Identifying Chemical Attractants and Repellents to Monitor and Manage the Black Twig Borer (*Xylosandrus compactus)* in Koa (*Acacia koa*) woodlots

Final Report

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Principal Investigator / Project Leader: Nick Dudley

Progress achieved in Accomplishing Project Goals & Objective

The black twig borer (*Xylosandrus compactus)* is a serious pest to over 200 plant species worldwide. In Hawaii, the black twig borer is a threat to numerous economically and ecologically important species such as coffee, avocado, citrus, and *Acacia koa*. The black twig borer is especially harmful because unlike many borer beetles it attacks young live wood on otherwise healthy plants. Current management practices focus on the removal of infested branches because insecticides are relatively ineffective.

The black twig borer infests many native Hawaiian species including *Acacia koa. Acacia koa* is one of the dominant canopy trees in native Hawaiian forests, and holds great ecological, economical, and cultural importance. Koa accounts for 90 % of the Hawaiian wood market, valued at $30 million annually. Koa is highly sought after for its unique wood quality and the due to the limited supply, koa is one of the world's most valuable hardwoods. The economic potential for koa is great due to interest in establishing koa plantations on currently underutilized land. The black twig borer is a factor inhibiting the viability of koa regeneration and an affordable management practice could greatly increase the overall health of koa regeneration sites.

The black twig borer is a type of ambrosia beetle, which are well known pests of trees and cut timber. These beetles bore galleries into sapwood and heartwood, inoculating the galleries with an ambrosia fungus. The ambrosia fungus grows to line the gallery, stimulating maturations of the female beetle's ovaries, and later providing an essential food source for the brood larvae. The black twig borer carries *Fusarium solani* as their primary ambrosia fungus. *Fusarium solani* is a well-known plant pathogen that can cause cankers, root rot, rapid wilt syndrome, depending on the strain of *F. solani* involved.

The long term objective of this study was to determine an efficient control method for the black twig borer.

The study had three primary immediate goals:

- Determine the effectiveness of Japanese beetle traps baited with ethanol as a method for trapping the black twig borer
- Determine the effectiveness semiochemicals, verbenone and limonene as repellents for the black twig borer
- Compare the effectiveness of Japanese beetle traps versus the more cumbersome Lindgren funnel traps

Ethanol as Attractant

The experiment showed that ethanol-baited Japanese beetle traps are a viable method for trapping the black twig borer. A total of over 11,000 black twig borers were trapped during the testing period (figure 1). The large number of beetles caught in only four weeks is impressive, but it is hard to determine the impact on beetle populations because the base population is not known. It would be useful to conduct beetle surveys within the test site to gain a better understanding of the populations. This would give a stronger indication of whether the traps effectively contribute to koa regeneration and overall forest health. As a crop protection strategy, trapping-out is expected to be more effective when combined with the use of repellents on or near the crop trees.

Repellents in trap-based tests

While the results of the first trial were inconclusive, the second test indicated that both verbenone and limonene are repellents for not only the black twig borer, but for two other borer beetle species as well (*Xyleborus saxeseni* and *Xylosandrus crassiusculus*). All three species are invasive pests that negatively effect forest health. The verbenone seems to be a stronger repellent for all three species as it proved to significantly reduce the number of beetles caught (see figures 2-4). The limonene appears to be less effective and only significantly reduced the number of *Xylosandrus crassiusculus* caught. The limonene did reduce the number of black twig borers and *Xyleborus saxeseni* caught, but the difference was not great enough to be proven statistically significant. The results of these trials were obtained by comparing the number of species caught in traps baited with ethanol (attractant) alone to those baited with ethanol and verbenone or limonene. The idea being that if verbenone or limonene are repellents, they will counteract the effect of the ethanol.

