Diversity of Auchenorrhyncha (Hemiptera: Cicadellidae: Delphacidae) Associated with Vicia villosa in Southern Buenos Aires Province, Argentina

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DIVERSITY OF AUCHENORRHYNCHA (HEMIPTERA: CICADELLIDAE: DELPHACIDAE) ASSOCIATED WITH *VICIA VILLOSA* IN SOUTHERN BUENOS AIRES PROVINCE, ARGENTINA

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Abstract

Among the Hemiptera, the Auchenorrhyncha are well known owing to their phytosanitary relevance since the group includes pathogen vector species able to damage commercial crops. *Vicia villosa* Roth (Fabaceae) is a fodder plant species, mainly distributed in central Argentina. Previous contributions have shown that *V. villosa* is colonized by diverse species of Auchenorrhyncha, either naturalized or native to valley of Colorado River area, in southern Buenos Aires province. To date, the only information about the species of hoppers associated with *Vicia* has come from preliminary field observations. The dearth of demographic knowledge about these phytophagous insects associated with this crop in Argentina motivates the study. The aims of this work were: 1) to characterize the diversity of the species of Auchenorrhyncha associated with *V. villosa* and 2) to determine the seasonal fluctuation of the most abundant species in relation to local weather variables and crop phenological phases. The study was conducted in *Vicia* plots located at EEA INTA Hilario Ascasubi (S 39° 23' 36" -W 62° 37' 59", 15 m.a.s.l.) southern Buenos Aires province. The specimens were collected with a sweep net during 2 yr (2009 and 2011). Weather variables were recorded using a meteorological station located at the sampling site. To measure species richness and community diversity we calculated both Margalef (D_{Mg}) and the Simpson (D) indexes, and also, the Relative Importance Index (RII). The relationships between population densities of the leafhoppers, *Paratanus exitiosus* (Beamer) and *Agalliana ensigera* Oman (Cicadellidae), with weather variables were analyzed through simple and multiple linear regression. A total of 17 species were associated with *V. villosa* crops in Argentina, of which 15 belong to the Cicadellidae and 2 to the Delphacidae. Abundance and species richness were higher in 2009 than in 2011. In general, the results of the Margalef index showed that species richness was higher in 2009, while Simpson Index (D) indicated a higher dominance in 2011 than in 2009. The species, *P. exitiosus* and *A. ensigera,* stood out for their abundance, frequency and phytosanitary relevance during the sampling period. Both species presented population increases since Nov coinciding with different phenological phases of the crop and the maximum density of the canopy. Additionally, the population density of *P. exitiosus* showed strong dependence on the hydric balance and photoperiod, while *A. ensigera* was influenced by Degree-days$_{10}$ and hydric balance . *Vicia villlosa* was a new host-plant record for 15 species. Buenos Aires province was cited as a new distribution record for 2 species.

Key Words: Auchenorrhyncha, communities, richness, abundance, seasonal fluctuation, *Vicia,* crop phenology

Resumen

Los hemipteros auquenorrincos son insectos de reconocida importancia fitosanitaria dado que reúnen especies vectoras de patógenos que ocasionan daños a cultivos de interés comercial. *Vicia villosa* Roth es una especie forrajera, distribuída fundamentalmente en la región central de Argentina. Observaciones preliminares evidenciaron que *V. villosa* es colonizada por una diversidad de auquenorrincos, establecidos o nativos, en el área de riego del valle del Río Colorado en el sur de la provincia de Buenos Aires. La falta de estudios poblacionales referidos a estos fitófagos asociados a dicho cultivo motivaron el planteo de los siguientes objetivos: 1) conocer la diversidad de las especies de auquenorrincos presentes a lo largo del ciclo de *V. villosa* y 2) estudiar la influencia de diversas variables climáticas locales sobre las poblaciones de las especies más abundantes y asociar la presencia de éstas a las fases fenológicas del cultivo. Los muestreos fueron realizados en lotes de vicia ubicados en la Estación Experimental Agropecuaria (EEA) INTA Hilario Ascasubi (62° 37' 59" LO, 39° 23' 36" LS 15 msnm), al sur de la provincia de Buenos Aires. Los especímenes fueron colectados con red entomológica de arrastre durante dos años (2009 y 2011). Las variables climáticas se registraron con una estación meteorológica instalada en el sitio de estudio. Para el cálculo de la riqueza específica y la diversidad se utilizaron los índices de Margalef (D_{Mg}) y Simpson (D). También se calculó el Indice de Importancia Relativa (IIR). La relación entre la densidad poblacional de los cicadélidos, *Paratanus exitiosus* (Beamer) y *Agalliana ensigera* Oman con las variables climáticas fue analizada mediante regresión lineal simple y múltiple. La abundancia y la riqueza específica fueron mayores en 2009. En general, los valores de Margalef (D_{Mg}) denotaron una mayor riqueza específica en 2009, mientras que el Índice de Simpson (D) mostró una mayor dominancia en el año 2011. En ambos años, las especies *P. exitiosus* y *A. ensigera* sobresalieron por su abundancia, frecuencia e importancia fitosanitaria. Las dos especies presentaron picos poblacionales desde noviembre en diferentes fases fenológicas del cultivo y cuando la canopea era ya muy densa. Sobre la base de los resultados obtenidos, la densidad de la población de *P. exitiosus* en el cultivo de vicia mostró una fuerte dependencia con el balance hídrico y el fotoperiodo; mientras que *A. ensigera* estuvo influenciada por los grados día10 y el balance hídrico. *Vicia villlosa* se registra como nuevo hospedante para 15 especies, de las cuales dos se citan por primera vez para la provincia de Buenos Aires.

