



DOI: <https://doi.org/10.29298/rmcf.v10i54.502>

Article

Insectos agalladores en los encinos (*Quercus* spp.) del parque estatal Cerro Gordo, Estado de México

Oak gall wasps of *Cerro Gordo* State Park in the State of Mexico

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Resumen:

El Parque estatal Cerro Gordo es una reserva constituida por áreas ejidales, comunales y privadas dentro del Valle de México. La vegetación nativa del parque está conformada por diversos taxa de encinos no identificados, y por lo menos dos de ellos están infestados con agallas, sobre todo en brotes y ramas; aunque, se desconoce la identidad del o de sus agentes causales. Por lo tanto, el objetivo de este trabajo consistió en identificar las especies de encinos, así como los insectos asociados a las agallas. Se eligieron y marcaron tres sitios dentro del parque, se colectaron ejemplares botánicos y mensualmente se recolectaron agallas en el periodo de febrero a julio del 2017. Las muestras vegetales se secaron, identificaron e integraron a la colección del herbario de la División de Ciencias Forestales de la Universidad Autónoma Chapingo. Las agallas se colocaron en cámaras de emergencia bajo condiciones controladas; los insectos se fijaron en etanol para su determinación taxonómica. Los encinos correspondieron a: *Quercus laurina* (número de registro 69 367), *Q. crassipes* (69 368), *Q. rugosa* (69 369) y *Q. microphylla* (69 370). En las agallas de las ramas de *Q. microphylla*, se registró la presencia de *Andricus carrilloi*, la de *Synergus mexicanus* como su inquilino y la de *Synergus* sp. en *Q. crassipes* se observó a *Amphibolips hidalgoensis*. Estos son los primeros registros tanto de los insectos formadores de agallas en la región del Valle de México, como de sus especies hospederas.

Palabras clave: *Amphibolips hidalgoensis* Pujade-Villar y Melika 2011, *Andricus carrilloi* Pujade-Villar 2013, Cynipidae, parasitoide, *Quercus* spp., *Synergus mexicanus* Gillette 1896.

Abstract:

Cerro Gordo State Park is a reserve constituted by *ejidos* and communal and private areas within the Valley of Mexico. The native vegetation is represented by several unidentified oak species, which are infested with galls, and the identity of causative agent of the disease is unknown. Therefore, the objective of this work was to identify the oak species, as well as the insects associated with the galls. Three sites were selected and marked, oak specimens and galls were collected on a monthly basis from February to July 2017. The plant specimens were dried, identified and integrated into the herbarium collection of the Forest Division of the *Universidad Autónoma Chapingo*. The galls were placed in emergency chambers under controlled conditions, and the insects were fixed in ethanol for taxonomic identification. The oak species identified were *Quercus laurina* (register number 69 367), *Q. crassipes* (69 368), *Q. rugosa* (69 369) and *Q. microphylla* (69 370). *Andricus carrilloi* was found in the galls on the branches of *Quercus microphylla*, *Synergus mexicanus* as its inquiline, as well as another species of *Synergus* that is in the process of being described. *Amphibolips hidalgoensis* was found in galls collected from *Quercus crassipes*. These are the first records of both these gall wasps and their oak hosts in the Valley of Mexico.

Key words: *Amphibolips hidalgoensis* Pujade-Villar y Melika 2011, *Andricus carrilloi* Pujade-Villar 2013, Cynipidae, *Quercus* spp., *Synergus mexicanus* Gillette 1896.

Fecha de recepción/Reception date: 20 de febrero de 2019
Fecha de aceptación/Acceptance date: 26 de junio de 2019

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Introduction

The *Cerro Gordo* State Park, which has a surface area of approximately 3 027 ha, was decreed as a natural reserve in May, 1977 (SEANPEM, 2016; CEPANAF, 2016). It encompasses three municipalities of the State of Mexico: *Axapusco*, *San Martín de las Pirámides* and *Temascalapa*. It is constituted by *ejidos*, communal and private lands, and it is the highest elevation in the Valley of *Teotihuacán* (3 000 masl) (SEANPEM, 2016; CEPANAF, 2016).

The highest part of the mountain has a temperate climate with dry winters and rainy summers (Cw₀b(e)g); in its lower areas, the climate is dry with summer rains (BS1K'w(w)(i')g). The mean annual temperature ranges between 12 and 18 °C, and the mean annual precipitation, approximately between 600 and 700 mm (CEPANAF, 2016).

