A Survey on Ambrosia Beetle (Coleoptera: Curculionidae) Problems in Ornamental and Pecan Industries in Georgia[1]

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Abstract The ambrosia beetles, mainly *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Curculionidae: Scolytinae), are serious pests of young trees in the ornamental industry and pecan orchards as infested trees develop branch dieback with occasional tree mortality. Surveys were conducted in the ornamental industry in 2020 and 2021 and the pecan industry in 2020 because clientele perspective on the extent of damage, phenology, monitoring, management, and loss related to the ambrosia beetle was unclear. Of 35 and 40 ornamental industry respondents, 68% and 82% indicated problems with this pest in 2020 and 2021, respectively. Of 66 pecan industry respondents, 52% reported beetle problems in 2020. About 85% of ornamental and 58% of pecan respondents indicated that 1–10 trees were attacked by ambrosia beetles and 1–30 or more trees were culled annually. The beetle problem persists throughout the growing season but appears greater during the spring than in other periods. About 73% of respondents indicated that current monitoring tools helped them with management decisions; however, a proportion did not use recommended monitoring tools but instead relied on visual signs to determine attacks on trees. In the 2020 surveys, only 37% of ornamental respondents and 43% of the pecan respondents used insecticide sprays, whereas in the 2021 survey, 71% of the ornamental clientele (mostly nurseries) sprayed pyrethroid insecticides for ambrosia beetle management. In 2020 surveys, about 48% and 56% of ornamental and pecan respondents, respectively, spent <$500 USD for ambrosia beetle management.

Key Words *Xylosandrus crassiusculus*, ornamental nursery, landscape maintenance, pyrethroids

Ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) are a serious threat to ornamental trees during the spring in field nurseries across the eastern United States (Ranger et al. 2016). In Georgia, the granulate ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky), is the most economically important species attacking young trees in the field nurseries and pecan orchards (Monterrosa et al. 2021, 2022). *Xylosandrus germanus* (Blandford) and the black twig borer, *Xylosandrus compactus* (Eichoff), are also important ambrosia beetle pests, although captures of the two species are often below 10% of total ambrosia beetle captures during the spring in Georgia (Monterrosa et al. 2021, 2022). Ambrosia beetles attack the trunks of young trees and colonize the

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heartwood, which cause branch dieback and occasional tree mortality (Ranger et al. 2016).

In Georgia, field nurseries were valued at $444 million USD in 2020 (The University of Georgia 2022), whereas pecan production in 2021 was valued at $384 million USD (The University of Georgia 2022). Any crop loss associated with ambrosia beetle attacks in field nurseries is important and affects the salability of the young ornamental trees as used in parking lots, parks, and residential yards. In addition, any damage to young, vulnerable pecan trees can decrease future nut production.

Mated females of *Xylosandrus* spp. emerge from the overwintering hosts in wood lots and fly toward trees in nurseries, orchards, and ornamental landscapes, seeking new hosts for colonization in the spring and early summer. In the spring, they initiate flight when the air temperature is above 20°C for at least 2 to 3 d (Reding et al. 2013). This flight typically coincides with bud break of ornamental trees in field nurseries. The spring flight of *Xylosandrus* spp. is particularly damaging to young trees in nurseries, ornamental landscapes, and pecan orchards. *Xylosandrus crassiusculus* adults attack the stressed trees and colonize the heartwood of the tree by inoculating *Ambrosiella roeperi* T.C. Harr. & McNew fungus that they carry with them (Harrington et al. 2014). The developing larvae and adults of ambrosia beetles remain within the galleries and only consume this symbiotic fungus. Nursery and pecan growers and owners or managers of ornamental landscapes are advised to monitor the flights of *Xylosandrus* spp. adults from the wood lots adjacent to production and landscape sites by using ethanol-baited bottle or bolt traps (Joseph et al. 2019). Early captures of *Xylosandrus* sp. adults in ethanol-baited bottle traps or attacks on ethanol-baited bolts indicate *Xylosandrus* sp. flight activity and indicate the vulnerability of young trees to beetle attacks. Thus, preventative trunk sprays with pyrethroids, especially permethrin or bifenthrin, are recommended (Joseph et al. 2019) in the spring upon captures of ambrosia beetles in traps. Because there is no curative management option for *Xylosandrus* spp., growers must apply preventative sprays for effective management.

