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Seasonal abundance and populational density of *Chaitophorus populialbae* (Hemiptera: Aphididae) and its natural enemies in central Mexico

Abundancia estacional y densidad de población de *Chaitophorus populialbae* (Hemiptera: Aphididdidae) y sus enemigos naturales en el centro de México

Daniela Domínguez-Rodríguez[1], Ana Lilia Muñoz-Viveros[2], Oscar Martínez-Morales[3], Nadia Salomé Gómez-Domínguez[4], Luis Enrique Páez Gerardo[5], Pedro González-Julián[6], Rebeca Peña-Martínez[7], Juan Manuel Vanegas-Rico[8*]

[1] Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Estado de México, México.
[2] Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Estado de México, México.
[3] Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Estado de México, México.
[4] Centro de Desarrollo de Productos Bióticos del Instituto Politécnico Nacional, Yautepec, Morelos, México.
[5] Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Estado de México, México.
[6] Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México.
[7] ENCB-Instituto Politécnico Nacional, Ciudad de México, México.
[8] Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Estado de México, México.
* Corresponding author: <entomologo.mexicano@gmail.com>

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Abstract

In Central Mexico, the population fluctuation of the aphid *Chaitophorus populialbae* was studied. This is an exotic species that develops on *Populus alba*, another exotic tree species commonly used for ornamental purposes. From February 2023 to April 2024, 41 specimens of these trees were examined at the facilities of the Iztacala Faculty of Higher Studies. The incidence and severity of the aphid were recorded to generate an infestation scale, and its natural enemies were collected and counted. An incidence of 93% was obtained, with low population densities (18 ± 1 individuals/leaf, ranging from 18 to< 300 individuals). Six predators were collected from the same leaves, listed in descending order: *Harmonia axyridis*, *Hippodamia convergens*, *Allograpta obliqua*, *Chrysoperla comanche*, *Leucopina* sp and *Scymnus loewii*. In addition, mutualism with *Linepithema humile* ants was recorded. Starting in February 2023, the population of parthenogenetic apterous forms increased, reaching its highest value during the first half of March 2023, when some winged parthenogenetic forms were present, with similar records in September 2023 and April 2024. Notably, the record of a winged male in March 2024 is unusual, as these organisms typically appear during autumn in their area of origin.

Keywords: Urban insects, exotic, Coccinellidae, white poplar.

Resumen

En el centro de México se estudió la fluctuación poblacional del áfido *Chaitophorus populialbae,* una especie exótica que se desarrolla sobre *Populus alba*, especie arbórea de naturaleza también exótica y utilizada como ornato. De febrero de 2023 a abril de 2024 se examinaron 41 ejemplares de estos árboles en las instalaciones de la Facultad de Estudios Superiores Iztacala. Donde se registró la incidencia y severidad del áfido, generando una escala de infestación, además de la recolecta y conteo de sus enemigos naturales. Se obtuvo una incidencia de 93%, con bajas densidades poblacionales (18 ± 1 individuos/hoja, rango de 18 a <300 individuos). En las mismas hojas se recolectaron seis depredadores, listados en orden descendente: *Harmonia axyridis*, *Hippodamia convergens*, *Allograpta obliqua*, *Chrysoperla comanche*, *Leucopina* sp. y *Scymnus loewii*. Además de registrar un mutualismo con las hormigas *Linepithema humile*. A partir de febrero de 2023 la población de formas ápteras partenogenéticas aumentó hasta alcanzar su valor más alto en la primera quincena de marzo 2023, donde se tuvo la presencia de algunas formas aladas partenogenéticas, así mismo con registros en septiembre de 2023 y abril 2024. Se destaca que un macho alado fue registrado en marzo 2024; esta presencia es inusual, ya que estos organismos se reportan generalmente en otoño en su zona de origen.

Palabras clave: Insectos urbanos, exóticos, Coccinellidae, chopo blanco.

