New Records and Accounts

First Field Collection of the Rough Sweetpotato Weevil, *Blosyrus asellus* (Olivier) (Coleoptera: Curculionidae), on Hawaii Island, with Notes on Detection Methods

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Abstract. Rough sweetpotato weevil, *Blosyrus asellus* (Olivier) (Coleoptera: Curculionidae), was first detected in the state of Hawaii at a commercial Okinawan sweetpotato farm in Waipio, Oahu, on 14 November 2008. Damage by this weevil species differs from other weevil pests of sweetpotato in Hawaii in that the rough sweetpotato weevil grubs feed on the surface of the sweetpotato root, creating channels on the surface of the root that damage the root and decrease its marketability. Reported here is the first detection of this pest in sweetpotato fields on the island of Hawaii (Pepeekeo), in October 2014, with subsequent documentation in Paauilo (November 2014) and Papaikou (May 2015). Also reported is a trapping system that incorporates a solar powered green light emitting diode (LED) that can be used for detection, and some level of control, of this pest species in the field. Given our experience that a green light trap containing a sweetpotato-based bait has some attraction for the sweetpotato weevil (*Cylas formicarius* [Summers] [Coleoptera: Brentidae]), the West Indian sweetpotato weevil (*Euscepes postfasciatus* [Fairmaire] [Coleoptera: Curculionidae]) and the rough sweetpotato weevil, there is hope that this trap design could also detect the presence of other weevil pests of sweetpotato that might invade Hawaii.

Key words: rough sweetpotato weevil, sweetpotato, *Blosyrus*, green light, detection

Introduction

Rough sweetpotato weevil, *Blosyrus asellus* (Olivier) (Coleoptera: Curculionidae) (Fig. 1), was first detected in the state of Hawaii at a commercial sweetpotato farm growing the purple-fleshed 'Okinawan' sweetpotato in Waipio, Oahu, on 14 November 2008. Damage by this weevil species differs from other weevil pests of sweetpotato in Hawaii in that the rough sweetpotato weevil grubs feed on the surface of the sweetpotato root, creating channels on the surface of the root that damage the root and decrease its marketability (Heu et al. 2014). Rough sweetpotato weevil was subsequently detected at other locations on Oahu, including the Mililani Agricultural Park in Mililani Town, the University of Hawaii Urban Garden Center and Leeward Community College in Pearl City, and in Waiahole and Poamoho. It was also subsequently collected from Akemama/Kipo Road in Lawai on Kauai and from the Na Aina Kai Botanical Garden in Kilauea on Kauai (Heu et al. 2014, Ko

Figure 1. Adult rough sweetpotato weevil, *Blosyrus asellus* (Coleoptera: Curculionidae). Photo by GTM.

and Young 2012). Up until October 2014, it had not been collected from sweetpotato fields on Hawaii island. However, in 2013, in the course of a USDA-APHIS-PPQ-Cooperative Agricultural Pest Survey (CAPS) for sweetpotato diseases and insect pests, Mann Ko (Hawaii Department of Agriculture) noticed feeding marks on leaves and on sweetpotato roots that could possibly have come from rough sweetpotato weevil adults and grubs, respectively, but was not able to recover any specimens. Subsequently, sweetpotatoes were harvested on 3 October 2014 from a sweetpotato variety trial conducted by Susan Miyasaka (University of Hawaii, College of Tropical Agriculture and Human Resources) in Pepeekeo, Hawaii island (Universal Transverse Mercator [UTM] grid: Easting 0279890, Northing 2194637, Zone 05 Q), ("Pepeekeo 1"; 0.0176 ha; 177 m elevation) and extensive damage was found on the harvested roots similar to damage of rough sweetpotato weevil as described by Heu et al. (2014). Adult weevils, though, needed to be recovered from the field to document the presence of the rough sweetpotato weevil. Prior research with the West Indian sweetpotato weevil, *Euscepes postfasciatus* (Fairmaire) (Coleoptera: Curculionidae), had indicated that it responded to green light (Nakamoto and Kuba 2004). It was subsequently discovered that green light could synergistically enhance the response of male sweetpotato weevils, *Cylas formicarius* (Summers) (Coleoptera: Brentidae), to the male lure (*Z*)-3-dodecenyl (*E*)-2-butenoate (McQuate 2014). Consequently, it was thought that a green light trap plus an attractant could be used to detect/recover the rough sweetpotato weevil. Here, we report on detection methods and field recovery of adult rough sweetpotato weevils from that site and from other recently harvested sweetpotato fields in Pepeekeo ("Pepeekeo 2"), Paauilo, and Papaikou, all on Hawaii island (Fig. 2).

