BIOLOGY AND CONTROL OF PACIFIC FLATHEADED BORER IN WALNUTS

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ABSTRACT

Pacific flatheaded borer has become a resurgent pest of commercial walnut production in California in the last few years. In 2018, a widespread infestation of this pest was reported from northern San Joaquin Valley and other walnut growing regions, and this scenario has continued to 2019 season as well. Since limited information was available regarding the biology and monitoring of this borer pest, we conducted studies that help to understand the extent of the problem and biology, document damage symptoms, determine pest phenology, and explore potential monitoring tools. We confirmed that Pacific flatheaded borer (PFB), *Chrysobothris mali* is the species largely causing damage in California walnuts. Also, we found that the adult emergence period ranges from May through June in the northern San Joaquin Valley. We identified that PFB adults were attracted to green colored sticky traps, although the overall capture rate was low. We will continue to generate more information on the biology and develop monitoring and potential management tools in the future.

OBJECTIVES

1. Document the pest status and damage symptoms of the Pacific flatheaded borer in walnut orchards
2. Explore monitoring tools and determine the phenology of the flatheaded borer in walnut orchards

SIGNIFICANT FINDINGS

- Flatheaded borer incidence in the past couple of years seems to be heightened throughout the walnut production regions in California. The infestation was reported from Colusa to Kings counties.
- The species of the flatheaded borer that has been causing economic damage to walnut orchards was identified as Pacific flatheaded borer, *Chrysobothris mali.*
- Based on a preliminary study in 2019, the adult emergence period for Pacific flathead borer ranged from May through June with the peak emergence in mid-June.
- Although very low capture rate, green-colored traps were most attractive to Pacific flatheaded borer adults based on a preliminary study from the 2019 field season.

PROCEDURES

Objective 1: Document the extent of the Pacific flatheaded borer problem in walnut growing areas

This objective focuses on documenting orchard-specific information from individual orchards that have been infested by the flatheaded borer. The information included, but not limited to: variety; the age of the orchard; the degree of infestation (based on visual sampling, ratings, and/or other kinds of assessment); tree part with significant feeding injury; and orchard production system

(irrigation, any visual nutritional issues). This information was collected based on the response from growers and/or PCAs after we published an extension article about the situation of the flatheaded borer in the northern San Joaquin Valley. In 2020, we will continue in documenting the flatheaded borer infestation incidence by visiting infested orchards at different times of the year, through farm calls, and most importantly by using formal survey to the growers during various extension meetings, this will be done in collaboration with local Cooperative Extension Advisors representing all walnut growing areas statewide.

Objective 2: Explore monitoring tools and determine the phenology of the flatheaded borer in walnut orchards

Determining phenology of PFB using adult emergence cages. During the winter of 2018-2019, we collected walnut branches from walnut orchards infested by PFB in the previous season for an adult emergence study. Three walnut orchards representing three frequently grown cultivars- 'Tulare,' 'Chandler,' and 'Howard,' were selected for this purpose. Collected branches (0.5-1.0 in. diameter) were cut into 24-34 in. long pieces; transferred to ventilated plastic storage containers, and kept outdoors to simulate orchard conditions for adult emergence (Fig. 1). Insect emerged from these infested branches were inspected visually 7-15 days interval April through August and reported the finds.

Figure 1. PFB adult emergence study set up

Developing monitoring tools using traps. It has been reported that green- or purple-colored sticky prism traps (14 in. × 24 in.) and purple multiple funnel traps (also called Lindgren funnel traps, Lindgren (1983) play a significant role in capturing several other buprestids such as emerald ash borers (Francese et al. 2008) and goldspotted oak borer (Coleman et al. 2014). The multifunnel traps are recyclable for repeat uses and more user-friendly for buprestid beetle trapping as the funnel traps do have the messy trap adhesive that coats the corrugated plastic prism traps (Francese

et al. 2011). In mid-April 2019, we deployed traps in six walnut orchards with a set of three traps, including one purple and one green sticky prism trap (Fig 2a), and one purple multifunnel trap (Fig. 2b). All of these traps were hung on ~10-ft tall stainless-steel conduit poles in orchard rows. Traps were checked bi-weekly and serviced as needed. All six sites were located within two counties, San Joaquin and Stanislaus.