The native vegetation in the best preserved area in the park consists of oak forests, oak shrubs and grasslands (CEPANAF, 2016), some of which are infested with abundant galls on their shoots and branches.

Oaks are susceptible to being parasitized by various wasps of the Cynipini tribe (Cynipidae), whose larvae cause the development of galls on any organ of the host tree, always in a specific form (Pujade-Villar *et al.*, 2009). More than 180 species of Cynipidae are cited today for Mexico, parasitizing approximately 30 *Quercus* taxa (Pujade-Villar *et al.*, 2009; Pujade-Villar and Ferrer-Suay, 2015a). Despite the fact that these insects have been detected in different locations across the country, their study is scarce. On the other hand, the identification of the gall wasps without accurate knowledge of their vegetal hosts or of adult Cynipidae can cause determination errors (Pujade-Villar *et al.*, 2009).

Furthermore, inquiline species may be found in galls induced by Cynipidae (Ronquist *et al.*, 2015). In general, these inquilines have lost the ability to induce galls, but they may modify their feeding site; also, in some cases, they have influence on the size and shape of the galls (Pujade-Villar *et al.*, 2016c).

Because oaks are structurally the most relevant elements of the native vegetation of the *Cerro Gordo* State Park, it is important to keep them in good health. For this reason, and due to lack of information, the *Quercus* species were determined, as were the insects associated to the galls and their distribution across the park.

Materials and Methods

Three collection sites were located in the southwest of the *Cerro Gordo* State Park (Figure 1), in the State of Mexico: site 1 (3 030 masl, 19°45´13.3" N, 098°49´38.4" W); site 2 (2 996 masl, 19°45´07.8" N, 098°49´42.5" W), and site 3 (2 985 masl, 19°45´00.1" N, 098°49´26.5" W).