Palabras Clave: Auchenorrhyncha, riqueza, abundancia, fluctuación, estacional, *Vicia,* fenología

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Auchenorrhyncha, especially the families Delphacidae (“planthoppers”) and Cicadellidae (“leafhoppers”), are phytophagous insects distributed worldwide. Several species are serious agricultural pests and may injure plants either directly, through feeding and oviposition, or indirectly, through the transmission of plant pathogens such as viruses and bacteria (Harris 1979; Nault & Ammar 1989). As occurs with other insects, the hoppers’ distribution, abundance and richness can be influenced by the climate conditions, vegetation and their interactions. The effects of host plant quality and plant species composition have been also shown to exert major influences on auchenorrhynchan dynamics (Masters et al. 1998).

Few contributions have been made about the population patterns of species of Auchenorrhyncha associated with commercially important crops in central Argentina. In the last 25 yr, some works have been published regarding only maize (*Zea mays* L.; Poaceae) (Tesón et al. 1986; Remes Lenicov & Virla 1999b; Paradell et al. 2001), wheat (*Triticum* spp.; Poaceae) (Remes Lenicov & Virla 1993), rye (*Secale cereale* L; Poaceae) (Ornaghi et al. 1993), oat (*Avena sativa* L.; Poaceae) (Dagoberto et al. 1985; Tesón et al. 1986), alfalfa (*Medicago sativa* L.; Fabaceae) (Meneguzzi 2008) and garlic (*Allium sativum* L.; Amaryllidaceae) (Catalano 2011).

The genus *Vicia* L., (Fabales: Fabaceae: Papilionoideae), with over 200 species distributed worldwide, has high genetic variability and a productive potential that has not been fully exploited to date. Native, naturalized or cultivated species of this genus are present in all temperate and tropical regions of the world. Their greatest diversity occurs in the Mediterranean basin, which is considered as its center of origin; although, secondary centers with high genetic variability have been found in southern Siberia, Europe, North and South America, including Argentina. Knowledge about natural distribution, taxonomy and productive potential of the genus *Vicia* is still scarce in America. At least, 20 species are considered to be part of the natural flora in southern Brazil, Paraguay, Chile, Uruguay and Argentina (Renzi 2009).

Vicia villosa Roth is a winter-spring legume species used as cover crop, and for soil improvement, grazing and seed production. Frequently, winter legumes are used as cover crops in insect pest management programs. In the United States *V. villosa* is probably the most commonly used cover crop (Baldwin & Creamer 2005). In Argentina, it is distributed in the provinces of Buenos Aires, Córdoba and La Pampa; and is becoming progressively more important in southern Buenos Aires province in recent yr (J. P. Renzi EEA INTA Hilario Ascasubi, Argentina, personal communication). *Vicia* is cultivated as monoculture or together with oat as a support (polyculture). This combination facilitates harvesting due to increase the height of the crop while the seed yield is not affected (Renzi 2009).

Several studies on insect communities affecting *V. villosa* are focused on the effects of cover crops on abundance and diversity of hervibores, parasitoids and predators (Haddad et al. 2001; Hall et al. 2004; Tillman et al. 2004). In Europe (Bulgaria), a recent contribution by Georgieva & Nikolova (2011) is the only study about the species of Auchenorrhyncha associated with this vetch. In Argentina, preliminary field observations by Dughetti & Zárate (2010) and Dughetti et al. (2012), revealed that 14 species of Auchenorrhyncha are associated with *V. villosa* in southern Buenos Aires province. These studies highlighted *Agalliana ensigera* Oman and *Paratanus exitiosus* (Beamer) as important pests that were confirmed as vectors of different viruses in Argentina (Fawcett 1927), Brazil (Costa 1952) and Chile (Oman 1949). Until now, there have been no relevant studies about the community structure of herbivores affecting *Vicia* in Argentina. Demographic studies should be carried out in order to know the importance of hoppers in this crop.

The hypotheses of this contribution are that *Vicia* crop hosts a great diversity of species of Auchenorrhyncha with phytosanitary importance, and that the population dynamics of the most abundant species respond to different weather variables and crop phenological phases. Accordingly, the aims of this work were: 1) to characterize the diversity of the species of Auchenorrhyncha associated with *V. villosa,* and 2) to determine the seasonal fluctuations of the most abundant species in relation to local weather variables and crop phenological phases. In addition, as a complementary approach, we recorded the geographical distribution, host plants and phytosanitary importance of the species with a relevant frequency range (very frequent-less frequent), and assembled the corresponding bibliographical references.

Materials and Methods

Study site and Record of Weather and Phenological Conditions

The study site were located at the experimental field of EEA INTA in the department of Hilario Ascasubi (S 39° 23' 36" -W 62° 37' 59", 15 m asl), southern Buenos Aires, Argentina. Sweep net samples were taken during 2 growing seasons (2009 and 2011). In 2009, the sample area comprised 850 m^2 and was sowed on Apr 24. On average, crop seedlings appeared on May 12th. In 2011, the area comprised 1,800 m^2 and was located within a 1.5 ha seed production plot; the sowing was done on May 11th and the seedlings appeared on May 28th. In 2009, sampling began in mid-Sep, when the crop was quite dense and the tendrils and stems interlaced to form a single plant mass, while in 2011, sampling was delayed to mid-Oct because the canopy was too light to begin sooner. The seed harvesting time varied according to the different sowing times and the weather conditions in each year.

