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Article

Bark beetle (Curculionidae: Scolytinae) record in the *La Primavera* Forest, *Jalisco* State

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Abstract:
The first registers of *Scolytinae* were obtained for the *La Primavera* Forest, *Jalisco* (a protected natural area), with 11 species and six genera, as well as their altitudinal distribution. The insects were captured by means of two Lindgren traps with ten funnels each (baited with *Dendroctonus ponderosa* and *Ips typographus* pheromones), installed on pine-oak vegetation, and three traps with the shape of a metal funnel (baited with 70 % ethyl alcohol and antifreeze on the outside, and thinner on the inside); of the latter, two were placed on pine and oak vegetation, and the third, in an acacia association. The five traps were distributed within an altitude range of 1 380 to 1 580 masl. The group that most abounded in bark beetle species included *Xyleborus affinis*, *X. ferruginueus*, *X. volvulus* and *Gnathotrichus perniciosus*. Three new species —*Hylurgops subcostulatus alternans*, *Premnobius cavipenni* and *Xyleborus horridus*— were collected and registered in the state of *Jalisco*, and two more —*Ips calligraphus* and *I. cribicollis*—, at a local level. The traps and baits elicited a good response and proved to be efficient for capturing bark beetle insects.

Keywords: Ethyl alcohol, altitudinal distribution, pheromones, Scolytinae, metal funnel trap, Lindgren traps.

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Introduction

The Insects of the Scolytinae subfamily are known as bark beetles and ambrosia beetles —names that refer to their diverse food habits (Atkinson and Equihua, 1986; Burgos-Solorio and Equihua, 2007; Raffa *et al*., 2015). The group exhibits the ability to destroy trees, having a wide variety of hosts and a unique system of galleries as a result of a long, complex evolution (Wood, 1982). In addition to trees, they affect shrubs and herbs (Burgos-Solorio, and Equihua, 2007); the damages may amount to total or partial death (Atkinson and Equihua, 1986). These insects establish themselves for two basic purposes: nutritional and reproductive (Burgos-Solorio and Equihua, 2007).

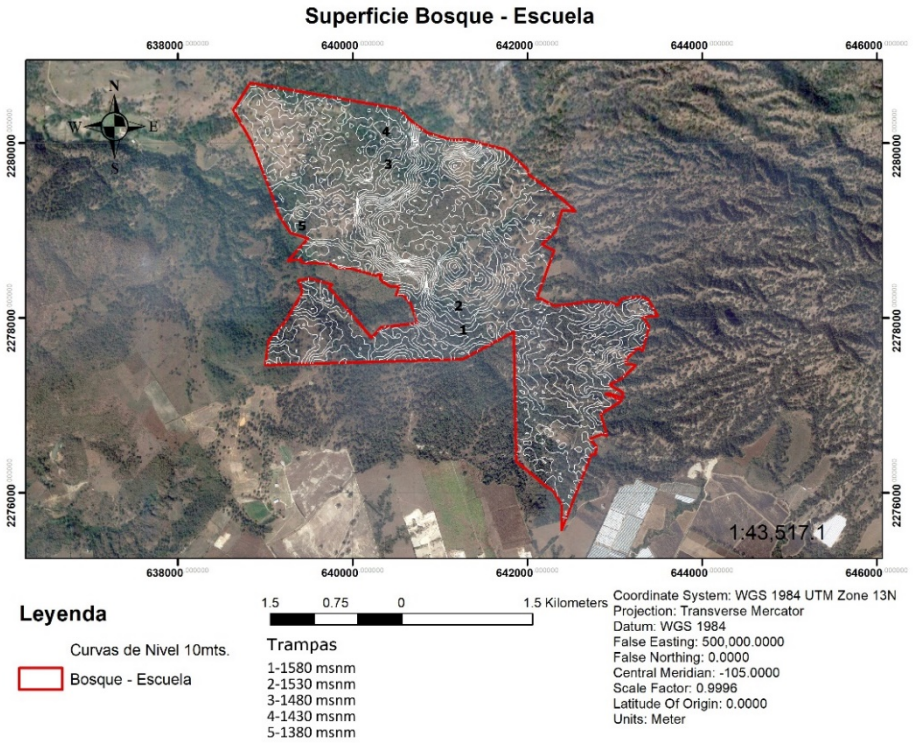
827 species of *Scolytinae* are cited in Mexico (Romero *et al*., 1997). According to Burgos-Solorio and Equihua (2007), the states with the largest number of taxa are *Oaxaca*, *Veracruz* and *Jalisco*. Based on the collected information, *Jalisco* has 85 species of the *Scolytinae* subfamily (Wood, 1982; Atkinson and Equihua, 1986; Burgos-Solorio and Equihua, 2007; Díaz-Ramos *et al*., 2016).

