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Emergent and possible invasive pest species of weevils in Mexico

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Abstract

Mexico is a center of New World crop origins with many insect species associated with the wild crop relatives, some of which have become pests of cultivated plants. Many of these indigenous pests of Mexico are weevils (Coleoptera: Curculionidae), and some represent potential quarantine pests. In the present work, we present some of the most important species of weevils considered as crop pests, which are presently restricted primarily to Mexico with the potential to invade other regions. We also present species of weevils exotic to Mexico, considered by national quarantine authorities to be possible threats to Mexican agriculture. Potential quarantine weevil pests for avocado include *Conotrachelus aguacatae* Barber, *Conotrachelus perseae* Barber, *Heilipus lauri* Boheman, *Heilipus albopictus* Champion, and *Copturus aguacatae* Kissinger (all Coleoptera: Curculionidae). For guava, species include *Conotrachelus dimidiatus* Champion and *Conotrachelus copalensis* Salas-Araiza and Romero-Nápoles (both Coleoptera: Curculionidae). Weevil pests reported with quarantine importance for sugar cane are *Sphenophorus incurrens* Gyllenhal (Coleoptera: Dryophthoridae), *Apinocis angustus* (Casey), and *Apinocis subnudus* (Buchanan) (both Coleoptera: Curculionidae). The weevil *Rhyssomatus nigerrimus* Fåhraeus (Coleoptera: Dryophthoridae) recently has been observed damaging soybeans in northern and southern Mexico. *Cactophagus spinolae* Gyllenhal (Coleoptera: Dryophthoridae) is a generalist cactus pest. *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae) is a well-known pest of cultivated and wild agaves. Several species of *Epicaerus* (Coleoptera: Curculionidae) have been reported on various crops in restricted areas including, among others, *Epicaerus operculatus* (Say) on garlic, and *Epicaerus cognatus* Sharp (both Coleoptera: Curculionidae) on potato. *Amphidees latifrons* (Sharp) (Coleoptera: Curculionidae) has been reported from apples in localized regions of northern Coahuila. Weevils exotic to Mexico of quarantine concern are *Naupactus cervinus* Boheman, *Diaprepes abbreviatus* (L.) (both Coleoptera: Curculionidae), and *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Dryophthoridae).

Key Words: Coleoptera; crops; tropical fruits; quarantine

Resumen

México es un centro origen de cultivos del Nuevo Mundo, con muchas especies de insectos asociadas con plantas silvestres, parientes de los cultivos. Algunos insectos se han convertidos en plagas de las plantas cultivadas. Muchas de estos insectos son picudos o gorgojos (Coleoptera: Curculionidae) nativas de México y varias son plagas cuarentenarias potenciales. En el presente trabajo, presentamos algunas de las especies de picudos más importantes que se consideran plagas de algunos cultivos que actualmente están restringidas principalmente a México y con potencial a invadir otras regiones. También, presentamos algunas de las especies de picudos exóticos a México que se consideran más importantes como plagas potenciales a la agricultura mexicana por las autoridades nacionales. Los picudos como plagas cuarentenarias potenciales del aguacate incluyen *Conotrachelus aguacatae* Barber, *Conotrachelus perseae* Barber, *Heilipus lauri* Boheman, *Heilipus albopictus* Champion, and *Copturus aguacatae* Kissinger (todo Coleoptera: Curculionidae). Para guayaba, las especies son *Conotrachelus dimidiatus* Champion and *Conotrachelus copalensis* Salas-Araiza and Romero-Nápoles (ambos Coleoptera: Curculionidae). Los picudos reportados como plagas de importancia cuarentenaria para caña de azúcar son *Sphenophorus incurrens* Gyllenhal (Coleoptera: Dryophthoridae), *Apinocis angustus* (Casey), and *Apinocis subnudus* (Buchanan) (ambos Coleoptera: Curculionidae). El picudo *Rhyssomatus nigerrimus* Fåhraeus (Coleoptera: Dryophthoridae) recientemente ha sido observado dañando soya en el norte y sur de México. *Cactophagus spinolae* Gyllenhal (Coleoptera: Dryophthoridae) es una plaga generalista de cactus. *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae) es una plaga bien reconocida de agaves, ambas cultivadas, y silvestres. Varias especies de *Epicaerus* (Coleoptera: Curculionidae) ha sido reportadas en varios cultivos en lugares restringidos incluyendo a *Epicaerus operculatus* (Say) sobre ajo y *Epicaerus cognatus* Sharp (ambos Coleoptera: Curculionidae) sobre papa. *Amphidees latifrons* (Sharp) (Coleoptera: Curculionidae) ha sido reportado en manzanas en zonas localizadas en el norte de Coahuila. Picudos exóticos a México de preocupación en términos cuarentenarios son *Naupactus cervinus* (Boheman), *Diaprepes abbreviatus* (L.) (ambos Coleoptera: Curculionidae), y *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Dryophthoridae).

