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The diversity of galls and their occurrence in productive forest systems of *Prosopis alba* (Griseb.) in Santiago del Estero, Argentina

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Galls are of frequent occurrence on *Prosopis alba* (Griseb.), both in native woodland and in productive systems (nurseries and plantations). They have been very little researched in this region. It is very important to undertake this work, so as to gain information useful for planning the cultivation management of this native species. The aim of this study is to classify galls which develop on *P. alba* in nurseries and plantations, characterize them, link them to the inducing organisms and find out their main growing seasons. Fortnightly inspections were carried out in nurseries and plantations in the province of Santiago del Estero, Argentina, between 2000 and 2006. Seventeen types of gall, found on different organs of the plant, were registered, with greater impact in the nurseries than the plantations. The gall-inducing insects were of the orders Homoptera, Lepidoptera, Diptera, Hymenoptera and Coleoptera. Two species of Hymenoptera new to Santiago del Estero were found.

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Key words: Cecidia, cecidogens, *Prosopis* sp., nurseries, plantations.

INTRODUCTION

Galls or cecidia are cells or vegetable tissues developing by hypertrophy and/or hyperplasia as a result of the action of harmful organisms living within these structures. These deformations of portions of the tissues or organs of the plants develop through the feeding or egg-laying activity of the gall-inducing organisms (Cock, 1923; Fernandes and Martins, 1985; Fernandes, 1986). The causes and exact mechanisms of gall induction are still not well-known, despite studies by a few researchers such as Bronner (1973). Galls produced by insects, particularly gall wasps (Cynipidae) and gall midges (Cecidomyiidae) host a rich associated community of other insects finding shelter and food within the structures formed.

Prosopis alba Griseb. (Leguminosae, Fabaceae), commonly known as "algarrobo blanco" ("white carob tree") has a wide distribution in South America. It is found in the central and northern parts of Argentina, in the phytogeographical provinces of Chaco, Espinal, and the north-western parts of Monte. In the Chaco region it is a second-story species, growing among *P. nigra*, *P.kuntzei* and *P. ruscifolia* and others, and, in certain humid areas, on its own. It is a very important species for semi-arid regions,

Figure 1. Galls developed on *Prosopis alba* leaves, induced by Diptera Cecidomyiidae.

offering many benefits for rural communities, such as food, fodder, firewood and hardwood of very desirable aesthetic qualities and excellent physical-mechanical properties (TORTORELLI, 1972). In the native white carob woodland of Santiago del Estero it is very common to find galls and various forms of cecidia, mainly on the branches. FERNANDES *et al* (2002) studied the diversity of galls in five areas of the semi-arid Argentinean Chaco, finding a total of 29 morphospecies on leguminous plants.

In recent years Argentinean authorities have legislated with a view to promoting forest development with exotic and native species, including *P. alba* (Law 24.847; 25080, Provincial Law 6.466). This has encouraged interest in growing seedlings of this species in nurseries. CARABAJAL DE BELLUOMINI and FIORENTINO (2006) studied and characterized the phytosanitary problems present in *P. alba* nurseries in Santiago del Estero, drawing attention to the importance of gall incidence in seedling production.

Because of the lack of research into the problem in this region, and of the frequency of gall incidence in productive systems of white carob, a specialized study was urgently needed in order to gain information useful for the planning of future cultivation management of this native species. The objective of the present study, therefore, was to carry out ample sampling of different types of cecidia developing on *P. alba* in nurseries and plantations. These could subsequently be categorized, characterized and linked to their inducing organisms, while their main growing seasons could be discovered.

MATERIALS AND METHODS

The work was carried out by means of fortnightly inspections from 2000 to 2006. Samples were taken in three nurseries in Fernández (Departamento Robles), San Carlos (Dpto. Banda) and on the U.N.S.E. estate (Dpto. Capital), in two plantations, of 2 and 6 years old, situated in Vuelta de la Barranca and Los Cardozo (both in Dpto. Capital). All the plantations and nurseries are in the province of Santiago del Estero, Argentina.

In the nurseries, sampling was from four

Figure 2. Galls developed on rachides of *Prosopis alba* leaves, induced by Diptera Cecidomyiidae.

Figure 3. Galls developed on petioles of *Prosopis. alba* leaves, induced by homopterans

plots of *P. alba*: one of 1m x 8m, containing about 3000 plants, and three of 1m x 6m, each with 2000 plants.

