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First report of *Aegomorphus quadrigibbus* and *Thryallis undatus* (Coleoptera: Cerambycidae) damaging Persian lime orchards in Veracruz, México

NÚÑEZ-CAMARGO, María C.[1], MARTÍNEZ-ROSAS, Román[2], LÓPEZ-LIMA, Daniel[1] & SALINAS-CASTRO, Alejandro.[3,*]

[1] Facultad de Ciencias Agrícolas, Universidad Veracruzana. Xalapa, Veracruz, México.

[2] Centro Nacional de Referencia Fitosanitaria. Tecámac, Estado de México, México.

[3] Centro de Investigación en Micología Aplicada, Universidad Veracruzana. Xalapa, Veracruz, México.

*E-mail: asalinas@uv.mx

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Primer reporte de *Aegomorphus quadrigibbus* y *Thryallis undatus* (Coleoptera: Cerambycidae) dañando huertos de limón Persa en Veracruz, México

RESUMEN. Las especies *Aegomorphus quadrigibbus* (Say) y *Thryallis undatus* (Chevrolat) (Coleoptera: Cerambycidae) fueron identificados causando daño a árboles de limón persa en huertas del municipio de Martínez de la Torre, en el centro del estado de Veracruz, México. Se observaron perforaciones realizadas por los adultos para ovipositar los huevos en troncos y ramas, con galerías de entre dos y cinco cm de profundidad, que causaron la desecación de las ramas y, en algunos casos, la muerte total de los árboles. En árboles previamente afectados por patógenos vasculares o con deficiencias de nutrientes, el daño fue más severo porque las larvas formaron galerías que rodearon el tronco o las ramas, impidiendo el flujo de nutrientes. La incidencia media en los árboles muestreados fue del 10,8%. Dado que la zona de Martínez de la Torre es la región productora de limón persa más importante de México, es necesario monitorear los cultivos para determinar la presencia de insectos y desarrollar estudios para definir niveles de daño y estrategias de manejo de las poblaciones de insectos cuando se requiera. Este es el primer registro de *A. quadrigibbus* y *T. undatus* asociados con árboles de la familia Rutaceae y que causan daños en los huertos de limón persa.

PALABRAS CLAVE. *Citrus latifolia*. Daño a los cultivos. Detección. Insectos barrenadores. Insectos plaga.

ABSTRACT. The species *Aegomorphus quadrigibbus* (Say) and *Thryallis undatus* (Chevrolat) (Coleoptera: Cerambycidae) were identified causing damage to Persian lime trees in Martínez de la Torre municipality orchards, in central Veracruz state, Mexico. Ovipositions made by the adults to lay eggs on trunks and branches were observed, with galleries between two and five cm deep, which caused the branches to dry up and, in some cases, complete death of the trees. In trees previously affected with vascular pathogens or with nutrient deficiencies, the damage was more severe because the larvae formed galleries that surrounded the trunk or branches, preventing the flow of nutrients. The average incidence in the sampled trees was 10.8%. Since the Martínez de la Torre area is the most important Persian lime production region in Mexico, it is necessary to monitor crops to determine the presence of insects and develop studies to define levels of damage and management strategies for their insects' populations when required. This is the first record of *A. quadrigibbus* and *T. undatus* associated with trees of the Rutaceae family and causing damage to Persian lime orchards.

KEYWORDS. Borer insects. *Citrus latifolia.* Crop damage. Detection. Insect pest.

Mexico is the first producer and exporter of Persian lime fruits *Citrus x latifolia* Tanaka ex Q. Jiménez in the world. It produces over 1.5 million 500 tons per year, in an area of more than 100 thousand ha, with an average yield of

15.1 t/ha (SIAP, 2022). Veracruz State is the main producer, with 52% of the national production, and the area of the municipality of Martínez de la Torre is the region with the largest number of crops destined for export. The high demand for export-quality fruits requires adequate crop management, including pest monitoring and control to maintain the level of production and comply with international food safety standards (Valencia & Duana, 2019; Osoyo & Elms, 2020). Persian lime trees are affected by several pest insects that reduce crop yield, such as scales, aphids, thrips, psyllids, leafminers, defoliator worms and borers among others (Botina et al., 2019; Bautista-Martínez et al., 2020; Montes-Rodríguez et al., 2020).

