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Alien Scolytines on the Osa Peninsula, Costa Rica (Coleoptera: Curculionidae: Scolytinae)

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Abstract

Alien (exotic) insects threaten trees, landscapes, and ecosystem stability. Bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) are saproxylic beetles that spend most of their life cycles under bark, and often are introduced to new locations through wooden packing materials used in international trade. This project reports the identification of 4 alien species reared on the Osa Peninsula of Costa Rica. Bait branches from 41 trees were exposed to saproxylic beetles in a mosaic of old growth and secondary forest. The branches yielded 6,578 scolytines in 33 species. Four of these were alien species: *Coccotrypes cyperi* Beeson, *Premnobius cavipennis* Eichhoff, *Xylosandrus crassiusculus* Motschulsky, and *Xylosandrus morigerus* Blandford (all Coleoptera: Curculionidae). At least 1 of the alien species, *Premnobius cavipennis*, was the most abundant scolytine, represented by 1,476 individuals, and it emerged from almost half of the trees sampled. It was reared from the plant families Lecythidaceae, Sapotaceae, and Fabaceae. Most individuals emerged from bait branches in old growth forest, and were disproportionately abundant at canopy stratum. Only 46 individuals of the economic pest *X. crassiusculus* were reared from bait branches. Two of the 4 alien scolytines were reared commonly from branches in old growth forest, even though mature forest typically resists invasions of alien species. Unfertilized females can disperse and found colonies by mating with haploid sons, and intra-colony mating promotes rapid population growth; therefore, these life history traits facilitate invasion.

Key Words: *Eschweilera biflava*; tropical wet forest; invasive species; competitive exclusion

Resumen

Los insectos alienígenas amenazan los árboles, los paisajes y la estabilidad del ecosistema. Los escarabajos de la corteza y ambrosía (Scolytinae) son curculiónidos saproxílicos que pasan la mayor parte de sus ciclos de vida debajo de la corteza, y a menudo se introducen en lugares nuevos a través de materiales de embalaje de madera utilizados en el comercio internacional. Este proyecto reporta la identificación de 4 especies exóticas criadas en la península de Osa de Costa Rica. Las ramas del cebo de 41 árboles fueron expuestas a los escarabajos saproxílicos en un mosaico de bosque con crecimiento antiguo y bosque secundario. Las ramas produjeron 6,578 escolinos en 33 especies. Cuatro de estos fueron especies exóticas: *Coccotrypes cyperi* Beeson, *Premnobius cavipennis* Eichhoff, *Xylosandrus crassiusculus* Motschulsky, y *Xylosandrus morigerus* Blandford (todo Coleoptera: Curculionidae). Salieron de casi la mitad de los árboles muestreado. *Premnobius cavipennis* fue la especie más abundante, representada por 1,476 individuos. Se crió en las familias de plantas Lecythidaceae, Sapotaceae y Fabaceae. La mayoría de los individuos emergieron de las ramas de cebo en el bosque antiguo, y fueron desproporcionadamente abundantes en el estrato del dosel. Solo 46 individuos de la peste económica *X. crassiusculus* fueron criados. Dos de los 4 escolinos alienígenas se criaron preferentemente de las ramas en el bosque antiguo, a pesar de que los bosques antiguos suelen resistir las invasiones de especies exóticas. Las hembras no fertilizadas pueden dispersar y encontrar colonias al aparearse con hijos haploides, este apareamiento dentro de la colonia promueve un rápido crecimiento de la población; por lo tanto, estos rasgos de historia de vida facilitan la invasión.

Palabras Claves: *Eschweilera biflava*; bosque húmedo tropical; especies invasoras; exclusión competitiva

Global trade has enormous economic benefits, but it introduces organisms to new environments that lack natural enemies, and often have abundant novel resources. Wood and bark-boring beetles potentially survive intercontinental transport in wood packing materials or logs, in some cases with serious economic cost. In the USA, these introduced pests can cost local governments $1.7 billion annually (Aukema et al. 2011). Alien invasive species also are detrimental to forest ecology; they are among the greatest threats to biodiversity, community structure, and forest sustainability (Pimentel et al. 2001; Keane & Crawley 2002; Kirkendall & Ødegaard 2007). They can transmit novel diseases that impact native species (Snyder & Evans 2006; Kenis et al. 2008) or outcompete native species, decreasing diversity and abundance (Parker et al. 1999; Sala et al. 2000; Clark et al. 2010; Vila et al. 2011; Miller-Piece & Preisser 2012). Disturbed habitats facilitate invasions from introduced species (Leinaas et al. 2015), while old growth habitats with high species richness may be able to resist some invasions (Kirkendall & Ødegaard 2007).