The plantations, each one 4 hectares in size, were fully inspected on a fortnightly basis.

In the nurseries, plants with gall were counted, and the types separated according to shape, size, situation on the plant and associated insects. The material with gall was isolated in the laboratory.

In the plantations, the different types of gall were separated from the vegetation. Later, in the laboratory, they were each placed in a glass tube, the mouth sealed with voile fabric, and information was filed on them according to the type of tree on which they had developed, shape, and some size parameters. Notes were later added about emerging insects.

Finally, a table was made, classifying the diversity of galls developing on *P. alba* and their inducing insect orders.

RESULTS AND DISCUSSION

Gall-inducing insects affect a wide variety of farm and forest plants, sometimes becoming serious plagues (FERNANDES, 1987). The preferences of gall-inducing insects is closely linked to certain plant taxons. It is thus known that 35.5% of insect-induced galls develop on Leguminosae. The plant under study, *P. alba*, belongs taxonomically within the Leguminosae, and hence within this percentage preference (FERNANDES and PRICE, 1988, 1990). NIEVES–ALDREY (1998) thus believe that a characteristic feature of a gall-inducing insect is its specificity with relation to the genus or species of its host, and to the part under attack. In this way, a certain gall-inducing insect is associated exclusively with one species or one closely-related group of botanical species, and always produces its galls exclusively on one organ of the plant. Moreover, the shape

Figure 4. Galls developed on branches of *Prosopis. alba* plantation trees, produced by microhymenopterans

Tabla 1. **Diversity and type of gall developed on different *Prosopis alba* plant modules**

Plant module organ where developed	Type	Gall			Emerging insect Order
		Shape	Average size	No. chambers	
Leaves	Dehiscent	Spheroid	1.6 mm	1	Diptera
Rachis	Indehiscent	Fusiform	0.8 mm	1	Diptera
Petioles	Indehiscent	Globular	2.4 mm	1	Homoptera
Branches	Indehiscent	Subcylindrical	40 mm	Many	Hymenoptera
	Indehiscent	Fusiform 1	30mm	Many	Hymenoptera
	Indehiscent	Fusiform 2	46 mm	1	Diptera
	Indehiscent	Globular	15 mm	2	Hymenoptera
	Indehiscent	No defined shape	56 mm	1	Lepidoptera
	Indehiscent	Globular	32 mm	Various	Hymenoptera
	Indehiscent	Corniform	40 mm	1	Diptera
	Indehiscent	Fusiform 3	34 mm	1	Coleoptera
	Indehiscent	Spheroid	2 mm	1	Coleoptera
Stems	Indehiscent	Subcylindrical	50 mm	Many	Hymenoptera
	Indehiscent	Fusiform	46 mm	Various	Diptera
	Indehiscent	Globosa	15 mm	1	Lepidoptera
Flower	Deshiscent	Spheroid	1.2 mm	1	Cecidomyiidae
Fruit	Indehiscent	Fusiform	18 mm	1	Lepidoptera

of the gall, its positioning and its occurrence at a give season are characteristic of the species of insect, as observations confirmed, since from each different shape of gall collected, a different insect would emerge. Thus, the gall-inducing insects have preferences for certain tissues of their host plant, meristematic tissues, for example, and their

Figure 5. Galls developed on stems of *Prosopis. alba* seedlings, produced by hymenopterans.

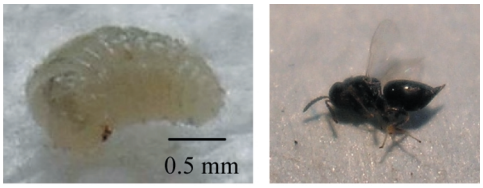

Figure 6. Larva and adult of Tanaostigmatidae microhymenopterans (*Tanaostigmodes* sp.)

preferences vary with the age of the plant (BRONNER, 1977). In order to support this affirmation, this study observed their activity on leaves, rachis, petioles, branches, stems, flowers, fruit and buds.

In this way, in the nurseries and plantations of *P. alba* under study, we have shown the development a wide variety of shapes, sizes and places of occurrence of insect-induced galls, with a great diversity of gall-inducing species, mainly of the orders Hymenoptera and Diptera, and, to a lesser degree, of Homoptera, Lepidoptera and Coleoptera. As a general rule, the highest rate of gall development was in spring and summer, the period of greatest vegetative activity.