The following phenological phases (adapted from Renzi 2009) were observed during sampling periods: Emergence: 90% of seedlings above the ground surface, based on presence of the first 2 expanded leaves; Vegetative: development of primary and secondary stems as well as leaves, until the onset of flowering; Flowering: the period after the opening of the first flower and until less than 10% of the plants still had open flowers**;** Pod Formation: 50% of plants with first growing pod; Pod Filling: period development of full pods; Maturity: 75% of plants with first discolored and dry pod, yellowed and senescent leaves.

Canopy height was measured for a total of 20 randomly selected plants in 2009 and on 10 randomly selected plants on 2011. Maximum height of each plant was recorded using a meter stick held perpendicular to the ground.

Weather variables were recorded by means of a meteorological station at the study site (EEA-INTA Hilario Ascasubi, Buenos Aires). For this analysis we recorded the following data: photoperiod (h), mean temperature (°C), 10 and 20 degree days, number of hours during which temperature was higher than 10 °C and 20 °C, mean RH, daily rainfall (mm), total wet foliage (12-12) and Penman's evapotranspiration (ETP) (mm).

The cultivated plots were treated with pre- and post-emergence herbicides in 2011, but not in 2009. Insecticides were not applied during the study.

In both yr, the spontaneous vegetation associated with *Vicia* was represented by the following species: *Raphanus sativus* L. "radish"; *Rapistrum rugosum* L. (Brassicaceae = Cruciferae); *Carduus nutans* L. "musk thistle"; *Senecio vulgaris* L. "groundsel"; *Taraxacum officinale* Weber "dandelion"; *Centaurea solstitialis* L. "yellow starthistle" (Asteraceae = Compositae).

In 2009 and 2011, other crops adjacent to *Vicia* plot were: *Avena sativa* L. (oat); *Hordeum vulgare* L. (barley); *Secale cereale* L. (rye); X *Triticosecale* Wittm. (triticale) (Gramineae) and *Medicago sativa* L. (alfalfa) (Fabaceae = Leguminosae).

Capture and Identification of Insects

Insects were collected weekly with a sweep net measuring 0.38 m × 0.70 m. The samples taken from 5 stations chosen at random, comprised 20 sweeps per station, a total of 100 sweeps per week (based on the asymptotic number of individuals per sweep during a preliminary sampling). The specimens collected were dry preserved, labeled and transported to the lab for identification. For taxonomic analyses, the specimens were counted and dissected under a stereoscope and identified following (Linnavuori 1959; Young 1977; Remes Lenicov 1982; Paradell 1995). The material was deposited in the Entomological Collection at Museo de La Plata, Argentina (MLP).

Abundance and Diversity

The samples were identified at the family, subfamily and species level. Total number of collected individuals (N) was determined by direct count and documented weekly. To measure the community's diversity we used the Margalef index (D_{Mg})

and the dominance index of Simpson (D). Margalef's index only considers the number of species, while Simpson's dominance index highlights the structure of the community by considering both the number of species and their relative importance, and by pondering the dominance of a few species. This index was chosen because it is well understood and provides a good estimate of diversity at relative small sample sizes. Both indexes were calculated as follows: D_{Mg} = S-1/lnN; D = 1–Σ (pi)^2; where N = number of individuals of all species, S = number of species, pi = ni/N, and ni = number of individuals of species "i" (Magurran 2004; Moreno 2001).

The Relative Importance Index (RII) allows for an estimation of the species not only considering its abundance but also its occurrence or frequency. In this way, species poorly represented in individual numbers but frequently recovered over a long period can be balanced with numerous species with sporadic occurrence (Remes Lenicov & Virla 1993; Murúa et al. 2006). The Relative Importance Index was calculated by the following formula:

$$\text{RII} = \text{Ni/Nt} \times \text{Mi/Mt} \times 100$$

where Ni = number of individuals of species "i"; Nt = total number of individuals of all species; Mi = number of samples in which species "i" occurred and Mt: total number of samples taken.

Species with RII values ≥ 10 were considered as "very frequent"; those with a RII between 1-9 "frequent"; RII between 0.2-0.99 "less frequent"; and RII ≤ 0.19 "occasional" (Table 1). Data regarding host plants, geographic distribution and phytosanitary importance of the species more frequently captured on *Vicia* are summarized in Table 2.

Statistical Analyses

The relationships between the population densities of the species *Paratanus exitiosus* and *Agalliana ensigera* and the weather variables were analyzed by means of simple and multiple linear regression using Statistical Graphics SGWIN® Plus 4.0 (Statgraphics Plus 4.0; Statistical Graphics Corporation, 1994-1999, Herndon, Virginia, USA) and Statistica® 99 (Statistica 7.0, StatSoft, Inc.). The original data were transformed in order to achieve linearization. The descriptive-predictive models for the population abundance of *P. exitiosus* and *A. ensigera* were determined by means of logistic regression, where P_x = proportion of captured insects and Q_x = proportion of uncaptured insects; odds = P/Q, with Q = 1–P; logit (P) = ln (odds) = ln (P/Q).