Nursery and pecan growers, as well as landscape managers, are regularly educated about the biology, phenology, timely monitoring, and management of ambrosia beetle through many training sessions, workshops, and one-on-one field meetings. However, it is unclear whether recommendations for ambrosia beetle management have been adopted. If so, it is unclear if growers are satisfied with the recommendations and if these recommendations are effectively reducing ambrosia beetle damage. If not, it is unclear which areas of recommendations are ineffective and whether the growers are suggesting the need for further research. The current survey aims to document the crop loss and impact of *Xylosandrus* sp. adult attacks on the trees in nurseries, landscapes, and orchards.

Materials and Methods

Survey design. In 2020 and 2021, surveys were conducted to document the current knowledge level on monitoring and management practices and to understand the management needs of growers or managers from the ornamental and pecan industries in Georgia. In 2020, 9 questions were included for ornamental and pecan grower clientele, whereas in 2021, 12 questions were included for nursery clientele (Table 1). The first 6 questions (not the same questions in 2020 and 2021; Table 1) were asked to assess the seriousness of the problem, current knowledge,

Table 1. Questionnaire and percentage of respondents answering.

No.	Questionnaire	% Responses		
		Ornamentals		Pecan
		2020 (n = 35)	2021 (n = 40)	2020 (n = 66)
1	Please self-identify:	100	100	100
2	Have you had ambrosia beetle infestations in the last five years?	100	100	91
3	If yes, can you estimate the percentages of trees/containers/landscape areas infested by ambrosia beetles each year in the past 5 years?		80	
4	Can you estimate the number of trees infested by ambrosia beetles.	89		45
5	For nursery producers, provide an estimate of how many species of trees were attacked each time.		50	
6	Provide an estimate of how many of those infested died or were culled.	86		58
7	In the last five years, provide an estimate ($) of how much you lost due to ambrosia beetle infestation?	77		55
8*	What is the most common period of the year for attacks?	80	88	50
9	Do you know whether ambrosia beetles attack stressed trees such as waterlogged, low fertility, drought-affected, frost-damaged?		90	
10	Do you monitor for ambrosia beetle activity?	94	-	83
11	Current monitoring tools, such as bolt traps or bottle traps, help with management decisions.		85	
12*	What techniques did you use to monitor ambrosia beetles?		90	

Table 1. Continued.

No.	Questionnaire	% Responses		
		Ornamentals		Pecan
		2020 (n = 35)	2021 (n = 40)	2020 (n = 66)
13	If you monitor for ambrosia beetles using traps, how often do you maintain the trap, such as changing the lure or adding alcohol.		75	
14	Do you manage (spray) for ambrosia beetles?	94	-	80
15*	If you have had ambrosia beetle problems before, what insecticide classes did you use for management?		73	
16	Do you have an adequate number of effective insecticides to manage ambrosia beetles?		85	
17	On average, how much does ambrosia beetle management cost per year?	77	78	65

* Respondents were allowed to select multiple answers.

and perspective on the biology of ambrosia beetles. The remaining questions were asked to assess the monitoring and management practices administered by clientele as well as crop loss.

Survey distribution. The questionnaire was distributed among members of ornamental industry associations, such as the Georgia Urban Agriculture Council and Georgia Green Industry Association, through their email list servers. The members of these associations included nursery producers and landscape installation and maintenance company managers, as well as turfgrass superintendents and managers. In addition, the paper format of the survey also was distributed during the "Wintergreen" annual conference of these associations in January 2020 and county agent meetings in 2021. The online surveys were made available to the ornamental industry using the Qualtrics (Provo, UT) webpage in both years. The responses obtained from January 2020 to November 2021 were included in the study. The Institutional Review Board (IRB) at the University of Georgia reviewed the survey questionnaire and deemed that IRB approval was not required, as personal information from the clientele was not requested using the questionnaire (IRB no PROJECT00001578).

