

Aphid (Hemiptera: Aphididae) Diversity in Potato Production Areas in Tucumán, Argentina

Authors: Avila , A. L., Vera, M. A., Ortego, J., Willink, E., Ploper, L. D., et al.

Source: Florida Entomologist, 97(4) : 1284-1289

Published By: Florida Entomological Society

URL: <https://doi.org/10.1653/024.097.0403>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

APHID (HEMIPTERA: APHIDIDAE) DIVERSITY IN POTATO PRODUCTION AREAS IN TUCUMÁN, ARGENTINA

A. L. AVILA^{1,2,*}, M. A. VERA¹, J. ORTEGO³, E. WILLINK¹, L. D. PLOPER^{1,2} AND V. C. CONCI⁴

¹Estación Experimental Agroindustrial Obispo Colombres (EEAOC), Sección Zoología Agrícola, Las Talitas (T4104AUD), Tucumán, Argentina

²Instituto de Tecnología Agroindustrial del Noroeste Argentino (ITANOA) - Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)

³Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Junín, Mendoza, Argentina.

⁴IPAVE, Instituto de Patología Vegetal-CIAP-INTA. Córdoba, Argentina - CONICET

*Corresponding author; E-mail: alavila@eeaac.org.ar

ABSTRACT

Aphids are recognized as important plant pests worldwide and they are major vectors of viruses. It is necessary to identify the aphid species in an agroecosystem in order to develop appropriate pest management strategies. The aim of this work was to determine the taxonomic diversity of aphid species present in potato crops in different agroecological regions of Tucumán, Argentina. Monitoring was done by 2 methods: modified Moericke yellow water traps were used for the alatae, while the apterae were collected directly from the plants. A total of 15,169 winged aphids were caught and 7,455 apterae colonizing the crop were collected. Fifty-six species were identified, 27 of which were present in all regions surveyed. Differences in species diversity between regions are discussed.

Key Words: aphids, biodiversity, taxonomy, virus vector

RESUMEN

Los áfidos son una importante plaga de plantas en todo el mundo y su importancia radica en ser uno de los principales vectores de virus. Es necesario identificar las especies de áfidos en un agroecosistema con el fin de desarrollar estrategias de manejo adecuadas. El objetivo de este trabajo fue determinar la diversidad taxonómica de las especies de áfidos presentes en cultivos de papa en diferentes regiones agrológicas de Tucumán, Argentina. El monitoreo se realizó utilizando dos métodos: se utilizaron trampas amarillas de agua Moericke para los alados y los ápteros fueron colectados directamente de las plantas. Un total de 15,169 áfidos alados y 7,455 ápteros colonizando el cultivo fueron capturados. Se identificaron 56 especies y 27 de ellas estuvieron representadas en todas las regiones evaluadas. Se observaron diferencias en la diversidad de especies entre las regiones, las cuales se discuten en el trabajo.

Palabras Clave: pulgones, biodiversidad, taxonomía, vector de virus

The province of Tucumán, Argentina, produces potato for consumption, industrial use and for use as seed potatoes. With regard to potato production for consumption and industrial use, Tucumán is characterized mainly by its early winter–spring production period (Caldiz 2006). Seed potatoes are grown during Oct to Mar in the department of Tafi del Valle (Fandos et al. 2011). Seed potato production is not an easy task, as crops are affected by multiple pests and diseases, including several viruses that contribute to the devaluation and rejection of seed stocks for certification (Carli & Baltaev 2008).

The most important virus diseases of potato are *Potato virus Y* (PVY = mosaic, Genus *Potyvirus*, Family *Potyviridae*) and *Potato leafroll virus* (PLRV, Genus *Polerovirus*, Family *Luteoviridae*), both being aphid (Hemiptera: Aphididae) transmitted (Radcliffe & Ragsdale 2002). Differences in transmission characteristics and number of vector species influence their spread of the virus and methods of control. PVY is transmitted in a non-

persistent manner and is acquired and inoculated during brief probes by aphids, including the alatae of many species that do not colonize potato. PLRV is transmitted in a persistent manner. It is confined to phloem tissues, and only those aphids that feed long enough acquire it, and then inoculate potato plants with PLRV (Woodford 1992).