Methods

Initial detection. In a first detection attempt, two green light traps were set out on 10 October 2014 at "Pepeekeo 1." Each trap contained a freshly cut sweetpotato root (2.5 x 2.5 x 1.2 cm [L x W x H]) placed inside, on the top of a 30 ml beaker on the bottom of the trap, which kept the root above a soapy water solution (0.1 ml Dawn Ultra dishwashing liquid [Procter & Gamble, Cincinnati, OH] in 100 ml water). The green light trap was a funnel-type trap developed by ISCA Technologies, Inc. (Riverside, CA) that incorporated a green light (wavelength 515–520 nanometers) light-emitting diode (LED) that ran off of a rechargeable battery charged by a solar cell on top of the trap (Fig. 3). The trap had an integrated light sensor so that the light did not turn on until the ambient light

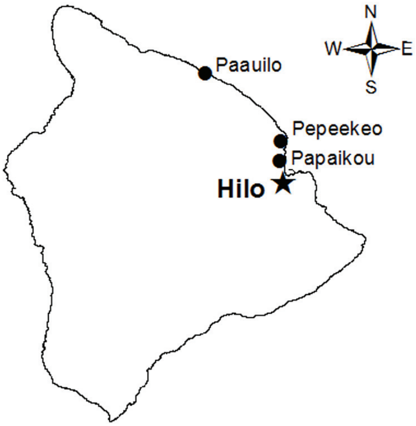

Figure 2. Locations on Hawaii island (marked with filled circles) where adult rough sweetpotato weevils have been recovered (map developed using ArcGIS [ESRI 2012]).

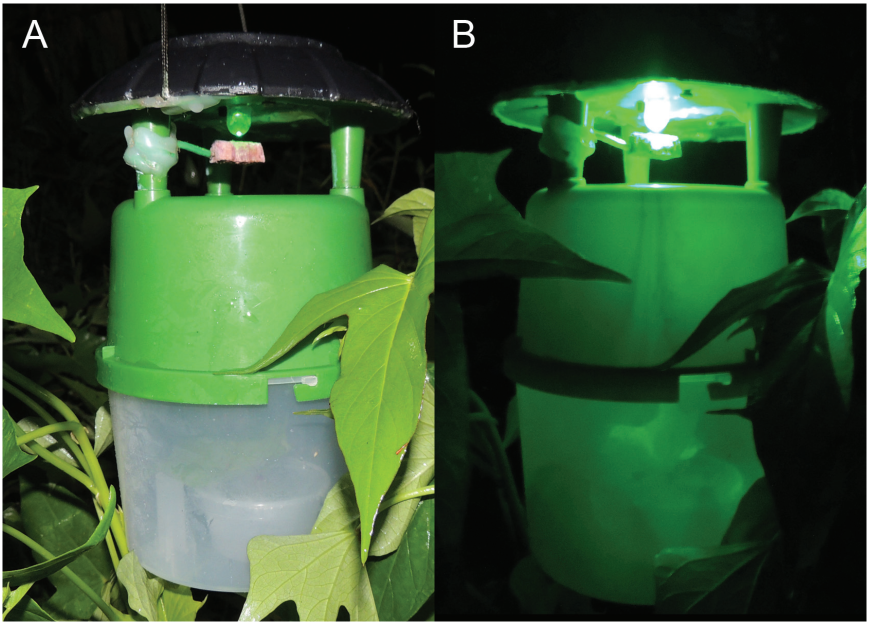

Figure 3. Trap used for rough sweetpotato weevil detection ('Treatment 9'). (A) Flash picture taken at night to show the sweetpotato root section held underneath the green light and the water container inside the trap holding a sweetpotato leaf. (B) Picture taken without flash to show the appearance of the trap at night.

Table 1. Set-up for the nine treatments used in the test of trap set-up for best detection of rough sweetpotato weevil. For traps incorporating a sweetpotato root section and/or a sweetpotato leaf, these were provided fresh at the start of each day of trapping. Additional treatment details are presented in the text.

