDS (HEMIPTERA: STERNORRHYNCHA: APHIDIDAE) OF THE VALLES CALDERA NATIONAL PRESERVE, NEW MEXICO, USA

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Abstract.—We report 39 species, belonging to 22 genera of aphids (Hemiptera: Aphididae), collected within and near the boundary of the Valles Caldera National Preserve in the Jemez Mountains of northern New Mexico, USA. Of these, 26 (67%) represent new distribution records for New Mexico. Plant genera/species from which the specimens were collected also are listed when available.

Key Words: Hemiptera, Aphidomorpha, Aphididae

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Situated at the southern portion of the Rocky Mountains, the Jemez Mountains in northern New Mexico are an isolated "sky island" supervolcano, created over 14 million years ago (mya) through a series of massive volcanic eruptions (Goff 2009). As a result, the Jemez Mountains constitute a Pleistocene biological refugium, with high-elevation forest and grassland ecosystems remaining after glacial retreat and climate warming 20,000 years ago. Lying in the center of the Jemez Mountains is the supervolcano's caldera, created by the most recent caldera-forming eruption 1.25 mya (Goff 2009). The present-day caldera is approximately 20-25 km in diameter, and contains numerous volcanic dome mountains and open grassy valleys (*valles* in Spanish).

Most of the volcano's caldera lies within the National Park Service's Valles Caldera National Preserve (VALL). Ranging in elevation from 2,400 to 3,430 m, the Preserve supports 20 vegetation assemblages (Muldavin et al. 2006). The upper elevations are dominated by spruce-fir-aspen forests, and grade downslope into mixed conifer and Ponderosa pine (*Pinus ponderosa*) forests. Grassland vegetation in the VALL includes upland valleys dominated by *Danthonia parryi*, *Festuca arizonica*, and *F. idahoensis* and mountain meadows dominated by *Poa pratensis*, *Deschampsia caespitosa*, and *Phleum* spp. Riparian wetlands are dominated by *Carex* spp. and *Juncus* spp. Annual precipitation in VALL averages 622 mm, of which 287 mm (46%) occurs in the summer monsoon (July-September); winter snowstorms provide most of the remainder. July maximum daily temperatures average 23.7° C, and January minimum daily temperatures average -13.8° C.

In 2000, the United States Congress purchased the 100,000 acre private Baca ranch and created the Preserve. The Preserve was managed by the Valles Caldera Trust under the U.S. Department of Agriculture through 2014, at which time Congress transferred the Preserve to the National Park Service. As a private ranch, a biological inventory had never been conducted; thus, as part of the initial inventory of the Preserve's natural resources, entomologists from the USDA's Systematic Entomology Laboratory and VALL scientists initiated an extensive invertebrate survey of the forests and valles, cataloguing and archiving invertebrate taxa for informing future management decisions, and as an archived baseline for evaluating the impacts of ongoing climate change on biodiversity and ecosystem structure/function.

Among those insect groups targeted in the inventory are the aphids (*sensu lato*) (Hemiptera, Aphidomorpha). Aphids are phloem-sucking insects with over 5,000 described species worldwide (Favret 2014). Most species are host-specific, many being restricted to plants of a single genus. The aphids of New Mexico are relatively understudied, the only significant aphid faunistic work in the state being that of TDA and WP Cockerell at the beginning of the 20th Century (TDA Cockerell 1903a, b, c, d, 1904, WP Cockerell 1903, WP Cockerell and TDA Cockerell 1901). Only 85 aphid species were officially recorded from New Mexico (Smith and Parron 1978, Pike et al. 2003). Given the unique geology and flora of VALL combined with the underrepresentation of New Mexico's aphids in the U.S. National collection (personal observation), we expected the VALL aphid fauna to be rich and interesting. With the exception of Miller et al. (2014), no aphids have previously been recorded in the area that is VALL. The work presented here constitutes the first inventory of the aphids of VALL.