Aphids include some of the most important pests of potato crops mainly because of their role as virus vectors (Adams & Kelley 1950; Kolbe 1970; Shands et al. 1972a). In South America 336 aphid species have been recorded (Ortego personal communication 2013) of which 237 are known to be present in Argentina (Nieto Nafría et al. 1994; Ortego et al. 2004; Mier Durante et al. 2011; Mier Durante et al. 2012; Ortego 2014 in press). Regarding the aphid diversity of Tucumán province, there are studies that date back to 1922 that cite a total of 82 species of aphids on several host plants (Ovruski de Martínez & Delfino 1990; Nieto Nafría et al. 1994; Ovruski de Martínez et al. 1997; A. L. Avila unpublished data).

Knowing the aphid species present in potato agroecosystems of Argentina is important in understanding the epidemiology of aphid-borne viruses of potato and the development of appropriate management strategies. Therefore, the present study aims to establish the aphid species composition in Tucumán Province, one of the potato production areas in Argentina.

MATERIALS AND METHODS

The following 3 agroecological regions of Tucumán were chosen from the "Agrologic outline of the Province of Tucumán" of Zuccardi & Fadda (1985), i.e.,

1. Alto Verde, in the southwest, department of Chicligasta (S 27° 21'-W 65° 40'; 390 m asl) is the principal production site of potatoes for consumption.
2. Tafí del Valle, in the northwest, department of Tafí del Valle (S 26° 54'-W 65° 45'; 2,000 m asl) is a significant production site of seed potatoes.
3. Las Talitas, in the northeast, department of Tafí Viejo, located (S 26° 48'-W 65° 12'; 481 m asl) is a production site of potatoes for consumption and industrial use.

Every week during 2 cropping seasons, winged forms of aphids were collected in the 3 regions with modified yellow Moericke water pan traps (Moericke 1955). Each pan was made of plastic and it was a little smaller than the original (53 × 35 × 11 cm). To determine which species colonized the crop, apterae aphids were collected weekly from plants evenly distributed throughout each plot. Potato plants were gently beaten against a vertical beat sheet used for sampling soybeans insects (Drees & Rice 1985). Specimens were preserved in 70% ethanol until identification. In each region, during 2 potato seasons, monitoring was conducted for various numbers of weeks because of weather conditions, the duration of the crop, etc.

In Alto Verde alatae were collected during 27 weeks and wingless aphids during 16 weeks. In Las Talitas, alatae individuals were monitored during 26 weeks and apterae during 15 weeks. Finally, in Tafí del Valle alatae were collected during 37 weeks and wingless individuals during 12 weeks.

Several keys were used to identify the species, i.e., Remaudière & Seco Fernandez (1990), Blackman & Eastop (2000), and Taylor & Robert (1984). Sometimes identifications could be done only to the genus. Aphid classification of Blackman & Eastop (2000) was followed in this work. Literature was consulted to highlight which of the species collected had been cited previously as a vector of an important potato virus.

RESULTS

A total of 15,169 alatae aphids were caught during this study. Fifty-six species were identified. Twenty-one of these species have been cited around

the world as vectors of PVY and PLRV virus (Völk 1959; Van Hoof 1980; Piron 1986; Blackman & Eastop 2000) (Table 1).

All the aphids collected belonged to the Aphididae family and within it, to 6 subfamilies: Aphidinae, Calaphidinae, Chaitophorinae, Eriosomatinae, Saltusaphidinae and Lachninae. In all 3 regions sampled, more than 95% of the species belonged to the Aphidinae. Regarding the aphids collected in both seasons, Tafí del Valle accounted for the greatest number of species, although Las Talitas had the largest number of individuals captured. Twenty-seven species appeared in the 3 regions, and within these, the genus *Aphis* was the most abundant. Furthermore, the following species were the most prominent in each region: *Hyperomyzus lactucae* (Linnaeus) at Las Talitas, *Acyrtosiphon kondoi* Shinji at Alto Verde and *Pemphigus* sp. at Tafí del Valle (Table 1).