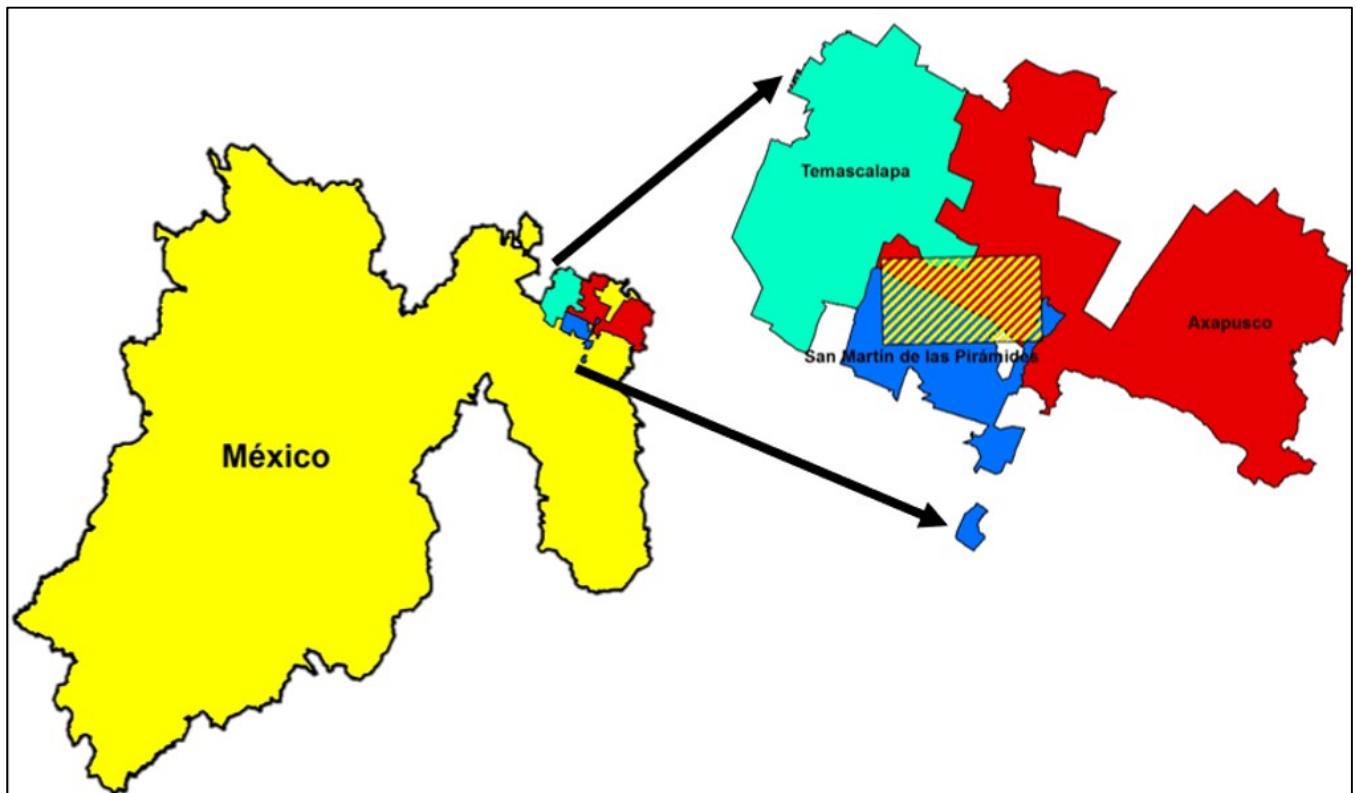


Figure 1. Location of the sampling area at the *Cerro Gordo* State Park.

Oak specimens with the presence of galls, mature leaves in good conditions, and fruits were collected; they were processed for subsequent identification with the aid of taxonomical keys (Zavala, 1995; Romero et al., 2002), and they were compared with the materials kept in the Herbarium of the Forest Division (CHAP) of the Universidad Autónoma Chapingo, where they were finally deposited.

50 × 50 m plots were established at the sites for the sampling of trees, and within them, 10 × 10 m subplots for the sampling of shrubs. In each plot, oaks with a normal diameter above 20 cm (aged 20 to 40 years) were selected and marked, as were shrubs with a height of over 70 cm. 40 galls on shoots and 20 on shrub branches were gathered in five monthly collections during the period of February to July, 2017.

The galls of the shoots and branches were separated and stored in different emergency chambers under controlled conditions (15-22 °C, 12:12 photoperiods). They were checked every other day during two months, and the adult insects obtained were placed in flasks with ethanol at 75 % for transportation to the *Universidad de Barcelona*, in Spain, where a photographic record of them was made (using a LEICA optic microscope) and they were identified with taxonomical keys (Melika et al., 2011; Pujade-Villar et al., 2013).

Results and Discussion

The oaks belonged to four species: *Quercus laurina* Bonpl. (herbarium registration number CHAP, 69 367), a somewhat scarce taxon in the area, without representatives at the sampling sites and without galls; *Q. rugosa* Née (herbarium registration number CHAP, 69 369), with 278 individuals ha⁻¹, and *Q. crassipes* Humb. & Bonpl (herbarium registration number CHAP, 69 368), with 278 individuals ha⁻¹; *Q. microphylla* Née (herbarium registration number CHAP, 69 370) is the dominant plant at the open sites located at an altitude interval of 2 700 to 3 000 m; this species forms 1 m tall oak shrubs, with a density of 878 individuals ha⁻¹ at the sampling sites. *Q. rugosa* and *Q.*

crassipes are distributed in the areas with the highest altitude; they form oak groves with a canopy height between 7 and 8 m. The only species exhibiting galls on the branches were *Q. crassipes*, where they occurred on the shoots, and *Q. microphylla*.

Galls of *Quercus microphylla*

These shrubs exhibited globe shaped, fully lignified galls that partially surrounded the smaller branches (Figure 2a and 2b); 15 to 27 galls were found in each specimen. Three cynipid species emerged during the period of May to July, 2017: *Andricus carrilloi* Pujade-Villar 2013, *Synergus mexicanus* Gillette 1896 and *Syrnergus* sp., besides other individuals of the family Eulophidae.

The main taxon was *Andricus carrilloi* (Figure 2c and 2d), a gall wasp first detected in Mexico City in 2013, on *Q. laeta* Liebm. (Pujade-Villar *et al.*, 2013); its galls are similar to those observed in the present study. This insect is characterized for having antennae with 13 flagelomers, a horny scutellum, line of the mesoscutellum, curved propodeal carinae, hyaline wings, and a relatively short radial cell; brown to black antennae and legs, dark (reddish to chestnut brown) body, and reddish to brown metasoma (Pujade-Villar *et al.*, 2013). The genus *Andricus* is the most numerous in the Cynipidae family, and it produces tuberous galls on oaks; 43 species are cited in Mexico (Pujade-Villar *et al.* (2016a and 2016 b).

Adults of the genus *Synergus* have inquiline habits and are associated with the galls of Fagaceae (Ronquist *et al.*, 2015).