The family Curculionidae (long snout weevils, bark and ambrosia beetles) is one of the most diverse groups of animals in the world, with over 50,000 described species; about half are saproxylic (Oberprieler et al. 2007). They provide important ecosystem services, such as initiating wood decomposition and nutrient recycling. Their ability to live for long periods within woody tissues is a key characteristic that contributes to humans spreading saproxylic beetles globally. If logs are

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not treated properly, saproxylic beetles can be transported unnoticed inside wooden packing material and timber (Brockerhoff et al. 2005).

The objective of this study was to investigate the community structure of Neotropical saproxylic Curculionidae in Costa Rica. Due to the proximity of the study site to the Panama Canal, we expected to rear alien bark beetles. We expected greater abundance from trees in secondary forest and, due to their association with fungi, at ground stratum. This paper reports the ecological associations of 4 alien scolytines and discusses potential interactions with native scolytines.

Materials and Methods

This study was conducted at the Piro Biological Station of Osa Conservation, Osa Peninsula, southwest Costa Rica, Puntarenas Province (8.4100°N, 83.34°W). The site contains a mixture of old growth and secondary forest (about 25 yr old, regenerated from cattle pasture). Annual rainfall is approximately 6,000 mm, and the vegetation is representative of a tropical wet forest (Cornejo et al. 2012). A rearing project (Apr 2013–Jun 2014) investigated community structure of saproxylic beetles (Li et al. 2017; Morillo 2017). The data reported herein represent an extract from that project. Forty-one trees were sampled, including 9 species in 6 families: the Brazil nut family (*Eschweilera biflava* S.A. Mori, *Gustavia brachycarpa* Pittier; Lecythidaceae), the fig family (*Castilla tunu* Hemsl.; Moraceae), the bean family (*Lonchocarpus macrophyllus* Kunth, *Tachigali tessmannii* Harms; Fabaceae), the chicle family (*Pouteria torta* (Mart.) Radlk.; Sapotaceae), the hibiscus family (*Apeiba tibourbou* Aubl., *Luehea seemannii* Planch. & Triana; Malvaceae), and the coffee family (*Chimarrhis* sp.; Rubiaceae) (see Li et al. 2017 for supplemental documents for tree details, including locations and diameters). Bait branches were cut during the transition to the rainy season (Apr–Jul 2013). For each tree, a single branch was cut. A canopy bait (about 8 cm × 75 cm) was suspended in the tree from which it was cut, and the remaining branch was exposed at ground stratum. After 2 mo, we collected and caged the canopy bait, along with 3 equivalent sections of thick ground branch (about 8 cm × 75 cm), and 6 sections of thin ground branch (about 3 cm × 75 cm) for each tree; we estimate the biomass ratio as 1:3:1 for thick canopy, thick ground, and thin ground branches. Cages were monitored daily until Jun 2014 for emerged adult beetles. Specimens were stored in 100% ethanol, exported to The City College of New York and sorted. Thomas Atkinson of the University of Texas determined the scolytines from a synoptic collection.

Host and habitat specificity were calculated from the proportion of individuals emerging from host plant and habitat (Wardhaugh et al. 2013). Host specificity was as follows: (H_k): Specialist: $H_k \geq 90\%$; Preference: $50\% \leq H_k < 90\%$; Generalist: $H_k < 50\%$. Habitat specificity (H_s) was modified for binary category (forest type) as follows: Specialist: $H_s \geq 90\%$; Preference: $75\% \leq H_s < 90\%$; Generalist: $H_s < 75\%$. We conducted a regression analysis for host trees that yielded aliens species (JMP ver. 11.0) (SAS Institute 2019) to determine if there was a negative correlation in the abundance of all alien scolytines vs. all other scolytines (a potential sign of competitive exclusion). We calculated the number of emergences per wk for the most abundant alien species, *P. cavipennis*, and native scolytines, to determine if either group was maturing (and might have colonized the branches) more rapidly.

Results and Discussion

The bait branches yielded 8,761 curculionid specimens (91 species in 8 subfamilies). Scolytinae had the highest abundance and species richness, with 6,578 individuals in 33 species (Morillo 2017). Nearly 24% of the scolytine individuals belonged to 4 alien species: *C. cyperi* (*N* = 30), *P. cavipennis* (*N* = 1,476), *X. crassiusculus* (*N* = 46), and *X. morigerus* (*N* = 7) (Table 1). Eighteen of the 41 trees yielded 1 or more alien species. Eleven trees in old growth (6 species, 5 plant families) yielded 1,509 individuals, while 8 trees in secondary forest (5 species, 3 plant families) yielded only 50 individuals. Overall, fewer than 10 individuals emerged from 13 trees, while almost 97% of the alien scolytines emerged from 3 trees in old growth forest: 2 specimens of *E. biflava*, and 1 specimen of *P. torta*.