INTRODUCTION

The *Populus alba* tree is a species native to the Western Mediterranean and Europe (Roiron et al., 2004; Fussi et al., 2012). It is widely distributed in temperate regions worldwide, where it is used as biofuel, for shade and windbreaks (Isebrands & Karnosky, 2001; Griu & Lunguleasa, 2016; Kollert & Lebedys, 2018); a potential phytoremediation effect has also been suggested (Miletić et al., 2024). Meanwhile, in other countries such as Mexico, *P. alba* is used in urban and semi-urban areas for aesthetic (Martínez & Chacalo, 1994; Pauleit et al., 2002; Martínez, 2008; Reséndiz-Martínez et al., 2019).

Green areas are vital spaces for recreation and promote the physical and mental health of citizens (Nutsford et al., 2013; Garber et al., 2025), providing ecosystem benefits that contribute to mitigating the effects of climate change (De la Sota et al., 2019; Muluneh & Worku, 2022) and serve as a reservoir for various groups of living beings, which facilitates biodiversity conservation (Nielsen et al., 2014; Vasquez & Wood, 2022) and supports a network of mutualistic, symbiotic and parasitic interactions (Vashis et al., 2025).

Aphids (Hemiptera: Aphididae) are a group of phytophagous insects comprising nearly 5000 species worldwide, of which almost 50 % are associated with trees (Favret & A.T.C., 2025). In high populations, they can affect tree vigor by sucking sap from leaves and branches (Peña-Martínez et al., 2017), which affects photosynthetic processes (Poljaković-Pajnik et al., 2024); They affect negatively their aesthetic quality by producing honeydew and developing sooty mold (Muñoz-Viveros et al., 2011; Flessa et al., 2022), as well as being potential vectors of viruses (James & Perry, 2004). In contrast, those aphid species that naturally maintain sparse populations can induce resistance in their host (Shen et al., 2023).

Species of the genus *Chaitophorus* are associated exclusively with Salicaceae family; they are specific to genera *Salix* or *Populus* but never to both (Favret & A.T.C., 2025) and do not alternate hosts (Pintera, 1987). Distinctive morphological characteristics of the genus include a body covered with setae, short siphuncles with reticulation, and a button-shaped tail (Pintera, 1987; Favret & A.T.C., 2025).

The aphid *Chaitophorus populialbae* (Boyer de Fonscolombe, 1841) *sensu lato* is a Palearctic species whose distribution has spread to several regions of Africa, the United States and Canada (Favret & A.T.C., 2025). In Mexico, this aphid was recorded in 2011 in central region on *P. alba* (Muñoz-Viveros et al., 2011); since then, no studies have been conducted in the country. Therefore, the aim of this study was to record the incidence and population density of the aphid *C. populialbae* and its natural enemies on *P. alba* trees found on a university campus in central Mexico.

MATERIALS AND METHODS

Study area.— The study was conducted on the campus of the Faculty of Higher Studies Iztacala (FESI), which covers an area of 420.000 m^2 (FESI, 2022). The site is located in the municipality of Tlalnepantla de Baz, north of Mexico City (19.535N, 99.20222W, 2,250 m) Figure 1.

Sampling methodology.— Four leaves were collected every two weeks from 10 randomly selected trees (40 leaves) during the period from February 2023 to April 2024. All aphids on each leaf, and their natural enemies were recorded by developmental stage (egg, larva, pupa, and adult), adults were sacrificed, while the immature ones were fed until their final stage for identification. Additional observations of other organisms on the foliage were included. A separate sample of 20 leaves with aphids was collected and isolated without predators to searching for parasitoids. All adult insects obtained were preserved in 70% alcohol. Selected specimens of natural enemies were mounted on paper triangles, while winged and wingless adult aphid specimens were prepared according to the modified Blackman & Eastop technique (Favret & A.T.C., 2025) and their identification was carried out by the ALMV specialist, co-author of this work.

Infestation scale.— A six-level scale of aphid infestation was generated based on the maximum and minimum abundances found, using literature data as a reference that showing a maximum of 471 individuals of *C. populialbae* / leaf of *P. euphratica* Olivier in Iraq (Jubouri & Abd Abdullah, 2023), so the scale was adjusted to 500 organisms as the highest value (Table 1).