Figure 2. a) Green sticky prism trap, b) Purple Lindgren multiple funnel trap

RESULTS

Reporting the pest status and documenting the flatheaded borer damage symptoms.

Flatheaded borer is the generic name of the wood-boring larvae of beetles in the insect family, Buprestidae. The larval stage of flatheaded borers has a greatly enlarged and flattened anterior part (technically, thorax) of the body, hence the name “flatheaded”. Pacific flatheaded borers had been known to cause damage to weaker, wounded, and sunburn-susceptible parts of trees. However, in our observations in the past few years visiting several walnut orchards in San Joaquin Valley, the feeding damage was not limited to wounded and sunburn-damaged branches, and this behavior as a primary pest is a concern for walnut growers. The damage observed was distributed randomly throughout the tree, including twigs (pencil-sized), branches (2-4 in. diameter), limbs, and even tree trunks. Attack on young trees (1-2) years can seriously jeopardize tree health and even end in tree mortality. In several English walnut orchards, we observed borer infestations on a range of tree ages [young (1-2 years) to mature (15-20 years)] and on a range of cultivars such as 'Howard', 'Chandler,' and 'Tulare.' High-density feeding galleries by the larvae had led to the flagging and breakage of nut-bearing branches.

After publishing an article about flatheaded borer incidence in the Fall 2018 (https://agfax.com/2018/11/19/california-walnuts-concerning-pacific-flatheaded-borer-activity/), we received over 20 flatheaded borer infestation reports voluntarily from the growers and pest control advisers representing 8 counties (Colusa, Yolo, San Joaquin, Stanislaus, Merced, Fresno, Kings, Tulare). Due to the lack of information about the flatheaded borer biology and feeding damage symptoms for diagnosis, the borer problem often misdiagnoses with other problems such as branch or trunk diseases (e.g., canker). In 2020, we will conduct a coordinated statewide survey to producers and PCAs about flatheaded borer issues.

Based on our initial assessment of several infested orchards, we were able to document the visual symptoms (Fig. 3) that can be used to diagnose the flatheaded borer infestation in the orchard:

- Brown colored sap oozing from under the bark on the trunk, limbs, and lower branches
- Presence of visual wounds on the tree branches and limbs that are prone to sunburn
- Feeding channels packed with frass (sawdust-like insect waste) and cream-colored larva underneath the bark after peeling of branches with suspected infestations
- D-shaped exit holes from adult beetle emergence on the bark

Fig. 3. Various injury symptoms caused by Pacific flatheaded borer in walnuts

Determining phenology of PFB using adult emergence cages.

Based on the preliminary results, we found that flatheaded borer adult emergence began in mid-May and continued through June. A total of 152 adults were recovered, and the highest proportion (~70%) of adults was recorded on June 12 regardless of the variety (Fig. 4-5). Although this provides some information about the adult emergence pattern, this study needs to be supplemented with the field data. The emergence timing may vary from year to year based on potential factors such as cultivar, temperature, locations, drought conditions, etc., and we plan to conduct additional research to understand various factors that might influence the seasonal emergence and borer incidence in orchards. In addition to PFB, we recovered a total of 8 specimens of a parasitic wasp from a group called Chalcids (likely *Trigonura californica* Rohwer) (Fig. 6). We don't have additional information on the effectiveness of these parasites in reducing the PFB incidence in walnut orchards.