For the pecan industry, the online questionnaire using the Qualtrics (Provo, UT) webpage was made available to stakeholders using The University of Georgia Extension Pecan Blog (The University of Georgia 2023) and email list server and was advertised during the online grower meetings held in 2020. The respondents were mostly members of the Georgia Pecan Grower Association, including growers, orchard managers, and pecan nursery owners.

Results and Discussion

In the 2020 ornamental survey, most of the respondents (88% of 35 respondents) were from the ornamental nursery industry (Fig. 1A), possibly managers or growers, whereas, in the 2021 survey, about 77% of 40 respondents almost equally represented field nurseries and the landscape installation and maintenance companies (Fig. 1B). The identity of the "other" 23% was unknown. These results suggest that responses represented the ornamental industry and their knowledge and perception of ambrosia beetles were likely reflected in their responses. The category others in the 2021 survey did not include respondents from other commodities, such as tree fruit and pecan, as they did not identify themselves as representing those commodities when specifically asked. However, the identity of respondents in the other category is unclear. In the 2020 survey that targeted pecan stakeholders, 91% of 66 respondents were pecan growers and 5% were tree fruit growers (Fig. 1C). None of the respondents were from the ornamental industry.

In the 2020 survey on the ornamental industry, 83% of 35 respondents indicated they had problems with ambrosia beetles once in 5–10 yr or never (Fig. 2A). In contrast, in the 2021 survey, 65% of 40 respondents indicated ambrosia beetle problems occurred every year or 2 to 3 yr (Fig. 2B). Based on the 2020 survey on pecan growers, most of the respondents never had a problem with ambrosia beetles or rarely had problems (once in 10 yr; Fig. 2C). The ornamental respondents in 2020 indicated that 1–10 trees were attacked by ambrosia beetles every year (84% of 35 respondents; Fig. 3A) and 60% culled 1–30 or more trees every year (Fig. 3C). These findings suggest that densities of ambrosia beetle attacking their trees were variable among operations for the threshold or tolerance to damage varied among operations.

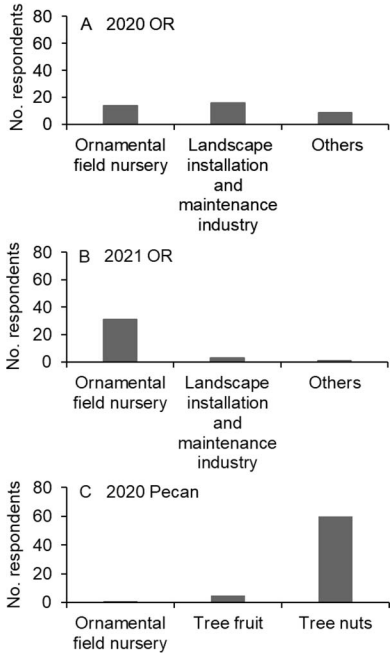

Fig. 1. The number of respondents to survey questionnaires in the 2020 (A) and 2021 (B) surveys from the ornamental industry and in the 2020 survey from pecan growers (C). OR, ornamental industry.

Previously, the densities of ambrosia beetle populations were reported to vary among ornamental nurseries (Monterrosa et al. 2022). In the 2020 pecan survey, respondents indicated that varied densities of pecan trees were affected, wherein 25% of respondents (n = 45) had 1–5 trees attacked (Fig. 3B) and 40% culled 1–10 trees (Fig. 3D). These unpredictable infestation patterns indicate that trees are at serious risk from attacks every year, possibly related to inconsistent "stress events." Some nurseries may flood or be subject to "freeze events" more readily than others.