Climatic information.— Climatic information on precipitation, maximum and minimum temperature was obtained using the NASA POWER software (2024), by selecting a single point in the center of the polygon where the *P. alba* specimens were located.

Table 1. Scale designed to evaluate the population density of *C. populialbae* per leaf.
Tabla 1. Escala diseñada para evaluar la densidad de población de *C. populialbae* por hoja.

Infestation level	Range*	Numeric**	Qualitative
0	0	0	Nule
1	1-25	13	Very low
2	26-50	38	Low
3	51-75	63	Media
4	76-100	87	High
5	101-300	200	Very High

*Number of aphids by leaf.
**minor range + mayor range/ 2.

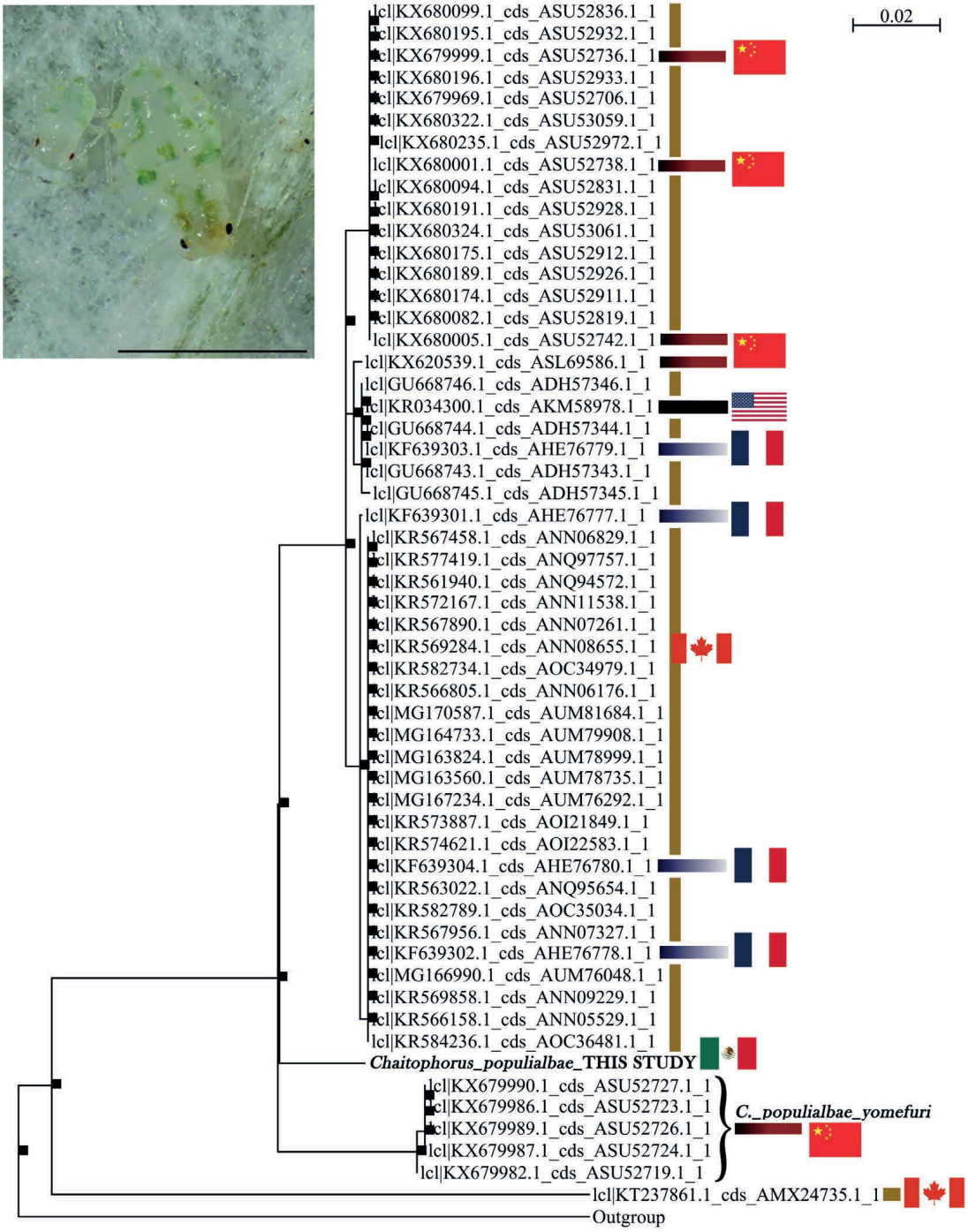

Fig. 1. Phylogenetic tree of *Chaitophorus populialbae.* Worldwide data and sequence of this study.