In 2016, Persian lime farmers from the Arroyo Blanco town in Martínez de la Torre municipality, Veracruz, Mexico, reported several trees with typical damage from borer larvae of the Cerambycidae family. The damage includes perforations in trunks and branches, which cause a decrease in plant vigor and dieback, with a consequent decrease in yield (Fig. 1a). Therefore, the aim of this work was to determine the insect species associated with the affectations to the trees.

Between October 2019 and December 2020, inspections were carried out every 15 days, in seven Persian lime orchards where the described damages were reported. In each orchard, approximately 15% of the total number of trees planted were monitored. All the trees were between three and ten years old. In the monitored trees, the presence of symptoms such as nutrient deficiency, wilting, yellowing, falling leaves and fruits, and damage such as perforations with galleries in trunks and branches were recorded. Larvae and pupae were extracted from the galleries and adults were collected from the branches of the affected trees. The specimens were moved to the Center of Investigation in Applied Mycology of the Universidad Veracruzana, conserved in 70% ethanol; they were identified using specialized taxonomic keys (Gorton & Chemsak, 1984; Chemsak & McCarty, 1997). Subsequently, the specimens were sent to the Entomology and Acarology Laboratory of the Centro Nacional de Referencia Fitosanitaria (CNRF) where the genitalia were extracted and mounted to corroborate the identification with specialized taxonomic keys (Gorton & Chemsak, 1984; Chemsak & McCarty, 1997). The total DNA extraction was performed following the methodology proposed by Saldamando & Márquez (2012) and SENASICA (2014). A larval segment of each sample previously preserved in 70% ethanol was used. A piece of larva was placed on sterile filter paper, where it was completely ground and then cut, placed in an Eppendorf tube with 400 µl of CTAB Buffer (2x) and incubated at 65 °C for 30 min. Finally, it was centrifuged at 11,000 g for 3 minutes, and the filter paper was removed from the tube, in order to be re-suspended in nuclease-free water. Subsequently, the extracted DNA was amplified by PCR for the molecular markers of the mitochondrial gene Cytochrome Oxidase Subunit I (COI) using two pairs of initiators: LCO1490 and HCO2198 (Folmer et al., 1994) and C1-J1718 and C1-N-2191 (Simon et al., 1994). The amplified fragments were purified with Promega's Wizard® SV Gel and PCR Clean-Up System kit and sequenced with the Sanger method (GA 3130 Applied Biosystem®) at the CNRF. The sequences were edited in the BioEdit program version 7.2.5 (Hall, 1999), compared by BLAST and uploaded in the NCBI GenBank data base.

In total, 1,800 trees were inspected, of which 70 presented two to three dry branches and 105 presented complete death. This represents an average incidence of 10.8% per orchard regarding the number of monitoring trees (Table I).

Table I. Incidence of Persian lime trees affected by larvae of *Aegomorphus quadrigibbus* and *Thryallis undatus* in Martínez de la Torre, Veracruz, México.

Collecting site	Area (ha)	Total trees	Monitored trees	Affected trees	Incidence %
20º13'15.78"N 97º04'59.51"W	5	1385	210	35	16,6
20º13'31.81"N 97º04'40.91"W	8	3200	500	49	9,8
20º13'47.62"N 97º03'31.70"W	6	1662	260	26	10
20º13'21.03"N 97º02'46.66"W	3	831	130	16	12,3
20º12'39.82"N 97º02'52.35"W	3	831	130	18	13,8
20º12'10.51"N 97º03'20.88"W	6	3000	450	21	4,6
20º12'24.29"N 97º03'50.39"W	2	800	120	10	8,3

In three to five-year-old trees, perforations made by adults to oviposit were observed only in trunks at a height of 30 cm from ground level, oval, 6 mm long and 3 mm wide approximately (Fig. 1b). A very fine light-yellow sawdust was also observed. In these trees, the larvae formed galleries 2 cm in deep (Fig. 1c), with reddish-colored sticky resinous secretion as a result of the wounds caused. These wounds impede the circulation of nutrients and cause the death of the branches, which appear chlorotic, defoliated with loss of leaves, flowers, and fruits. In six to ten-year-old trees, oviposition perforations were observed between 30 and 150 cm above ground level, in trunks and branches. The larvae formed galleries up to 5 cm deep with the same reddish and sticky secretion. Torn and weak branches with chlorotic leaves, defoliation and falling flowers and fruits were observed. The damage caused to the *C. latifolia* trees is devastating when the larvae bore galleries in the trunk, whereas when the damage is in the branches, it is feasible that it recovers by carrying out a healing pruning directed at the damaged branches. In trees previously diseased or with nutritional deficiencies, deeper and ring-shaped galleries were observed around the trunk or branches, causing the rapid