MATERIALS AND METHODS

The preponderance of work supporting this report is based on identifications made of material collected 20-22 August 2007. An additional species, Atheroides vallescaldera Miller and Jensen, 2014 collected 23 September 2010, is also included in the list. All localities are from USA: NM: Sandoval Co., with short site descriptions and GPS coordinates included. Localities were referenced using Google Earth[™]. Plant host identity is important to aphid identification thus sampling was primarily done by hand following visual inspection. A beating sheet was used on occasion for sampling conifers. Plants were identified on site by the authors. Aphids were preserved directly into 95% ethanol for molecular analysis. Aphids were mounted in Canada balsam on microscope slides. Species identification was done by the authors using a range of literature sources and the reference specimens in the U.S. National Aphid Collection (Beltsville, MD). Particularly useful were the hostbased keys by Blackman and Eastop

(1994, 2006). Aphid nomenclature was verified with Aphid Species File (Favret 2014). Aphid specimen records and determinations were entered into the KEMu content management system and are deposited in the U.S. National Aphid Collection, National Museum of Natural History. Electronic records for the specimens included in this report will be available on the National Museum of Natural History Department of Entomology Collections site (http://collections. nmnh.si.edu/search/ento/). Unique specimens identifiers for the specimens in the National Aphid Collection where available are indicated by the text "USNMENT XXXXXX."

The list of collected aphid species was cross-referenced with Smith and Parron (1978) and Pike et al. (2003) to determine if they had been previously recorded from New Mexico.

RESULTS

We identified 36 species from 15 sites within the VALL boundary (Fig. 1, Sites 1-15), with an additional three just outside its perimeter (Fig. 1, Site 16). The three species collected outside the boundary are certain to also occur within the preserve. Of these 39 species, 26 represent new state records, bringing the total count of New Mexico aphid species to 111.

List of Localities, Aphid Species, and Their Associated Plants

Site 1 (near unit 12, lower Santa Rosa Creek watershed; 35.951, -106.521)

Atheroides vallescaldera Miller and Jensen, 2014 (USNMENT 826485) Collected on/ from: Poaceae

Site 2 (road VC02 in valley; 35.932, -106.501)



	Richness of	
Site	plants	aphids
1	1	1
2	1	1
3	3	3
4	1	1
5	8	8
6	6	6
7	3	3
8	7	7
9	2	2
10	1	1
11	3	3
12	1	1
13	1	1
14	4	4
15	8	11
16	3	3

Fig. 1. Map of collection sites.

Macrosiphum euphorbiae (Thomas, 1878) Collected on/from: Geranium richardsonii

Site 3 (road VC02 at VC03; 35.921, -106.501)

- Aphis lugentis Williams, 1911 Collected on/ from: Senecio sp.
- *Iziphya flabella* (Sanborn, 1904) Collected on/from: *Carex* sp.
- Nasonovia alpina (Gillette and Palmer, 1928) Collected on/from: Orthocarpus luteus

Site 4 (road VC03 near concrete retaining wall, pond; 35.889, -106.582)

Nearctaphis bakeri (Cowen, 1895) Collected on/from: Trifolium repens

Site 5 (road VC03; 35.887, -106.583)

- Aphis holodisci Robinson, 1984 Collected on/from: Holodiscus dumosus
- Appendiseta robiniae (Gillette, 1907) Collected on/from: Robinia pseudoacacia
- *Chaitophorus populicola* Thomas, 1878 Collected on/from: *Populus tremuloides*;
- Brachycaudus helichrysi (Kaltenbach, 1843) (USNMENT 396726) Collected on/from: Senecio sp.
- Hyalopteroides humilis (Walker, 1852) Collected on/from: Poaceae
- Macrosiphum stanleyi Wilson, 1915 Collected on/from: Sambucus racemosa
- *Oestlundiella flava* (Davidson, 1912) Collected on/from: *Alnus incana*
- Uroleucon zymozionense (Knowlton, 1946) Collected on/from: Asteraceae

Site 6 (road VC03 at Redondo Creek; 35.879, -106.588)

- Brachycaudus tragopogonis (Kaltenbach, 1843) Collected on/from: Tragopogon dubius
- Cavariella aegopodi (Scopoli, 1763) (USNMENT 396764) Collected on/from: Apiaceae (umbell)
- Chaetosiphon thomasi Hille Ris Lambers, 1953 Collected on/from: Potentilla norvegica

Cinara glabra (Gillette and Palmer, 1924) (USNMENT 396762) Collected on/from: *Pinus ponderosa*

- *Macrosiphum euphorbiae* (Thomas, 1878) Collected on/from: *Geranium richardsonii*;
- Macrosiphum stanleyi Wilson, 1915 Collected on/from: Sambucus racemosa

Site 7 (road VC03 near Preserve gate; 35.867, -106.621)

- Aphis carduella Walsh, 1863 Collected on/ from: Cicuta sp.
- Braggia urovaneta (Hottes, 1950) Collected on/from: Eriogonum racemosum
- *Macrosiphum euphorbiae* (Thomas, 1878) Collected on/from: unknown umbell

Site 8 (road VC0301; 35.899, -106.559)

