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There's an app for that: development of a decision support tool for the management of Twolined Spittlebug on Hawaii rangelands

Thorne, MS; [2]Wright, M; [3]Wilson, S; [4]Peck, D; [5]Oshiro, M

[1]Range and Livestock Extension Specialist, University of Hawai´i, thornem@hawaii.edu; [2]Entomology Specialist, University of Hawai´i; [3]Post-Doctoral Fellow, Daniel K. Inouye US Pacific Basin Agriculture Research Center, USDA-Agricultural Research Service [4]Director of International Field Development Post-Doctoral Fellow, Daniel K. Inouye US Pacific Basin Agriculture Research Center, USDA-Agricultural Research Service; Vestaron Corp., [5]Livestock Extension Agent, University of Hawai´i

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Abstract

Twolined spittlebug (TLSB), *Prosapia bicincta*, was detected in Hawaii in 2016 where it had damaged over 2,000 acres of rangeland. Research revealed that TLSB expanded its range to over 178,000 acres in approximately six generations. In highly infested areas, TLSB resulted in nearly 100% die back of key range grasses including Kikuyu (*Pennisetum clandestinum*) and pangola (*Digitaria eriantha*) grasses when nymph densities exceeded 50/m^2. The loss of these important forages provided entry for the establishment of invasive plants including Pamakani (*Eupatorium adenophorum*), wild blackberry (*Rubus* spp.), and fireweed (*Senecio madagascariensis*) among others. These losses forced livestock producers to reduce stocking rates resulting in significant economic losses. Work on a smartphone application to identify, report, and facilitate management of the TLSB started in 2020. The app has four main features. First, an information guide provides an overview of TLSB biology and ecology. Next, the app provides a tool to help users identify TLSB in the field and distinguish it from other, non-pest species. A third tool allows users to report sightings of TLSB. Reports include a geo-referenced picture and basic details about the habitat and geographical location of the pest. The reported data is then captured in a database and displayed on a web-based mapping tool. Users have the option to enter data on TLSB population density and provide estimates on spatial extent and observed damage in their report. Data on TLSB populations is determined by following sampling protocols provided in the fourth tool. This tool allows users to determine the size of the TLSB population, and then, based on the potential damage threshold calculated, select from a series of integrated pest management decisions. It is anticipated that this app will facilitate tracking and documenting the spread of the pest and lead to better pest management decisions for rangeland managers.

Introduction

Twolined spittlebug (TLSB), *Prosapia bicincta* (Say), a pasture and turfgrass pest native to southeastern United States (Shortman et al. 2002, Thompson and Carvalho 2016), was detected in the South Kona district of Hawai´i Island in 2016 (Wilson et al. 2023). The pest negatively impacts rangelands by feeding on important forage grasses (Byers and Wells 1966, Shortman et al. 2002, Wilson et al. 2024). Our research found that between 2017 and 2020 the pest rapidly expanded its range at rate of over 14,000 ha per year and by the end of 2021 occupied over 72,183 ha across the South Kona district in just six generations (Wilson et al. 2023).

The Hawai´i beef industry is economically, culturally, and ecologically important to the state. Over 142,000 head of beef animals are managed across nearly 300,000 acres of rangelands (20% of Hawai´i's land mass) that are managed by over 1,300 ranches. The value of Hawai´i-raised beef cattle is estimated to be more than $48 million annually (USDA-NASS 2022). Over 60% of the beef cattle in the state are raised on the island of Hawai´i where the TLSB currently poses the most significant threat.

In highly infested areas, TLSB resulted in nearly 100% die back of key range grasses including Kikuyu (*Pennisetum clandestinum*) and pangola (*Digitaria eriantha*) grasses when nymph densities exceeded 50/m^2 (Wilson et al. 2023). The loss of these important forages provided entry for the establishment of invasive plants including Pamakani (*Eupatorium adenophorum*), wild blackberry (*Rubus* spp.), and fireweed (*Senecio madagascariensis*) among others. Twolined Spittlebug's rapid rate of spread and devastating impact on important forage grasses in the South Kona district forced livestock producers to reduce stocking rates resulting in significant economic losses.