Among known vectors of PVY and PLRV, the green peach aphid, *Myzus persicae* (Sulzer), was the most abundant in the 3 regions, while *Capitophorus elaeagni* (Del Guercio) was quite evenly abundant among all 3 regions (Table 1). Main differences were observed for alates both of *Brevicoryne brassicae* (Linnaeus) and *Lipaphis erysimi* (Davis). *Brevicoryne brassicae* was much more abundant at Tafí del Valle than in the other 2 regions. *Lipaphis erysimi* was most prominent at Las Talitas, where it constituted more than 16% of the catches in contrast to representing less than 1% of the catches at Tafí del Valle. The total number of specimens of known vectors was 8,898 winged individuals (Table 1), which represented 58.66% of the total, with the higher quantity collected in Las Talitas (5,470 individuals, 60.6%), followed by Alto Verde (2,291 individuals, 59%) and Tafí del Valle (1,137 individuals, 50.2%). It is worth noting that several species within the *Aphis* genus are known as virus vectors, and that the identities of species of the alatae captured in the flight phase cannot be reliably determined, except for a few species whose alatae are highly distinctive (Stroyan 1984). Since in this work we did not identify the species belonging to this genus, further studies could modify these results.

With regard to apterous aphids (Table 2), a total of 7,455 individuals of 9 different species were collected, all of which belonged to the Aphididae. Two subfamilies were found within this family, i.e., Aphidinae and its Macrosiphini (97.2%) and Aphidini tribes (2.7%), and Eriosomatinae and its Pemphigini tribe (< 0.01%) (Table 2). In Alto Verde and Tafí del Valle the preponderance of *M. persicae* was very clear, different from what occurred in Las Talitas, where the dominance was shared by *M. persicae* and *Macrosiphum euphorbiae* (Thomas).

DISCUSSION

Our trapping data demonstrate that there are numerous species of winged aphids visiting potato fields that do not colonize the crop. Information on

TABLE 1. ALATAE APHIDS COLLECTED IN POTATO CROPS IN TUCUMÁN, ARGENTINA. *PVY VECTORS AND **PLRV VECTORS. VALUES ARE NUMBER AND PERCENT OF THE TOTAL SPECIMENS FOR EACH LOCATION.