The statistical significance of each linear model obtained was evaluated by comparing F_{value}, P_{value} (significance level < 0.05 is statistically significant) and the coefficient of determination (R^2).

Normality was corroborated by the Kolmogorov-Smirnov test using the program GraphPad Instat V 3.01 and the normality hypothesis test of the software Statgraphics Plus 4.0. Homoscedasticity was verified by Bartlett's test using the software GraphPad Instat (Graph pad Software, Inc, Copyright 1992-1998, San Diego. California, USA).

The hypothesis proposed for this analysis is that the temporal pattern of accumulation of adults would be partly explained by the thermal regime, the photoperiod and the water balance (precipitation – evapotranspiration).

Results

A total of 1,618 individuals (N_{2009} = 1259; N_{2011} = 359) were collected and 18 species identified; most of which were included in the Cicadellidae (Cicadomorpha), represented by 16 species distributed in 5 subfamilies (Deltocephalinae, Agallinae, Xerophloeinae, Cicadellinae and Gyponinae), followed by Delphacidae (Fulgoromorpha) with only 2 species included in the subfamily Delphacinae (Table 1).

The number of collected specimens varied over sampling and, in both yr, the highest number was recorded in Nov (N_{2009} = 261; N_{2011} = 66). Likewise, the Species Richness varied between 2009 and 2011 (S_{2009} = 15; S_{2011} = 10). Of these species, 7 were present in both yr, including the most abundant ones.

In both yr sampled, the leafhopper *P. exitiosus* was the species most abundant with 1,097 specimens identified, followed by *A. ensigera* (316) and *Xerophloea viridis* Fabricius with 85 specimens. The species *P. exitiosus* and *A. ensigera* remained markedly numerous through the crop cycle.

In terms of species succession, neither seasonal nor phenological succession were observed and most of the them were collected over the whole growing season.

In general, Margalef values showed lower species richness in both yr (D_{Mg2009}: 1.96 and D_{Mg2011}: 1.54), with a clear increase in 2009. The diversity was also estimated by Simpson Index. The values obtained for each year (D_{2009}: 0.43 and D_{2011}: 0.65) suggested a rising inequality in the species abundance distribution in 2011, that means a lower diversity than in 2009.

The RII values determined that the species shared by both cycles showed almost the same frequency pattern. The leafhoppers *P. exitiosus* and *A. ensigera* were the most frequent (RII ≥ 10), followed by *Bergallia signata* (Stål) and *X. viridis* (RII 1-9), in 2009. These latter species, together with *B. neosignata* (Oman) were the "frequent" species in 2011 (Table 1), while the remaining species were "occasional".

In both yr, the most frequent species, *P. exitiosus* and *A. ensigera,* presented population increases during the months of Nov and Dec. In 2009, *P. exitiosus* registered 3 increases, the highest (N = 215) coinciding with pod formation phase; while in 2011, there was only 1 increase (N = 53) at the end of flowering phase (Fig. 1). *Agalliana ensigera* showed a similar behavior the 2 yr, with a single increase (N_{2009} = 49; N_{2011} = 26) coinciding with the pod filling phase (Fig. 2). Increases were always registered when plants of *Vicia* showed its maximum height (h_{2009} = 39 cm; h_{2011} = 35 cm) in Nov.

From the application of simple linear regression models, a statistically significant association was found between the dependent variable (density of *P. exitiosus* and *A. ensigera*) and some of the independent variables. However, when the multiple regression linear models were applied, some of these variables explained the same patterns (autocorrelation) while others did not show statistically significant associations.

These analyses indicate that the models that best describe the population density of each species are as follows:

For *P. exitiosus*:

$$\text{Ln } (P/Q)_{Accum} = -4.48 - 0.0042 \times \text{Hydric Balance (mm)}_{Accum} + 0.0049 \times \text{Photoperiod (Hs)}_{Accum}.$$

($P_{value} < 0.01$; ***F*:** 1918; *GL*: 12; R^2: 0.997)

and, for *A. ensigera*:

$$\text{Ln } (P/Q)_{Accum} = -3.93 + 0.0218 \times \text{Degree-days}_{10\ Accum} + 0.0213 \times \text{Hydric Balance (mm)}_{Accum}.$$

($P_{value} < 0.01$; ***F*:** 1204; *GL*: 12; R^2: 0.996)

where P is the estimated proportion of adults of *P. exitiosus* and *A. ensigera*, Hydric Balance $_{Accum}$ is the difference between the readings for precipitation and evapotranspiration (accumulated) and Degree $days_{10\ Accum}$ is the number of accumulated heat units during a certain period when the average daily temperature exceeds the developmental zero of 10 °C.

For both *P. exitiosus* and *A. ensigera*, the ANOVA results indicated strong associations between the dependent and the independent variables: (Hydric Balance ($P_{value} < 0.0038$) // Photoperiod ($P_{value} < 0.01$)) and (Degree $days_{10\ accum}$ ($P_{value} < 0.00001$)// Hydric Balance ($P_{value} < 0.0001$)) respectively.

The resulting fits show that the population density of *P. exitiosus* is strongly dependent on photoperiod and hydric balance, (difference between the precipitation and evapotranspiration); whereas the population density of *A. ensigera* is strongly influenced by hydric balance and the accumulated degree $days_{10}$ (Figs. 1 and 2).