Verbenone as Repellent deployed in Plastic Pouches

It is also possible that verbenone can be effectively deployed in pouches to repellent for the black twig borer in koa stands, but we were not able to demonstrate that in this study. The verbenone pouches used may not have a high enough release rate to affect the black twig borer, or the meteorological conditions (wind or rain) may have resulted in either rapid flushing of the pheromone from the area (from wind) or slower release of the pheromone (from rain). It has been speculated that it is harder to maintain high pheromone levels in an open stand than in a closed stand, so the physical structure of the stand may also have been a contributing factor. A higher release rate pouch will be tested in the future. It is also possible that the ethanol is such a strong attractant that it overpowers the repellency of the verbenone. A higher release rate of verbenone should help address this concern. Finally, a different pheromone release system (one that maintains higher pheromone levels near the trees) may be needed. Such systems are under development (see below). As in the earlier repellent trials this trial compared the number of target insects caught in attractant (ethanol) only traps to those baited with ethanol and verbenone.

Another factor that may have influenced the results is the high concentration of beetles in some trap locations. This indicates that the black twig borer populations appear to vary greatly within the stand and this may be skewing the results. In subsequent studies, the traps have been rotated to minimize this effect.

Aceophone as a Repellent

In this trial a new pheromone, aceophone, was tested as a potential repellent. The trial also retested verbenone. The trial replicated the previous trials in that traps were baited with ethanol and the potential repellents as well as traps baited with only ethanol as a control. Both the verbenone and aceophone baited traps yielded lower trap counts than the ethanol only traps, with verbenone being slightly more effective.

Traps

Both traps yielded high trap counts for the black twig borer but the Japanese beetle trap had significantly higher yields. The Lindgren funnel traps caught more *Xyleborus saxeseni* but the difference is not significant. The traps yielded relatively similar amounts of *Xylosandrus crassiusculus* (see figure 5). From these results we recommend the use of the Japanese beetle traps not only because they are more effective at catching the twig borer, but also because of their small size, durability and price. The Lindgren funnel traps are bulky, fragile and more expensive than the Japanese beetle traps.

Non-target Scolytidae

An interesting aspect of our work thus far has been the lack of any Scolytidae other than the three invasive species. No other Scolytidae has been caught with any regularity in the koa plantings. We also plan to test the traps in coffee and a native restoration site to ensure indigenous Scolytidae are not negatively affected in those habitats.

Verbenone as a deterrent to tree damage

All previous work focused on verbenone's ability to reduce the number of black twig borers caught in traps. In order to determine if verbenone can significantly reduce damage to target tree species we planned to monitor black twig borer damage to

Flueggea neowawraea in Kahanhaiki Management Unit (KMU). We planned to monitor twig borer damage in areas "protected" by verbenone to areas without. Progress on this trial was stopped because an increase in twig borer activity was noticed in the areas where verbenone was deployed. This result indicates that while verbenone may be able to counteract the effectiveness of ethanol as an attractant, it is not likely to be the panacea hoped for by resource managers. For a more detailed description please refer to Appendix 1.

Black Twig Borer Population Monitoring

The difficulties encountered in the previous trial at KMU illustrated a lack of proper methodologies needed to evaluate the effectiveness of potential twig borer repellents. Specifically it demonstrated a need to better understand the relationship between the number of twig borers caught in traps and the number of new galleries in the target host. A yearlong monitoring program was completed using both traps and damage assessments. For a detailed description of the monitoring program and the results to date please refer to Appendix 1.

Future Trials

Future work will be focus on black twig borer trapping strategies in an *Acacia koa* nursery setting.