Region	Alto Verde		Las Talitas		Tafi del Valle		Total	
	2010/2011	%	2011/2012	%	2010/2011	%		
Traps	5		6		6		17	
Total number of specimens	3,881		9,024		2,264		15,169	
Vectors of PVY and PLRV: total number of specimens	2,291		5,470		1,137		8,898	
Total number of species	37		40		45		56	
Taxa	N°	%	N°	%	N°	%	N°	%
<i>Acyrtosiphon (Acyrtosiphon) kondoi</i> Shinji	175	4.51	146	1.62	17	0.75	338	2.23
<i>Acyrtosiphon (Acyrtosiphon) pisum</i> (Harris)*	4	0.10	10	0.11	—	—	14	0.09
<i>Aphis</i> spp.	1,126	29.01	2,814	31.18	699	30.87	4,639	30.58
<i>Aploneura lentisci</i> Passerini	—	—	—	—	1	0.04	1	0.01
<i>Aulacorthum (Aulacorthum) solani</i> (Kaltenbach)**	15	0.39	—	—	19	0.84	34	0.22
<i>Brachycaudus (Brachycaudus) helichrysi</i> (Kaltenbach)*	36	0.93	39	0.43	37	1.63	112	0.74
<i>Brachycaudus (Mordvilkomemor) rumexicolens</i> (Patch)	5	0.13	295	3.27	4	0.18	304	2.00
<i>Brevicoryne brassicae</i> (Linnaeus)*	47	1.21	605	6.70	386	14.84	988	6.51
<i>Capitophorus elaeagni</i> (Del Guercio)*	152	3.92	295	3.27	126	5.57	573	3.78
<i>Capitophorus hippophaes</i> (Walker)*	19	0.49	3	0.03	8	0.35	30	0.20
<i>Capitophorus</i> sp.	—	—	—	—	50	2.21	50	0.33
<i>Cavariella (Cavariella) aegopodii</i> (Scopoli)*	9	0.23	4	0.04	—	—	13	0.09
<i>Chaetosiphon</i> sp.	—	—	—	—	1	0.04	1	0.01
<i>Chaetosiphon leucomelas</i> Koch	—	—	—	—	18	0.80	18	0.12
<i>Cinara</i> sp.	—	—	4	0.04	4	0.18	8	0.05
<i>Cryptomyzus (Cryptomyzus) ballotae</i> Hille Lis Lambers*	98	2.53	174	1.93	19	0.84	291	1.92
<i>Dysaphis acupariae</i> (Buckton)	20	0.52	5	0.06	5	0.22	30	0.20
<i>Eucarazzia elegans</i> (Ferrari)	—	—	5	0.06	3	0.13	8	0.05
<i>Hyadaphis foeniculi</i> (Passerini)*	—	—	3	0.03	2	0.09	5	0.03
<i>Hyperomyzus (Hyperomyzus) lactucae</i> (Linnaeus)*	55	1.42	871	9.65	6	0.27	932	6.14
<i>Illinoia</i> sp.	1	0.03	4	0.04	—	—	5	0.03
<i>Lipaphis (Lipaphis) erysimi</i> (Kaltenbach)*	265	6.83	1,462	16.20	22	0.97	1,749	11.53
<i>Macrosiphoniella (Macrosiphoniella) artemisiae</i> (Boyer de Fonscolombe)	8	0.21	1	0.01	7	0.31	16	0.11
<i>Macrosiphoniella (Macrosiphoniella) tapuskae</i> (Hottes & Frison)	—	—	—	—	3	0.13	3	0.02
<i>Macrosiphum (Macrosiphum) euphorbiae</i> (Thomas)**	3	0.08	499	5.53	44	1.94	546	3.60
<i>Macrosiphum (Macrosiphum) rosae</i> (Linnaeus)	—	—	—	—	2	0.09	2	0.01
<i>Metopolophium (Metopolophium) dirhodum</i> (Walker)*	4	0.10	29	0.32	9	0.40	42	0.28
<i>Myzaphis rosarum</i> (Kaltenbach)*	2	0.05	—	—	—	—	2	0.01

TABLE 1. (CONTINUED) ALATAE APHIDS COLLECTED IN POTATO CROPS IN TUCUMÁN, ARGENTINA. *PVY VECTORS AND **PLRV VECTORS. VALUES ARE NUMBER AND PERCENT OF THE TOTAL SPECIMENS FOR EACH LOCATION.

