THE MEXICAN PINE BEETLE, *DENDROCTONUS MEXICANUS:* FIRST RECORD IN THE UNITED STATES AND CO-OCCURRENCE WITH THE SOUTHERN PINE BEETLE - *DENDROCTONUS FRONTALIS* (COLEOPTERA: SCOLYTIDAE OR CURCULIONIDAE: SCOLYTINAE)[1]

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ABSTRACT: The Mexican pine beetle (XPB) *Dendroctonus mexicanus,* is recorded here for the first time as a new introduction for the United States (US). Individuals of XPB and its sibling species, the southern pine beetle (SPB) *Dendroctonus frontalis,* were found infesting the same logs of Chihuahua pine, *Pinus leiophylla* var. *chihuahuana* and those of several other pine species in the Chiricahua Mountains, AZ. Both species were also captured in Lindgren traps baited with southern- and western pine beetle attractants, both of which contained the pheromone frontalin. XPB outnumbered SPB 16:1 in the traps. Both XPB and SPB were trapped during warm periods in winter. It is possible that XPB attack trees during winter as SPB do in the southeastern US. Both XPB and SPB are highly destructive to pines, and XPB could pose a threat if accidentally introduced to pines in the higher elevations of the eastern US.

KEY WORDS: Southern pine beetle, *Dendroctonus frontalis, Dendroctonus mexicanus,* invasive species, bark beetle, Curculionidae, Scolytidae, Scolytinae

Dendroctonus mexicanus Hopkins (Coleoptera: Curculionidae or Scolytidae: Scolytinae), the Mexican pine beetle (XPB), and *D. frontalis* Zimmermann (Coleoptera: Curculionidae or Scolytidae: Scolytinae), the southern pine beetle (SPB), are sibling species so closely related that they are nearly impossible to tell apart by visual examination and/or behavior. Until the discovery that males of the two species could be reliably differentiated by examining their seminal rods (Payne, 1980; Lanier et al., 1988), the two species were separated only with difficulty, presumably by the relative lengths of the setae on their elytral declivities (Cibrian et al., 1995).

The range of the XPB is limited in Mexico from the northern state of Sonora to the southern state of Chiapas (Cibrian et al., 1995). The SPB occurs north of, south of, and within the range of the XPB (Salinas-Moreno et al., 2004) (Fig. 1). Although the XPB normally exists at higher elevations than the SPB (Wood, 1982), the coexistence of these two species in the same tree was noted by Wood (1982) and even in adjacent galleries of the same tree (Zuniga et al., 1995). The biologies of the two species differ only slightly, and they both periodically cause extensive economic damage to pine forests (Cibrian et al., 1995).

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Figure 1. Approximate distribution of *Dendroctonus mexicanus* (XPB, black areas) (from Salinas-Moreno et al. 2004) and *D. frontalis* (gray areas) (from Payne 1980) in the United States and Mexico. Arrow indicates approximate location of new record of the XPB in Chiricahua National Monument, Arizona, U.S.A.

On August 23, 2000, an aerial survey by the U.S. Forest Service discovered approximately seven hectares of damage by bark beetles in Southern Arizona on the Chiricahua National Monument, as well as over 4,700 hectares acres on the Coronado National Forest, and 26 hectares on private land. We document here the dominant species of bark beetles involved in these infestations, the first record of the XPB in the U.S.A., and provide additional data that the XPB and the SPB coexist within the same trees, and that both respond to semiochemical-baited traps.

METHODS

Study areas. We selected two sites of bark beetle infestation on the Coronado National Forest, Arizona, U.S.A. Both sites – Pinery Canyon (31º 57.327' N, 109º 18.729' W) and Turkey Creek (31º 51.280' N, 109º 19.883' W), about 12 km south of Pinery Canyon – were located on ridge tops at elevations of approximately 1750 m. Host species on the sites included *Pinus engelmannii* Carrière, *Pinus leiophylla* Schiede & Deppe var. *chihuahuana* (Engelm.) Shaw, *P. ayacahuite* Ehrenberg ex Schlechtendal, and *Pinus ponderosa* P. & C. Lawson var. *scopulorum* Engelm. *P. leiophylla* var. *chihuahuana* appeared to be the species most impacted by bark beetles at both sites.