Fig. 4. Seasonal trend of Pacific flatheaded borer emergence from infested walnut branches

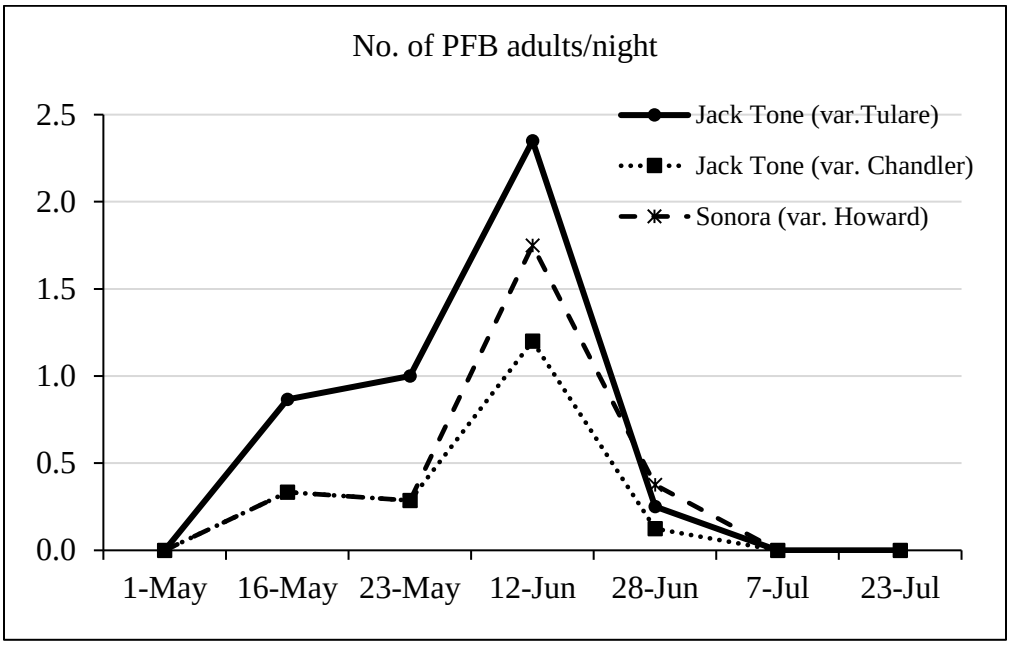


Fig. 5. Percent distribution of PFB adults emerged within the season

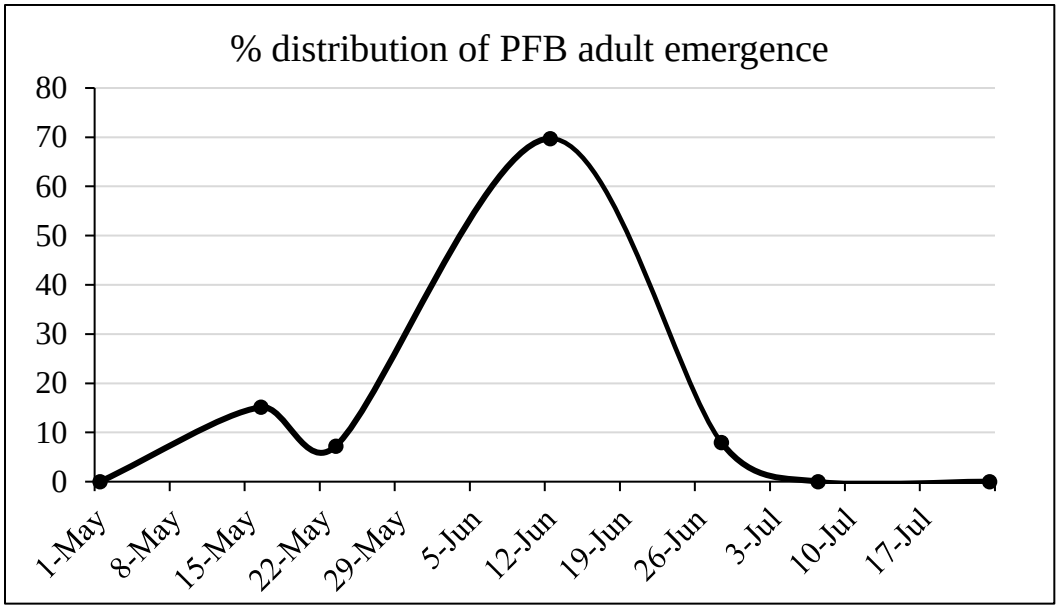
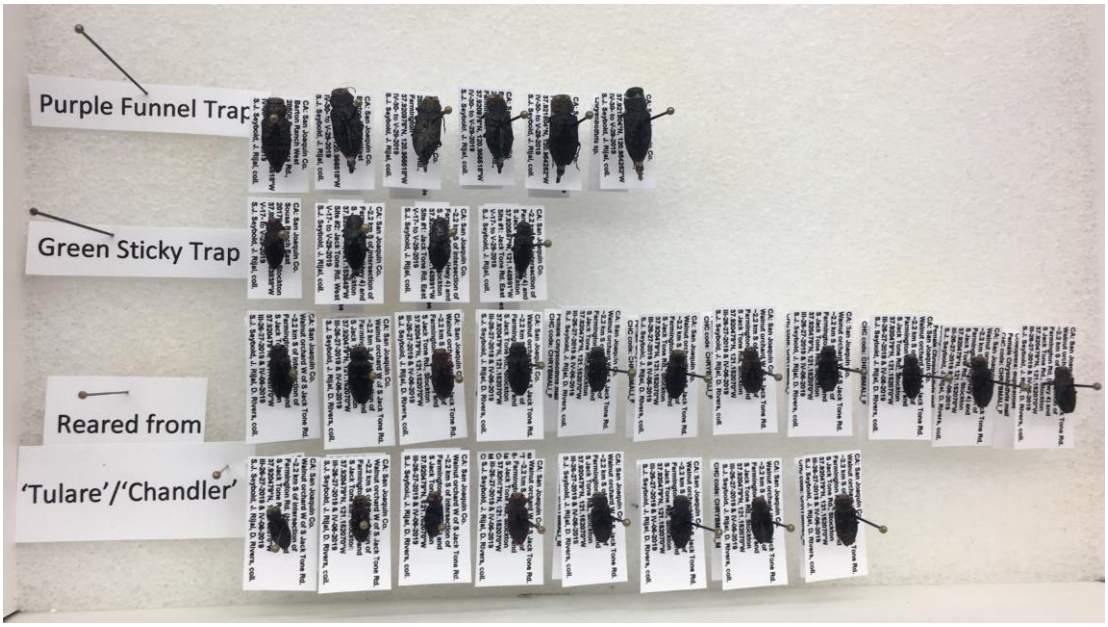


Fig. 6. Parasitoid emerged from the PFB emergence cages

Exploring monitoring tools for adult trapping

All buprestid beetles captured in the prism and funnel traps were counted and later identified (Westcott et al. 2015) (Fig. 7). Based on preliminary results from the early part of the season (April-May), ten *Chrysobothris* sp. were captured in green prism traps (n = 4) and purple funnel traps (n = 6). All of the specimens that we caught on the green sticky traps were *Chrysobothris mali* (4 specimens: 2 males and 2 females from two of the six sites). In contrast, all of the six specimens (all females) that we caught in the purple funnel traps were a species in the flatheaded appletree borer, *Chrysobothris femorata* (Olivier), species group, which has been recently described and named, *Chrysobothris wintu* Wellso and Manley (Wellso and Manley 2007). Named for the Pacific Coast Wintu Native American tribe, *C. wintu* occurs from Baja California north through Arizona, California, Oregon, and Washington. Although *C. wintu* is known to develop in larger branches of English walnut (Westcott et al. 2015), the relative risk of this species causing economic damage in walnut orchards is lower. Also, the fact that we recovered only *C. mali* (i.e., Pacific flatheaded borer), but not *C. wintu* from the infested walnut branches in the study reported earlier indicates that Pacific flatheaded borer is the species that is causing damage to walnut orchards. Since all Pacific flatheaded borer captured in green sticky traps shows the green color preference of these beetles. We are still processing the trap captures that occurred between June-October, and the trapping results reported here are considered preliminary.