Fig 1. Árbol filogenético de *Chaitophorus populialbae*. Datos y secuencias de este estudio a nivel mundial.

Molecular analysis.— Molecular analyses were performed using cytochrome c oxidase I (COI) (Folmer et al., 1994; Nováková et al., 2013; Zhang et al., 2011). A PCR reaction to amplify a COI fragment was performed using the primers LCOI490 and HCO2198 (Folmer et al., 1994). The amplicon was purified using a QIAGEN PCR Purification Kit following the manufacturer's instructions and sequenced using Sanger method, and the sequence was uploaded to NCBI (accession number PV798376). Aphid identification was performed by BLAST (Altschul et al., 1990). Similar sequences were downloaded, cropped, and aligned (muscle algorithm) using MEGA XI. Phylogenetic trees were made using the maximum likelihood method (Tamura et al., 2021).

Data analysis.— The incidence of aphids was obtained by dividing the number of *P. alba* trees with aphids present by the total population of *P. alba* in the FESI. Two variables were analyzed: a) weighted value of the number of aphids/leaf/sample and b) number of natural enemies/leaf/sample. Normality was analyzed with a Shapiro-Wilk test ($p=0.05$) on the 40 fortnightly data points from each collection period. Based on this, a Spearman correlation test ($p=0.05$) was used to evaluate the relationship between aphids and their predators over time. The population fluctuation of aphids and their natural enemies was established every two weeks along with climate information on temperature and precipitation. Central tendency and standard error values were calculated for all variables.

RESULTS

A total of 41 specimens of *P. alba* were recorded on the FESI campus, mainly located in the central parking area. The phytophagous *Chaitophorus populialbae* was the only aphid species on these trees and was present throughout the sampling period.

According to molecular information, 55 sequences of *C. populialbae* from five countries were processed: Canada (39), China (10), France (4), and the United States (1). Besides the sequence corresponding to this study in Mexico, which is closer to populations taken from Canada (Fig. 1).

Incidence of the aphid was 93%, while the overall infestation during the period from February 2023 to April 2024 was very low, infestation level 1 (18.35 ± 1.1 individuals/leaf). At the beginning of 2023, there were 45 ± 9.1 aphids/leaf lLow infestation, level 2), increasing to high infestation, level 4 (78.0 ± 6.0 individuals/leaf) with range 13 to 200 aphids in March 2023 (Fig. 2) and then decreasing to near zero; the following year, it increased from February to March 2024. Winged parthenogenetic forms were recorded during the second half of March (7 individuals), the first half of September 2023 and second half of January 2024, with 1 individual, respectively; while in the two samples taken in April 2024, 22 winged individuals were recorded on the trees closest to the perimeter fence of the faculty.