Palabras Claves: Coleoptera; cuarentena; cultivos; frutos tropicales

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Mexico, together with northern Central America, is considered one of the 8 centers of crop origins of the world (Harlan 1971). Many insect species were undoubtedly associated with the ancestors of these crops or their close relatives in this region, and now have adapted to and become important pests of these domesticated and widely cultivated species. Some of these indigenous species already have invaded, and become important pests of crops in regions beyond the borders of Mesoamerica. One of the most famous of these is the cotton boll weevil which appeared in southern Texas in the late 19th century, and subsequently invaded cotton growing regions of the southern US and later South America (Burke et al. 1986). However, there are many indigenous insect pests that still remain confined to Mesoamerica, and are found on wild and cultivated hosts in the region.

Of the indigenous pests of Mexico, many are weevils (Coleoptera: Curculionidae). Weevils are of particular importance for quarantine for several reasons. First, many weevils have high specificity to cultivars, the apparent result of evolution over extended periods on ancestral species of cultivars or their close relatives (Burke et al. 1986; Patrock & Schuster 1992; Alvarado et al. 2017). Second, many weevil pests feed directly on the harvested product of crops, such as fruits and seeds. Finally, weevils often are difficult to detect and control due to endophytic feeding of the larvae (Anderson 1995; Thomas et al. 1995; Augustin et al. 2012).

Several weevil species have gained notice recently in agricultural sectors of Mexico for the damage they have caused and their abundance in various crops and, therefore, represent possible invasive pests for other regions of the world (Pérez-De la O et al. 2014a, b; Ruiz-Montiel et al. 2015). These species represent possible emergent pests, some of which have been reported only recently as pests, whereas others previously have been considered occasional pests that now have become more damaging in recent years.

In the present work (Figs. 1–18), we provide information on some of the most important weevils considered to be crop pests in Mexico. They are presently restricted primarily to the country, but have the potential to invade other regions. The weevils represent 2 types of potential invaders. The first are the indigenous pests of crops that are relatively well-known to Mexican entomologists, but have yet to extend their range beyond national borders. The second are weevil species that were considered previously as non-pests or minor pests, but that have emerged recently as principal crop pests in some regions in Mexico or Central America. Although some of these species are present outside of Mexico, they may represent distinct biotypes that have arisen within Mexico with the potential to become principal pests in other regions. Finally, we also present other species of weevils exotic to Mexico, presently considered by national quarantine authorities as potential threats to Mexican agriculture.

The information presented here is from a review of the existing literature, and from reports and information received from growers and government agencies seeking identification and management recommendations. Specimens were sent either directly to one of the authors for identification, or relayed from other entomologists. Biological and distributional data also were gathered in the field in affected areas.

WEEVIL PESTS OF AVOCADO

Conotrachelus perseae Barber (Coleoptera: Curculionidae) (Fig. 1) is very similar to *Conotrachelus aguacatae* Barber (Coleoptera: Coleoptera) in morphology and the characteristics of crop damage, but it has a greater distribution that extends from Mexico into northern Central America and Costa Rica. In Mexico, it is reported from the states of Puebla, Oaxaca, Veracruz, Guanajuato, Hidalgo, Michoacán, Puebla, Chiapas, and the state of Mexico (Castañeda-Vildózola et al. 2015; Vázquez et al. 2015). Despite this wide distribution and its importance as a primary pest of avocado, internal Mexican quarantine regulations have prevented this weevil from entering the principal commercial production areas of avocado in the center of the country. Morphological characters to distinguish *C. perseae* and *C. aguacatae* are given in Bautista-Martínez (2006).

Conotrachelus aguacatae (Fig. 2), the Mexican avocado seed borer or small seed weevil, is endemic to Mexico and Guatemala, and is a fruit pest of avocado. The female penetrates the mesocarp tissues with her rostrum and places the egg near the seed. The emerging larva feeds on the mesocarp and can move into the seed, causing direct damage and loss of avocado fruit (Coria-Ávalos 1999). This species is not in the principal regions of avocado cultivation in Michoacán (Bautista-Martínez 2006).