Three of the alien species emerged from branches cut in both old growth and secondary forest (Table 1; see Morillo 2017 for all specialization categories); *C. cyperi* and *X. crassiusculus* were considered forest successional stage generalists, and *P. cavipennis* an old growth specialist. Each of these emerged from 5 plant species, in 3 or 4 families, but each had a preference for Lecythidaceae. *Coccotrypes cyperi* and *X. crassiusculus* emerged from both thick and thin branches at ground stratum, while *P. cavipennis* had a preference for canopy stratum, and at ground stratum individuals emerged in greater abundance from thin branches. *Xylosandrus morigerus* appeared to be a secondary forest specialist, but was represented by few individuals. This species emerged from 2 tree species in different families, with a preference for Malvaceae, from both thick and thin branches, and at both strata.

The specimen of *P. torta* that was densely colonized by *P. cavipennis* (Table 1) yielded few other scolytines (Morillo 2017), but the regression analysis showed no consistent negative correlation between the abundance of alien scolytines and other scolytines ($R^2 = 0.0044$; $P > 0.74$). However, within trees, branches that were heavily colonized by introduced species were not well colonized by other scolytines. Most *P. cavipennis* emerged from canopy branches, while native scolytines emerged in greatest abundance from thick ground branches. Thin ground branches yielded either *P. cavipennis* and very few native scolytines (Fig. 1, specimen 31), or native scolytines but few individuals of *P. cavipennis* (Table 1, specimen 28) (Morillo 2017). Scolytines tended to emerge first from thin ground branches, then from thick ground branches, and finally from canopy branches, but there were no obvious differences in emergence sequence between *P. cavipennis* and the native scolytines.

For *P. cavipennis*, this is the first record in Costa Rica with locality data, and for *X. crassiusculus*, this is the first record on the Osa Peninsula. It is hardly surprising that there are alien scolytines on the Osa Peninsula, given its proximity to the Panama Canal and the port of Colón. The very moist conditions probably favor small-bodied curculionids (Fassbender et al. 2014), especially ambrosia beetles that disperse and feed on symbiotic fungi. The 4 alien scolytines reared in this study are commonly collected in old growth forests, and they are all polyphagous inbreeders (Kirkendall & Ødegaard 2007; Atkinson 2016). These traits facilitate invasions because potential host plants can be readily located, and subsequent population growth is rapid. In this study, alien scolytines were more abundant in old growth forest; habitat fragmentation may favor their establishment and concentration in old growth patches. Given their geographically widespread distributions (Atkinson 2016), these alien species probably are established in other Osa forest reserves (Cornejo et al. 2012), including Corcovado National Park.

The 3 species of Asian origin, *C. cyperi*, *X. crassiusculus*, and *X. morigerus* (Kirkendall & Ødegaard 2007), were not abundant in any single branch. *Premnobius cavipennis*, of African origin (Zanuncio et al. 2005), reached high population densities in several branches that were sparsely colonized by other scolytines. Its preferential association with canopy branches and thin ground branches (both of which lose

Table 1. Host associations of 4 alien scolytines reared in a mosaic of old growth (OG) and secondary forest (Sec). For each host tree, the number of emergences is listed by partition as Thick Canopy/Thick Ground/Thin Ground.

			Species of Scolytinae				
Forest stage	Plant family	Plant species (specimen ID)	CC	PC	XC	XM	Total *N*
OG	Fab	*Tachigali tessmannii* (14)	—	1/0/0	—	—	1
OG	Fab	*Tachigali tessmannii* (18)	—	14/0/0	—	—	14
OG	Lec	*Eschweilera biflava* (28)	0/2/0	224/4/87	0/4/1	—	322
OG	Lec	*Eschweilera biflava* (29)	—	0/31/0	—	—	31
OG	Lec	*Eschweilera biflava* (31)	0/5/0	230/68/146	0/4/0	—	353
OG	Lec	*Gustavia brachycarpa* (40)	0/6/0	—	—	—	6
OG	Lec	*Gustavia brachycarpa* (42)	0/0/4	—	—	—	4
OG	Mal	*Apeiba tibourbou* (44)	0/0/3	—	—	—	3
OG	Mor	*Castilla tunu* (16)	—	—	0/5/0	—	5
OG	Sap	*Pouteria torta* (17)	—	663/0/3	0/3/0	—	669
OG	Sap	*Pouteria torta* (27)	—	1/0/0	—	—	1
Sec	Fab	*Lonchocarpus macrophyllus* (35)	0/1/0	0/1/0	—	—	2
Sec	Lec	*Eschweilera biflava* (32)	—	0/1/1	0/7/20	—	29
Sec	Lec	*Gustavia brachycarpa* (33)	0/0/1	—	—	—	1
Sec	Lec	*Gustavia brachycarpa* (34)	—	1/0/0	—	0/0/2	3
Sec	Mal	*Apeiba tibourbou* (39)	—	—	—	2/0/0	2
Sec	Mal	*Apeiba tibourbou* (49)	—	—	0/1/0	0/3/0	4
Sec	Mal	*Luehea seemannii* (1)	0/3/4	—	—	—	7
Sec	Mal	*Luehea seemannii* (6)	0/1/0	—	0/1/0	—	2
Total *N* per partition (Canopy/Ground Thick/Ground Thin)			0/18/12	1134/105/237	0/25/21	2/3/2	1559