In 2020 we started development of a smartphone application to provide livestock producers struggling to manage rangelands in the wake of TLSB infestations a decision support tool. The app was designed with four main user portals. The first portal was an information guide that provided an overview of TLSB biology and ecology. Next, the app provided portal to help users identify TLSB in the field and distinguish it from other, non-pest species. A third portal allowed users to report sightings of TLSB. The fourth portal allowed users to determine the size of the TLSB population, and then, based on the potential damage threshold calculated, select from a series of integrated pest management decisions.

The user reporting portal was designed to facilitate tracking TLSB infestations and distribution. User reports included a geo-referenced image of TLSB nymph or adult, and basic details about the habitat and geographical location of the pest. Users also had the option to enter data on TLSB population density and provide estimates on spatial extent and observed damage in their report. The reported data was then captured in a database and displayed on a web-based mapping tool that was managed by the TLSB research team and yielded important information on the distribution and intensity of infestations, as well as early detection of incipient TLSB populations.

Methods

The purpose of the Twoline Spittlebug (TLSB) smartphone (mobile) application was twofold. First the app would provide a mechanism for users to report positively identified sightings of the pest to the TLSB research team (reporting tool). This information would assist researchers in understanding and mapping the distribution and density of TLSB populations, intensity of infestations, and early detection of incipient infestations. The second intent of the TLSB mobile app was to provide the user, and specifically, affected land managers, information on TLSB habitat, biology, and ecology (information tool), a means of proper identification (identification tool), and a decision support tool for the management of TLSB infestations.

We desired the TLSB mobile application to be available to users on both Android and Apple smartphones. When considering options for programming of the mobile application software we evaluated the advantages and disadvantages of three options: 1) University of Hawaii-Manoa computer science student led development; 2) in-house University of Hawaii-Manoa Informational Technology led development; and 3) professional smartphone application company development. Although the more expensive option ($33,024 mobile app programming, $8,192 administrative website development), the complexity of the mobile application functions we envisioned led us to select working with a professional mobile application software company (Zco Corporation, 58 Technology Way, Suite 2W10, Nashua NH 03060). Static and dynamic data content for the four mobile application portals (information, identification, reporting, and management decision support) were developed from our research on the ecology, biology, and impact of the TLSB on Hawai´i rangelands (Wilson et al. 2023, Wilson et al. 2024). Development of the mobile application began in August of 2020 and was completed in September of 2022.

Information Portal

The purpose of the TLSB mobile application information portal was to provide users with basic information on the habitat, biology and ecology of the pest. This information was static within the mobile application. The information in this portal included background information on the three species of spittlebugs found in Hawai´i including the Twolined Spittlebug, Meadow Spittlebug, and Sunflower Spittlebug. Only the TLSB causes significant damage to Hawai´i rangeland grasses thus recognition of the differences between the spittlebug species are critical to proper management decisions for the control of TLSB. Additionally, the information portal provided users with a general description and development of the three life stages of TLSB (egg, nymph, and adult). The biology and ecology of these three life stages are critical to successful management of the pest in Hawai´i rangelands. Pictures of the three spittlebug species, TLSB life stages, and damage from the pest were provided for visual reference for the user. Finally, links to the other portals (identification, reporting, and management decision support) were provided to guide the user on the use of the mobile application.

Identification Portal

The purpose of the pest identification portal was to provide a process through which the user could positively distinguish TLSB from the other two species of spittlebug found in Hawai´i, and through a positive identification of TLSB, provide an accurate report through the mobile application reporting portal. The identification portal was designed using static information organized as a dichotomous key to guide the user in evaluating spittlebug specimens in the field following Thorne et al. 2022.

Reporting Portal

The purpose of the reporting tool was to provide users a mechanism to report sightings of TLSB that could be verified and mapped providing researchers with critical data on the pest distribution, infestation intensity, and early detection of incipient populations, and provide feedback to users of the mobile app on the distribution and spread of the pest on lands they manage.