Figure 1

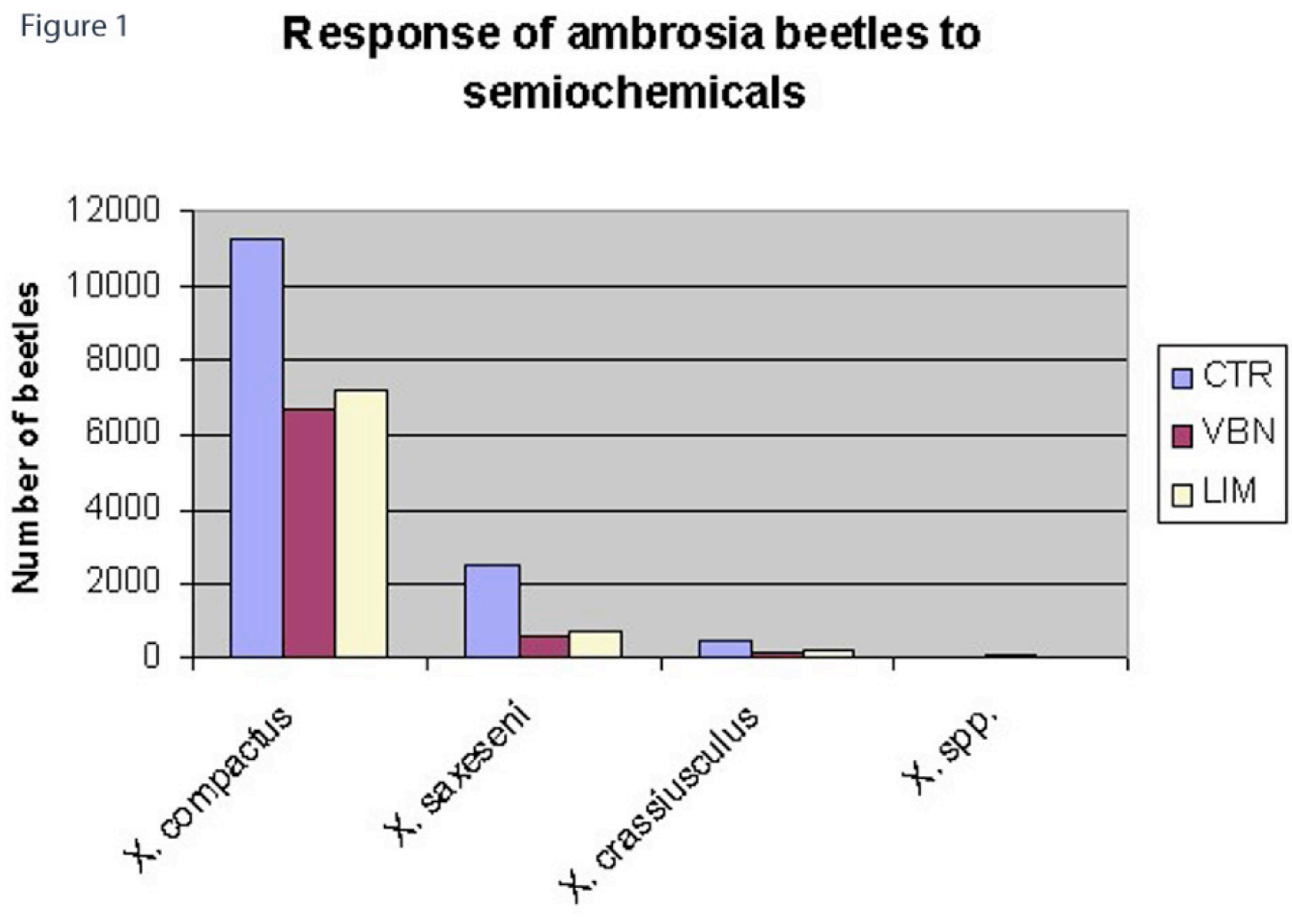

Response of ambrosia beetles to semiochemicals
Number of beetles
12000
10000
8000
6000
4000
2000
0
X. compactus
X. saxeseni
X. crassiusculus
X. spp.
CTR
VBN
LIM