Heilipus lauri Boheman (Coleoptera: Curculionidae) (Fig. 5), the avocado seed weevil or large seed weevil, is found in Mexico (Veracruz, Guerrero, Hidalgo, Morelos, and the state of Mexico), Central America, and Colombia (O'Brien & Wibmer 1982; Wibmer & O'Brien 1986). Damage is similar to that of *C. perseae* and *C. aguacatae*, although due to the larger size, the degree of damage by a single larva is greater. Eggs are placed in mesocarp near the seed, and upon eclosion, the larvae move into the seed to feed (Castañeda-Vildózola 2008). Evidence of the infestation of larvae is given by the presence of white exudates around the oviposition hole. The time from oviposition to emergence was a mean of 74.7 d at 26 °C in the laboratory (Castañeda-Vildózola 2008). This species is not in the principal regions of avocado cultivation in Michoacán (Bautista-Martinez 2006).

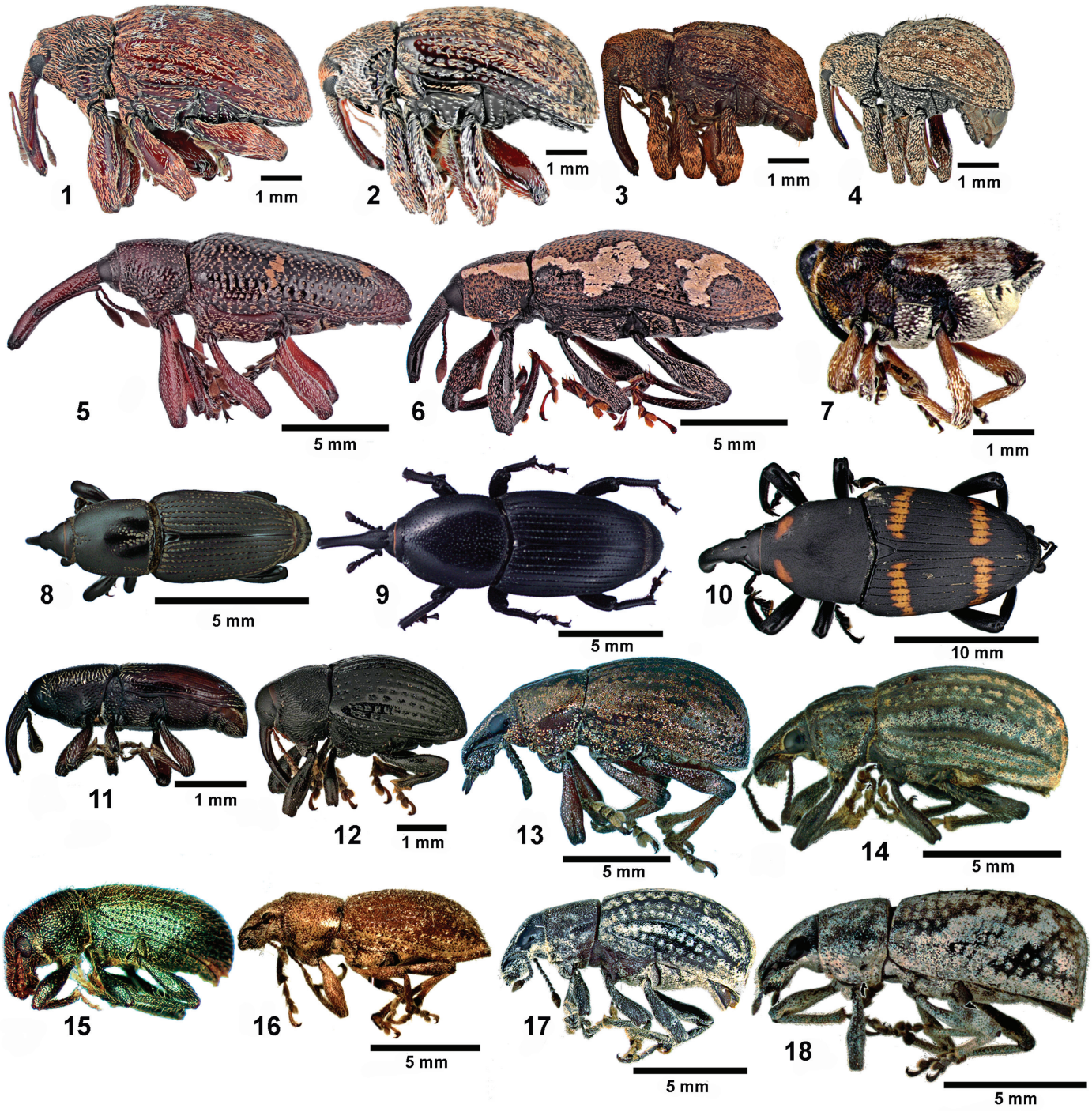
Heilipus albopictus (Champion) (Curculionidae: Molytinae) (Fig. 6) bore into the stems and trunks of avocado trees as larvae, and occasionally damage fruit. It has been reported in Hidalgo, Morelos, the state of Mexico (Morrone 2003; Castañeda-Vildózola et al. 2010; López-Martínez et al. 2015), and Nayarit (Soto-Hernández et al. 2013). The importance of the damage from larval feeding of this species is not well established, although there are reports that the damage can cause the death of avocado trees (Muñiz-Vélez et al. 2015).