Fig. 7. Photo illustrating the size difference between the buprestid beetles recovered



DISCUSSION

Flatheaded borer has become a resurgent pest in walnut orchards in California. Since the Fall of 2018, we observed increasing evidence of flatheaded borer attacking in several walnut orchards in the northern San Joaquin Valley, as well as in other parts of the Central Valley. Based on the reared-out specimens of the infested walnut branches collected in the winter of 2018, we identified the species as Pacific flatheaded borer (PFB), *Chrysobothris mali* Horn. Pacific flatheaded borer adults are ½ to ¾ inch long small-sized, with brown and gray markings on the wing covers, and have an oval head with the wedge-shaped body. Female beetles deposit ~100 eggs singly in potentially weaker portions of the wood (i.e., sunburnt, freshly pruned areas, etc.) on in bark crevices or depressions. Larvae bore through the outer bark and feed on the phloem and cambium layer of the wood initially, but eventually reach the xylem (wood) and mine the woody surface and interior. The larvae are cream-colored and legless. They construct pupal chambers and molt into the final larval instar (i.e., prepupal stage) to overwinter. Pupation occurs in the spring and early summer, followed by adult emergence. The PFB has one generation per year, but the life cycle may be longer (1-3 years).

The Pacific flatheaded borer has long been known throughout western North America as a native pest of hardwood trees in orchards, urban landscapes, and in the forest (Burke 1929; Furniss and Carolin 1977; and Solomon 1995). It has an extremely wide host range that includes at least 70 forest and other tree and shrub species from 21 plant families. A few examples are alder, apple, apricot, ash, avocado, birch, beech, boxelder, ceanothus, cherry, cotoneaster, currant, elm, English walnut, fig, loquat, mahogany, maple, willow, oak, peach, pear, and plum. Indeed, it was originally described in 1886 from specimens collected on apples in California's Central Valley (Burke 1929). However, in most reports, it had been characterized as an occasional pest on trees with compromised health in a limited number of orchards (i.e., walnuts, almonds, cherries, and plums) (Davis et al. 1968). Burke (1929) suggested that Pacific flatheaded borer does not infest various

black walnuts. The current resurgence and infestation on commercial English walnuts appeared to be much more severe and widespread throughout the walnut growing regions of California. There could be multiple reasons on why is this happening. Walnut production practices have changed with the newer varieties with more dense plantings and small stature trees, clean cultivation practice, and more. Walnut acreage in California has increased by over 60% in the last ten years, meaning a lot more opportunity for flatheaded borer to become residential pest in walnuts. The extreme drought condition that started in 2012 might have impacted tree health while likely favored the borer populations. Overall increase in global temperuature due to the climate change might have created flatheaded borer resurgence issue as increase activities of the borers have been reported in other parts of the U.S. Example includes high borer infestation in hazelnut production in oregon (Wiman et al. 2019), and in nursary, lanscape, and various tree crops across the U.S. (Oliver et al 2019).

Although there are old reports in the literature that mention PFB infestation in fruit trees in California (Burke 1929, Davis et al. 1968, McNelly et al. 1969), there has been a significant lack of basic information related to this pest in California such as seasonal phenology, life history, extent of damage to modern cultivars of walnuts and other crops in general. Our study indicated that PFB beetles begin to emerge from infested branches as soon as May with peak activity in mid-June. This information might have some implications on in-season control of this pest. It is also crucial to identify effective monitoring tools. Our limited study indicated the green color preference by these beetles, and continuous study in exploring potential attractants or trap types will be our research priority for coming seasons.

Infestations of PFB may be reduced by adopting cultural practices that encourage vigorous, healthy plants, although the PFB seems to attack healthy trees (UC IPM Guidelines 2017). Young trees may be protected from sunburn by applying white latex paint or using mechanical covers over the trunk (e.g., trunk guard), although the systematic evaluation of these practices is needed. One of the general practices for these kinds of borers is orchard sanitation, which includes the removal of the weakened, injured, dead, and flagged branches, but the effectiveness and timing of this practice needs to be investigated. Additional future research areas include the role of different types of tree guards, the potential role of orchard factors such as cultivar, age of the orchard, soil type, moisture condition, temperature and drought conditions, weed control, etc. To our knowledge, there is no insecticide registered for this pest in English walnuts in California, and therefore, it is critical to explore various preventative and curative control measures to minimize the impact of this pest in walnut production.

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