Region	Alto Verde		Las Talitas		Tafi del Valle		Total	
	2010/2011	2011/2012	2011/2012	2010/2011	2010/2011	2010/2011		
Traps	5	6	6	6	6	17		
Total number of specimens	3,881	9,024	9,024	2,264	2,264	15,169		
Vectors of PVY and PLRV: total number of specimens	2,291	5,470	5,470	1,137	1,137	8,898		
Total number of species	37	40	40	45	45	56		
Taxa	N°	%	N°	%	N°	%	N°	%
<i>Myzus (Nectarosiphon) persicae</i> (Sulzer)**	1,450	37.36	1,355	15.02	448	19.79	3,253	21.45
<i>Nasonovia (Nasonovia) ribisnigri</i> (Mosley)	5	0.13	1	0.01	2	0.09	8	0.05
<i>Ovatus crataegarius</i> (Walker)	—	—	3	0.03	—	—	3	0.02
<i>Pemphigus</i> sp.	48	1.24	72	0.80	139	6.14	259	1.71
<i>Pleotricophorus glandulosus</i> (Kaltenbach)	—	—	—	—	1	0.04	1	0.01
<i>Rhodobium porosum</i> (Sanderson)	1	0.03	—	—	—	—	1	0.01
<i>Rhopalomyzus poae</i> (Gillette)	—	—	—	—	1	0.04	1	0.01
<i>Rhopalosiphoninus (Rhopalosiphoninus) latysiphon</i> (Davidson)**	—	—	—	—	3	0.13	3	0.02
<i>Rhopalosiphum maidis</i> (Fitch)*	4	0.10	5	0.06	33	1.46	42	0.28
<i>Rhopalosiphum padi</i> (Linnaeus)*	68	1.75	31	0.34	10	0.44	109	0.72
<i>Rhopalosiphum rufiabdominale</i> (Sasaki)	97	2.50	49	0.54	15	0.66	161	1.06
<i>Rhopalosiphum</i> sp.	—	—	13	0.14	—	—	13	0.09
<i>Saltusaphis scirpus</i> Theobald	2	0.05	9	0.10	1	0.04	12	0.08
<i>Schizaphis (Schizaphis) graminum</i> (Rondani)*	—	—	19	0.21	2	0.09	21	0.14
<i>Sipha (Rungia) maydis</i> Passerini	1	0.03	11	0.12	18	0.80	30	0.20
<i>Sitobion (Sitobion) avenae</i> (Fabricius)*	49	1.26	32	0.35	12	0.53	93	0.61
<i>Tabacallis arundinariae</i> (Essig)	7	0.18	—	—	3	0.13	10	0.07
<i>Tabacallis taiwanus</i> (Takahashi)	—	—	—	—	1	0.04	1	0.01
<i>Tetraneura (Tetraneurella) nigriabdominalis</i> (Sasaki)	2	0.05	19	0.21	45	1.99	66	0.44
<i>Therioaphis (Rhizoberlesia) riehmi</i> (Börner)	18	0.46	16	0.18	—	—	34	0.22
<i>Therioaphis (Pterocalldium) trifolii</i> (Monell)	18	0.46	22	0.24	12	0.53	52	0.34
<i>Toxoptera aurantii</i> (Boyer de Fonscolombe)	—	—	5	0.06	—	—	5	0.03
<i>Tuberculatus (Tuberculoides) annulatus</i> (Hartig)	—	—	2	0.02	2	0.09	4	0.03
<i>Tuberculatus (Tuberculatus) querceus</i> (Kaltenbach)	1	0.03	3	0.03	—	—	4	0.03
<i>Uroleucon (Uroleucon) spp.</i>	3	0.08	—	—	—	—	3	0.02
<i>Uroleucon (Uromelan) spp.</i>	9	0.23	14	0.16	5	0.22	28	0.18
<i>Uroleucon (Uroleucon) sonchi</i> (Linnaeus)*	11	0.28	34	0.38	1	0.04	46	0.30
<i>Wahlgeniella nervata</i> (Gillette)	—	—	—	—	16	0.71	16	0.11
Unidentified	43	1.11	41	0.45	52	2.30	136	0.90

aphids of Tucumán is sparse, and the few available sources of literature indicate that 82 species have been cited in Tucumán province (Ovruski de Martinez & Delfino 1990; Nieto Nafria et al. 1994; Ovruski de Martinez et al. 1997; A. L. Avila, unpublished data)

The discovery of apterous individuals in the crop belonging to 3 taxa that normally do not colonize potato plants (*Pemphigus* sp., *H. lactucae* and *C. fragaefolii*) may be due to the presence of nearby strawberry plants from some previous crop and weeds growing between the potato plants, such as Cruciferae and *Sonchus* spp. (Asterales: Asteraceae), that are hosts of these species.

Virus transmission rate depends on many factors such as the vector abundance and vector population dynamics, the efficiency of transmission, and environmental factors (Boukhris-Bouhachem et al. 2013). During this study, only species diversity and abundance were surveyed. Each region presented its own epidemiological characteristics but they all harbor PVY and PLRV vectors in abundance. In this regard, Tafi del Valle seems different because it had the lowest number of aphids and the greater diversity. This could be because of certain characteristics of the valley such as altitude and climatic conditions, mainly temperature and rainfall that allow the expression of a different vegetation composition (Meyer & Weyrauch 1966).