Some taxa are important pests that have been introduced from Asia to the east of North America; their genera include *Ambrosiodmus*, *Xylosandrus* and *Xyleborus* (Atkinson *et al.*, 1990). In Mexico, they are associated to both temperate pine forests and cocoa crops (Pérez *et al*., 2011; Atkinson, 2017), mangroves (Geronimo-Torres *et al.*, 2015) and avocados (Castrejon-Antonio *et al.*, 2017). Semiochemicals are currently available for the purposes of monitoring the distribution and gaining knowledge of various groups of bark beetles (Díaz *et al.*, 2006; Domínguez-Sánchez *et al*., 2008; Rodríguez-Ortega *et al*., 2010; Díaz-Ramos *et al*., 2016).

In spite of the studies carried out in the state of *Jalisco*, there is still a need to have entomological inventories and to know the importance of Scolytinae. Therefore, the aim of this study was to carry out the first entomological study within the natural protected area of the *La Primavera* Forest, *Jalisco*, at a different altitude gradient.

Materials and Methods

The work was carried out in the natural wildlife protected area known as *La Primavera* Forest, with a total surface area of 36 000 ha (Semarnat, 2000). The *Campo Experimental Bosque Escuela* (CEBE) (Forest-School Experimental Station) of the *Universidad de Guadalajara* (University of Guadalajara) is located to its southwest, in the municipality of *Tala*, at the coordinates 20°58'02.27'' N and 103°63'49.77'' W (Figure 1); it comprises five types of vegetation: pine forest, oak forest, secondary vegetation (*Acacias*), grassland and aquatic-subaquatic vegetation; its altitudinal range is 1 400 to 2 270 m, with a (A)Ca(w_o)(w)e climate and an average annual temperature of 16.3 °C (Ruiz *et al.*, 2012).



Leyenda = Key; *Curvas de nivel* = Level curves; *Trampas* = Traps; *Superfice* = Area

Figure 1. Experimental Field Forest-School, Sierra La Primavera.

The five traps were installed from January of 1989 to February of 1990; they were placed in five sites, each at a different altitude between 1 380 and 1 580 masl, every 50 m (Table 1), with the support of the topographic chart F14-D-65 1:50 000, corresponding to *Tala, Jalisco*, and a compass manufactured by Brunton Inc.

Table 1. Location of the traps according to their altitude gradient.

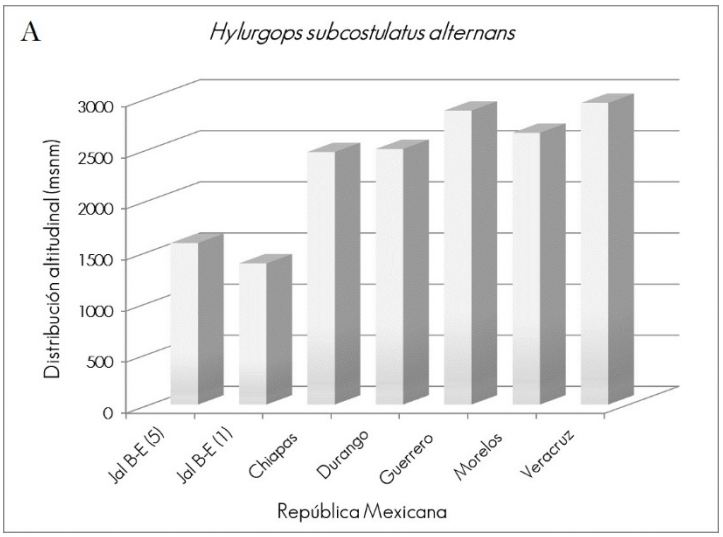
Site	Altitude	Type of trap	Type of vegetation
1	1 580	Pheromones	Pine-Oak
2	1 530	Pheromones	Pine-Oak
3	1 480	Funnel	Holm oak
4	1 430	Funnel	Pine
5	1 380	Funnel	Subtropical (*Acacia*)