Figure 2 ***Xylosandrus compactus***

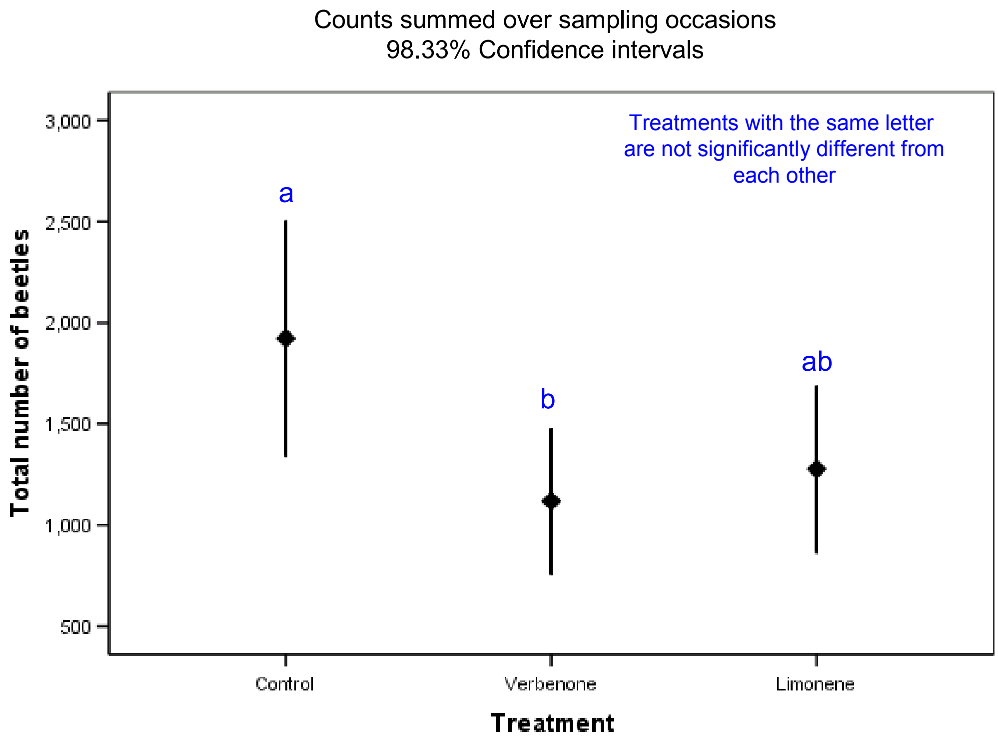


Figure 3 ***Xyleborus