Treatment no.	Green light	Sweetpotato root section	Sweetpotato leaf in water
1	off	under light	none
2	off	on trap bottom	none
3	off	none	on trap bottom
4	off	under light	on trap bottom
5	on	none	none
6	on	under light	none
7	on	on trap bottom	none
8	on	none	on trap bottom
9	on	under light	on trap bottom

dropped at dusk, then turned off by dawn. The traps were serviced on 14 October 2014.

Assessment of best bait system for rough sweetpotato weevil detection. Because adult rough sweetpotato weevils were recovered in the initial detection trapping described above (recovery detailed in the Results section below), a nine-treatment trapping trial was initiated to identify the best bait system to use in a green light trap for detection purposes. The nine different treatments are characterized in Table 1, with further details presented below: (1) [green light off]; freshly cut root section (averaging 2.5 x 1.2 x 1.0 cm [L x W x H] and 2.5 g) held on a wire just below the green light LED; (2) [green light off]; freshly cut root section at the bottom of the trap; (3) [green light off]; mature sweetpotato leaf (averaging 5.1 by 7.6 cm [L x W]) with petiole inserted in a small container of water (Sweetheart Cup Co., Owings Mills, MD; 30 ml capacity) at the bottom of the trap; (4) [green light off]; freshly cut root section held on a wire just below the green light LED and mature sweetpotato leaf with petiole inserted in a small container of water at the bottom of the trap; (5) [green light on]; no bait in trap; (6) [green light on]; freshly cut root section held on a wire just below the green light LED; (7) [green light on]; freshly cut root at the bottom of the trap; (8) [green light on]; mature sweetpotato leaf with petiole inserted in a small container of water at the bottom of the trap; and (9) [green light on]; freshly cut root section held on a wire just below the green light LED and mature sweetpotato leaf with petiole inserted in a small container of water at the bottom of the trap. The top 2.5 cm on the inside of the bucket of each trap was treated with a band of fluon (Insect-a-slip insect barrier [BioQuip Products, Rancho Dominguez, CA]) to prevent escape of captured weevils. The fluon treatment was used, as opposed to a soapy water solution used previously, both to facilitate placement of a sweetpotato root section at the inside bottom of the trap in two treatments and to facilitate live recovery of trapped weevils.

On each of 10 days (replication was in time, not in space) within the time period 21 October to 6 November 2014, traps having the nine different treatments were deployed, with random positioning, in "Pepeekeo 1" (where vines and roots had both been removed in the harvesting process). On each day of deployment, trap position was re-randomized. Traps were placed directly on the ground and staggered throughout the plot with a 3.7 m inter-trap spacing. Traps were serviced to recover trapped insects 24 hours after deployment.

Additional detection trapping. Detection trapping using Treatment 9 (described above) was initiated at three other recently harvested sweetpotato fields where characteristic rough sweetpotato weevil grub-damaged roots were found. These sites were: "Pepeekeo 2" (UTM grid: Easting 0281244, Northing 2194430, Zone 05 Q; 99 m elevation), "Paauilo" (UTM grid: Easting 0252541, Northing 2219305, Zone 05 Q; 70 m elevation) and "Papaikou" (UTM grid: Easting 0279405, Northing 2187430, Zone 05 Q; 186 m elevation). Trapping at "Pepeekeo 2" was conducted from 30 October to 4 November 2014 (4 traps). Trapping at "Paauilo" was conducted from 10 to 17 November 2014 (5 traps). Trapping at "Papaikou" was conducted from 11 to 15 May 2015 (4 traps)

Statistical analysis. Significance of difference in average adult rough sweetpotato weevil catch per trap per day among treatments was tested by analysis of variance (ANOVA) following square root transformation (sqrt[catch + 0.5]) of catch results, with Tukey HSD used for mean separation (SAS Institute Inc. 2012).

Results

Initial detection. When the traps were serviced on 14 October 2014, a total of 7 adult rough sweetpotato weevils were recovered (specimens from this recovery were positively identified as this species by BRK). Overall, 115 adult rough sweetpotato weevils were recovered from "Pepeekeo 1" spanning from initial detection through testing of trapping designs. Using data only from green light trapping with both the root section under the LED bulb and the leaf in the trap (Treatment 9), catch averaged 5.60 adult rough sweetpotato weevils/trap/day at "Pepeekeo 1." Also recovered from the Treatment 9 traps were 166 sweetpotato weevils (16.6 weevils/trap/day) and 3 West Indian sweetpotato weevils (0.3 weevils/trap/day). It is possible that the catch of sweetpotato weevils may have been elevated somewhat because of possible residue of male sweetpotato weevil pheromone from previous use of the traps.