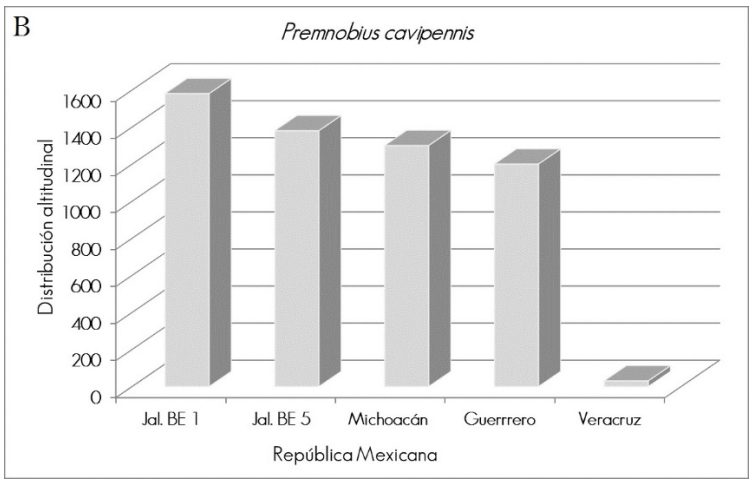
The first two were Lindgren™ traps with 10 funnels; one was baited with aggregation pheromone for *Dendroctonus ponderosae* Hopkins, 1902 (myrcene, trans-verbenol, exo-brevicomin, Phero Tech), replaced on a monthly basis; pheromones for *Ips typographus* (Linnaeus, 1758) (cis-verbenol, 2m-butyl-2-ol, *Pheroprax*) (pheromones donated by the *Universidad Autónoma Chapingo* (Autonomous University of *Chapingo*) were used at site two and replaced every three months. The collecting flask of both Lindgren™ traps contained 70 % alcohol, mixed with a bit of antifreeze to reduce evaporation. Funnel traps made of aluminum were used for the other three sites; each trap had a galvanized hexagonal mesh base inside, where an amber bottle with 200 mL of thinner was placed as an attractant for the beetles, and the cover had a hole through which a cotton wick was introduced to release of the product. The captured insects fell into a bottle with 70 % alcohol and antifreeze. The collection was made on a monthly basis, and the material was carried to the forestry laboratory of the *Departamento de Madera Celulosa y Papel*, *Universidad de Guadalajara* (Department of Wood Pulp and Paper of the University of *Guadalajara*) for cleaning, assembly and separation by morphospecies; the taxonomic keys developed by Wood (1982) were used to identify them.