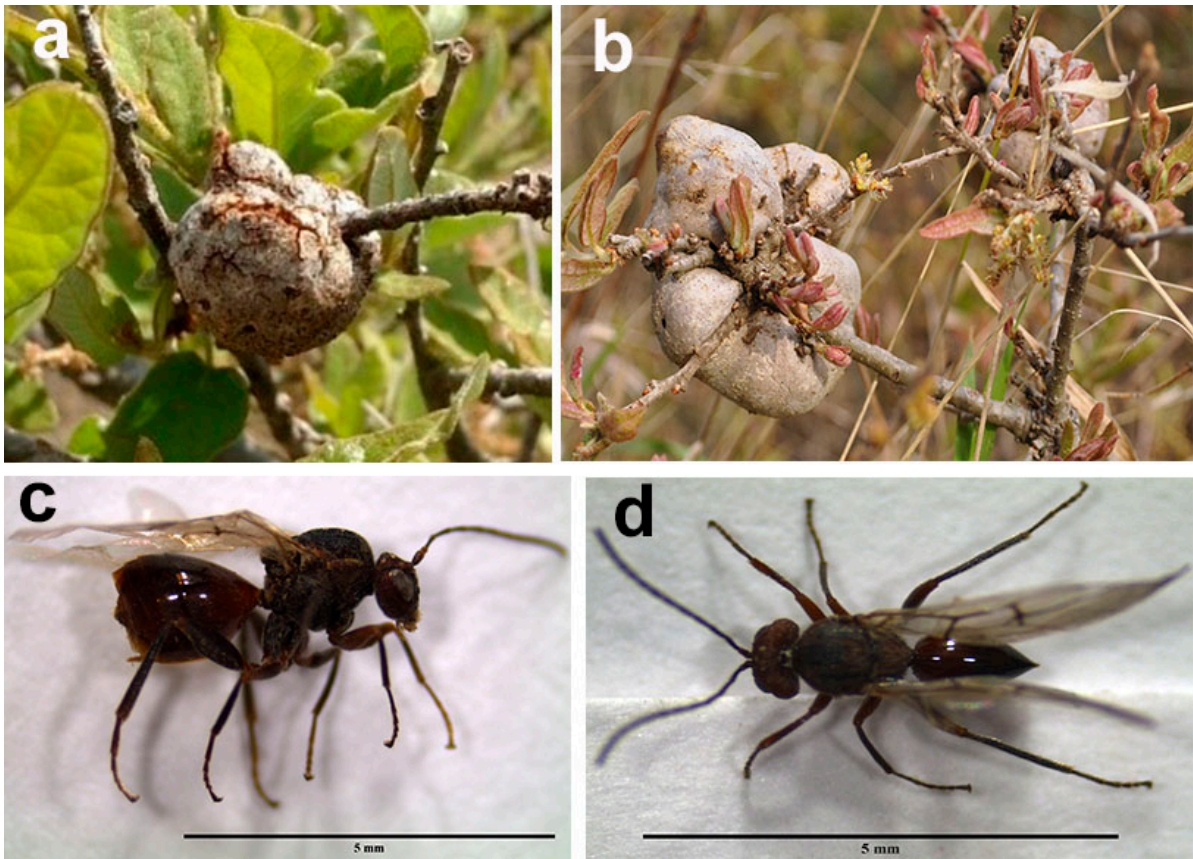


Figure 2. Galls on *Quercus microphylla* Née and emerged wasps. 1 a and b) Globe-shaped galls. 1 c and d) *Andricus carrilloi* Pujade-Villar 2013 adults associated with the galls.

A total of 200 taxa of inquiline Cynipidae, belonging to 10 genera and classified into three tribes (Synergini, Ceroptresini and Diastrophini) are known at world level (Ronquist *et al.*, 2015). 87 species have been detected in the Nearctic region, and 15, in the Neotropical region (Pénzes *et al.*, 2012). *Ceroptres*, *Synophromorpha* and *Synergus* have been registered in Mexico (Pujade-Villar *et al.*, 2008).