Table 1 presents the different types of gall present in *P. alba* nurseries and plantations, showing the part of the plant on which it develops, the zone of formation, morphology and taxonomic order of the associated insect.

Galls on foliage: On both the nursery and plantation plants there were galls between the leaf folioles, and on their rachides or petioles.

Those between the **folioles** were of spheroidal shape, and with an average diameter of 1.6 mm. These were of dehiscent type, thus splitting in half when the insect completed

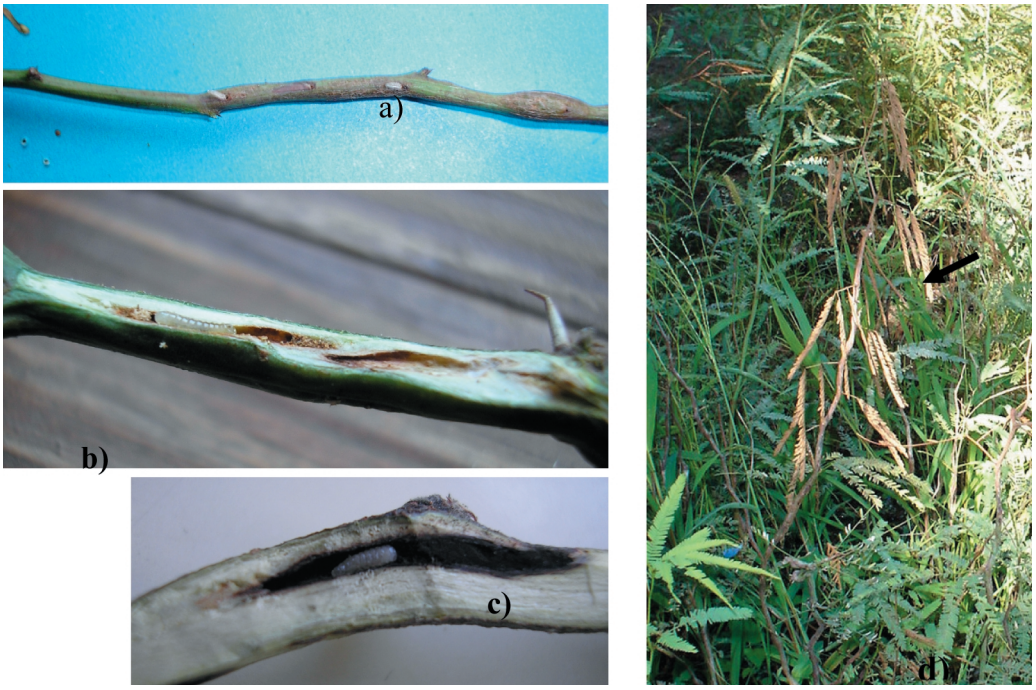

Figure 7. a) Galls developed on stems and branches of *Prosopis alba.* a) branch with exuviae left by emerging micro Lepidoptera; b) & c) galleries produced by larva of Lepidoptera; d) seedling killed by lepidopteran activity.

Figure 8. Galls developed on branches of *Prosopis alba,* produced by Cecidomyiidae dipterans

its cycle, and were formed with a single chamber (Fig. 1). This type of gall appeared in spring and was more frequent in nursery seedlings, and from them emerged Cecidomyiidae of the Diptera order.

On the **rachides** of the leaves reddish fusiform indehiscent galls developed. These were usually positioned on the middle part of the rachis, causing it to curve (Fig.2). The average length of these was 0.8mm, and they consisted of a single chamber. They were present in both nurseries and plantations, but with a higher incidence in the former. The organism associated with them were Cecidomyiidae of the Diptera order.

Galls appearing on **petioles** were globular in shape, indehiscent, reddish-green in colour, and with a single chamber. Their average length was 2.4mm. They were induced by homopter (Fig. 3).

Galls on branches and stems: In both nursery and plantation, the greatest variety of shapes, sizes and positions of development were found in galls on branches. There were subcylindrical, spheroidal, fusiform, corniform, globular and twisted shapes, developed on or between nodes, some of them stretching along several nodes and even on buds or shoots.