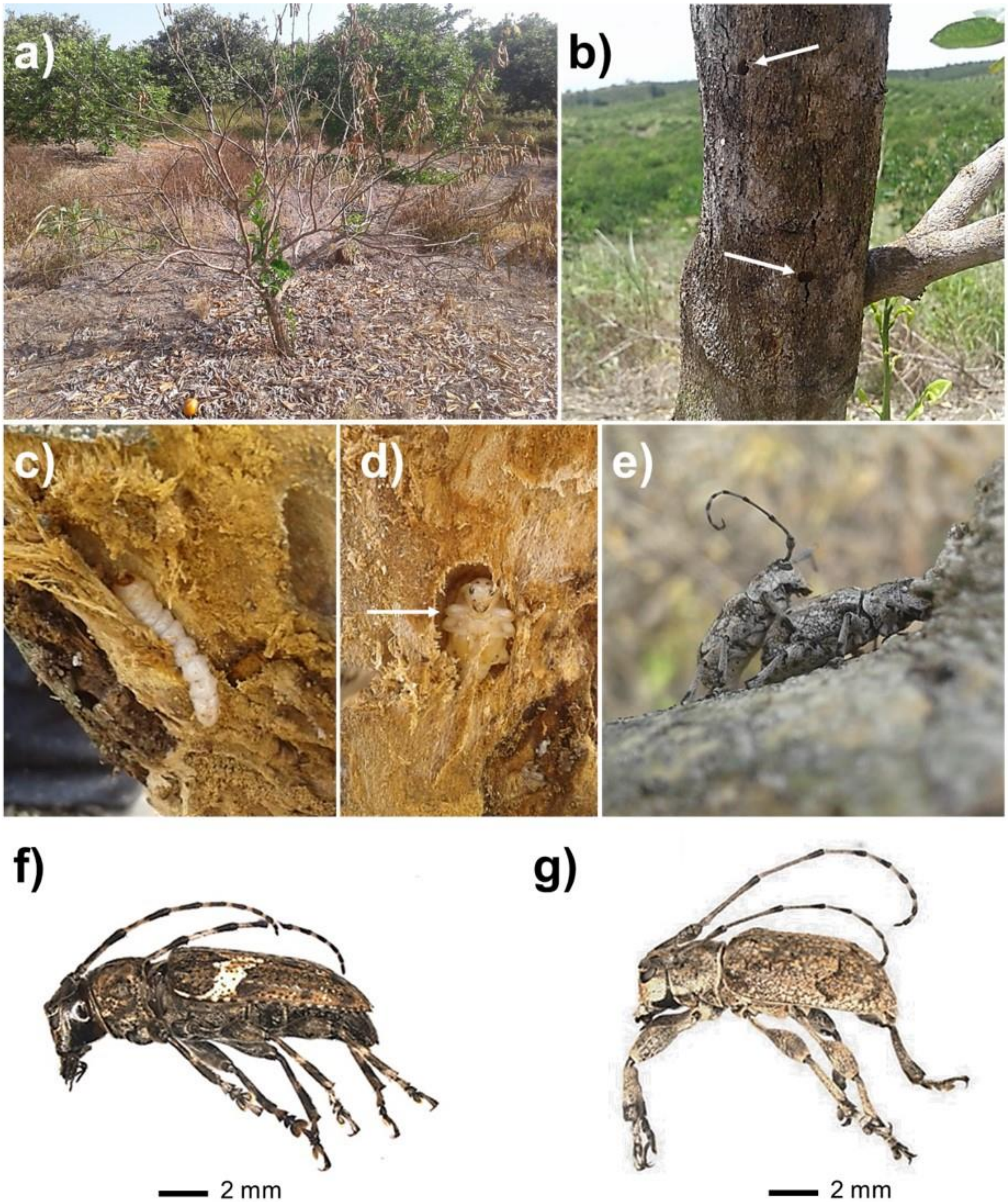

Fig. 1. Damage to Persian lime orchards caused by *Aegomorpus quadrigibbus* and *Thryallis undatus* in Martínez de la Torre, Veracruz, Mexico. a. Tree with drying symptoms. b. Oviposition perforations in trunk. c. Larva. d. Pupae. e. Adults of *T. undatus* on a branch. f. Lateral view of *A. quadrigibbus* adult. g. Lateral view of *T. undatus* adult.

death of the plant. For all ages of trees, the presence of eggs was observed in the field in the second half of November with a duration of 18 to 20 days, the larval stage, was observed from the second half of December to mid-April, with an interval of 110 to 122 days, the pupae (Fig. 1d) were observed from mid-April to early May with a variation of 18 to 21 days, the adult appeared in mid-May (Fig. 1e). According to these observations in the field, it was determined that the biological cycle is approximately 180 days.