It has been reported that any aphid visiting the potato plant is a potential vector of non-persistent viruses (Harrewijn et al. 1981). However, only 47 species of aphids including many species that do not colonize potato crop, have been proven capable of transmitting PVY with varying efficiencies (Völk 1959; Van Hoof 1980; Piron 1986; Ortego 1991; Pérez et al. 1995; Kerlan 2006) and only 30 of them are cited in Argentina (Ortego & Mier Durante 2010). Twenty-one of the species collected in this work were previously cited as capable of transmitting PVY and/or PLRV (Table 1). Of these, *M.*

persicae is known to be a major vector of these 2 viruses and merits special attention because of its importance as a crop pest. For example, *M. persicae* can transmit more than 100 viruses (Kennedy et al. 1962). Additionally, *M. persicae* stands out from the rest of the aphid species because of its wide geographic distribution and its wide host range (Van Emden et al. 1969). More than 400 of plant species belonging to 50 families are hosts of *M. persicae* (Osianilsson 1966). It is possible that secondary hosts of *M. persicae* are allowed to grow in the 3 regions evaluated. Therefore, if the abundance of secondary host species could be drastically reduced, then the incidence of potato plants infected with these viruses would be greatly reduced as well.

PLRV is mainly transmitted by aphids colonizing potato crops but not by all colonizing aphid species (Harrewijn et al. 1981). The literature mentions the existence of 10 aphid species as vectors of PLRV, 9 of which are present in Argentina (Kennedy et al. 1962; Ortego & Mier Durante 2010) and 5 of them were collected in Tucumán province during this survey (Table 2). A remarkable number of apterae of *M. persicae* was found colonizing the crop, and this species is well known as an efficient virus vector in several crops including potato. Results have shown that the number of green peach aphids in the crop had reached remarkably great densities, being present throughout the crop cycle, and representing more than 97% of the whole in Tafi del Valle (the region dedicated to seed potato production) and Alto Verde, but being much less abundant in Las Talitas. These findings must be considered only as a first step of a more complete epidemiological study and the development of an effective strategy to minimize virus transmission.

ACKNOWLEDGMENTS

We thank to all the members of Horticulture Department of EEAOC, especially to Ing. Agr. Ramiro Lobo and Ing. Agr. Alicia Fornas. Also to Dra. Gabriela Murua and

TABLE 2. APTERAEE APHIDS COLLECTED ON POTATO CROPS IN THE THREE MAJOR POTATO PRODUCTION REGIONS OF TUCUMÁN PROVINCE, ARGENTINA. *PVY VECTORS AND **PLRV VECTORS. VALUES ARE NUMBER AND PERCENT OF THE TOTAL SPECIMENS FOR EACH LOCATION.

Region	Alto Verde		Las Talitas.		Tafi del Valle		Total	
	N°	%	N°	%	N°	%	N°	%
Total number of specimens	3,927		1,353		2,175		7,455	
Total number of species	5		5		7		9	
Species	N°	%	N°	%	N°	%	N°	%
<i>Aphis gossypii</i> Glover**	12	0.306	150	11.09	25	1.149	187	2.508
<i>Aphis fabae</i> Scopoli**	—	—	7	0.517	5	0.23	12	0.161
<i>Aulacorthum solani</i> (Kaltenbach)**	13	0.331	—	—	12	0.552	25	0.335
<i>Macrosiphum euphorbiae</i> (Thomas)**	23	0.586	553	40.87	2	0.092	578	7.753
<i>Myzus persicae</i> (Sulzer)**	3,877	98.73	636	47.01	2,121	97.52	6,634	88.99
<i>Rhopalosiphum rufiabdominale</i> (Sasaki)	2	0.051	—	—	—	—	2	0.027
<i>Pemphigus</i> sp.	—	—	—	—	4	0.184	4	0.054
<i>Chaetosiphon fragaefolii</i> (Cockerell)	—	—	—	—	6	0.276	6	0.08
<i>Hyperomyzus lactucae</i> (Linnaeus)*	—	—	7	0.517	—	—	7	0.094

Ing. Agr. Gerardo Gastaminza for excellent technical support. Thanks to Ing. Zoot. Lorena Soulé Gómez for the climatic information. This study was supported by EEAOC and CONICET and it is part of the first author's doctoral thesis.