Colouring was also very variable between the different types and according to the phenology or maturity of the gall's development. There were similarly major differences at tissue level, depending on the organ of the affected plant. These structural differences are adaptations perfectly evolved between the host and parasite, ensuring the survival of both. Most revealed various chambers of larval development of varying shapes and positions.

Other types of gall observed included those hanging in tree branches. These were lengthy, with a succession of bulges making up a twisted shape, and dark reddish-brown in colour. They were induced by micro hymenopterans (Fig. 4). Others,

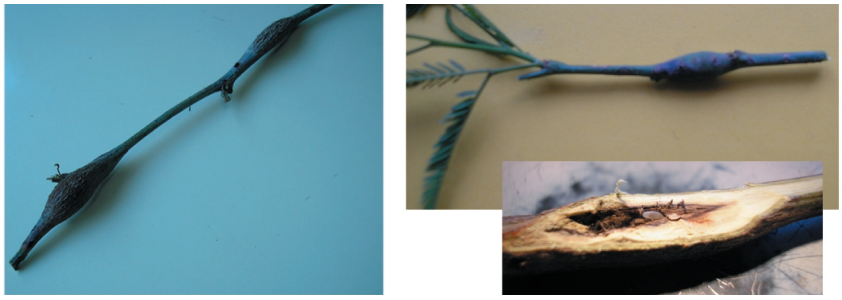

Figure 9. Galls developed on branches of *Prosopis alba*, produced by Diptera Cecidomiidae

appearing on branches, globular in shape and hollow, had inside a single lepidopteran larva.

On **stems** and **branches** of the nursery seedlings, the most common shapes were subcylindrical, followed by twisted, fusiform and globular.

Subcylindrical galls on stems and branches of nursery seedlings showed a highly modified internal tissue structure, formed by

Figure 10. Galls developed on branches of *Prosopis alba,* produced by Euritomydae microhymenopterans (*Prodecatoma* sp..)

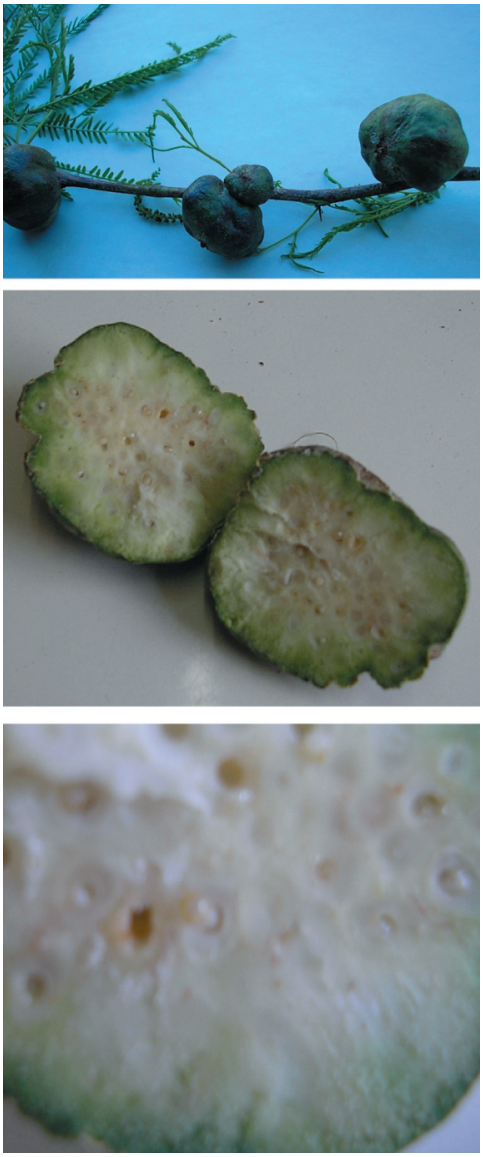

Figure 11. Galls developed on branches of *Prosopis alba,* produced by microhymenopterans of the Cynipidae family, genus *Eschatocerus*

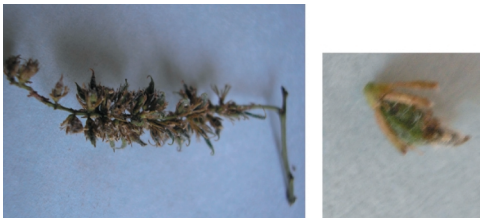

Figure 12. Galls developed on floral ovaries of *Prosopis alba,* produced by Diptera Cecidomyiidae (*Asphondilia* sp..)

various layers of cells, themselves modified, making up as many cells or chambers as insect larvae growing within them. Each chamber or growing cell showed carious layers of tissue, particularly a layer of nutritive tissue with a pod or cover surrounding it. The number of cells in this type of gall varied between 2 and 47, with the the most frequent cases showing between 12 and 20. This number was related to the sizes of the galls - between 15mm and 54mmin length and 4mm and 11mm in width (Fig. 5).