Multiple tree species were grown in ornamental nurseries, and ambrosia beetles have a broad host range (Joseph et al. 2019). In the 2021 ornamental survey (mostly represented by nurseries), respondents (70% of 20 respondents) indicated that ambrosia beetles attacked about two to five species of ornamental trees in their operations (Fig. 4A), which were <10% area of their operations (91% of 32 respondents; Fig. 4B).

The survey conducted in ornamental industries in 2020 indicated that each year ambrosia beetles caused <$500 USD for 55% of the 27 respondents (Fig. 5A). Among the remaining respondents, 22% lost $501–1,000 USD per year. In the pecan survey, about 56% of 36 growers lost <$500 USD to ambrosia beetle attacks (Fig. 5B).

According to the 2020 ornamental survey, ambrosia beetle problems persisted throughout the year (Fig. 6A). In contrast, 84% of 45 responses in the 2021 ornamental industry survey indicated that ambrosia beetle problems occurred primarily during the spring (40 respondents could choose more than one interval; Fig. 6B).

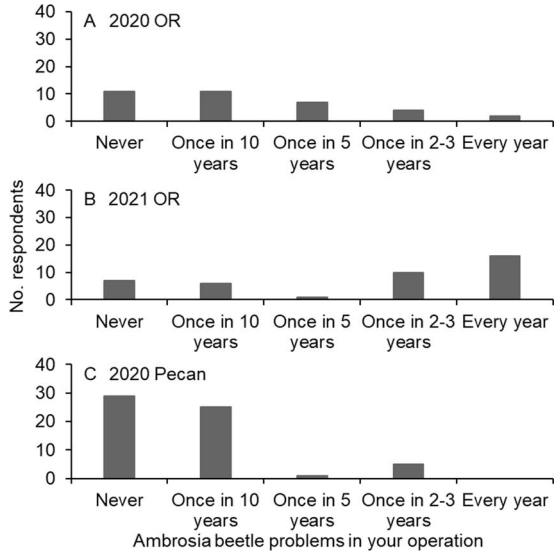

Fig. 2. The responses to the frequency of ambrosia beetle problems in the facility in the 2020 (A) and 2021 (B) surveys from the ornamental industry and in the 2020 survey from pecan growers (C). OR, ornamental industry.

Perhaps this variation in responses is associated with the timing of stress events, such as flooding, which may be responsible for some of the variation. The pecan survey indicated that ambrosia beetle problems were more or less prevalent during spring and early summer (Fig. 6C). A greater number of respondents agreed that tree stress could increase the risk of ambrosia beetle attacks (89% of 36

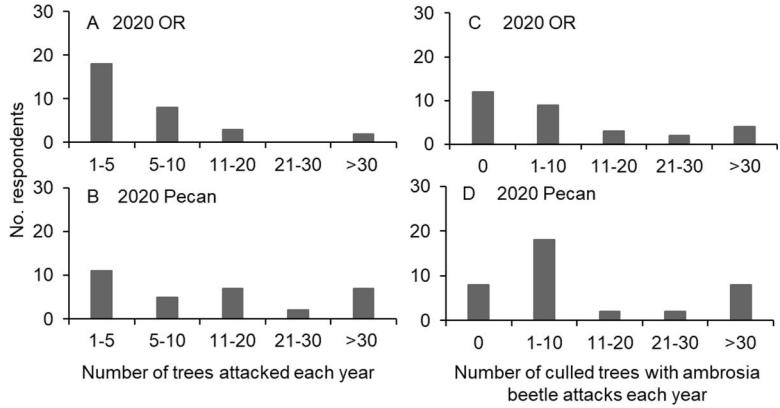

Fig. 3. The responses to the numbers of trees affected in the 2020 surveys from ornamental industries (A) and pecan (B) and the numbers of trees removed in 2020 from (C) ornamental industry and (D) pecan. OR, ornamental industry.