REFERENCE CITED

- ADAMS, J. B., AND KELLEY, R. A. 1950. Potato aphid control studies, 1946-1949, at Woodstock, New Brunswick, Canada. *American Potato J.* 27: 175-182.
- BLACKMAN, R. L., AND EASTOP, V. F. 2000. Aphids on the world's crops: An identification and information guide. Wiley and Sons, Chichester. 475 pp.
- BOUKHRIS-BOUHACHEM, M., S., SOUSSI, R., TURPEAU, E., ROUZÉ-JOUAN, J., FAHEM, M., BEN BRAHIM, N., AND HULLÉ, M. 2013. Aphid (Hemiptera: Aphidoidea) diversity in Tunisia in relation to seed potato production. *Ann. Soc. Entomol. France* 43(3): 311-318.
- CALDIZ, D. O. 2006. Producción, cosecha y almacenamiento de papa en la Argentina. McCain Argentina SA, Balcarce-Basf Argentina SA, Capital Federal. Argentina. 226 pp.
- CARLI, C., AND BALTAEV, B. 2008. Aphids infesting potato crop in the highlands of Uzbekistan. *Potato J.* 35(3-4): 134-140.
- CERMELI, M. 1987. Control de áfidos plagas en Venezuela. En: Curso de áfidos. Artículos selectos sobre áfidos y su importancia económica en la Agricultura de Centroamérica. CATIE. Panamá. 20-35 pp.
- DREES, B. M., AND RICE, M. L. 1985. The vertical beat sheet: A new device for sampling soybeans insects. *J. Econ. Entomol.* 78: 1507-1510.
- FANDOS, C., SCANDALIARIS, P. SORIA, F., CARRERAS BALDRÉS, J., AND LOBO ZAVALÍA, R. 2011. Estimación satelital de la superficie cultivada con papa en el pedemonte y llanura tucumano durante la campaña 2010. *Rev. Avance Agroindus.* 32(3): 35-39.
- HARREWLN, P., VAN HOOF, H. A., AND NOORDINK, J. P. W. 1981. Flight behavior of the aphid *Myzus persicae* during its maiden flight. *European J. Plant Path.* 87: 111-117.
- KENNEDY, J. S., DAY, M. F., AND EASTOP, V. F. 1962. A conspectus of aphids as virus vector of plant viruses. Commonwealth Inst. Entomol. London. 114pp.
- KERLAN, C. 2006. *Potato virus Y*. AAB Descriptions of Plant Viruses, No. 414.
- KOLBE, W. 1970. Influence of direct feeding damage on yields of heavily aphid-infested potato crops. *Pflanzenschutz-Nachr.* 23: 273-282.
- MEYER, T., AND WEYRAUCH, V. 1966. Guía para dos excursiones biológicas en la Provincia de Tucumán. Misc. N° 23 de la U.N.T. Tucumán, Argentina. 127 pp.
- MIER DURANTE, M. P., FOOTITT, R., VON DOHLEN, C. D., AND ORTEGO, J. 2012. First American records of *Aphis intybi* (Hemiptera: Aphididae) with notes on two other related adventives species in Argentina. *Florida Entomol.* 95(4): 1154-1162.
- MIER DURANTE, M. P., ORTEGO, J., PÉREZ HIDALGO, N., AND NIETO NAFRÍA, J. M. 2011. Three aphid species (Hemiptera: Aphididae) recorded for the first time from South America. *Florida Entomol.* 94(4): 839-842.
- MOERICKE, V. 1955. Über die Lebensgewohnheiten der gelbten Blattlaus (Aphidina) unter besonderer Berücksichtigung des Verhaltens beim Landen. *Z. Angew. Entomol.* 37: 29-91.
- NIETO NAFRÍA, J. M., DELFINO, M. A., AND MIER DURANTE, M. P. 1994. La áfido-fauna de la Argentina: su conocimiento en 1992. Universidad de León, León, España. 235pp.
- ORTEGO, J. 1991. Presencia y actividad de áfidos vectores de PVY en dos localidades productoras de tubérculos semilla de papa en Malargüe, Mendoza, Argentina. *Rev. Latinoamericana Papa* 4: 86-102.