In considering these results, it is important to take into account the fact that the method used to collect adult *P. exitiosus* and *A. ensigera* was

TABLE 1. MEAN ABUNDANCE AND RELATIVE IMPORTANCE (RII) OF THE AUCHENORRHYNCHA SPECIES ASSOCIATED WITH *VICIA VILLOSA* IN SOUTHERN BUENOS AIRES PROVINCE DURING 2009 AND 2011.

CICADELLIDAE				
Subfamily	Species	Abundance	RII	
Agallinae	*Agalliana ensigera* Oman	158	25.15	Very frequent
	Bergallia confusa (Oman)	10	0.365	Less frequent
	Bergallia signata (Stål)	20.5	2.26	Frequent
	Bergallia neosignata (Oman)	6.5	1.75	Frequent
	Bergallia lateralis (Oman)	0.5	0.0035	Occasional
	Bergallia chileana (Oman)	2	0.0635	Occasional
Deltocephalinae	*Paratanus exitiosus* (Beamer)	548.5	62.25	Very frequent
	Atanus viridis Linnavuori	0.5	0.015	Occasional
	Haldorus sexpunctatus (Berg)	1	0.005	Occasional
	Amplicephalus marginellanus (Metcalf)	3	0.09	Occasional
	Amplicephalus dubius (Linnavuori)	0.5	0.015	Occasional
	Spangbergiella vulnerata Signoret	0.5	0.0035	Occasional
Xerophloeinae	*Xerophloea viridis* Fabricius	42.5	2.95	Frequent
Gyponinae	*Curtara samera* DeLong & Freytag	0.5	0.0035	Occasional
Cicadellinae	*Ciminius platensis* (Berg)	0.5	0.0035	Occasional
	Syncharina punctatissima (Signoret)	1	0.005	Occasional
DELPHACIDAE				
Delphacinae	*Delphacodes kuscheli* Fennah	7.5	0.25	Less frequent
	Delphacodes argentina Remes Lenicov & Tesón	0.5	0.0035	Occasional

TABLE 2. GEOGRAPHIC DISTRIBUTION, HOST PLANTS AND PHYTOSANITARY IMPORTANCE OF THE AUCHENORRHYNCHA SPECIES COLLECTED ON *VICIA VILLOSA* IN BUENOS AIRES DURING 2009 AND 2011.

	CICADELLIDAE	
	Agalliana ensigera Oman	
GEOGRAPHIC DISTRIBUTION	HOST PLANTS	PHYTOSANITARY IMPORTANCE
Argentina: Jujuy, Salta Tucumán, La Rioja, Catamarca, Santiago del Estero, Chaco, Misiones, Entre Ríos, San Juan, Mendoza, Santa Fe, La Pampa, Buenos Aires, Río Negro (Christensen 1942; Remes Lenicov 1982; Remes Lenicov et al. 2004; Paradell 1995; Dughetti et al. 2012; Varela et al. 2007).	pumpkin *Cucurbita maxima* (Ducht.), potato *Solanum tuberosum* L. (Christensen 1942); pepper *Capsicum annum* L., “tomato” *Lycopersicum esculentum* Hill , fababean *Vicia faba* L., zucchini *Cucurbita pepo* L, berrie *Fragaria* spp., cotton *Gosypium hirsutum* L. , wheat *Triticum aestivum* L., maize *Zea mays* L , alfalfa *Medicago sativa* L., soibean *Glycine max* L. (Christensen 1942; Remes Lenicov 1982; Meneguzzi 2008); sugar beet *Beta vulgaris* L. (Bennet & Munck 1946, Remes Lenicov 1982); sorghum *Sorghum vulgare* (Pers.) (Remes Lenicov et al. 2004; Remes Lenicov et al. 2006), tobacco *Nicotiana tabacum* L., sunflower *Ricinius communis* L. (Zanol & Menezes 1982), oat *Avena sativa* L., prairie grass *Bromus unioloides* Kunth and weeds (Paradell 1995), garlic *Allium sativum* L. (Catalano 2011), citrus *Citrus* sp**.,** carrot *Daucus carota* L**.,** hairy vetch *V. villosa* (Dughetti et al. 2012).	Confirmed vector of “Argentine Curly Top Virus” to sugar beet (Fawcett, 1927) and of “Brazilian Curly Top Virus” to tomato (Costa, 1952). Possible vector of “Witches-Broom Disease” of alfalfa in San Juan (Meneguzzi 2008). Potential vector of the phytoplasm 16SrIII X-disese which cause the disease “Garlic decline” (Catalano 2011).
	Bergallia confusa (Oman)	
Argentina: Jujuy, Tucumán, San Juan, Mendoza, San Luis, Córdoba, La Pampa, Buenos Aires (Remes Lenicov 1982; Paradell 1995; Remes Lenicov et al. 2004; Remes Lenicov et al. 2006; Varela et al. 2007).	potato, red clover *Trifolium pratense* L., maize, wheat, sorghum, weeds (Remes Lenicov 1982; Paradell 1995; Remes Lenicov et al. 2004; Remes Lenicov et al. 2006), garlic (Catalano 2011), alfalfa (Meneguzzi 2008), oat, linen *Linum usitatissimum* L.*,* alfalfa, sorghum, tomato (Varela et al. 2007). New record for hairy vetch *V. villosa.*	Vector of the phytoplasm (grupo 16Sr VII Ash Yellows) associated to “Witches-Broom Disease” of alfalfa in San Juan province, Argentina (Meneguzzi 2008).
	Bergallia signata (Stål)	
Argentina: Jujuy, Tucumán, Chaco, Misiones, San Juan, Mendoza, Buenos Aires, Río Negro (Remes Lenicov 1982; Remes Lenicov et al. 2004; Varela et al. 2007).	alfalfa, white clover *Trifolium* spp., maize, wheat, “pririe grass” *Bromus unioloides* Kunth, potato, beet *Beta vulgaris*L., radish root *Raphanus sativus* L., turnip *Brassica raba* L., purslane *Portulaca oleracea* L. (Remes Lenicov 1982; Remes Lenicov et al. 2004), pepper *Capsicum annuum* var, tomato, carrot (Varela et al. 2007). New record for hairy vetch *V. villosa*.	unknown
	Bergallia neosignata (Oman)	
Argentina: San Juan, Buenos Aires, La Pampa y Neuquén (Remes Lenicov 1982; Remes Lenicov et al. 2004).	potato, alfalfa, wheat y maize (Remes Lenicov 1982; Remes Lenicov et al. 2004). New record for hairy vetch *V. villosa.*	unknown