The species associated with damaged trees were identified as *Aegomorphus quadrigibbus* (Say) and *Thryallis undatus* (Chevrolat) (Coleoptera: Cerambicidae) (Fig. 1f-g). In total, 81 larvae and 45 adults of *A.*

quadrigibbus and 32 larvae and 67 adults of *T. undatus* were collected. The taxonomic characteristics of each species are described below.

The species *Aegomorphus quadrigibbus*, females 16 mm long and 6 mm at the widest part of the body; males 14 mm long and 5 mm wide. Ribbed elytron with subcostal suture, a white transverse band in the anterior part and indistinct humps at the base. Pronotum with four projections in the form of tubercles. Strongly faceted eyes, with large lower lobe. The observed taxonomic characteristics coincide with those described by Gorton & Chemsak (1984) for this species. The genitalia of the adults are shown in (Fig. 2a-c) Examined material: 8♀ and 8♂. In the molecular analysis, a 652bp sequence was obtained, and it was deposited in the NCBI Gene Bank database under accession number OP684284.1. In the BLAST analysis, the sequence coincided in 97% with the accession HM433162.1 and 96% with the accession OP958775.1, only sequences corresponding to *A. quadrigibbus* available in the GenBank.

The specie *Thryallis undatus*, females and males 9-15 mm long. Reddish brown integument. Antenna with scape shorter than second and third segments, rest of antennal segments shorter than scape. Elytron slightly longer than wide; moderate basal humps; dense gray pubescence with scattered orange villi on all parts. Apical third of each elytron with two wavy faciae with rounded apices. Legs with gray and orange hairs; dorsally pubescent gray tarsi. The observed taxonomic characteristics coincide with those described by Chemsak & McCarty (1997) for this species. The genitalia of the male are shown in (Fig. 2d-f) Examined material: 8♀ and 8♂. In the molecular analysis, a 478 bp sequence was obtained, and it was deposited in the NCBI Gene Bank database under accession number OP684241.1. In the BLAST analysis, the sequence coincided 98% with the accession MW982893.1 of the GenBank that corresponds to *T. undatus.*

The genus *Aegomorphus* Haldeman, 1847 currently includes 91 species distributed throughout the American continent (Bezark, 2022; Heffern et al., 2022). In particular, the presence of *A. quadrigibbus* has been recorded in Ontario, Canada, Pennsylvania, Maryland, Florida, Louisiana, and Texas in United States. In Sinaloa, Nayarit, Jalisco, Guerrero, Veracruz, Yucatán, and Quintana Roo in Mexico; and in Nicaragua and Costa Rica in Central America. The registered hosts include plants from the families Aceraceae, Annonaceae, Betulaceae, Caesalpiniaceae, Cannabaceae, Fagaceae, Juglandaceae, Malvaceae, Meliaceae, Mimosaceae, Moraceae and Ulmaceae (Staines, 2008; Vlasak & Vlasakova, 2021; Bezark 2022; Monné & Nearns, 2022). The genus *Thryallis* Thomson, 1858 is distributed from southern Texas to Costa Rica, the host range is not well known for all species, but most have been found on branches and trunks of dead trees (Chemsak & McCarty, 1997). *T. undatus* is distributed from southern Texas to Honduras, having several records in Mexico in the states of Chiapas, Hidalgo, Jalisco, State of Mexico, Oaxaca, Tamaulipas, Veracruz, Quintana Roo and Yucatán (Noguera & Gutiérrez, 2016). Five species of host trees of the families Fabaceae, Cannabaceae and Oleaceae are reported (Chemsak & McCarty, 1997).