Of the 125 *Synergus* taxa in the world (Pénzes *et al.*, 2012; Schweger *et al.*, 2015; Lobato-Vila *et al.*, 2017), 10 have been identified in Mexico: *S. cibriani* Pujade-Villar & Lobato-Vila 2017; *S. citriformis* Ashmead 1922; *S. equihuai* Pujade-Villar & Lobato-Vila 2016; *S. estradae* Pujade-Villar & Lobato-Vila 2016; *S. filicornis* Cameron 1883; *S. gilletti* Pujade-Villar & Lobato-Vila 2017; *S. longimalaris* Pujade-Villar & Lobato-

Vila 2017; *S. longiscapus* Pujade-Villar & Lobato-Vila 2016; *S. mexicanus* Gillette and *S. striatifrons* Pujade-Villar & Lobato-Vila 2017 (Ritchie and Shorthouse, 1987; Pujade-Villar and Melika, 2005; Lobato-Vila and Pujade-Villar, 2017). The present study documents the first detection in *Q. microphylla*.

Synergus mexicanus (Figure 3) exhibits an open radial cell, whereby it differs from most representatives of the genus and is the only one with this characteristic in Mexico (Figure 3a). Females have 12 flagelomeres and frontal lateral carinae that may be complete or incomplete but are always present (Pujade-Villar *et al.*, 2015). *Q. rugosa* tumor-like galls produced by individuals of *Andricus* spp. were collected in 2015 (Pujade-Villar *et al.*, 2015).

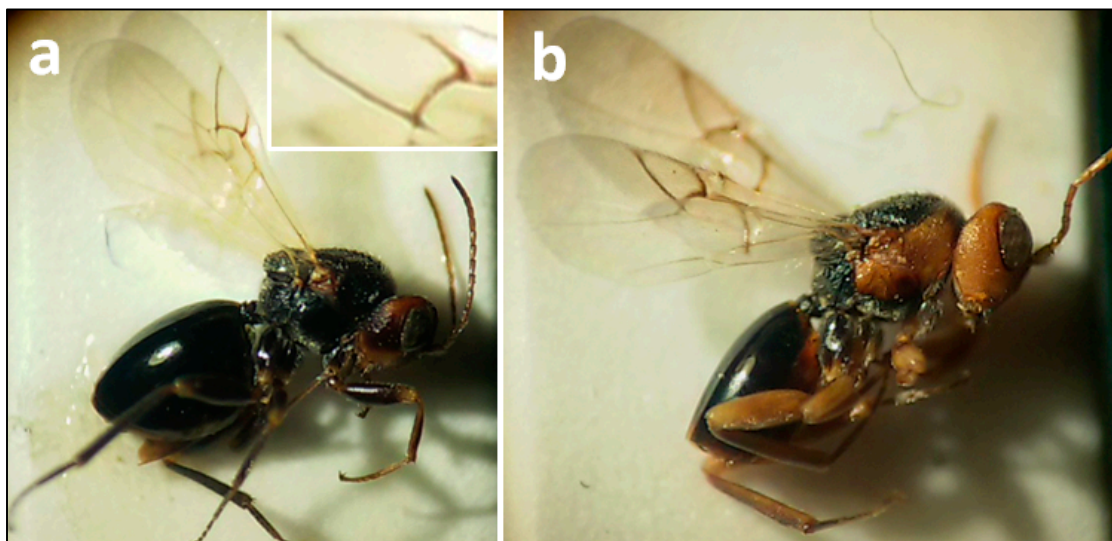


Figure 3. Adult specimens of *Synergus mexicanus* Gillette 1896; a) *habitus* of the female and detail of the radial cell; b) *habitus* of the male.

Other detected inquiline species were adults of the Eulophidae family, Tetrastichinae subfamily (Figure 4). The Eulophidae (Chalcidoidea) family is one of the most common groups of parasitoids in cynipid galls, and 59 oak species have been detected in Europe (Csóka *et al.*, 1998). The taxonomy of this group is little studied, and therefore the identification of its genera is complex due to its enormous diversity and your morphological uniformity (Gómez *et al.*, 2006).

36 taxa belonging to genera associated with Cynipidae galls have been identified in the Palearctic region (Serrano-Muñoz *et al.*, 2015; 2016); the Eulophidae species developed in oak galls are unknown in Mexico.



Figure 4. a) Male and b) female specimens of Eulophidae: Tetrastichinae collected from galls on *Quercus microphylla* Née.

Galls on *Quercus crassipes*

They were located on the buds; their shape was round (Figure 5a), and their size ranged between 7.3 and 8.2 cm; their color was green at the beginning of the collections, and later turned red; its consistency was soft and, when a longitudinal cut was practiced on them, only one larval chamber was observed. In January and February, only 25 to 45 mummified galls were found in each tree individual; however, from March on, their number increased to above 80. Only in the material collected that month, the larval chamber had more than one larva of the inquiline or parasitic species; yet, no adult insects were present. Adult *Amphibolips hidalgoensis* Pujade-Villar & Melika 2011, cynipids emerged from galls collected from April onward, which were red and larger (Figure 5b); this happened at the end of February and in July (Figure 5c and d).