saxeseni***

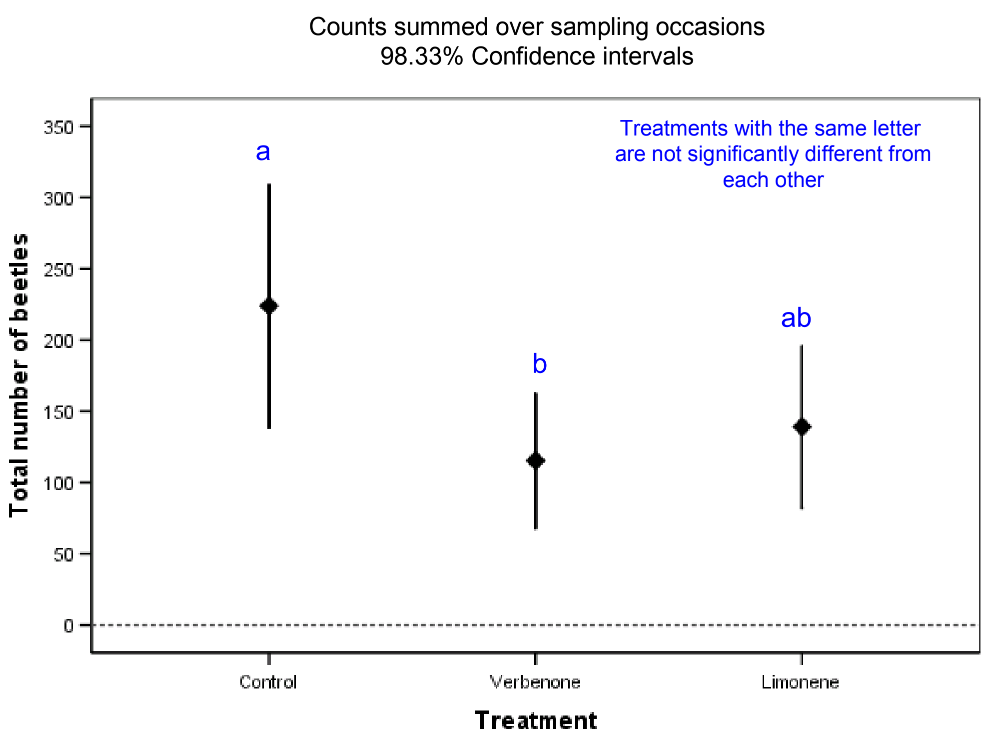


Figure 4

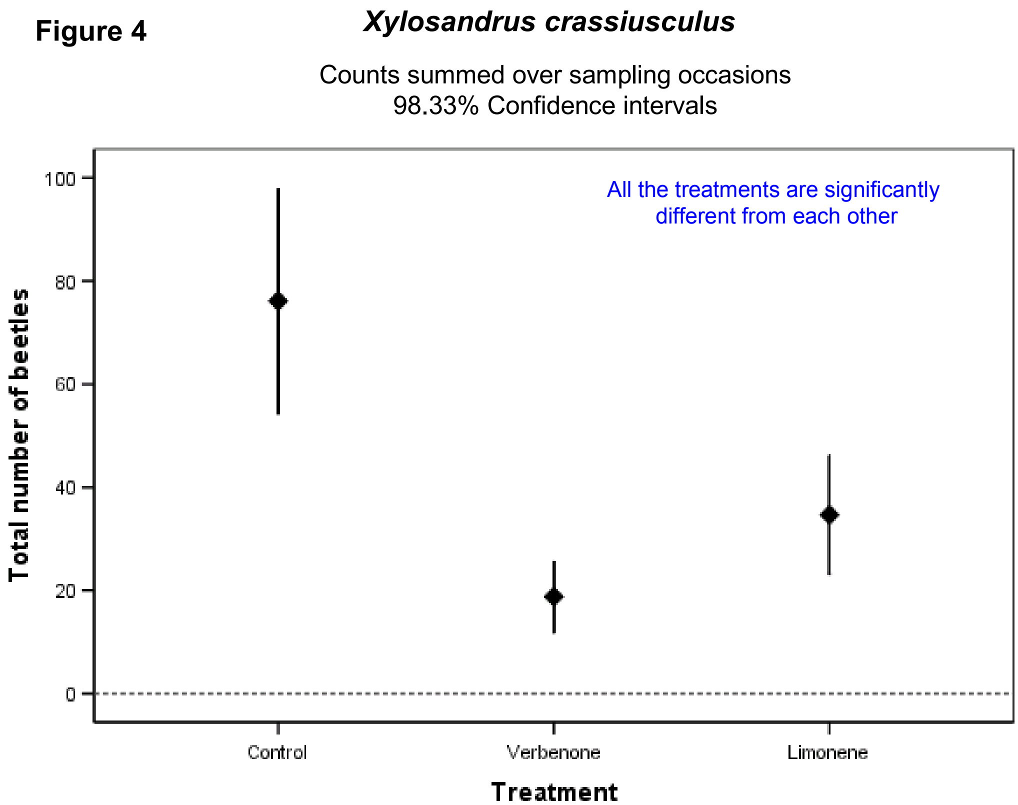