Assessment of best bait system for rough sweetpotato weevil detection. There was a significant difference in catch among treatments that included green light (Treatments 5–9) ($F = 7.54$; df = 4,45; $p < 0.0001$). Treatments where the green light was off (Treatments 1–4) were not included in the statistical analysis because no rough sweetpotato weevil adults were recovered in any of the treatments where the green light was not allowed to come on at night ("green light off"). Average adult weevil catch in "green light on" traps baited with both a freshly cut root section and a fresh leaf (Treatment 9) was significantly higher than catch in any other trap design (Fig. 4). This trapping was conducted in harvested sweetpotato fields, but we have also been able to recover rough sweetpotato weevils using this trap design in fully vegetated sweetpotato fields (where we hang the trap from a pole so that the light shines just above the sweetpotato foliage and the bottom of the trap is nestled in sweetpotato foliage). An average catch of 2.125 rough sweetpotato weevils/trap/day (range = 0–7) was recorded in fully vegetated 'Okinawan' sweetpotato plantings at "Pepeekeo 1" based on daily trap servicing from 26 to 30 January and from 2 to 6 February 2015.

Additional detection trapping. Rough sweetpotato weevil adults were also recovered in "Pepeekeo 2," "Paauilo,"

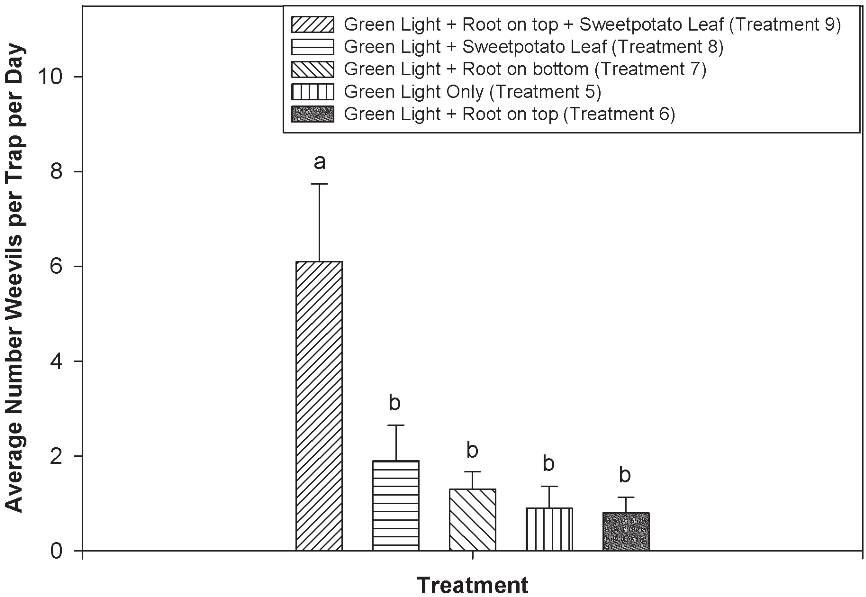

Figure 4. Average (+ SEM) catch of adult rough sweetpotato weevils/trap/day in green light traps with and without added attractant(s). Treatments having the same letter above the error bar are not significantly different at the $\alpha = 0.05$ level. Only results of treatments which included green light (Treatments 5–9) are presented here because there was no catch in this trial in traps of any of the treatments where the green light was off (Treatments 1–4).

and "Papaikou." Species identification of specimens from "Paauilo" and "Pepeekeo 2" were confirmed by BRK. He indicated that typically confirmation ID is not needed beyond the first three recoveries for island records, so specimens from "Papaikou" were not submitted for species confirmation. A total of 57 adult rough sweetpotato weevils was recovered from "Pepeekeo 2" and a total of 17 adult rough sweetpotato weevils was recovered from "Paauilo." Using data only from green light trapping with both the root section under the LED bulb and the leaf in the trap (Treatment 9), catch averaged 7.12 adult rough sweetpotato weevils/trap/day at "Pepeekeo 2" and 0.32 weevils/trap/day at "Paauilo." Subsequent trapping in "Paauilo" (March 2015) using the Treatment 9 trap design, however, produced catches as high as 38.7 rough sweetpotato weevils/trap/day. That, though, was in a high-population area where there was abundant evidence of adult feeding damage (i.e., feeding notches on the edge of leaves). The grower chose to not harvest the roots in the section where these traps were placed because the root damage was too great. Trap catch in "Papaikou" averaged 27.0 rough sweetpotato weevils/trap/day.