Subcylindrical galls on stems and branches of nursery seedlings were induced by gall wasps *Tanaostigmatidae albitarse* and *T. coeruleus*, Chalcidoidea of the Himenoptera order. This was the first time *Tanaostigmatidae* were noted in Santiago del Estero province. The larvae of the neotropical *Tanaostigmatidae* showed phytophagous habits, behaving as gall-inducers or as parasites in other zoocecidia. They are in general associated with woody shrubs and trees of the Fabaceae family (Fig. 6). La Salle (1987), unlike this study, reported *T. coeruleus* as linked to globular galls with multiple chambers set along the stems of *P. alba*, *P. nigra*, *P. alpataco* and *P.chilensis*, noting that it was originally registered as a parasitoid of *Eschatocerus Niger,* a cynipid of the Hymenoptera family, with a distribution area over the provinces of Córdoba, Tucumán and Santa Fe.

On stems and branches of nursery seedlings there also appeared *twisted lumps* of indefinite shape, developing along various nodes and internodes. When cut lengthwise, the tissue structure was preserved, and only showed a longitudinal borehole along its axis. This type of deformation is produced by microlepidopterans of the

Figure 13. Galls developed on fruits of *Prosopis alba* plantation trees, produced by Lepidoptera

Figure 14. Corniform galls developed on branches and shoots of *Prosopis alba* trees, produced by Diptera Cecidomyiidae

Gelechiidae family, which leave pupal exuviae visible in the exit holes. The branches and stems attacked finally dry out (Fig. 7 a-b-c-d).

These galls, owing to the characteristics described, have a serious effect on nursery production, not merely because they reduce leaf mass or modify plant architecture, but because in severe attacks they can lead to the death of the seedling. These twisted lumps were not found on the plantation trees, even when on the branches of these there did develop subglobular or irregular galls produced by Cecidomyiidae of the Diptera order (Fig. 8).

Fusiform galls on nursery seedlings developed between the nodes of stems and branches. These were almost always induced by Cecidomyiidae of the Diptera order. These consisted structurally of longitudinal galleries, parallel to the axis of the stem, ending in orifices leading to the exterior, through which the adults emerged. In this type of gall, fungi often appeared, sealing the galleries (Fig. 9).

Less frequent were multi-chambered fusiform galls, out of which would emerge a *Prodecatoma* sp. of the Eurytomidae Chalcidoidea microhymenopterans (Fig 10).

There were also, only in the plantation, *globular-shaped galls*, with colours ranging from green, when recently formed, to chestnut when mature. Their diameters varied from 1.2cm to 3.8 cm, and their internal structure consisted of many layers of cells growing in a disordered way, with thin cell walls and abundant cytoplasmic liquids from which the developing larvae fed (Fig. 11). These galls were induced by the *Eschotocera acaciae* hymenopterans, a cynipid noted for having a wide variety of associated parasites, mainly hymenopterans, but also paraitoids and predators of the insect and bird classes. These galls appeared in early spring at budding time.

Galls on fruit and flowers: Fruit and flowers did not escape the action of gall-inducing insects. *Globular-shaped* galls were induced on flower **ovaries**. These were a few millimetres in diameter, and Cecidomyiidae dipterans of the genus *Asphondilia* sp. (Fig. 12) emerged. In the young fruit **pods** appeared fusiform galls, in which were found lepidopteran caterpillars (Fig. 13).

Galls on buds: On bud apices there appeared *corniform galls*, with compact internal structure, and very hard when mature. They had a central borehole and were generated by dipteran Cecidomyiidae (Fig. 14).