TABLE 2. (CONTINUED) GEOGRAPHIC DISTRIBUTION, HOST PLANTS AND PHYTOSANITARY IMPORTANCE OF THE AUCHENORRHYNCHA SPECIES COLLECTED ON *VICIA VILLOSA* IN BUENOS AIRES DURING 2009 AND 2011.

GEOGRAPHIC DISTRIBUTION	HOST PLANTS	PHYTOSANITARY IMPORTANCE
	Paratanus exitiosus (Beamer)	
South America. Chile (Oman, 1949) and Argentina: Río Negro (Beamer 1943; Bennett & Munck 1946), Jujuy, Chaco, San Luis, Córdoba (Linnavuori 1959; Paradell et al. 2005), Buenos Aires (Remes Lenicov et al. 2006); San Juan (Galdeano et al. 2009, Meneguzzi 2008); Mendoza (Catalano 2011).	maize (Paradell et al. 2005), rice *Oryza sativa* L., wheat, sugar beet *Beta vulgaris* L. var. *saccharifera* (Linnavuori, 1959), sorghum (Remes Lenicov et al. 2006), garlic (Paradell et al. 2003, Galdeano et al. 2009; Catalano 2011), alfalfa (Meneguzzi 2008), hairy vetch *V. villosa* (Dughetti et al. 2012).	Vector of "Virus Sugar Beet Yellow-Wilt" (Bennet & Munck 1946), causing disease "Yellow Wilt" of sugar beet (Hepp & Vargas 2002); potential vector of the phytoplasm 16SrIII X-disease which cause the "Garlic decline" disease (Catalano 2011).
	Xerophloea viridis (Fabricius)	
EEUU, México, Perú, Venezuela, Brasil, Bolivia and Argentina: Salta, Tucumán, Misiones, Córdoba, Mendoza, San Juan, Santa Fe, Buenos Aires, Neuquén (Nielson 1962; Paradell 1995; Remes Lenicov et al. 2004; Meneguzzi 2008; Catalano 2011).	weeds (Tesón et al. 1986), wheat (Remes Lenicov & Virla, 1993), maize, barley *Hordeum vulgare* L., sweet potato *Ipomoea batatas* Poir., tomato , lettuce *Lactuca sativa* L., San José weed *Ageratum conyzoides* L., *Sida rhombifolia* L., *Digitaria decubens* Stent (Zanol & Menezes 1982; Paradell 1995), citrus *Citrus sinensis* L. (Paradell et al. 2000), alfalfa (Meneguzzi 2008), garlic (Catalano 2011). New record for hairy vetch *V. villosa*.	Vector of "Virus Sugar Beet Yellow-Wilt" to sugarcane in Argentina (Bennet & Munck 1946).
	DELPHACIDAE	
	Delphacodes kuscheli Fennah	
Chile (Fennah 1955), Uruguay (Remes Lenicov et al. 2000) and Argentina: Jujuy, Salta, Tucumán, Chaco, Córdoba, Santa Fe, Entre Ríos, San Luis, Catamarca, La Rioja, San Juan, Mendoza, Buenos Aires, La Pampa, Neuquén, Río Negro (Remes Lenicov & Tesón 1978; Remes Lenicov & Virla 1992, 1999a; Virla & Remes Lenicov 2000; Laguna et al. 2002, 2003).	maize, wheat, oat, sorghum, barley, pririe grass, *Sorghum halepense* L., *Cynodon dactylon* (L.) Pers. (Remes Lenicov & Virla, 1999b). New record for hairy vetch *V. villosa*	Vector of "Mal de Rio Cuarto virus" (MRCV) on maize in Argentina (Remes Lenicov et al. 1985)

sampling without replacement of individuals into their natural habitat. This could influence population density and generate errors in readings subsequent to taking samples. For this reason, some errors may be expected in the capacities of the models to estimate population density of these species. Thus further studies in coming yr should be made to validate the models.