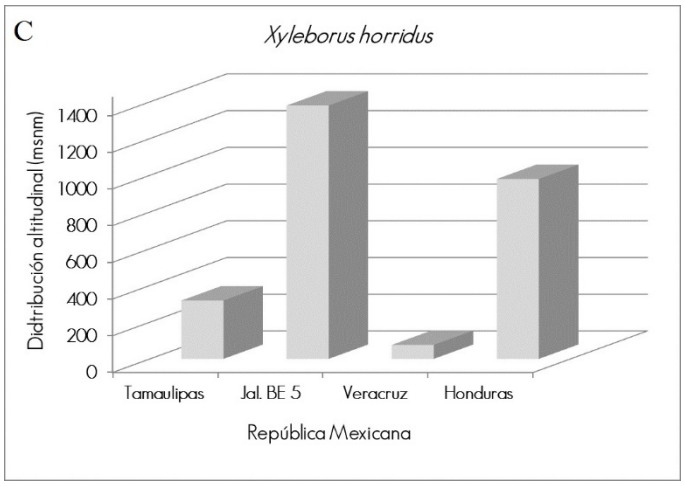
Results and Discussion

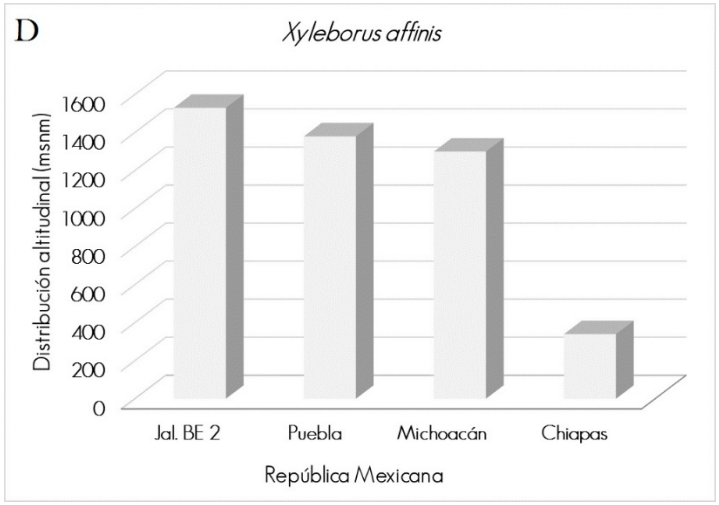
Out of the material collected from 1989 to 1990, 11 species were identified; from these, three were new to the state and to the altitude where they were collected: *Hylurgops subcostulatus alternans* (Chapuis, 1869)*; Premnobius cavipennis* Eichhoff and *Xyleborus horridus* Eichhoff; new to their altitude gradients were: *X. affinis* Eichhoff*; X. ferrugineus* (F. 1801)*; X volvulus* (F. 1775) and *Gnathotrichus perniciuosus* Wood*, and* new to the region: *Ips calligraphus* (Germar) and *I. cibricollis* (Eichhoff). Two species already registered in *Jalisco* were *Pityophthorus cacuminatus* Blandford and *P. confusus* Blandford.

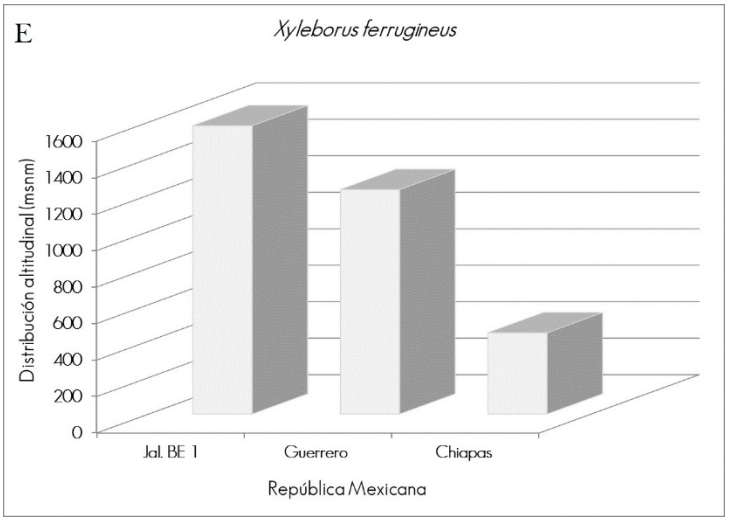
Hylurgops subcostulatus alternans was captured at 1 580 and 1 380 masl (Figure 2A) and found to be new to this altitude range and to this state; it is widely distributed from Canada to Guatemala (Atkinson, 2018; Atkinson *et al.*, 1985; Atkinson *et al.*, 1986a), and has been registered in *Durango* at an altitude of 2 500 m; in *Veracruz*, at 2 950 m; in *Chiapas*, at 2 470 m, and in *Morelos*, at 1 900 and 2 870 m. Romero *et al.* (1997) mention that this species is distributed within an altitude range of 1 600 to 3 800 masl, without specifying a location. In *Tala, Jalisco*, it is distributed at a lower altitude range than previously reported for Mexico. *Hylurgops subcostulatus alternans* is associated with coniferous forest; it can be found in the bark of felled pine trees in which a fermentation process is present (Atkinson *et al.*, 1986a).