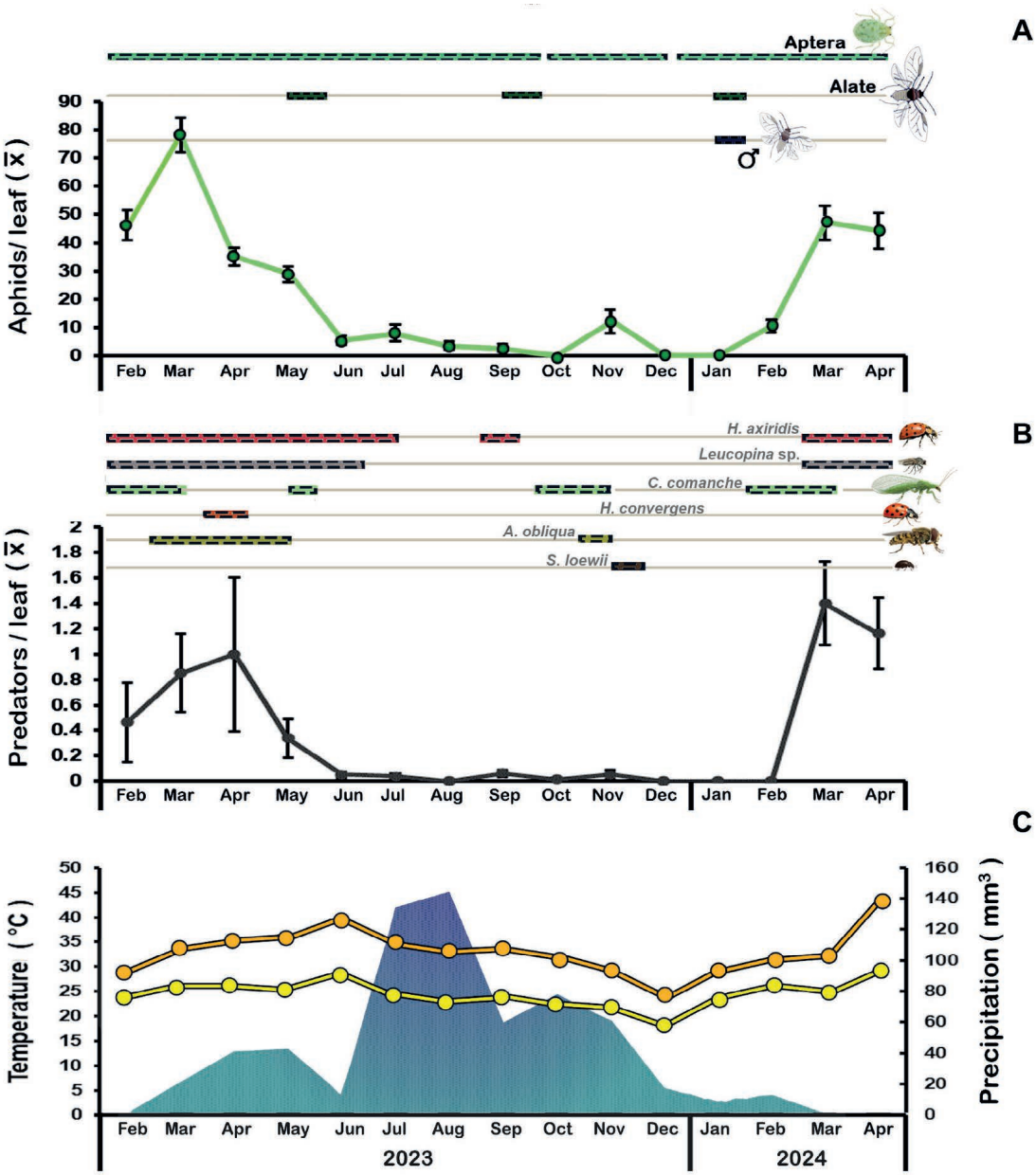

Fig 2. Population fluctuation of *Chaitophorus populialbae* and its natural enemies on *Populus alba* on the FESI campus, Mexico. **a**, Fluctuation of *C. populialbae* of wingless and winged forms; **b**, Fluctuation of natural enemies; **c**, Minimum and maximum temperatures in the FESI car park; **d**, Precipitation at FESI. Bars with dotted lines indicate the periods when they occurred. Al = winged forms, Ap = wingless forms.

Fig. 2. Fluctuación poblacional de *Chaitophorus populialbae* y sus enemigos naturales en *Populus alba* en el campus de FESI, México. a, Fluctuación de *C. populialbae* en formas aladas y ápteras; b, Fluctuación de enemigos naturales; c, Temperaturas mínimas y máximas en el estacionamiento de FESI; d, Precipitación en FESI. Las barras con líneas punteadas indican los periodos en que ocurrieron. Al = formas aladas, Ap = formas ápteras.