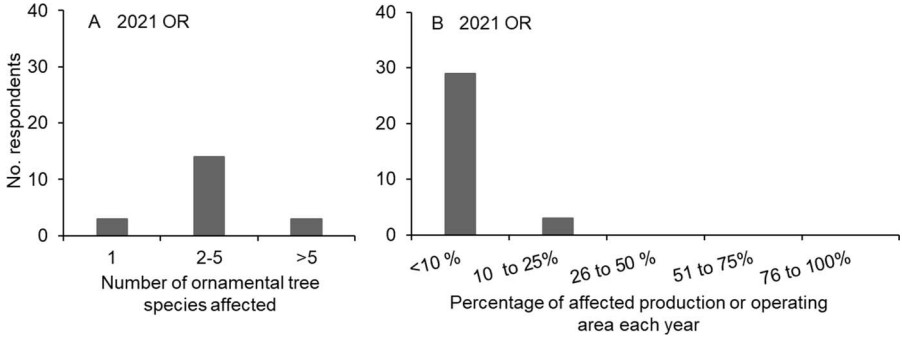

Fig. 4. The responses to the number of trees affected (A) and the area of the operation affected (B) by ambrosia beetle attack surveyed from the ornamental industry in the 2021 survey. OR, ornamental industry.

respondents; Fig. 7A). Previous studies indicated that stress factors, such as flood, frost, and drought, increase the risk of ambrosia beetle attacks as the stressed trees were likely to emit ethanol signals and attract ambrosia beetles (La Spina et al. 2013; Ranger et al. 2013, 2019; Reding et al. 2021).

Respondents in the 2021 survey mostly agreed that current monitoring traps, such as ethanol-baited bolts or bottles, helped them monitor ambrosia beetle flights (73% of 34 respondents; Fig. 7B). The ornamental industry (Fig. 8A) and pecan (Fig. 8B) surveys in 2020 indicated that about the same numbers of respondents monitor for ambrosia beetle attacks. Ethanol-baited bolts and bottle traps were effective in detecting ambrosia beetle flights (Ranger et al. 2016). In the 2021 survey, a greater number of respondents who monitored for ambrosia beetles indicated that they monitored beetle activity at 3-d intervals (64% of 17 respondents, others 13 indicated "not applicable" [10 respondents did not respond to this question, Table 1]; Fig. 8C), and they did not use traps to monitor ambrosia beetle but

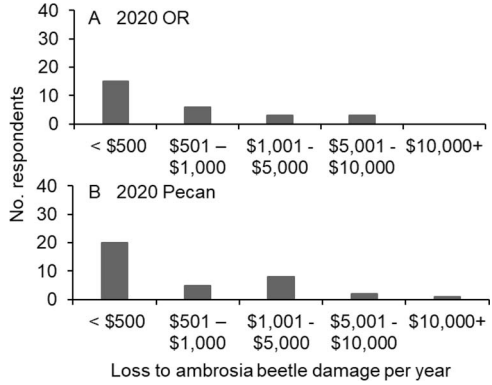

Fig. 5. The responses to the loss to the growers from ambrosia beetle attacks in the 2020 surveys from the ornamental industry (A) and pecan growers (B). OR, ornamental industry.

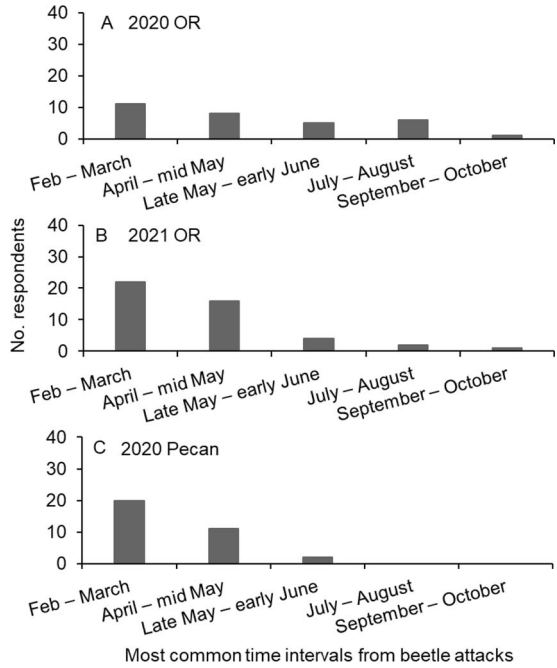

Fig. 6. The responses to the most common window for ambrosia beetle attack in the ornamental industry in the 2020 (A) and 2021 (B) surveys and from the pecan growers in the 2020 survey (C). OR, ornamental industry.