Copturus aguacatae Kissinger (Coleoptera: Curculionidae) (Fig. 7), the avocado twig borer or avocado branch weevil, is a species endemic to Mexico. Females oviposit in the young buds and shoots of avocado trees, and larvae bore in small stems, larger branches, and the trunk (Muñiz 1959; Coria-Avalos 1999). In the state of Michoacán, the weevil infestations are greatest at around 1,200 masl where infestation rates can reach 100% of trees, and these rates decrease with altitude (Coria-Avalos et al. 2007). The life cycle is relatively long, with time from oviposition to sexual maturity of adults in the field calculated at a mean of 285 d (Talavera & Padilla 2003).

WEEVIL PESTS OF GUAVA

Conotrachelus dimidiatus Champion (Coleoptera: Curculionidae) (Fig. 3) is one of the principal pests of guava in Mexico. The species is found also in Honduras and Guatemala (O'Brien & Wibmer 1982). Guava fruits are damaged when females oviposit into the mesocarp and larvae penetrate the interior of the fruit, blackening the mesocarp and seeds, and causing fermentation and fruit yellowing (Aragón et al. 2015). The main damage occurs in the upper and inside zone of infested trees (Tafoya et al. 2010). When fruit is absent, adults often feed on terminal buds and affect terminal growth (personal observation).

Conotrachelus copalensis Salas and Romero (Coleoptera: Curculionidae) (Fig. 4) was described in 2012, and has been reported only for the central Mexican states of Guanajuato and Aguascalientes (Salas-Araiza & Romero-Nápoles 2012). Its biology is similar to *C. dimitiatus*. The females of *C. copalensis* oviposit in the mesocarp, and the larvae



Figs. 1-18. (1) *Conotrachelus perseae* Barber; (2) *Conotrachelus aguacatae* Barber; (3) *Conotrachelus dimidiatus* Champion; (4) *Conotrachelus copalensis* Salas and Romero; (5) *Heilipus lauri* (Boheman); (6) *Heilipus albopictus* (Champion); (7) *Copturus aguacatae* Kissinger; (8) *Sphenophorus incurrens* Gyllenhal; (9) *Scyphophorus acupunctatus* Gyllenhal; (10) *Cactophagus spinolae* (Gyllenhal); (11) *Apinocis subnudus* (Buchanan); (12) *Rhyssomatus nigerrimus* (Fåhraeus); (13) *Epicaerus operculatus* (Say); (14) *Epicaerus cognatus* Sharp; (15) *Amphidees latifrons* (Sharp); (16) *Naupactus cervinus* (Boheman); (17) *Epicaerus aurifer* Boheman; (18) *Epicaerus mexicanus* Boheman.

feed in the interior of the fruit. Up to 70% of the fruit of a tree can be infested with this weevil in Guanajuato (Salas-Araiza & Romero-Nápoles 2012).