Table 2. Population density of aphids and their natural enemies on *Populus alba* on central Mexico.
Tabla 2. Densidad de población de pulgones y sus enemigos naturales en *Populus alba* en el centro de México.

Group / Order	Insects		Density/Leaf (Media ± EE)
	Family	Species	
Phytophagous	Aphididae	*Chaitophorus populialbae*	**18.32 ± 1.13**
Predators			**0.29 ± 0.04**
Coleoptera	Coccinellidae		0.212 ± 0.037
		Harmonia axyridis	0.191 ± 0.037
		Hippodamia convergens	0.002 ± 0.001
		Scymnus loewii	0.003 ± 0.002
Diptera	Chamaemyiidae	*Leucopina* sp.	0.056 ± 0.012
	Syrphidae	*Allograpta* sp.	0.006 ± 0.002
Neuroptera	Chrysopidae	*Chrysoperla comanche*	0.018± 0.005

Additionally , a winged male appeared in a sample in January 2024 (Figure 2A).

Average minimum and maximum temperatures during the sampling year were 9 and 24°C, increasing from May to October 2023, decreasing in November until February 2024, and increasing again in April and May. Precipitation from February to March remained low until July and August, which were the months with the highest precipitation of the entire sampling period (150 mm^3), decreasing until April (Figure 2A). The period of highest precipitation coincided with the decline in the aphid population (Figure 2).

Regarding trophic relationships with entomophages, no parasitoids were recorded, only generalist predators: *Chrysoperla comanche* Banks (Neuroptera: Chrysopidae), *Harmonia axyridis Pallas*, *Hippodamia convergens* Guérin-Méneville, *Scymnus loewii* Mulsant. (Coleoptera: Coccinellidae), *Leucopina* sp. (Diptera: Chamaemyiidae) and *Allograpta obliqua* (Say) (Diptera: Syrphidae) (Table 2). In contrast, mutualism was observed with the ants *Linepithema humile* (Mayr) (Hymenoptera: Formicidae).

Entomophagous were scarce (0.29 ± 0.04 individuals/leaf), with Coccinellidae being the most abundant with 0.2 ± 0.03 individuals/leaf (Table 2). The trend in fluctuation was similar to that of their prey, occurring regularly until May 2023 and with a population peak in the first half of April 2023. They then decreased considerably, increasing from February 2024 with the highest values in the second half of March 2024 (1.8 ± 1.2 individuals/leaf) (Fig. 2). Except for *H. convergens* and *S. loewii*, aphid populations and their natural enemies were correlated (P= 0.406, p=0.000), of which *Ha. axyridis* (P= 0.34, p=0.000) and *Leucopina* sp. (P= 0.261, p=0.000) had the highest correlation.

DISCUSSION AND CONCLUSIONS

The aphid *C. populialbae* comprises two subspecies, *C. populialbae yumifrui*, restricted to China, Japan, Korea and Mongolia; and the subspecies *C. populialbae populialbae*, recorded across 11 countries: South Africa (Africa), China, Iraq, Mongolia, Russia (Asia), Germany, Bulgaria, France, Greece, Holland, Hungary, Switzerland (Europe), Canada, United States (America) (Holman, 2009; Ali & Kamal, 2018; Stekolshchikov & Buga, 2018; Fravret & A.T.C., 2025; GBIF, 2025).

The record of *C. populialbae* in Mexico (Muñoz-Viveros et al., 2011) did not have international scope. Therefore, this study represents the first formal record of this species and provides the first population fluctuation data for the genus in Mexico. The known studies on aphid population fluctuation are based mainly on species of agricultural importance (Risco et al., 2015; Fortoul-Díaz et al., 2020; Magaña-López et al., 2020; Raina et al., 2022; Petrova et al., 2024). Unlike the few forestry studies, which provide a list of species associated with a particular tree, documenting some impact of certain *Chaitophorus* species on *Salix* and *Populus* (Peña-Martínez 1985; Reséndiz-Martínez et al., 2019, 2020, 2024).