Stage: OG = old growth, Sec = secondary. Plant Family: Fab = Fabaceae, Lec = Lecythidaceae, Mal = Malvaceae, Mor = Moraceae, Sap = Sapotaceae. Adult emergences are shown for 4 alien species: CC = *Coccotrypes cyperi*, PC = *Premnobius cavipennis*, XC = *Xylosandrus crassiusculus*, and XM = *X. morigerus*. — = no emergences.

moisture more rapidly than thick ground branches) (Berkov unpublished data), suggests that it is more drought-tolerant than many other scolytines. This is a cause for concern: *P. cavipennis*, along with *P. ambitiosus* (Schaufuss), is an important pest of both healthy and stressed *Eucalyptus* (Myrtaceae) in Brazil (Zanuncio et al. 2005). *Premnobius cavipennis* commonly is collected in Mexico, and its geographic distribution extends throughout Florida (Atkinson 2016). Given its broad host plant range and its ability to build up large populations in branches not favored by other scolytines, *P. cavipennis* may be able to spread into South America and, like *X. crassiusculus*, throughout the eastern US.

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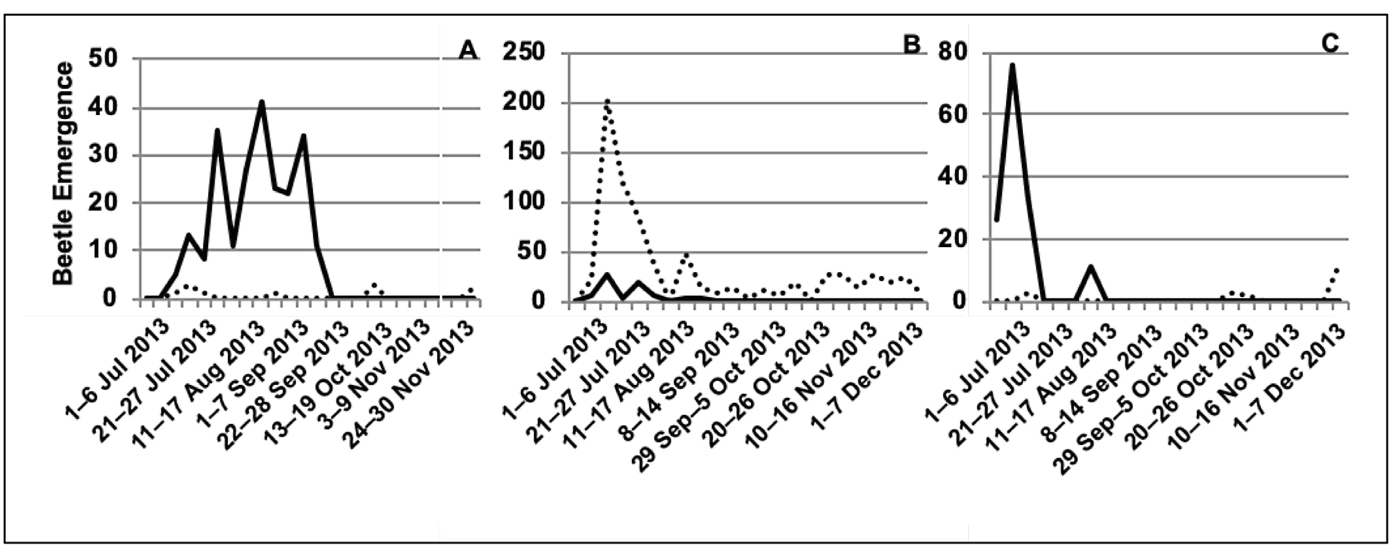

Fig. 1. Emergence sequence of scolytine beetles from *E. biflava* (31). Emergences are shown by stratum and diameter: A = Thick Canopy branches, B = Thick Ground branches, C = Thin Ground branches. Solid lines = *P. cavipennis*; dotted lines = native scolytine species.

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