instead relied on visual tree inspection (40% of 66 responses as respondents could choose more than one monitoring method; Fig. 8D). They also received monitoring information from various sources, including university extension communications (Fig. 8D). This information suggests that educational activities should emphasize the value of monitoring beetle activity by using ethanol-baited traps for management decisions.

According to the 2020 surveys, most respondents from the ornamental (67% of 33; Fig. 9A) and pecan (57% of 53; Fig. 9B) industries did not spray insecticides for ambrosia beetle management. This information suggests that some clients are tolerant to some beetle attacks or that their densities are low enough in their operations, making it difficult to justify using an insecticide. In the 2021 ornamental industry survey, most of the respondents indicated they used pyrethroids for ambrosia beetle management (71% of 32 respondents as they could choose multiple management tools; Fig. 9C). In ornamental nurseries, preventative trunk sprays of pyrethroids, especially permethrin and bifenthrin, were effective at reducing ambrosia beetle attacks on trees, although there were occasions in which pyrethroid sprays were ineffective (Brown et al. 2020, Ranger et al. 2016). Among those respondents who used insecticide spray, most (53% of 34 respondents) indicated they did not have adequate insecticides or were not aware of effective insecticides for ambrosia beetle management (Fig. 9D). This finding suggests that more

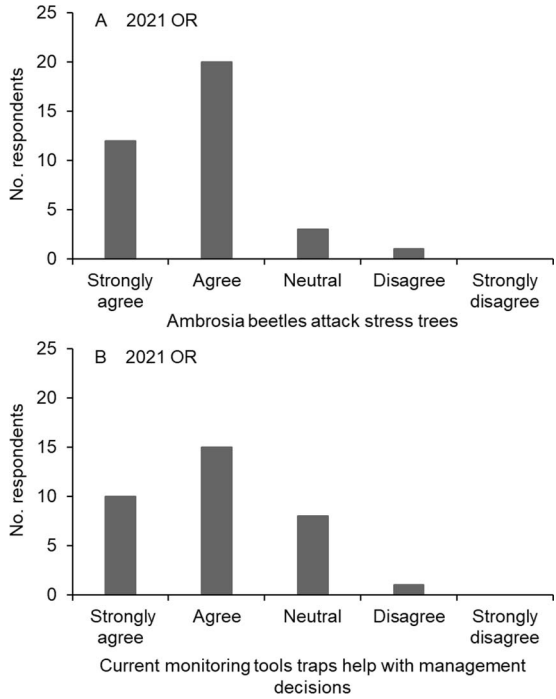

Fig. 7. The responses to whether ambrosia beetle attack stressed trees (A) and current monitoring tools are adequate to make management decisions (B) in the ornamental industry in the 2021 survey. OR, ornamental industry.

research is warranted to develop effective insecticides or other nonchemical options as currently only some selective pyrethroids have been tested, recommended, and widely used in nurseries (Ranger et al. 2016). In all of the surveys in ornamental industries and pecan growers, about half of the respondents (55% of 27 respondents, 42% of 31 respondents, and 56% of 53 in 2020 [Fig. 10A] and 2021 [Fig. 10B] ornamental industry surveys and 2020 pecan grower survey [Fig. 10C], respectively) spent <$500 USD for ambrosia beetle management, and the remaining respondents reported they spent $500–5,000 USD. These costs are likely for insecticide material, equipment, and labor, among other items.