- Aphis carduella Walsh, 1863 Collected on/ from: Cirsium scopulorum
- Aphis coweni Palmer, 1938 Collected on/ from: Veratrum californicum
- Aphis lugentis Williams, 1911 Collected on/from: Packera cana
- Aphis oenotherae Oestlund, 1887 Collected on/from: *Epilobium halleanum*
- *Iziphya flabella* (Sanborn, 1904) Collected on/from: *Carex* sp.
- Nasonovia ribifolii (Davidson, 1917) Collected on/from: *Ribes montigenum*
- Uroleucon rudbeckiae (Fitch, 1851) Collected on/from: Rudbeckia laciniata

Site 9 (road VC03 at road VC06; 35.897, -106.560)

- Illinoia thalictri (MacGillivray, 1958) Collected on/from: Thalictrum fendleri
- *Iziphya flabella* (Sanborn, 1904) (USNMENT 396740) Collected on/from: *Carex* sp.

Site 10 (seep on road VC0301; 35.895, -106.557)

Capitophorus elaeagni (Del Guercio, 1894) Collected on/from: Cirsium scoplorum

Site 11 (Redondito Peak; 35.885, -106.546)

- Aphis lugentis Williams, 1911 Collected on/ from: Asteraceae
- Macrosiphum creelii Davis, 1914 Collected on/from: Lathyrus lanszwertii
- *Nasonovia aquilegiae* (Essig, 1917) Collected on/from: *Aquilegia* sp.
 - Site 12 (road VC02; 35.852, -106.528)
- Schizolachnus piniradiatae (Davidson, 1909) Collected on/from: Pinus ponderosa

Site 13 (road VC0201; 35.846, -106.537)

Chaetosiphon thomasi Hille Ris Lambers, 1953 Collected on/from: Fragaria virginiana

Site 14 (road VC02; 35.841, -106.542)

- Macrosiphum creelii Davis, 1914 Collected on/from: Vicia americana
- Macrosiphum euphorbiae (Thomas, 1878) Collected on/from: Viola canadensis
- Nasonovia cynosbati (Oestlund, 1887) Collected on/from: *Ribes leptanthum*
- Uroleucon taraxaci (Kaltenbach, 1843) Collected on/from: Taraxacum officinale

Site 15 (near Visitor Center; 35.856, -106.490)

- *Brachycaudus helichrysi* (Kaltenbach, 1843) (USNMENT 396726) Collected on/from: *Senecio* sp.
- *Capitophorus elaeagni* (Del Guercio, 1894) Collected on/from: *Cirsium* sp.
- *Cinara juniperi* (de Geer, 1773) (USNMENT 396808) Collected on/from: *Juniperus* sp.
- *Essigella hillerislambersi* Sorensen, 1994 (USNMENT 396756) Collected on/from: *Pinus* sp.
- *Illinoia morrisoni* (Swain, 1918) (USNMENT 396738) Collected on/from: *Juniperus* sp.
- *Iziphya flabella (Sanborn, 1904)* (USNMENT 396721, USNMENT 396740) Collected on/from: *Carex* sp.
- Macrosiphum euphorbiae (Thomas, 1878) (USNMENT 396718) Collected on/from: Descurainia sp.

- Macrosiphum walkeri (Robinson, 1980) Collected on/from: Cystopteris sp.
- Nasonovia cynosbati (Oestlund, 1887) Collected on/from: unknown.
- Protaphis middletonii (Thomas, 1879) (USNMENT 396822) Collected on/from: Oenothera flava
- Rhopalosiphum padi (Linnaeus, 1758) Collected on/from: Descurainia sp.

Site 16 (across from main Preserve gate)

- *Cinara bonita* Hottes, 1956 Collected on/ from: *Picea* sp.
- *Cinara petersoni* Bradley, 1963 Collected on/ from: *Juniperus* sp.
- *Cinara ponderosae* (Williams, 1911) Collected on/from: *Pinus* sp.

Alphabetical Listing of Aphid Species in VALL (n=36) geographic origin if outside North America, North American pest status, and economic host(s) noted after species in parentheses (from Foottit et al. 2006)

*previously known from NM (n=9) *Adventive species (n=6)

- Aphis carduella Walsh, 1863
- *Aphis coweni Palmer, 1938

Aphis holodisci Robinson, 1984.