The reporting portal was designed to provide a geo-referenced data and picture cache of sightings of adult and/or nymphs by application users. Data collected included a geo-referenced photograph and descriptive information, date, time, and location description of reported sightings. Reported data were cached in an administrative website database and used to verify and map sightings. The map generated was viewable on the administrative website public facing map minus personal/landowner identification information.

Management Decision Support Portal

The purpose management decision support portal was to provide information to the mobile app user, and particularly those landowners affected by TLSB, a decision supported process to assess the level of damage and take economically feasible management actions. Static and dynamic information and data were used in the development of the portal functions with most being created specifically for the functionality of the management decision support portal or modified from existing information. Static information included descriptions of sampling protocols to guide users in determining nymph population densities and/or adult abundance, integrated pest management protocols, and monitoring guidelines for TSLB free areas, known areas of TLSB activity, and areas recovering from TLSB damage. Dynamic data included a scale for determining nymph age class, calculators for quantifying average nymph density by age class or adult abundance, a selection tool to estimate the percentage of area affected (0-25%, 26-50%, 51-75%, or 76-100%), and a cell to enter the total acreage of land affected. Sampling and monitoring protocols, based primarily on quantifying TLSB nymph densities and adult abundance were modified for the mobile application from field sampling protocols described by Wilson et al 2023.

Results and Discussion

Nymph Density by Age Class and Damage Threshold Rating

Assessment of the five TLSB instar stages indicated that the stage one and two, and three and four, could be combined into two age classes based on sharp distinctions in width and length (Table 1). Instar five, comprised a single and final age class for nymph development toward adulthood. Approximate days to adulthood, by age class was derived based on a 50-day egg to adult development of the nymphal stage and divided across the three age classes (Table 1). A tool within the mobile application assists the user in determining age class. The count of nymphs per age class are then input into an in mobile application calculator that yields an average nymph density by age class.

Field data relating nymph densities to observed pasture damage following adult emergence (Wilson et al. 2023, Wilson et al. 2024) were classified as light (< 10 nymph/m^2), medium (11-59 nymph/m^2), and critical (> 60 nymph/m^2) based on expected forage loss. These data were combined with the nymph density by age class and expected days to adult hood to derive a Damage Threshold Rating Scale (Table 2). Damage ratings (1-3) were linked to specific IPM recommendations.

Table 1. Twolined Spittlebug Age Classes (1, 2, or 3) with dimensions and expected days to adulthood.

Age Class	Age class dimensions (mm)		Approximate Days Expected to Adult
	Width	Length	
1	< 0.6 mm	< 2.1 mm	More than 35 days
2	1.0 -1.4 mm	2.1-5.2 mm	Between 15 and 35 days
3	>1.5 mm	> 5.3 mm	Within 15 days

Note: Approximate Days Expected to Adult assumes an average 50 days from egg hatch to adult and an even development rate of 10 days between instar stage and selected to be the half-way point between classes in days.

Table 2. Age Class distribution and Expected Days to Adult by Nymph Density estimates in relation to Potential Future Damage. Yellow (damage level 1) light to moderate forage loss; Orange (damage level 2) moderate to heavy forage loss; Red (damage level 3) heavy to catastrophic forage loss.

Age Class	Nymph Density/Potential Future Damage			Expected Days to Adult
	< 10/ m2	11-59/m2	> 60/m2	
1	1	2	3	More than 35
2	1	2	3	15-35
3	2	3	3	Within 15

Integrated Pest Management Strategies

Integrated Pest Management practices for the control of TLSB in Hawaii rangelands includes intensive grazing management and strategic applications of recommended pesticides. With increasing damage from adult TLSB feeding, additional measures include using herbicides to control emerging weeds, and reseeding with TLSB resistant forages. Recommendations on specific IPM measures to employ depend on the expected level of impact and progress from intensive grazing management (applied for damage ratings 1-3), strategic pesticide applications (applied for damage ratings 2-3), to weed management and seeding TLSB resistant grasses (applied at damage rating 3). Within the mobile application, the user is directed to a specific IPM recommendations depending on the calculated damage rating from their input data.

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