Discussion

The presence of grooves or channels on the surface of sweetpotato roots caused by feeding by rough sweetpotato weevil grubs and/or the presence of notches along leaf margins from adult feeding can be indications that the rough sweetpotato weevil is present in a sweetpotato field. However, because the roots are under ground and the adult weevils are primarily night active, it can be difficult to confirm the presence of the weevil. Although adults are primarily night-active, we have been able to find and hand-collect some adult rough sweetpotato weevils on sweetpotato leaves, and on the ground after shaking leaves (and pulling back old decaying leaf litter, leaves and vines), during daylight hours. Weevil recovery through hand-collection seems to be better if collection is done under overcast (cooler) conditions.

Detection of adult weevils, though, is enhanced through use of the trap described herein, and minimizes search time and/or damage to foliage from shaking. All of our catches were made using green light traps. Sometimes catches were made in green light traps that had no lure, but catch was best where the green light trap also had a freshly cut root and a fresh leaf. This is consistent with the hypothesis presented in McQuate (2014) that the green light may serve as a long-distance attractant, but a bait is needed in the trap to lure weevils inside and get capture (in the McQuate [2014] publication, the reference is made to the catch of sweetpotato weevils). Several authors have reported that female sweetpotato weevils are attracted to both root and leaf volatiles (Nottingham et al. 1989, Wang and Kays 2002), while Nottingham et al. (1989) also noted that males are attracted to sweetpotato leaf volatiles, but not root volatiles. Adult rough sweetpotato weevils feed directly on sweetpotato leaves and have also been observed to feed on sweetpotato roots in the laboratory when leaves were not present (CDS unpublished observations). It is interesting to note in the present studies that having elements of both root and leaf present in the trap induces better weevil response than if only one or the other would be present. Both males and females were caught based both on dissections made by BRK on a subset of the trapped weevils and through recovery of viable eggs from some holding containers of field-collected weevils that were supplied with mature sweetpotato leaves held in water.

Although the trapping system described herein can be used to detect rough sweetpotato weevil adults, we are also continuing to conduct trapping trials to identify improved trapping systems for detection, monitoring, and control of this pest species. Thus far, we have completed preliminary tests of some promising attractants which, when used with the green light trap, may lead to enhanced female capture, or at least provide catch comparable to the Treatment 9 trap set-up, but without requiring daily replacement of fresh leaf and root section.

More studies are yet needed of rough sweetpotato weevil basic biology in order to better understand the risk of spreading this species through farmer transport of sweetpotato stem cuttings (used for propagation) and to develop control methods. Identification of detection methods, as presented here, presents a critical component for the development of an integrated pest management system for rough sweetpotato weevils. Other assistive pest management activities include the removal of sweetpotato vines and culled roots from the field after harvest and the application of pesticides. Grubs can continue to feed on roots left in the field and adults can continue to feed on leaves of new sweetpotato sprouts from culled sweetpotato roots or directly on the culled roots. These feeding activities can help build up a rough sweetpotato weevil population that could attack other nearby plantings. Recently published research results have identified some pesticides, registered for weevil control in sweetpotato plantings in Hawaii, that can help in minimizing sweetpotato root damage by rough sweetpotato weevils (Pulakkatu-thodi et al. 2016).

Worldwide, there are 101 named species within the genus *Blosyrus* (Mahendiran and Ramamurthy 2013). Weevil species in this genus have diversified only in the Sub-Saharan Africa and Asia regions. Out of the 101 named *Blosyrus* species, 92 occur in Sub-Saharan Africa, with most species occurring in the Congo (23 species), Tanzania (9 species), Angola (8 species), and India (8 species). *Blosyrus asellus* has been reported in India, Cambodia, Indonesia, Malaysia, and the Philippines (Mahendiran and Ramamurthy 2013). It is certainly hoped that none of the other species in this genus will show up in Hawaii, but given our experience that a green light trap containing a sweetpotato-based bait has some attraction for the sweetpotato weevil, the West Indian sweetpotato weevil and the rough sweetpotato weevil, there is hope that this trap design could also detect the presence of other invading weevil pests of sweetpotato.

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