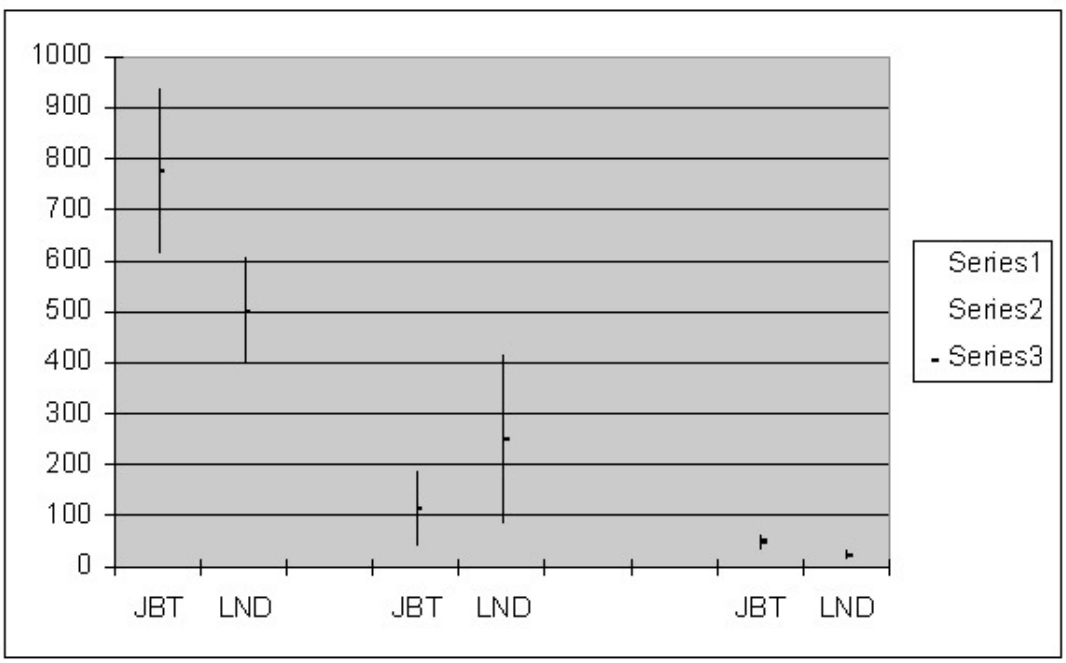
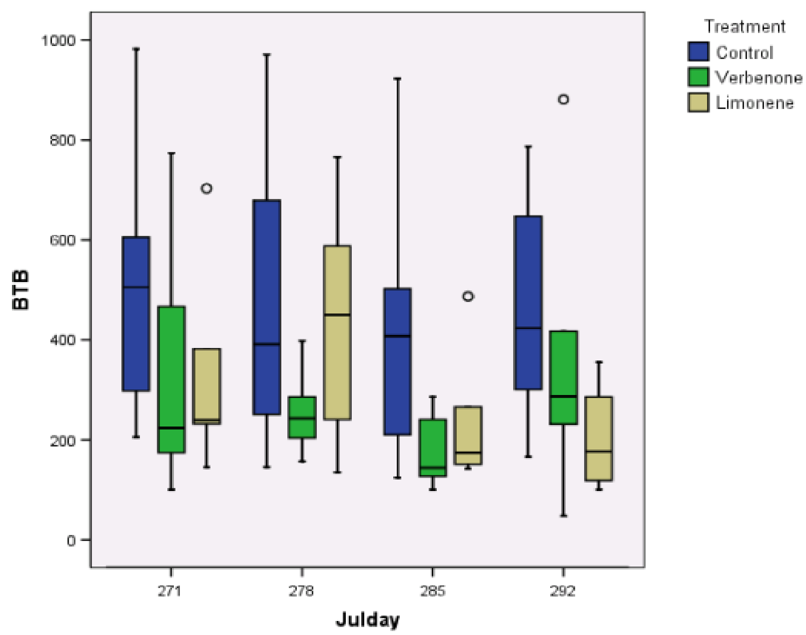