WEEVIL PESTS OF SUGAR CANE

Sphenophorus incurrens Gyllenhal (Coleoptera: Dryophthoridae) (Fig. 8) is a recognized pest of sugar cane in Mexico and Central America, and its importance has increased in recent years in the state of Morelos (Pérez-De la O et al. 2014a) and Veracruz (Ruiz-Montiel et al. 2015; Domínguez-Monge et al. 2017). Principal damage is by the larvae which feed on and in stems, rhizomes, and roots (Ruiz-Montiel et al. 2015). It is unknown if the increased importance of this species as a pest of sugar cane in Mexico is due to genetic changes in populations or host shifts spurred by climate change, but the present situation increases the possibility of invasion by this species into uninfested areas.

Apinocis subnudus (Buchanan) (Coleoptera: Curculionidae) (Fig. 11) and *Apinocis angustus* (Casey) (Coleoptera: Curculionidae) have been considered as possible emergent pests in Mexico. Although smaller than *S. incurrens*, the site of damage is similar, and larvae feed in stems, shoots, and roots. Growers in some areas now consider this pest more important than the better-known pyralid and crambid (Lepidoptera) stalk borers (Pérez-De la O et al. 2014b). *Apinocis angustus* (Casey) is reported from the state of Morelos (Pérez-De la O et al. 2014b) and *A. subnudus* (Buchanan) has been identified from Veracruz (Ruiz-Montiel et al. 2015). However, characters defining species limits of *Apinocis* are poorly defined, and the situation is further complicated by the possibility that some species may represent recent introductions from South America (J. Prena, personal communication). Further studies of the genus, including molecular analysis, are needed to better identify species, their geographic distributions in Mexico, and to determine origins.

A NEW WEEVIL PEST OF SOYBEAN

Rhyssomatus nigerrimus (Fåhraeus) (Coleoptera: Curculionidae) (Fig. 12), first described in 1837, was reported from Mexico, Panama, Lesser Antilles, Honduras, Guatemala, and Belize by Champion (1903). The species is listed from the state of Guanajuato by Salas-Araiza et al. (2001), where it was reported to be associated with various plant species. This widespread weevil was first reported feeding on soybeans in Mexico by López-Guillén et al. (2012) from 2 widely separated localities: (1) southeastern Tamaulipas, near Tampico, and (2) in southeastern Chiapas, near Tapachula. Damage was considerable at both sites, and up to 48% of the soybean pods were lost. The adult feeds on both the vegetative and reproductive parts.

WEEVIL PESTS OF CACTACEAE AND ASPARAGACEAE

Cactophagus spinolae (Gyllenhal) (Coleoptera: Dryophthoridae) (Fig. 10), is a well-known weevil pest of Mexico, and is widely distributed across the country where it feeds on commercial and native Cactaceae and Asparagaceae. The species is considered the principal pest of prickly pear, *Opuntia* spp. (Cactaceae), in Central Mexico, and has a large number of reported hosts in the Transmexican Volcanic Belt (López-Martínez et al. 2016). The weevil was introduced as a natural enemy of *Opuntia* spp. in Africa (Sellers 1952).

The agave weevil, *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae) (Fig. 9), is a serious pest of cultivated and wild agaves (Asparagaceae) (Figueroa-Castro et al. 2016), and of the ornamental *Polianthes tuberosa* L. (Asparagaceae) (López-Martínez et al. 2011). The damage caused by this pest can severely affect yield and quality of agaves, particularly the tequila agave, *Agave tequilana* Weber (Asparagaceae) (Solís-Aguilar et al. 2001), as well as increasing pesticide applications on ornamental *P. tuberosa* (personal observation). This species has expanded its natural distribution within the US, and into South America and Europe (Molina 2013).

ENTIMINE WEEVIL PESTS OF VARIOUS CROPS

Several species of *Epicaerus* (Coleoptera: Curculionidae), endemic to Mexico, recently have gained notice in agricultural sectors of Mexico for causing crop damage. *Epicaerus operculatus* (Say) recently has been reported as a pest of garlic (Amaryllidaceae) in the region of Tepeaca in the state of Puebla, where larvae were found feeding on the bulbs and rhizomes at plant infestation rates greater than 50% (Vicencio et al. 2017). We found no reports of this weevil as a pest of garlic in other production regions of the country. The Mexican endemic, *Epicaerus cognatus* Sharp (Fig. 14), is a pest of potato in Hidalgo, Puebla, Tlaxcala, and Veracruz (Muñiz-Vélez 2001; Bautista-Martínez 2006). Several other species of *Epicaerus* are localized alfalfa (Fabaceae) pests including, *Epicaerus curvipes* (Sharp), *Epicaerus vilis* Sharp, and *Epicaerus aurifer* Boheman (Fig. 17) (Muñiz-Vélez 2001). This latter species, along with *Epicaerus bicolor* Sharp and *Epicaerus mexicanus* Boheman (all Coleoptera: Curculionidae) (Fig. 18), are reported as pests of sugar cane (Muñiz-Vélez et al. 2015), and *E. mexicanus* is reported as a pest of citrus, and is found in Mexico and the Rio Grande Valley of Texas (O'Brien & Wibmer 1982; Woodruff 1985; French & Skaria 2001).