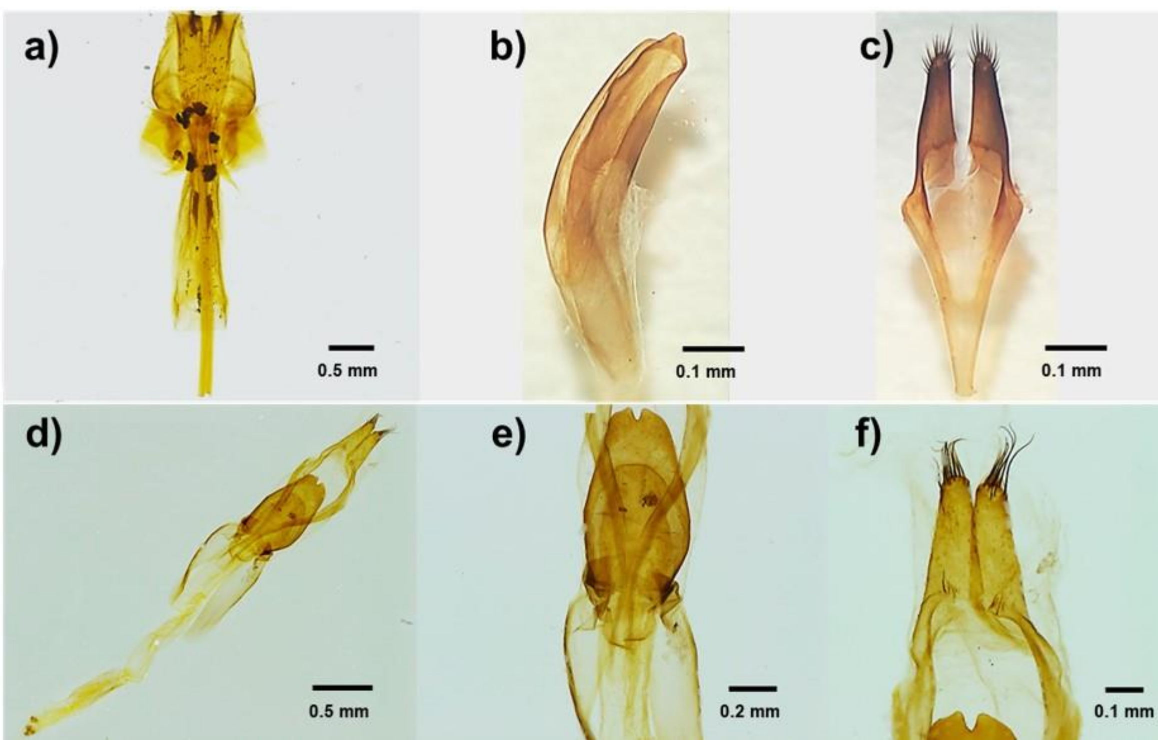

Fig. 2. *Aegomorphus quadrigibbus* genitalia. a. Genitalia of the female. b. Aedeago. c. Tegmen. ***Thryallis undatus* genitalia**. d. Complete genitalia of male. e. Apophysis. f. Tegmen.

The individuals of this taxonomic group mainly inhabit forests, their ecological role is to initiate the process of degradation of dead wood. Their role in the degradation process varies according to the species, the hosts, and the region, nevertheless, this group is considered fundamental at the beginning of the wood degradation process (Ulyshen et al., 2016; Evans et al., 2007; Kariyanna et al., 2017). Under disturbed conditions, some cerambycids can cause serious damage to tree species of commercial value or, in some cases, attack living plants of ornamental or horticultural value (Rice et al., 2020).

According to our literature review, this is the first record of *A. quadrigibbus* and *T. undatus* damaging trees of the Rutaceae family and as potential insect pests of the Persian lime crops. Previously, *A. quadrigibbus* was recorded affecting soursop trees infested with the phytopathogenic fungus *Lasiodiplodia* sp. in orchards of Compostela Nayarit, Mexico (Hernández-Fuentes et al., 2016, 2018). The effects observed in this work coincide with those reported in soursop, since *A. quadrigibbus* and *T. undatus* were found affecting live trees and in the case of previously diseased trees, the damage was more aggressive. It is possible that the weakening of Persian lime trees caused by vascular pathogens, or by nutritional deficiencies, is related to the aggressiveness of the damage caused by the larvae of *A. quadrigibbus* and *T. undatus*, as occurs with other species of cerambycids in several trees (Ramos-Robles et al., 2020). The study to determine the interactions between trees with dieback symptoms and the incidence of xylophagous larvae in the region is in progress.

The cerambycids *A. quadrigibbus* and *T. undatus* were identified as species causing damage to Persian lime trees. The damage caused reduces the development of the plants and is devastating for some trees. Since Martínez de la Torre, Veracruz is the most important Persian lime production area in Mexico, it is necessary to carry out more basic and applied studies on the distribution, level of damage and management strategies in the field, to prevent the affectations caused by borer insects from significantly increasing.

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