The limited number of publications on these aphids is probably due to the fact that they are not a primary forest pest in European or Asian countries, and therefore no assessments are carried out (Dr. Kadyrbekov -Russia-, Ing Fryč -Czech Republic-, Dr. Bugaj-Nawrocka -Poland-; pers. comm.). In Mexico, however, phytosanitary studies in parks and green areas report a relative abundance of *P. alba* of less than 1% (Saavedra-Romero et al., 2016; Martínez-Juárez et al., 2022; Muñoz-Gutiérrez et al., 2022; Benavides-Meza & García-Ponce, 2023; Reséndiz-Martínez et al., 2024). This may be a consequence of policies to replace exotic species in order to preserve native ones, a practice that began approximately two decades ago.

The closest reference for comparing the population fluctuation in this work is a study conducted in Iraq on *C. populialbae* on *P. euphratica*, where peak density (471 nymphs) was recorded during the third week of June (Jubouri & Abd Abdullah, 2023); while in the present study, the highest value was close to 300 aphids on the most infested leaf, which occurred in the second half of March and is consistent with the increase in temperature in both regions.

The factors influencing aphid population dynamics can be abiotic (Ahmed et al., 2016; Jan et al., 2017; El Fakhouri et al., 2021; Jan et al., 2017; Juhász & Szénási, 2024), anthropogenic factors such as chemical applications (El Fakhouri et al., 2021), fertilization (Nevo & Coll 2001; Müller et al., 2001) and plant spacing in the crop (Juhász & Szénási, 2024), as well as biotic aspects such as plant-phytophagous interaction (Jaouannet et al., 2014; Catto et al., 2022; Pastierovič et al., 2024), and phytophagous-natural enemy interaction (Apak & Akşit, 2016; Glacet et al., 2024).

In the Palearctic region, oviparous females and wingless and winged males of *C. populialbae sensu lato* occur from September to November, when sap flows decrease (Pintera, 1987; Favret & A.T.C., 2025). In Mexico, the presence of males is now represented by an apterous individual in February 2011 and a winged individual in March 2024. This is a relevant finding, as sexual forms had only been reported in the Palearctic region (Pintera, 1987; Stekolshchikov & Buga, 2018). The presence of males in February and March is new in the literature and represents an unknown factor to be resolved, since the climate in central Mexico is mainly tropical, tempered by the high altitude of the Valley of Mexico (2200 meters above sea level), also called temperate subhumid (Cw) according to the Köppen classification. Therefore, the formation of sexes could be related to other biotic or abiotic factors (Bonnemaison, 1951; Weisser et al., 1999; Müller et al., 2001; Carrera & Cermeli, 2003).

The natural enemies that affect *Chaitophorus* spp. populations associated with *Populus* species mainly belong to the families Chamaemyiidae, Chrysopidae, Coccinellidae and Syrphidae associated with another vegetation and aphis species (Lomeli-Flores et al., 2001; Şahbaz & Uysal, 2006; Zhang et al., 2009; Joshi & Ballal, 2013; Satar et al., 2015; Ordoñez et al., 2017; Lara et al., 2022; Palomares-Pérez et al., 2022). There are also entomophagous species of Anthocoridae and Hemerobiidae reported in Turkey (Şahbaz & Uysal, 2006), trombidid mites that parasitize them (Dransfield & Brightwell, 2025), and dipterans of Cecidomyiidae family developed on *C. populeti* in *P. tremula* in Italy (Raspi, 1996).

Since the first record of *C. populialbae* in Mexico, two predators have been mentioned, the coccinellids *Adalia bipunctata* (L.) and *Ha. axyridis* (Muñoz-Viveros et al., 2011). The latter coleoptera was the most abundant in the present study, and in the area, it is a notorious entomophagous species on other *Chaitophorus* species, which is currently being studied (unpublished work). The association between *Ha. axyridis* and *C. populialbae* was already known in Asia, where studies were conducted on prey selection (Wang et al., 2011ab), larval development (Zhang et al., 2009) and functional response (Li et al., 1993).