Figure 5 **Trap Preference: Japanese beetle vs. Lindgren funnel traps**

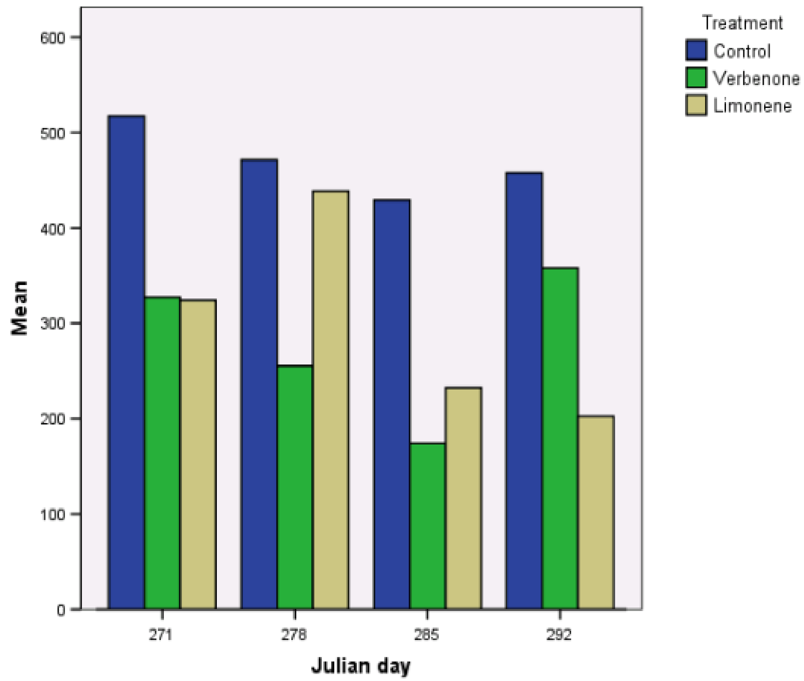


X. compactus *X. saxeseni* *X. crassiusculus*

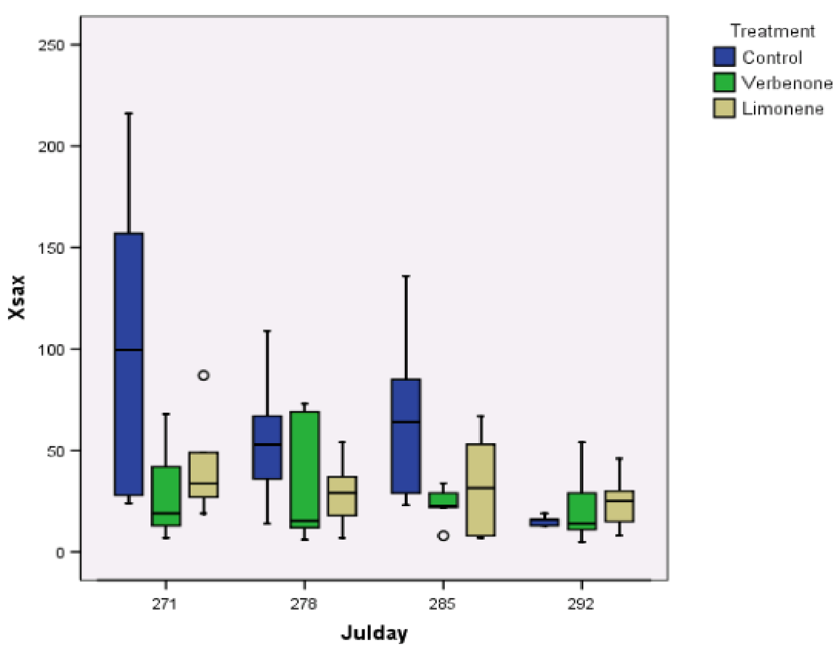
Xylosandrus compactus