Trapping. At each site we placed four Lindgren 12-unit multiple-funnel traps (Phero Tech, Inc., Delta, British Columbia, Canada), each separated by about 40 m, at each site. We baited two of the traps with a standard (SPB) lure (racemic frontalin, loaded with 296 mg active ingredient/ bait, releasing at 5.2 mg /d @ 23˚C; Phero Tech, Inc.). Because the response of *D. frontalis* to frontalin in the southeastern US is synergized by α-pinene (a host monoterpene), we also baited those traps with a 170 g poly bag loaded with 70 percent (-)α-pinene (releasing at 1000 mg /d @ 23˚C; Phero Tech, Inc.). Since we suspected the presence of the western pine beetle *Dendroctonus brevicomis* LeConte (WPB) in this area, we baited the other two traps at each site with the standard WPB three-component lure: racemic frontalin, exo-brevicomin, and myrcene releasing at 2.6 mg, 17 mg, and 100 mg per day (@ 23˚C; Phero Tech, Inc.). The pheromone baits were placed near the tops of the traps, and the baits were replaced at least every three months. We sampled the traps weekly from May 15, 2001 until February 22, 2002.

By January 2002, the Pinery Canyon infestation had begun to decline. We moved the four traps about 12 km south on February 22, 2002 to the Turkey Creek location, which now possessed a much larger number of actively infested trees. The placement and pheromone components of the traps were the same as at Pinery Canyon, except that the baits were replaced monthly.

Each week, contents of each of the four traps were placed in a Nasco Whirl-pak® with 70 percent ethanol, by personnel of the Coronado National Forest, and sent to the senior author at Pineville (Louisiana, U.S.A.), for processing. Here *Dendroctonus* species were separated from the other insects, and cleared for a minimum of 12 hrs in lactophenol to facilitate visualizing the genitalia. The beetles were sexed and the males identified to species using seminal rod morphology. Due to a lack of reliable taxonomic characters, we did not attempt to identify the females to species.

Collection from host trees. On October 3, and November 19, 2001, bark samples were removed from eight and two *P. chihuahuana*, respectively, from the Turkey Creek location from the lower bole to the crown. Live and dead *Dendroctonus* spp. were removed from the galleries in these bark pieces and sent to Pineville, LA, for identification to species. These trees were in various stages of infestation. On December 6, 2001, five additional *P. chihuahuana* in various stages of infestation were cut in Pinery Canyon. Bark samples were also removed

from these trees, and live and dead *Dendroctonus* spp. were removed from the galleries and sent to Pineville, (Louisiana, U.S.A.), for identification to species.

Daily maximum and minimum temperatures and rainfall data were obtained from the Coronado National Monument (CNM) weather station, about 7 km north of, and at the same elevation as, the Pinery Canyon site.

RESULTS AND DISCUSSION

The trapping at the Pinery Canyon site (May 2001 – Feb 2002) with both SPB and WPB baits confirmed the presence of both the XPB and the SPB at the Pinery Canyon site (Fig. 2). This represents the first record of the XPB within the US, and the first recorded attraction of the XPB to semiochemical baited traps. Ground checks of bark beetle galleries of infested *P. leiophylla* var *chihuahuana* revealed that both the SPB and the XPB were infesting the lower, mid, and upper boles of the same trees. Collection from *P. leiophylla* var *chihuahuana* at Turkey Creek in October and November 2001 yielded a total of 31 male XPB, two male SPB, and 69 female *Dendroctonus* spp. A total of 10 male XPB, seven male SPB, and 37 female *Dendroctonus* spp. were collected from *P. leiophylla* var *chihuahuana* at Pinery Canyon in December 2001.

At the Pinery Canyon site, one trap baited with WPB pheromone consistently caught the most beetles. In contrast, at Turkey Creek a trap baited with SPB pheromone consistently caught the largest number of beetles. In all but one collection (in September 2000 when only a few SPB were captured) XPB was always the predominant bark beetle captured, outnumbering SPB about 34:1.

Trapped SPB (74) and XPB (997) males together outnumbered the combined total of females of both species (484) by about 2:1 at Pinery Canyon. The SPB (416) and XPB (15,944) males trapped at Turkey Creek together outnumbered XPB and SPB females (1,526) about 10:1. These ratios are consistent with those recorded for populations of SPB only in the southeastern US (Payne, 1980). However, for beetles collected from trees, females were recovered over twice as often as males. This sex ratio is greater than the 1:1 ratio recorded for emerging SPB in the southeastern USA (Coster et al., 1977; Osgood and Clark, 1963). However, we only sampled beetles within trees; it is possible that males may have re-emerged and vacated the galleries before the females, and therein changed the sex ratio.