Amphidees latifrons (Sharp) (Coleoptera: Curculionidae) (Fig. 15) is another species of the subfamily Entiminae that has an interesting and markedly localized association with cultivated apples. This species has been reported from the Sierra de Arteaga, in Coahuila by Guerrero et al. (2004). This species feeds on leaves, apple buds, and fruits as adults, and on secondary roots of apple trees as larvae. The species is parthenogenic and apterous. Within its localized distribution, the weevil is a principal pest and can damage up to 70% of the apple blossoms (Guerrero et al. 2004).

EXOTIC WEEVILS OF QUARANTINE CONCERN FOR MEXICO

The weevils of foremost concern for the Mexican Quarantine Agency, the National Service of Health, Safety and Quality of Agricultural Food Products (SENASICA: Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria) are the fuller rose weevil, *Naupactus cervinus* Boheman (Coleoptera: Curculionidae) (Fig. 16), the diaprepes root weevil, *Diaprepes abbreviatus* (L.) (Coleoptera: Curculionidae), and the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Dryophthoridae). The fuller rose weevil is present in Mexico and of concern because of possible quarantine restrictions of exports of citrus to countries in Asia. The diaprepes root weevil does not occur in Mexico, but is of concern for the citrus industry, given its impact on this crop in countries with similar tropical climates. The species would be expected to have little trouble colonizing the citrus producing regions of Mexico. The red palm weevil, eradicated in California in 2015 after an unfortunate introduction in 2010, remains of high concern to quarantine officials due to the high potential of the species to damage palm trees.

Discussion

There are several factors to consider in evaluating the risk of the weevil pests presented here as possible quarantine invaders to other regions. Concerning the well-known indigenous pests of avocado and guava (*Conotrachelus* spp., *Helipus* spp., and *C. aguacatae*), the cultivated acreage of the host of these weevils, especially avocado, has expanded greatly in the past 10 yr due to the high value and demand of the crop (Peterson & Orden 2008; Barsimantov & Antezana 2012). Changes in land tenure laws in Mexico have facilitated the conversion of forest to tropical fruit production, resulting in land degradation and forest fragmentation (Bravo-Espinosa et al. 2014). The increased area of cultivation of these native fruits makes the detection of pests more problematic, and also increases the chance of contact of cultivated plants with indigenous populations of the weevils on their uncultivated (wild) hosts. This situation requires the continued monitoring for pests in production areas and sustaining the internal quarantine measures between infested and non-infested areas.

Among the several factors that may have promoted new host shifts and adaptation of weevils to cultivated hosts in Mexico, habitat loss and climate change are certainly possible culprits. Mexico was considered among the top 10 countries with the largest annual net loss of

forest area from 1990 to 2010 (FAO 2010). Loss of natural vegetation may force weevils, such as the polyphagous species of Entiminae and *Rhyssomatus nigerrimus* mentioned above, to disperse and adapt to other habitats and host plants, including cultivated crops. Combined with habitat loss, climate change can further promote this process. In many regions of Mexico, the principal effects of climate change are predicted to be variations in patterns of precipitation (Cambrón-Sandoval et al. 2014; Herrera-Pantoja & Hiscock 2015; Molina-Navarro et al. 2016). This variation will be most evident in its effect on the highly seasonal rain patterns of much of Mexico, and consequently will affect the phenology and appearance of established host plants, further promoting dispersal and host switching of weevils.

Clearly, monitoring of the species of weevils mentioned herein, as well as detection of possible new weevil pests, is critical in the prevention of Mexican weevils becoming exotic species in other regions. Monitoring may be greatly aided by use of pheromone trapping, such as has been used for the agave weevil (Figueroa-Castro et al. 2016), and development of new trapping methodologies for other weevil species are needed. Habitat niche modeling analyses (López-Martínez et al. 2016) can be used to indicate areas of probable infestations and suggest the most probable routes of dispersion.

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