On the other hand, the association of *C. populialbae* with ants was mentioned as occasional, without specifying species or location (Pintera, 1987). The first specific association of *C. populialbae* with ants was recorded in 1991 with the species *Lasius niger* (L.) on *P. alba* in Spain; years later, it was reported on *Li. humile* attending *Chaitophorus* sp. and *C. leucomelas* Koch on *P. nigra*, and *C. populeti* (Panzere) on *P. alba* (Suay-Cano et al., 2002). In addition, *Myrmica* sp. was observed to attend adults and nymphs of *C. populialbae* (Dransfield & Brightwell, 2025). Another record of ants shows ingesting molasses fallen on the ground from *C. populialbae* by *Polyrhachis simplex* (Mayr) in France (Degen et al., 1986), with no direct ant-aphid interaction.

Therefore, the presence of *Li. humile* is a second specific record of mutualistic association with *C. populialbae* in the world and the fifth with the genus *Chaitophorus*, considering the work on *Populus fremontii* in California (Mondor & Addicott, 2007).

The surveys did not contain any parasitized organisms. Five species of wasps associated with *Chaitophorus* sp. are known worldwide (Bhagat 1982; Ortego et al., 1999; Lumbierres & Stary, 2005; Baker & Broad, 2009; Tomanović et al., 2009; Rakhshani et al., 2012); In particular, the wasp *Ephedrus chaitophori* (Gardenfors) (Hymenoptera: Braconidae) is known as a parasitoid of *C. populialbae* in the province of Lleida, on the Iberian Peninsula (Lumbierres & Stary, 2005). Meanwhile, in Mexico, the only record of parasitoids corresponds to another braconid, *Adialytus salicaphis* (Fitch), obtained from *Chaitophorus* sp. in *Populus balsamifera*, without mentioning the location (Stary, 1983; Cervantes-Mayagoitia et al., 2004). It is likely that, due to the low density of the colonies in which *C. populialbae* occurs in this study, parasitism has not been detected, since the action of natural enemies depends on prey density (Alaserhat & Canbay, 2017); another reason could be the exotic nature of the organism, so the parasitoids are still adapting to their host, like *Pseudoregma panicola* (Takahashi), another exotic aphid recent recorded in Central Mexico (Muñoz-Viveros et al., 2025).

The populations of the aphid *C. populialbae* in the urban trees evaluated were low, with the highest values occurring between March and May 2023. Six generalist predators belonging to the families Chamaemyiidae, Chrysopidae, Coccinellidae and Syrphidae were found, with a population density of less than one individual per leaf, with the highest value occurring in the first half of April, coinciding with the decline in prey density. This indicates a process of adaptation and regulation; and so far, the Asian ladybird beetle, *Ha. axyridis*, has a greater presence on populations of this aphid. Some studies demonstrate their ability to respond to varying aphid densities (Bannerman et al., 2018), including *C. populialbae* (Li et al., 1993). While this may be positive, their exotic status is a factor to consider (Brown et al., 2011). Therefore, efforts are currently underway to develop a breeding program for native ladybugs with the aim of reintroducing them to this study area. It is possible that the association of *C. populialbae* with *Li. humile* ants, another exotic pest, serves as a defense strategy against its predators, as reported for other phytophagous insects.

Based on the above, it is considered that the exotic aphid *C. populialbae*, fourteen years after its first record in the country, does not represent a risk to silver poplar populations under the conditions of the present study in an urban environment. However, the sexual forms of the aphid, the absence of parasitism and the low fluctuation itself are relevant factors for continuing its study. Given that low densities of phytophagous insects can confer some resistance to the host against other parasitic insects (Shen et al., 2024).

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CONTRIBUTION STATEMENT

Daniela Domínguez carried out the fieldwork and part of the laboratory work. **Ana Lilia Muñoz** performed the taxonomic determination of the aphid and supervised the laboratory work. **Oscar Martínez** carried out the phytosanitary evaluation and part of the fieldwork. **Nadia Salomé** contributed to revising the manuscript at all stages. **Luis Enrique Páez** performed the technical review. **Pedro González** contributed to writing the manuscript. **Juan Vanegas** designed the sampling, analyzed the data, and completed the manuscript. **Rebeca Peña** reviewed the manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare no conflict of interest.

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