Maximum temperatures at the collecting sites at the times of flight (~1000 to ~1700 hrs.) varied from ~19°C in winter to ~38°C in summer. Trap catches of the XPB stopped when average temperatures dropped below 16°C, and SPB seemed even less active at cold temperatures. In both years of trapping, we observed a distinct spring peak for male XPB and SPB (Fig. 2). Though numbers of SPB were at least an order of magnitude lower than those of XPB, the correspondence in their peak flight activity was striking. Perhaps by way of explanation, we noted a correspondence between peak trap captures and average daily temperature [obtained by adding the maximum and minimum daily temperatures and dividing by two (Figs.

3 and 4)]. Both species showed the highest propensity for flight during average daily temperatures in the range of 20-25ºC, with the most beetles captured at approximately 22ºC. This unimodal pattern of flight activity is in agreement with previous observations for SPB in the southern US (Moser and Thompson, 1986).

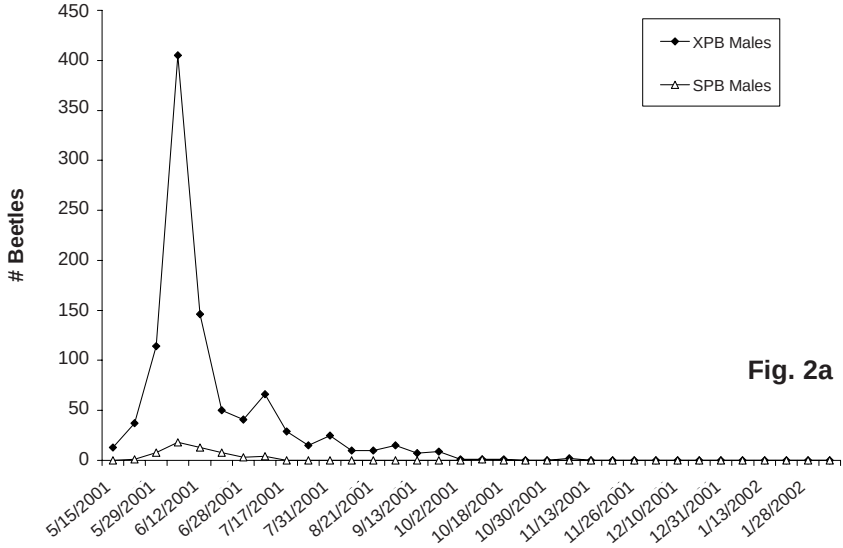

Fig. 2a

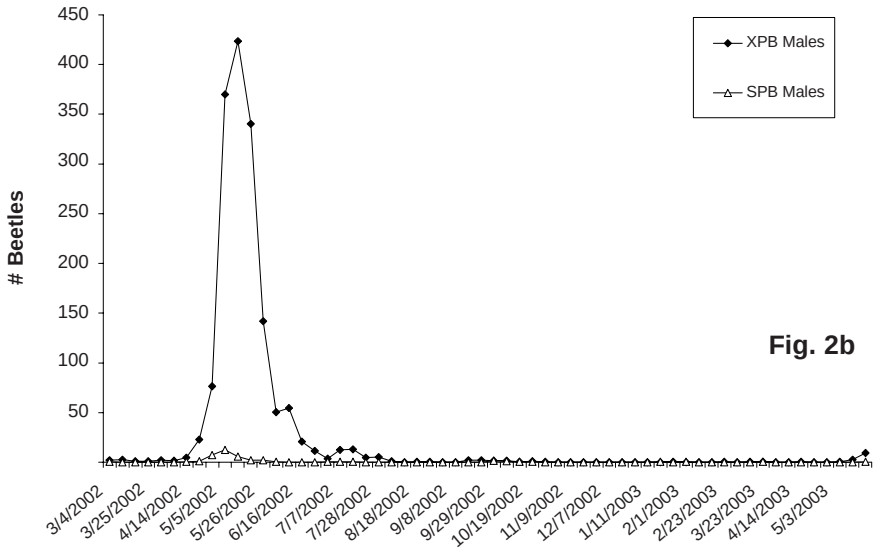

Fig. 2b

Figure 2. Total number of male *Dendroctonus mexicanus* (XPB) and *D. frontalis* (SPB) captured in funnel traps at a) Pinery Canyon, Coronado National Forest, Arizona, U.S.A.; b) Turkey Creek, Coronado National Forest, Arizona, U.S.A.