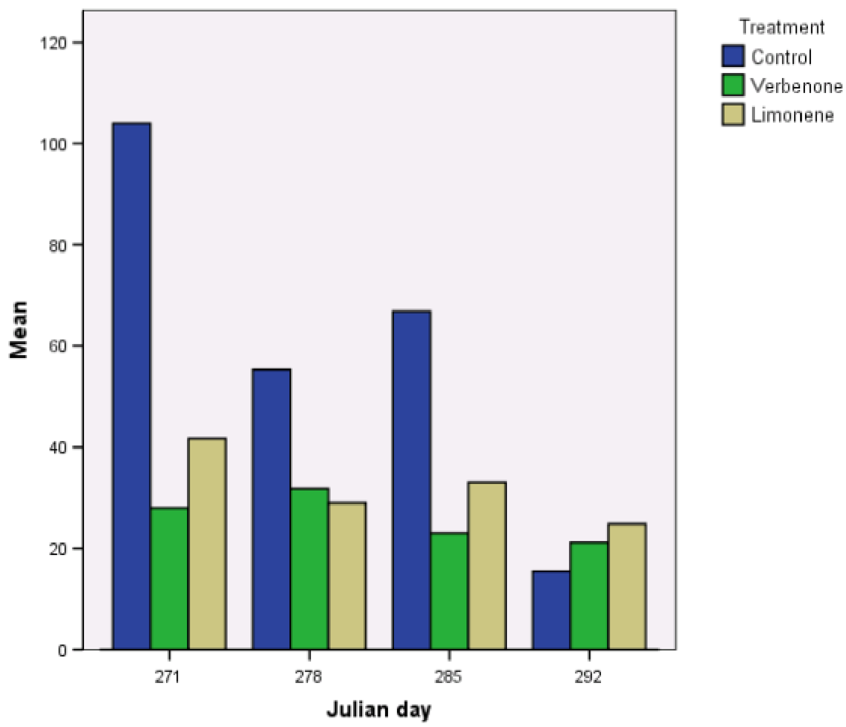
Xylosandrus compactus



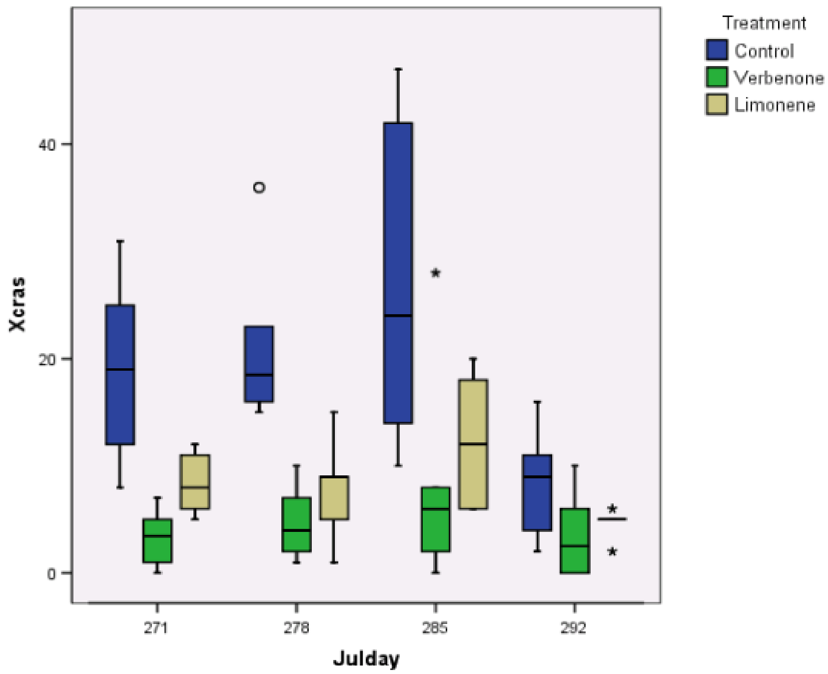
Xyleborus saxeseni



Xyleborus saxeseni



Xylosandrus crassiusculus



Xylosandrus crassiusculus