Aphis lugentis Williams, 1911

*Aphis oenotherae Oestlund, 1887

Appendiseta robiniae (Gillette, 1907)

- Atheroides vallescaldera Miller and Jensen, 2014
- *†Brachycaudus helichrysi (Kaltenbach, 1843) (Palearctic (Europe), major pest, Prunus spp., Compositae)
- *†Brachycaudus tragopogonis* (Kaltenbach, 1843) (Palearctic)
- Braggia urovaneta (Hottes, 1950)
- *Capitophorus elaeagni* (Del Guercio, 1894)(VCNP20) (VCNP28) (Palearctic, potential plant virus vector)
- *†Cavariella aegopodi* (Scopoli, 1763) (Palearctic (Europe), pest, *Daucus carota*)

Chaetosiphon thomasi Hille Ris Lambers, 1953 *Chaitophorus populicola Thomas, 1878 *Cinara glabra (Gillette and Palmer, 1924) Cinara juniperi (de Geer, 1773) Essigella hillerislambersi Sorensen, 1994 *†Hyalopteroides humilis* (Walker, 1852) (VCNP53) (Palearctic) Illinoia morrisoni (Swain, 1918) Illinoia thalictri (MacGillivray, 1958) Iziphya flabella (Sanborn, 1904) Macrosiphum creelii Davis, 1914 *Macrosiphum euphorbiae (Thomas, 1878) Macrosiphum stanleyi Wilson, 1915 Macrosiphum walkeri (Robinson, 1980) Nasonovia alpina (Gillette and Palmer, 1928) Nasonovia aquilegiae (Essig, 1917) Nasonovia cynosbati (Oestlund, 1887) Nasonovia ribifolii (Davidson, 1917) Nearctaphis bakeri (Cowen, 1895) Oestlundiella flava (Davidson, 1912) Protaphis middletonii (Thomas, 1879) *Rhopalosiphum padi (Linnaeus, 1758) *Schizolachnus piniradiatae (Davidson, 1909) *Uroleucon rudbeckiae (Fitch, 1851) *†Uroleucon taraxaci* (Kaltenbach, 1843) (Palearctic (Europe), *Taraxacum* spp.)

Uroleucon zymozionense (Knowlton, 1946)

Species at the boundary of VALL *n*=3 *previously known from NM (*n*=1)

- *Cinara bonita* Hottes, 1956 Field note: *Picea* sp.
- *Cinara petersoni* Bradley, 1963 Field note: *Juniperus* sp.
- **Cinara ponderosae* (Williams, 1911) Field note: *Pinus* sp.

DISCUSSION

This initial survey of the aphid fauna occurring in or near VALL increases the known aphid fauna of New Mexico to 111 species. With a land area of 360 km², VALL constitutes slightly more than 0.1% of the total land area of New Mexico (314,915 km²) and accounts for

35% (39 species) of the 111 aphid species known from the state. Published aphid diversity from other geopolitical areas include: Quebec $(1,542,056 \text{ km}^2)$ with 425 species (Entomofaune du Québec, Les Hémiptères; http://entomofaune.qc. ca/entomofaune/Pucerons/liste especes. html); Honduras (110,000 km²) with 46 species (Evans and Halbert 2007); and Brazil (8,459,417 km²) with 115 species, 92 species being adventive (Costa et al. 1993). A multi-year inventory of the aphid fauna of the Great Smoky Mountains National Park (GRSM; North Carolina and Tennessee) (2,114 km²) recovered 121 aphid species and estimated a total of 201 to 206 (Favret et al. 2010). It has already been suggested that tropical areas seem to have fewer aphid species than north-temperate areas (Dixon et al. 1987). These geopolitical areas have not been explored for aphid diversity with equal effort. And there is a high likelihood that previous aphid surveys include misidentified specimens. As insect collections around the world are databased, and those databases made public online, it will become much easier to gather numbers on species known from given geopolitical areas and make illustrative comparisons.

The proportion of adventive (Wheeler and Hoebeke 2009) aphids in North America is 18% (Foottit et al. 2006). Six (15%) of the species in or near VALL are considered adventive to North America and are from Europe (Foottit et al. 2006). There are however adventive species recorded from New Mexico that likely occur in the vicinity of VALL, but have not been found there, yet. For example, the Russian wheat aphid, Diuraphis noxia (Mordvilko), has been recorded in New Mexico (Webster and Ammosson 1994). It feeds on a variety of grasses, and both native and exotic grass species occur in the VALL.

Continued efforts in determining the aphid fauna richness of VALL are ongoing. With the recent description of new aphid species (Miller et al. 2014), seasonality of different host plants, and unique habitat diversity, we expect VALL to yield greater richness of aphid species. The second author makes annual collecting expeditions through New Mexico and neighboring states, and has accumulated an extensive set of material. The diversity of the VALL might in the future be postulated beyond the current list based on the known plant habitats and diversity of the VALL compared to his ongoing collection records from throughout the state and neighboring ecologically related areas much as was done for the Great Smoky Mountains National Park (Favret et al. 2010).