- ORTEGO, J. 2014. Primer registro en Argentina de *Drepanosiphum oregonense* Granovsky (Hemiptera: Aphididae) hallada sobre arces (Sapindaceae). *Rev. Facultad Cien. Agrarias, U.N. CUYO*. In press. <http://www.scielo.org.ar/pdf/refca/v44n1/v44n1a17.pdf>
- ORTEGO, J., AND MIER, DURANTE, M. P. 2010. Distribución territorial de los áfidos vectores de *Potato virus Y* (PVY) y *Potato leaf roll virus* (PLRV) en la Argentina. *En XXIV Congreso de la Asociación Latinoamericana de la Papa (ALAP)*, Cusco, Perú.
- ORTEGO, J., DIFABIO, M. E., AND MIER DURANTE, M. P. 2004. Nuevos registros y actualización de la lista faunística de los pulgones (Hemiptera: Aphidoidea) de la Argentina. *Rev. Soc. Entomol. Argentina* 63(1-2): 19-30.
- OSSIANNILSON, F. 1966. Insects in the epidemiology of plant viruses. *Annu. Rev. Entomol.* 11: 213-232.
- OVRUSKI DE MARTINEZ, N. E., AND DELFINO, M. A. 1990. Aspectos biológicos de los áfidos (Homóptera: Aphidoidea) de interés económico en Tafi del Valle (Tucumán-Argentina). *Rev. Ind. y Agríc. de Tucumán.* 67 (1): 91-117.
- OVRUSKI DE MARTINEZ, N. E., ZAMUDIO, N., AND LOBO, R. 1997. Relación entre la ocurrencia de áfidos alados y la infección de virus en el cultivo de papa de Tafi del Valle, Tucumán. *Rev. Ind. Agríc. Tucumán* 74(1-2): 59-64.
- PÉREZ, P., COLLAR, J. L., AVILLA, C., DUQUE, M., AND FERERES, A. 1995. Estimation of vector propensity of *Potato virus Y* in open field pepper crops of Central Spain. *J. Econ. Entomol.* 88: 986-991.
- PIRON, P. G. M. 1986. New aphid vectors of *Potato virus Y*. *Netherlands J. Plant Path.* 92: 223-229.
- RADCLIFFE, E. B., AND RAGSDALE, D. W. 2002. Aphid-transmitted potato viruses: The importance of understanding vector biology. *American J. Potato Res.* 79: 353-386.
- REMAUDIÈRE, G., AND SECO-FERNÁNDEZ, M. V. 1990. Claves para ayudar al reconocimiento de pulgones alados trampeados en la Región Mediterránea (Hom. Aphidoidea). Universidad de León. (Secretariado Publicaciones). 2 vol., 205pp.
- SHANDS, W. A., SIMPSON, G. W., SEAMAN, B. A., ROBERTS, F. S., AND FLYNN, C. M. 1972a. Effects of differing abundance levels of aphids and of certain virus diseases upon yield and virus disease spread in potatoes. *Life Sci. Agric. Exp. Sta., Univ. Maine Tech. Bull.* No. 56. 40 pp.
- STROYAN, H. L. G. 1984. Aphids-Pterocommatinae and Aphidinae (Aphidini) Homoptera, Aphididae. *In Handbooks for the Identification of British Insects.* Vol. II. Part 6. R. Entomol. Soc. London. 232 pp.
- TAYLOR, L. R., AND ROBERT, Y. 1984. A handbook for aphid identification. Ed. L. R. Taylor. Harpenden. 171 pp.
- VAN EMDEN, H. F., EASTOP, V. F., HUGHES R. D., AND WAY, M. S. 1969. The ecology of *Myzus persicae*. *Annu. Rev. Entomol.* 14: 197-270.
- VAN HOOF, H. A. 1980. Aphid vectors of *Potato virus Y*. *Netherlands J. Plant Path.* 86: 159-162.
- VÖLK, J. 1959. Zur Übertragung des Y-Virus durch Insekten und Kontakt. *Ztschr. Pflanzenkrankh.* 66: 563-571.
- WOODFORD, J. A. T. 1992. Virus transmission by aphids in potato crops. *Netherlands J. Plant Path.* 98(2): 47-54.
- ZUCCARDI, R. B., AND FADDA, G. S. 1985. Bosquejo agrológico de la provincia de Tucumán. *Miscelánea* 86. 51pp.