Figure 5. a) *Quercus crassipes* Humb. & Bonpl. tree with galls, b) Galls found and collected in May, and c and d) *Amphibolips hidalgoensis* Pujade-Villar & Melika 2011 adults associated to the galls.

Amphibolips hidalgoensis was first detected in the state of Hidalgo, in *Q. candicans*, *Q. crassifolia* and *Q. candicans* galls (Melika *et al.*, 2011). Its presence in *Q. crassipes* signifies a new register of a host species. This species has a posterior edge of the mesoscutellum, and a dark line along the anterior edge of the wings, which is interrupted by a light-colored band that crosses the cell delimited by R1+Sc and Rs+M. Its head is black, except for the maxillary and labial palps, which are of a light brown hue. Its antennae, mesosoma, and legs are black, although tarsomeres 2-5 are dark brown (Melika *et al.*, 2011).

The wasps of the *Amphibolips* genus of the Nearctic and Neotropical regions produce galls on the oak trees of the Lobatae section. So far, 50 species have been described, of which 19 are exclusive of Mexico (Pujade-Villar and Ferrer-Suay, 2015b).

Two morphological groups stand out within the genus (Nieves-Aldrey *et al.*, 2012): *niger*, which consists of adults that have antennae with 14-15 flagelomers and extremely pubescent galls, with an extremely hard central gall, and *nassa*, characterized by the presence of 11-12 antenomers and galls that are neither pubescent nor hard. Female *Amphibolips* adults obtained in this research belong to the *nassa* group. Both groups have a robust body, with a dark, horny head and mesosoma (Melika *et al.*, 2011). Both the sexual and the asexual generation of the *Amphibolips* species induce galls on the leaves, buds or shoots of red oaks. The *nassa* group produces galls resembling a spongy globe- or pear-shaped gall with a single larval chamber located at the center of its spongy parenchyma, or attached with radiate filaments (Melika and Abrahamson, 2002; Nieves-Aldrey *et al.*, 2012).

The health of the oak trees of the *Cerro Gordo* Park is a relevant topic that should be addressed in future papers. According to the known literature, tumor-like galls produced by *A. carrilloi* on branches cause apparent aesthetic damage. However, *Andricus quercuslaurinus* Melika and Pujade-Villar 2009 is known to severely affect *Quercus laurina* Humb and Bonpl. and *Q. affinis* Scheidw, in *Hidalgo* (Melika *et al.*, 2009; Pujade-Villar, 2013). Besides, other harmful taxa of this genus have been described in Mexico on *Q. laeta* (Pujade-Villar *et al.*, 2014). The damage caused to the buds by *A. hidalgoensis* is well known (Melika *et al.*, 2011). At the state park, galls were observed on all the specimens of *Q. crassipes*.



Conclusions

The oak species *Quercus laurina*, *Q. crassipes*, *Q. rugosa* and *Q. microphylla* are found at the *Cerro Gordo* State park. *Q. crassipes* and *Q. microphylla* are new registers of hosts of the endoparasitic wasps *A. hidalgoensis* and *A. carrilloi*, respectively. Both these species are the first gall cynipids detected at this park. Associated to these insects, parasitoids of the subfamily Tetrastichinae (Eulophidae) and inquilines of the genus *Synergus* were identified. The development of globe-shaped galls of *A. hidalgoensis* harms the buds of *Q. crassipes*, whereas, according to the literature, the tuberous galls produced by *A. carrilloi* seem to cause its host, *Q. microphylla*, only aesthetic damage.

Acknowledgments

The authors wish to express their gratitude to *Departamento de Preparatoria Agrícola* of the *Universidad Autónoma Chapingo* for the support with transportation; to the municipal representatives and *ejidatarios* of *San Martín de las Pirámides* for their help during the field trips.

Conflict of interests

The authors declare that they had no conflict of interest in the development of the present research.

Contribution by author

Erika J. Zamora-Macorra: field collection, drafting and editing of the document; Ro L. Granados-Victorino: collection and identification of oaks; Eduardo Santiago-Elena: collection of galls and editing of the document; Karla G. Elizalde-Gaytán: taking of photographs and editing of the document; Irene Lobato-Vila: identification of insects; Juli Pujade-Villar: identification of insects, and drafting and editing of the document.

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