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LITERATURE CITED

- Blackman, R.L. and V.F. Eastop. 1994. Aphids on the World's Trees. CAB International, Wallingford, England. 986 pp.
- Blackman, R.L. and V.F. Eastop. 2006. Aphids on the World's Herbaceous Plants and Shrubs. Volume 1, Hosts Lists and Keys. John Wiley & Sons, West Sussex, England. 1024 pp.

- Cockerell, T.D.A. 1903a. A new aphid on thistle. Entomological News 14(8):248.
- Cockerell, T.D.A. 1903b. Aphididae. Transactions of the American Entomological Society 29:114–116.
- Cockerell, T.D.A. 1903c. Some Aphididae of the genus *Nectarophora* from New Mexico. Canadian Entomologist 35(6):167–171.
- Cockerell, T.D.A. 1903d. Notes on the entomology of Pecos, New Mexico. Canadian Entomologist 35(12):342–343.
- Cockerell, T.D.A. 1904. Some notes on Aphididae. Canadian Entomologist 36(9):262–263.
- Cockerell, W.P. 1903. Some aphids associated with ants. Psyche 10:216–218.
- Cockerell, W.P. and T.D.A. Cockerell. 1901. A new gooseberry plant-louse. Canadian Entomologist 33(8):227–228.
- Costa, C.L., V.F. Eastop, and R.L. Blackman. 1993. Brazilian Aphidoidea: I. Key to families, subfamilies and account of the Phylloxeridae. Pesquisa Agropecuária Brasileira 28: 197–215.
- Dixon, A.F.G., P. Kindlmann, J. Leps, and J. Holman. 1987. Why there are so few species of aphids, especially in the tropics. The American Naturalist 129(4):580–592.
- Evans, G.A. and S.E. Halbert. 2007. A checklist of the aphids of Honduras (Hemiptera: Aphididae). Florida Entomologist 90(3): 518–523.
- Favret, C. 2014. Aphid Species File. Version 5.0/ 5.0. [13 May 2014]. http://Aphid. SpeciesFile.org.
- Favret, C., J.J. Duggan, N.J. Sanders, and L. Richard Phillippe. 2010. Actual and inferred checklist of the Aphids (Hemiptera: Aphididae) of the Great Smoky Mountains National Park, with attendant ant and host plant associations. Proceedings of the Entomological Society of Washington 112(3): 381–403.
- Foottit, R.G., S.E. Halbert, G.L. Miller, H.E. Maw, and L.M. Russell. 2006. Adventive aphids (Hemiptera: Aphididae) of America North of Mexico. Proceedings of the Entomological Society of Washington 108(3): 583–610.
- Goff, F. 2009. Valles Caldera A geologic history. University of New Mexico Press, Albuquerque, NM.114 pp.
- Miller, G.L., A.S. Jensen, M.A. Metz, and R.R. Parmenter. 2014. A new species of *Atheroides* Haliday (Hemiptera, Aphididae) native to North America. Zookeys 452: 35–50.
- Muldavin, E., P. Tonne, C. Jackson, and T. Neville 2005. A vegetation map of the Valles Caldera National Preserve, NM. Final Report for

Cooperative Agreement No. 01CRAG0014. Albuquerque: University of New Mexico, Natural Heritage Museum.

- Pike, K.S., Boydston, L.L., and Allison, D.W. 2003. Aphids of western North America north of Mexico with keys to subfamilies and genera for female alatae. Washington State University, Cooperative Extension MISC0523, Pullman, Washington. 282 pp.
- Quednau, F.W. 1966. A list of aphids from Quebec with descriptions of two new species (Homoptera: Aphidoidea). Canadian Entomologist 98(4): 415–430.
- Smith, C.F. and C.S. Parron. 1978. An annotated list of Aphididae (Homoptera) of North America. Technical Bulletin of North Carolina Agricultural Experiment Station 255: 1–428.
- Webster J.A. and S. Amosson. 1994. Economic impact of the Russian wheat aphid in the western United States: 1992-1993. Great Plains Agricultural Council Publication No. 152.
- Wheeler, A.G., Jr. and E.R. Hoebeke. 2009. Adventive (Non-native) insects: Importance to science and society. Pp. 475–521. *In* Foottit, R.G. and P. H. Adler, eds. Insect Biodiversity. Wiley-Blackwell. 632 pp.