DISCUSSION

The results of this study demonstrate that Cicadellidae species associated with *V. villosa* are very diverse. Five subfamilies were registered: the most represented were Deltocephalinae species (37.5%), and Agallinae species (37.5%), which together contributed 75% of the total diversity, followed by species of Cicadellinae (12.5%), and Xerophloeinae and Gyponinae each contributing 6.25%. However, both yr sampled showed remarkable differences in species richness and abundance for all the Auchenorrhyncha associated with *Vicia*, probably related to differences in densities of various spontaneous plant species. Weeds within crops could serve as food plants and oviposition alternative hosts, and thus able to increase insect populations (Norris & Kogan

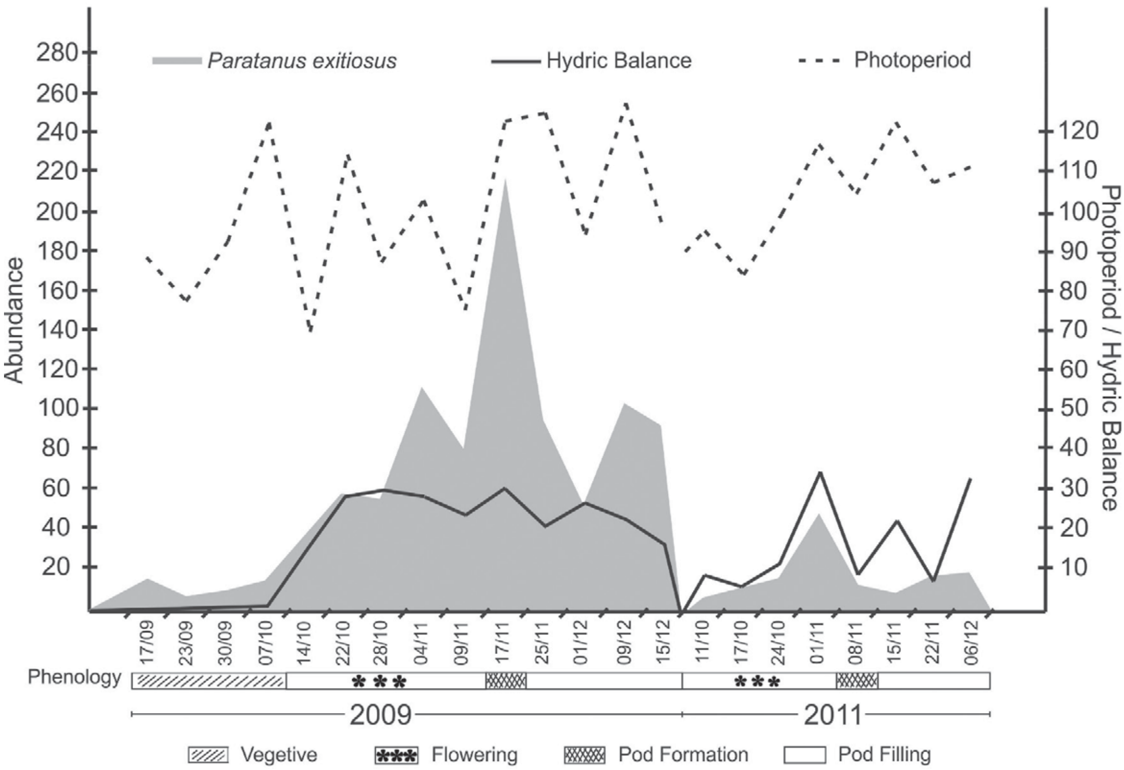

Fig. 1. Relationship between climatic (hydric balance, photoperiod) and phenological conditions and density of *Paratanus exitiosus* (Beamer), in Buenos Aires, during 2009 and 2011. Hydric balance is the difference between the cumulative precipitation and evapotranspiration in a certain period of time.

2005). It is well known, that food resources could influence the spatial distribution of insects, even more in temperate areas where vegetation have a marked seasonality. A previous contribution by Haddad et al. (2001) suggests that high plant densities would increase the resource concentrations potentially attractive to a greater number or diversity of insects. So, the higher abundance and species richness in 2009 (N = 1259; S = 15) may be due to a major density of spontaneous vegetation within *Vicia*. In 2011, the use of pre- and post-emergence herbicides caused a density decrease of such vegetation, which could cause a reduction in the observed abundances (N = 359) and perhaps also influence the spatial distribution of hoppers leading to migration to adjacent crops and/or spontaneous vegetation. Contributions made by Balwin & Creamer (2005), Hall et al. (2004) and Tillman et al. (2004) demonstrate that *Vicia* can attract both beneficial and harmful insects into cropping systems, and that such species can also disperse to other cash crops when the vetch matures or dies. This suggests that the effects on insect populations will depend on the subsequent/adjacent crops and other environmental factors (Balwin & Creamer 2005). Given that most of the collected leafhoppers use grasses as their primary hosts, for feeding and oviposition and most crops sown adjacent to *Vicia* were gramminae, cicadellids may come from grasses to *Vicia* and probably uses *Vicia* as a food, overwintering or shelter plant or as an alternative host.

The seasonal pattern of insect abundance is synchronized with the availability of food resources, which can vary with the climate (Wolda 1978). Weather conditions play an important role in insect population increases, even more so in the case of sap feeders that can exploit plant sap throughout the year. Besides this, the most frequent species found in *Vicia* showed seasonal patterns in their abundance, with greater abundance in Nov-Dec, i.e., *P. exitiosus* N_{2009} = 215 and N_{2011} = 53, and *A. ensigera* N_{2009} = 49 and N_{2011} = 26). The increase in temperature, photoperiod and availability of water (air humidity and precipitation) showed a significant positive relation with the abundance of these 2 species, and appear to be the factors favoring the increases in their populations (Figs. 1 and 2).