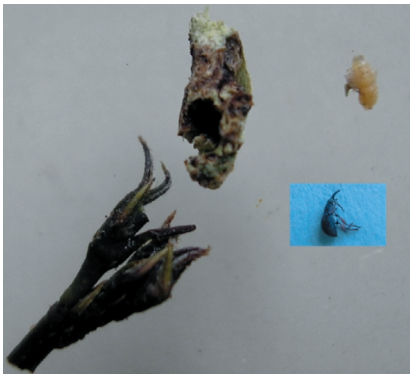

Figure 15. Galls developed on terminal buds of *Prosopis alba,* produced by Apionidae coleopterans (*Apion* sp..)

Figure 16. Galls developed on *Prosopis alba* stems, induced by Diptera Cecidomyiidae

Coleopterans of the Apionidae family of the *Apion* sp. genus induced *subglobular-shaped galls* on terminal buds on branches of both nursery and plantation plants (Fig. 15)., while *long galls* were induced by Cecidomyiidae on the tender shoots of nursery plants (Fig. 16).

Incidence of gall-inducing insects in nurseries and plantations: On analysing the effect of gall-inducing insects in the nurseries, we found that, while 40% of seedlings were affected, mortality was low - barely 1%. A slowing of growth was observed, together with a loss of apical dominance and the development of lateral shoots - modifying the tree's shape and visual impact and thereby its commercial viability.

In younger plantations there was high incidence of galls on branches, causing the slowing of their growth or even death, death of the main branch and proliferation of secondary branches, resulting in the modification of the plant's architecture.

In older plantations, with well-established and formed plants, the impact was less, though the diversity of galls increased with the diversity of susceptible positions on the plants. Even so, the trunks were not threatened, and the impact could in any case be controlled by prunings.

The first galls appeared in the nursery, every year during the course of the study, after 40 days from the sprouting of the plants, regardless of the date of sowing or of stem diameter (there were infected plants over 60 days old, with stem diameters under 2mm)

The greatest infestation was in mid-March in the nurseries, and mid-spring in the plantations. There were no new infestations of seedlings in the months of December and January in the nurseries, nor in the winter months in the plantations.

In the nurseries and plantations, seventeen types of gall were found to develop on various *P.alba* plant organs.

Galls were found to be associated with insects from the orders of Hymenoptera, Diptera, Lepidoptera, Homoptera and Coleoptera.

Two Hymenoptera Cynipidae species, *Tanaostigmodes albitarse* and *T. coeruleus,* were new findings in the province of Santiago del Estero, Argentina.

Nursery seedlings infested by galls lost apical dominance, developing lateral shoots, and thus having their architecture affected.

The impact of galls was greater in the nurseries than in the plantations.

The periods of greatest gall incidence were at the end of summer in the nurseries, and in mid-spring in the plantations.

RESUMEN

CARABAJAL DE BELLUOMINI, M. V., L. CASTRESANA, V. SALIM, A. NOTARIO. 2009. Diversidad de agallas y su incidencia en sistemas forestales productivos de *Prosopis alba* (Griseb.) en Santiago del Estero Argentina. *Bol. San. Veg. Plagas*, **35**: 255-265.

Las agallas sobre *Prosopis alba* (Griseb.) aparecen con mucha frecuencia en el bosque nativo pero también están presentes en los sistemas productivos (viveros y plantaciones). Los estudios realizados sobre este tema en la región son muy escasos, por ello se considera de gran interés abordarlos ya que aportará información útil para la planificación del manejo del cultivo de esta especie autóctona. El objetivo planteado es tipificar las agallas desarrolladas sobre *P. alba* tanto de vivero como de plantación, caracterizarlas, vincularlas con el organismo inductor y dar a conocer las épocas de mayor incidencia. Las observaciones se llevan a cabo en viveros y plantaciones de la provincia de Santiago del Estero (Argentina) de los años 2000 a 2006. Se registran 17 tipos de agallas, situadas en diferentes órganos de la planta, que producen un impacto mayor en los viveros que en las plantaciones. Los insectos vinculados a la inducción de las agallas pertenecen a los órdenes Homoptera, Lepidoptera, Diptera, Hymenoptera y Coleoptera. Se citan, por vez primera, dos especies de Hymenoptera en Santiago del Estero.

Palabras claves: Cecidias, gallígenos, *Prosopis* sp., viveros, plantaciones.

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