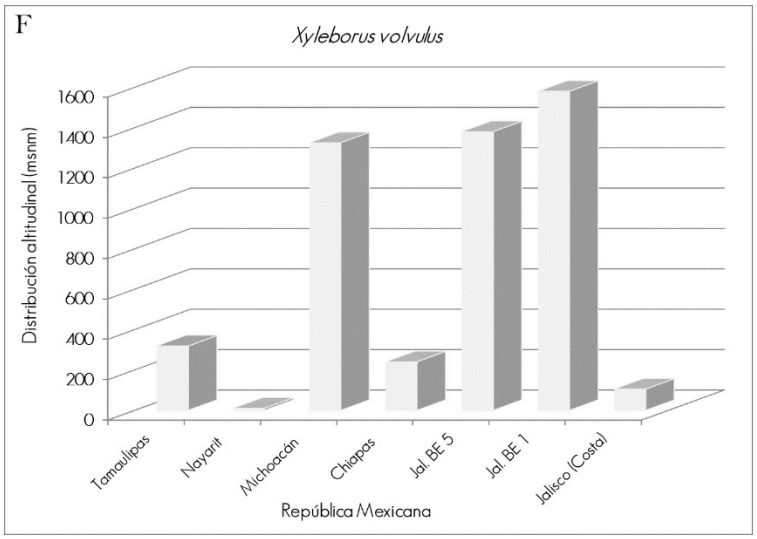

A
Hylurgops subcostulatus alternans
Distribución altitudinal (msnm)
3000
2500
2000
1500
1000
500
0
Jal B-E (5)
Jal B-E (1)
Chiapas
Durango
Guerrero
Morelos
Veracruz
República Mexicana


B
Premnobius cavipennis
Distribución altitudinal
1600
1400
1200
1000
800
600
400
200
0
Jal. BE 1
Jal. BE 5
Michoacán
Guerrrero
Veracruz
República Mexicana


C
Xyleborus horridus
Didtribución altitudinal (msnm)
1400
1200
1000
800
600
400
200
0
Tamaulipas
Jal. BE 5
Veracruz
Honduras
República Mexicana


D
Xyleborus affinis
Distribución altitudinal (msnm)
1600
1400
1200
1000
800
600
400
200
0
Jal. BE 2
Puebla
Michoacán
Chiapas
República Mexicana


E
Xyleborus ferrugineus
Distribución altitudinal (msnm)
1600
1400
1200
1000
800
600
400
200
0
Jal. BE 1
Guerrero
Chiapas
República Mexicana



Distribución altitudinal = Altitudinal distribution

Figure 2. Altitudinal distribution of species of the Scolytinae genera registered in the *Campo Experimental Bosque Escuela (CEBE)*.

The second species that was new to the state and to the altitude range was *Premnobius cavipennis* (Figure 2B), captured at an altitude of 1 580 to 1 380 m (Figure 2B). It thrives in Africa, South America (introduced), North America (introduced), the Antilles, *Costa Rica*, *Honduras*, the United States of America (Florida) and Mexico (Rabaglia *et al.*, 2006). In *Michoacán*, is has been located at 1 200 masl, (Atkinson and Equihua, 1985); in *Veracruz*, at 30 masl. (Wood, 1982); Romero *et al*. (1997) cite its presence at 60 to 1 600 m, based on reviews of entomological collections. It is a species associated with the tropical forest (Pérez-De la Cruz *et al.*, 2009).

The third species newly registered in this state and within this altitude range was *Xyleborus horridus*, found at 1 580 masl (Figure 2-C). It is distributed in *Tabasco, Veracruz* and *Tamaulipas* (Wood, 1982; Atkinson and Equihua 1985; Pérez *et al.*, 2015), and there are registers of its presence in the states of *Chiapas, Guerrero* and *San Luis Potosí*. In regard to its altitudinal distribution, these authors do not mention any of the locations cited above.

Xyleborus affinis was captured at 1 530 masl and first registered at this altitude (Figure 2D). (Figure 2D). It is distributed in the United States of America (Hawaii), *Argentina*, tropical Africa and almost all of Mexico (Burgos-Solorio and Equihua, 2007); in *Michoacán*, at 1 300 masl; in *Puebla*, at 1 380 masl, and in *Chiapas*, between 60 and 250 masl. (Atkinson and Equihua, 1985).