To sum up, the seasonal abundance of these species cannot be explained only by climate factors, although climate certainly has a great influence.

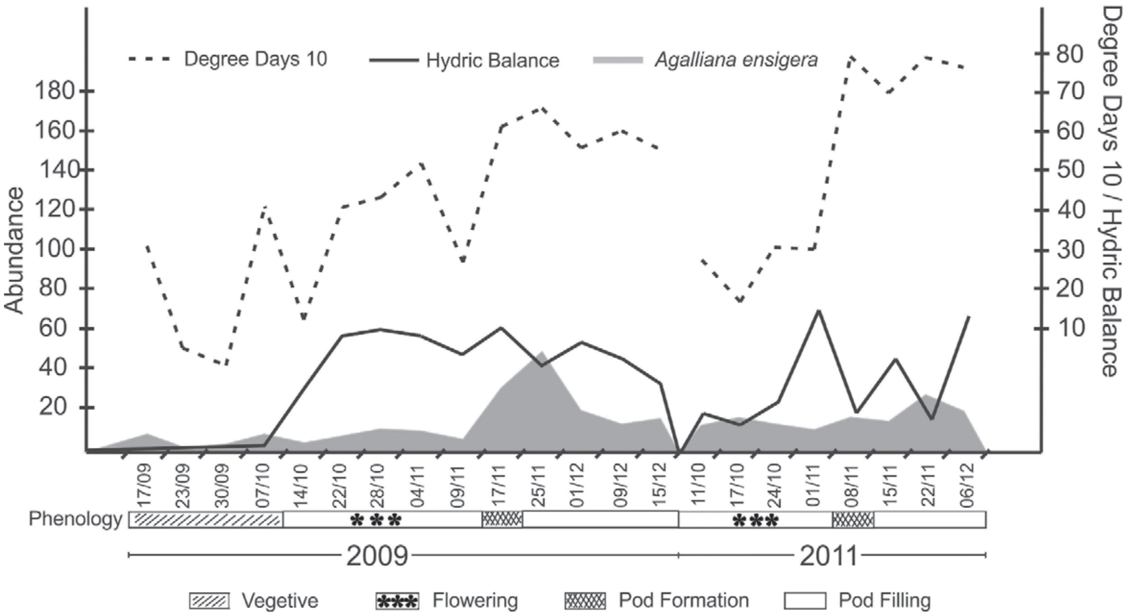

Fig. 2. Relationship between climatic (hydric balance, degree days$_{10}$) and phenological conditions and density of *Agalliana ensigera* Oman in Buenos Aires, during 2009 and 2011. Hydric balance is the difference between the cumulative precipitation and evapotranspiration in a certain period of time. Degree days$_{10}$ are the number of accumulated heat units during a certain period when the average daily temperature exceeds the developmental zero of 10 °C

Many other factors, such as interspecific competition, predation, parasitism, distribution of a food resource at a particular time of the year, among others, appear to act together with climate factors to mold the patterns of distribution and abundance of these insects (Pereira da Silva et al. 2011).

Considering sanitary importance of the most frequent species, *P. exitiosus* is a confirmed vector of Sugar beet yellow wilt virus to sugar beet in Chile (Oman 1949). Studies conducted in Argentina showed that *P. exitiosus* is a frequent species in the central region, colonizing garlic crops and is considered a potential vector of the phytoplasm 16 Sr III (X-disease) which causes the garlic decline disease (Catalano 2011). Also the leafhopper *A. ensigera* is the most important vector in South America responsible for transmission of Argentine curly top disease of sugar beet (Fawcett 1927) and Brazilian curly top of tomato (Costa 1952). *Agalliana ensigera* is widely distributed in Argentina, and frequently found in the central region on several plant hosts, particularly maize (Paradell et al. 2001), alfalfa (Meneguzzi 2008) and garlic (Catalano 2011). This species is mentioned as potential phytoplasm vector of Ar AWB (witches broom) in alfalfa and 16 SrIII (X-disease or garlic decline disease) by Meneguzzi (2008) and Catalano (2011), respectively.

Delphacodes kuscheli Fennah (Delphacidae) was scarcely represented in *Vicia* crops, however, it deserves to be mentioned because of its well known role as the main vector of the Mal de Río Cuarto virus (MRCV) of maize in the central area of Argentina (Remes Lenicov et al. 1985). The occurrence of *D. kuscheli* could be influenced by the presence of oat in adjacent areas - one of the preferential hosts for this vector species (Dagoberto et al. 1985; Tesón et al. 1986; Remes Lenicov & Virla 1999a).

This work represents the first diversity analysis of Auchenorrhyncha on *Vicia* crops. We emphasize that *Vicia villosa* is a new host-plant record for 15 species studied here (except: *P. exitiosus* and *A. ensigera*). Buenos Aires province was cited as a new distribution record for the species: *Atanus viridis* Linnavuori 1955 and *Curtara samera* (Delong & Freytag 1972).

More studies should be conducted in order to better understand how both the abundance and diversity of these insects are influenced in order to help generate preventive cultural practices to minimize their activity (Purcell & McBride, 1999).

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