The survey shows that ambrosia beetles are still an important problem for nursery growers, landscape managers, and pecan growers. The problem with ambrosia beetle in the operations varies by year; in some cases, the problem persists every year. Early spring appears to be a critical risk period for most ornamental sites and pecan orchards with vulnerable younger trees, although the problem persists throughout the growing periods in some cases. Monitoring ambrosia beetle flight in the spring is critical for determining management sprays (Ranger et al. 2016). However, the surveys suggested that more educational activities are warranted to emphasize the value of monitoring for the effective management of ambrosia beetles. The respondents also

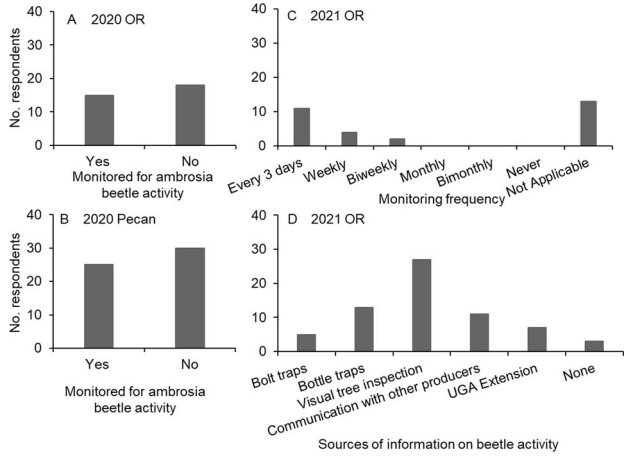

Fig. 8. The responses to whether respondents monitor for ambrosia beetle flight in the ornamental industry (A) and pecan in the 2020 surveys (B). Responses from the 2021 ornamental industry survey on how often they monitor (intervals between observations) (C) and which tool (s) are used to monitor ambrosia beetle flight (D). OR, ornamental industry.

indicated that more effective tactics, in addition to pyrethroid sprays, are needed to manage ambrosia beetles. The information derived from this survey will be used to develop and refine future research and extension activities related to ambrosia beetle management in the ornamental industry and landscapes.

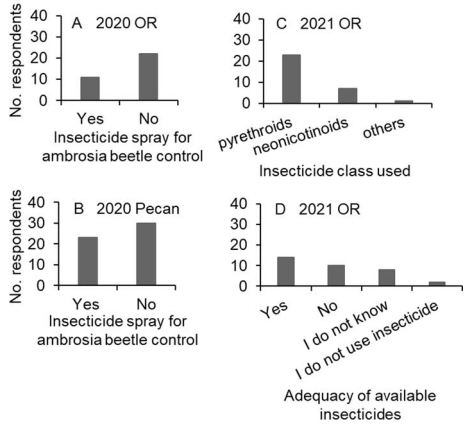

Fig. 9. The responses to whether respondents use insecticide to manage ambrosia beetle in the ornamental industry (A) and pecan (B) in the 2020 surveys. Also shown are the management strategy pursued (C) and whether adequate insecticides are available for use in ambrosia beetle management in the ornamental industry in the 2021 survey (D). OR, ornamental industry.

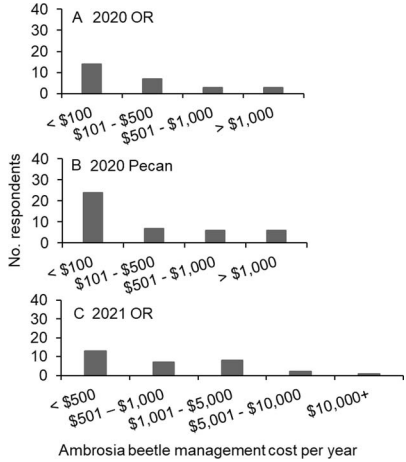

Fig. 10. The responses to how much money was spent for ambrosia beetle management in the ornamental industry (A) and pecan in the 2020 surveys (B) and in the ornamental industry in the 2021 survey (C). OR, ornamental industry.

Acknowledgments

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