Another species newly registered within this altitude range was *Xyleborus ferrugineus*, at 1 580 masl (Figure 2-E). Wood (1982) cites this taxon as one of the most destructive in tropical areas, found at an altitude of 500 masl and widely distributed in *Jalisco, Chiapas, Guerrero, Nayarit, Oaxaca, Puebla, Quintana Roo, San Luis Potosí, Sinaloa, Sonora* and *Veracruz*, without specifying location or altitudinal distribution. Burgos-Solorio and Equihua (2007) mention its presence in *Chamela*, *Jalisco*, at 100 masl, and Atkinson and Equihua (1985) cite it in *Guerrero*, at 1 230 masl, and in *Chiapas*, between 640 and 250 masl.

The last species to be registered at this altitude was *Xyleborus volvulus*, at 1 580 to 1 380 masl (Figure 2F). In Mexico, it is distributed in *Baja California, Tamaulipas, Chiapas, Guerrero, Estado de México, Morelos, Nayarit, Oaxaca, Puebla, Quinta Roo, San Luis Potosí, Tabasco, Veracruz* and *Yucatán*, without an altitudinal distribution (Wood, 1982; Atkinson and Equihua, 1985). Burgos-Solorio and Equihua (2007) document its presence in *Jalisco*, at 80 and 130 masl; Atkinson and Equihua (1985), in *Michoacán* at 1 300 and 1 350 masl, and in *Chiapas*, at 250, 310 and 160 masl. *Xyleborus* is considered to be aggressive for tropical species, since it can establish itself in healthy or weak trees, in logs and sawmills (Rangel *et al.*, 2012). However, Atkinson (2018) points out individuals of the genus *Pinus* as its hosts. Studies on the biological aspects, hosts and altitudinal distribution of this insect at a national level are required. The present paper documents two new registers for *Jalisco* because, although some species are very destructive to tropical vegetation, they may also cause heavy damage to agricultural crops and forest trees.

Another of the species identified as a new local register was *Ips calligraphus*, which was captured at 1 580 and 1 380 masl and is distributed in the Bahamas, Canada, the United States of America, *Jamaica*, the Dominican Republic, the Philippines, and

Mexico: *Jalisco, Michoacán, Sinaloa, Nuevo León, Chiapas, Hidalgo, Morelos, Oaxaca, Puebla, Estado de México* and *Veracruz* (Wood, 1982; Burgos-Solorio and Equihua, 2007; Cognato, 2015). Atkinson and Equihua (1985), cited its presence in *El Tuito*, *Jalisco*, at 650 masl; in *Michoacán*, at 1 640 masl; in *Guerrero* to 1 900 and 2 040 masl; in *Cuernavaca*, at 1 880 and 1 900 masl; in *Oaxaca*, at 100 to 400 masl, and in *Chiapas*, at 1 000 masl (Atkinson and Equihua, 1988). *I. calligraphus* has a wide distribution in pine forests throughout the country. This species can behave as a primary bark beetle, in healthy standing or weak pine trees, branches and felled logs (Cibrian *et al.*, 2001).

Another local record was *Ips cribricollis*, collected at 1 530 and 1 380 masl. It is found in the Dominican Republic, *Honduras*, New Mexico and southeast of the United States of America. In Mexico, it has been observed in *Chihuahua, Colima, Durango, Estado de México, Morelos, Oaxaca, Querétaro, Veracruz, Chiapas, Hidalgo, Jalisco, Michoacan, Nuevo León* and *Sinaloa* (Wood, 1982; Cognato, 2015). Like *I. calligraphus*, it has a wide distribution in the country. Studies on the *Ips* genus carried out at the national level have not yet provided any information about its hosts or its altitudinal distribution.

Pityophthorus cacuminatus, with previous registers in Jalisco, was captured at 1 530 and 1 380 masl. It is distributed in *Honduras*, *Guatemala*, and the Mexican states of *Jalisco, Michoacán, Guerrero, Morelos* and *Durango* (Wood, 1982). Atkinson *et al.* (1986a) reported its presence in *Hidalgo* (1 860 masl) and *Guerrero* (2 600 masl). Atkinson and Equihua (1988) identified it in *Chiapas* (at 1 300 and 800 masl) and in the state of *Tlaxcala* (2 870 masl). The species has a wide altitudinal distribution and prefers pine forests.