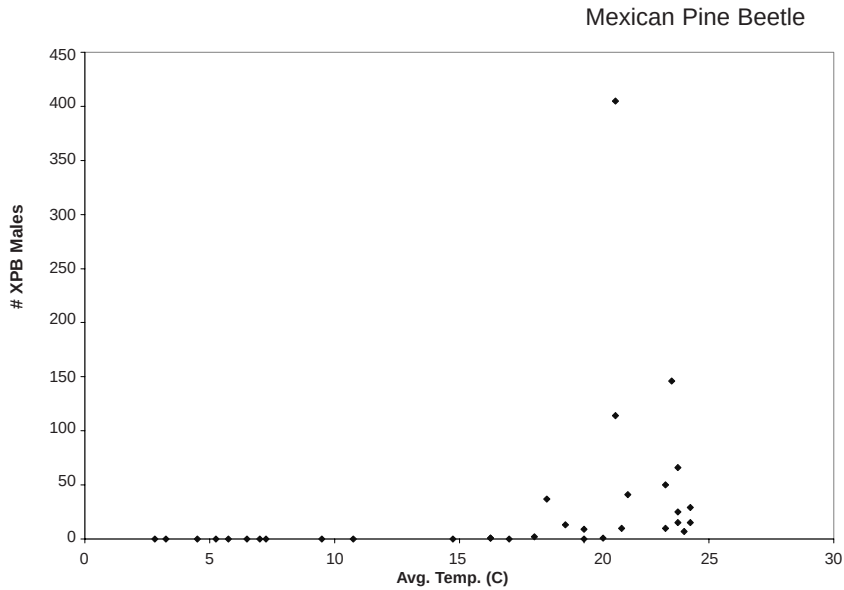

Figure 3. Total number of male *Dendroctonus mexicanus* (XPB) captured at various daily average temperatures in funnel traps at Turkey Creek and Pinery Canyon, Coronado National Forest, Arizona U.S.A. Each data point represents a collection attempt (regardless of whether any beetles were collected).

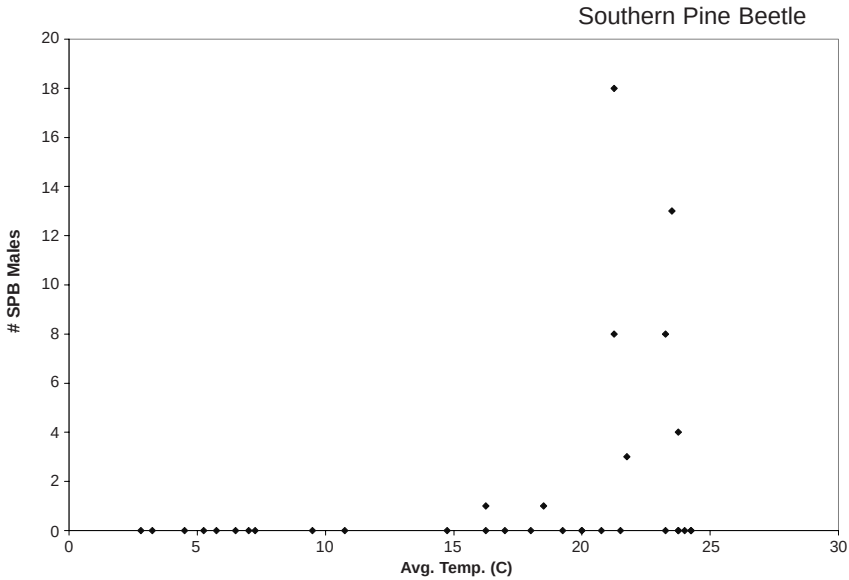

Figure 4. Total number of male *Dendroctonus frontalis* (SPB) captured at various daily average temperatures in funnel traps at Turkey Creek and Pinery Canyon, Coronado National Forest, Arizona U.S.A. Each data point represents a collection attempt (regardless of whether any beetles were collected).

Although it is difficult, given our limited sampling, to estimate the number of generations per year in this area of Arizona, our data indicate far less than the 7-9 generations that this beetle produces per year in the southern U.S. (Payne 1980). Also, SPB numbers declined in mid-Summer but never recovered when cooler weather returned in September. This is in contrast with SPB behavior in the southeastern U.S. where beetles routinely fly during cool weather in the winter (Moser and Thompson 1986). However, ground surveys in October indicated that another possible cause for the decline was that the Pinery Canyon infestation was moribund and producing few beetles.

Examination of 474 SPB and 7,541 XPB males over the course of two years yielded no evidence of seminal rods which were intermediate in appearance (between one or more *Dendroctonus* species) (Fig. 5). This supports similar lack of evidence for hybrid individuals reported by others (Lanier et al., 1988; Zuniga et al., 1995).