Pityophthorus confusus, also registered before in *Jalisco*, was collected at 1 580 masl. It occurs from Pennsylvania to Texas and Florida, and in Mexico, in *Jalisco, Chiapas, Durango* and *Veracruz* (Wood, 1982; Burgos-Solorio and Equihua, 2007). Atkinson and Equihua (1988), documented its presence in *Guerrero* at 2 000 masl. *Cacuminatus pityophthorus* and *P. confusus* are regarded as secondary bark beetles that affect the twigs of pine trees (Díaz-Ramos *et al.*, 2016).

Finally, *Gnathotrichus perniciosus* was observed at 1 380 masl; its distribution includes Honduras, Nicaragua and Mexican the states of *Jalisco, Chihuahua, Sinaloa, Michoacán, Colima,* Mexico City*, Morelos, Chiapas* and *Guerrero* (Wood, 1982). Atkinson *et al*. (1986) cite its presence in Morelos within a range of 1 580 to 1 900, 2 500 and 2 950 masl. This species is ambrosial and is associated with pine and other hard wood trees (Smith and Hulcr, 2015).

The collected species belonging to the genera *Ips*, *Xyleborus*, *Pityophthorus*, *Hylurgops* and *Premnobius* have preferences for different types of vegetation (Burgos and Equihua, 2007; Atkinson, 2018); in the *La Primavera* Forest, their altitudinal distribution corresponds to the range of 1 380 to 1 580 masl. On the other hand, *Premnobius* is associated to the tropical forest vegetation —which is not present in the *La Primavera* Forest—, and, therefore, its hosts belong to the subtropical forest. The genera with a preference for conifers are *Hylurgops*, *Ips*, *Pityophthorus* and *Gnathotrichus*. *Xyleborus* and *Premnobius* have different hosts (Burgos-Solorio and Equihua, 2007; Pérez-De la Cruz *et al.*, 2009).

Hylurgops subcostulatus alternans was notably captured at a lower altitude range than indicated by Romero *et al.* (1997). Eight insect species were captured in trap five, followed by trap one, which caught specimens of seven taxa; the low incidence of specimens in traps two, three and four can be due to the low densities of Scolytinae insects in the region, compared to those pointed out by Pérez-De la Cruz *et al.* (2009), for which the best attractant was alcohol.

The low captures of insects in the traps may be due to the facts that attractants specifically meant for *Dendrcotonus ponderosae* and *Ips typographus* were utilized and that only one trap was placed in each altitude range. Therefore, it is necessary to intensify the sampling by placing a larger number of traps and to use a wider diversity of attractants for each of the groups of insects.

Conclusions

Six genera with 11 species have been recorded, among which *Hylurgops subcostulatus alternans*, *Premnobius cavipennis* and *Xyleborus horridus* were found for the first time in the state and within the specified altitude interval. *Xyleborus affinis*, *X. ferrugineus*, *X. volvulus* and *Gnathotrichus perniciosus* are new altitudinal registers, and *Ips calligraphus* and *I. cribicollis* are new local registers.

It should be noted that this is the first sampling in *Jalisco* in which semiochemicals have been used for *Dendroctonus ponderosae* (myrcene, trans-verbenol, exo-brevicomin and *Ips typographus* (cis-verbenol, 2m-butyl-2-ol). With regard to the trapping of insects, today a large variety of species-specific pheromones is available.

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Conflict of interest

The authors declare no conflict of interests.

Contribution by author

Antonio Rodríguez-Rivas: field activities, location of sites, establishment and collection of material, preparation of the first draft of the manuscript, results and design of Figure 1; Sara Gabriela Díaz-Ramos: identification of species, support in the abstract, design of Table 1 and Figure 2, discussion and conclusions, as well as the correction of the first draft; Héctor Jesús Contreras-Quiñones: results, discussion, conclusions and correction of the manuscript; Lucia Barrientos-Ramírez and Teófilo Escoto García: collection of material in the field, cleaning and assembly, support in writing of the sections of the manuscript of introduction, materials and methods; Armando Equihua-Martínez: identification of the species, suggestions for the content and review of the manuscript.

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