Although we used a limited number of traps, and were unable to statistically analyze the data, beetle capture seemed to be more influenced by trap location than by bait type. At Pinery Canyon a WPB pheromone baited trap caught the greatest number of beetles, while at Turkey Creek, a SPB pheromone baited trap caught the most beetles. These results indicate that the baits may have little to do with the numbers caught, and suggest that these two traps may merely have been closer to heavily infested trees. Because the XPB (and SPB) were trapped during warm periods in winter, we speculate that they attack trees during the winter, as the SPB do in the southeastern U.S. (Payne, 1980).

The reasons for the predominance of XPB over SPB at our sites are hard to ascertain. It may be that competitive displacement favored the XPB over the SPB, because the XPB is apparently better adapted to higher elevations (Lanier et al., 1988; Wood, 1982). Regardless, the SPB and the XPB were found infesting the same trees. This confirms previous observations by Zuniga et al. (1995). Although SPB have been reported for this area at least once (Lanier et al., 1988), we suspect that earlier XPB populations may have been overlooked because a reliable technique for separating the two species was not developed until 1988, and because SPB may have been the dominant species at that particular time and place when the collections were made (such as during our September 27, 2000 trapping).

We describe XPB here as a new introduction to the U.S. However it is beyond the scope of this study to determine the degree to which this is a recent introduction. Given the morphological and biological similarities of the XPB and the SPB, it is possible that the two species have been co-occurring in this area for some time. The possibility of a more recent invasion (mediated by climatic changes) or introduction (via log transport), however, cannot be discounted. The mechanisms and spatiotemporal aspects of the occurrence of this insect within the U.S. remain to be determined.

Mexican pine beetle

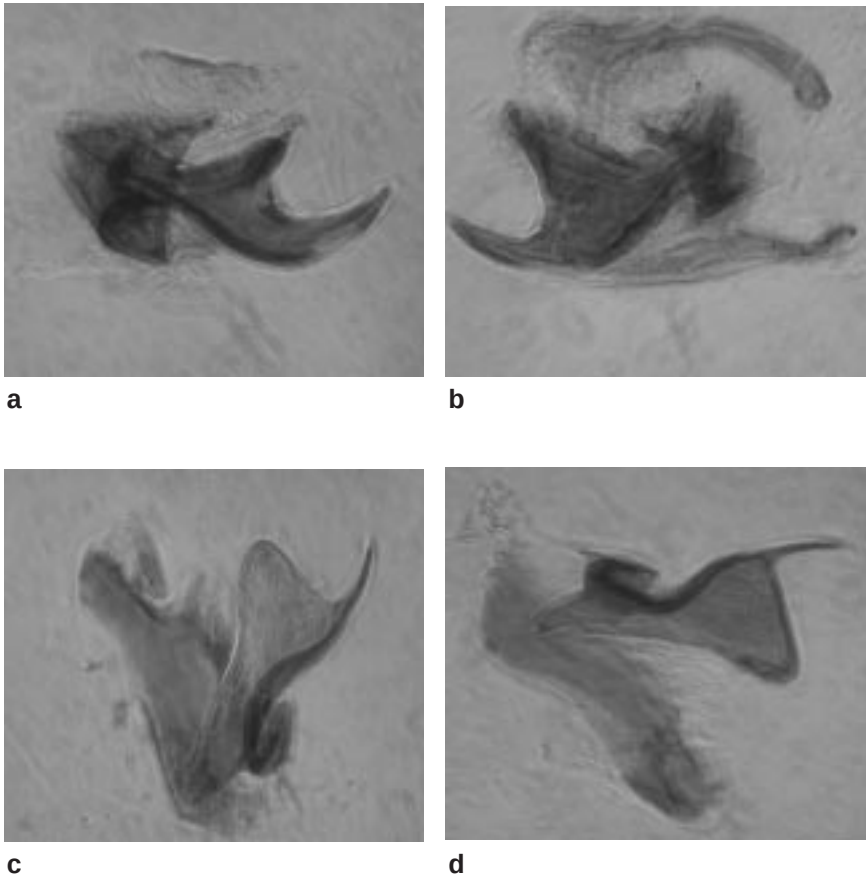

Figure 5. Seminal rods of male XPB (a, b) and SPB (c, d) collected at Turkey Creek and Pinery Canyon, Coronado National Forest, Arizona U.S.A. Photographs by Rich Hofstetter, Northern Arizona University.

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