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Effect of trap color and height on captures of blunt-nosed and sharp-nosed leafhoppers (Hemiptera: Cicadellidae) and non-target arthropods in cranberry bogs

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ABSTRACT

A series of field experiments was conducted in cranberry bogs in 2006–2010 to determine adult attraction of the two most economically important leafhopper pests of cultivated *Vaccinium* spp. in the northeast USA, the blunt-nosed leafhopper, *Limotettix vaccinii* (Van Duzee), and the sharp-nosed leafhopper, *Scaphytopius magdalensis* (Provancher), to colored (yellow, green, red, blue, white, and clear) sticky traps. We also determined the effects of trap height on insect captures, evaluated trap color characteristics (i.e., reflectance spectra, and red, green, and blue RGB values) for maximizing leafhopper capture while minimizing beneficial arthropod capture, and correlated within-season adult leafhopper captures from traps with nymphal captures from sweep nets. Leafhopper species exhibited distinct preferences to particular colors differing in intensities along a spectrum of wavelengths and RGB values: green was the most attractive color to blunt-nosed leafhoppers, followed by red and yellow; while yellow was most attractive to sharp-nosed leafhoppers, followed by green and red. Attraction of leafhoppers to other colors was similar to clear. Most insect predators (e.g. lady beetles, hoverflies, and minute pirate bugs), parasitic wasps, and honey bees also exhibited preferences to particular trap color characteristics, whereas green lacewings and spiders did not. An effective attraction radius was calculated for each color of trap and species. Additionally, we measured mean ± SD of flight heights of several species and showed that more leafhoppers and hoverflies were captured on red and yellow traps placed 0.1 m above the canopy; while captures of lady beetles were highest on traps placed 0.5 m above the canopy. Numbers of adult leafhoppers on traps were largely uncorrelated with numbers of nymphs in sweep net samples, except for blunt-nosed leafhoppers captured on red traps which were positively correlated with sweep net counts. We discuss the potential of using colored sticky traps to monitor leafhopper populations in the context of their non-target species effects in cranberries.

1. Introduction

Two leafhoppers (Hemiptera: Cicadellidae), the blunt-nosed leafhopper, *Limotettix* (=*Scleroracus*) *vaccinii* (Van Duzee), and the sharp-nosed leafhopper, *Scaphytopius magdalensis* (Provancher), are commonly found in cranberries, *Vaccinium macrocarpon* Ait., in the northeast USA (Beckwith and Hutton, 1929a,b; Averill and Sylvia, 1998). These leafhoppers feed on cranberry stems and leaves, which can cause loss of sap material; but this injury is rarely noticeable and its economic impact has yet to be determined (Beckwith and Hutton, 1929b). Besides damage caused by direct feeding and perhaps more importantly, these leafhoppers are vectors of diseases of wild and cultivated *Vaccinium* spp. (Chen, 1971). The blunt-nosed leafhopper is of particular economic importance to cranberry growers because it vectors a phytoplasma that causes false blossom disease (Beckwith and Hutton, 1929b; Dobroscky, 1931; Wilcox and Beckwith, 1935; Chen, 1971). This disease almost destroyed the cranberry industry in New Jersey (USA) in the 1920s (Averill and Sylvia, 1998). Conversely, the sharp-nosed leafhopper does not transmit false blossom (Dobroscky, 1931), but transmits a similar phytoplasma that causes stunt disease in blueberries, *Vaccinium corymbosum* L. (Tomlinson et al., 1950; Hutchinson, 1955; Chen, 1971). However, blueberry stunt disease is of no economic importance in cranberries (Averill and Sylvia, 1998).

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In New Jersey, the blunt-nosed leafhopper can complete one generation a year in cranberries, while the sharp-nosed leafhopper can complete two generations a year. Both species overwinter as eggs. The overwintered eggs hatch in May, and nymphs go through five instars (Beckwith and Hutton, 1929a; Dobroscky, 1931; Averill and Sylvia, 1998). Blunt-nosed leafhopper adults appear in early July and remain active until early August; eggs are laid mostly at the end of July and in August. First- and second-generation sharp-nosed leafhopper adults appear from mid-June into July and from mid-August into September, respectively.

Leafhoppers are difficult insects to monitor in cranberry bogs. Historically, monitoring for leafhoppers in cranberries has relied on sweep net sampling (Beckwith and Hutton, 1929a,b; Franklin, 1935). However, monitoring leafhoppers using sweep nets is challenging for cranberry growers because samples are typically taken only prior to bloom of cranberry (i.e., month of May in New Jersey), and then discontinued due to potential damage to flowers and fruit (Averill and Sylvia, 1998). Prior to bloom, only leafhopper nymphs are present in cranberry bogs, and using sweep nets to monitor immature leafhoppers is problematic because of their small size, which often requires bringing the samples to a laboratory for processing under a microscope. Although adult leafhoppers are more easily recognized from sweep net samples, they are mostly active after bloom (i.e., July–August in New Jersey) when sweep net samples have been discontinued. Furthermore, blunt-nosed leafhopper adults are the most mobile stage and more likely than nymphs to spread false blossom disease among cranberry bogs; it also remains poorly known to what extent immatures can transmit the disease. Thus, developing an alternative sampling technique that can be used to monitor adult leafhoppers, as opposed to nymphs, and that can be easily adopted by growers will improve current IPM practices in cranberries.

Colored sticky traps may be a sampling technique acceptable to cranberry growers for monitoring adult leafhoppers. These traps have been commonly used to monitor insect pests in agricultural fields (Prokopy, 1975; Cross et al., 1976; Prokopy and Owens, 1983; Meyerdirk and Moreno, 1984; Knight and Miliczky, 2003; Atakan and Canhilal, 2004), including leafhoppers (Alverson et al., 1977; Meyerdirk and Oldfield, 1985; Todd et al., 1990a,b; DeGooyer et al., 1998; Lessio and Alma, 2004). Most critical, these traps are very useful when pheromone traps are unavailable or when use of other sampling methods can damage the crop; which is the case for leafhoppers in cranberries. Yellow, in particular, is effective for capturing leafhoppers (Ball, 1979; Van Steenwyk et al., 1990; Mensah, 1996; DeGooyer et al., 1998; Demirel and Yildirim, 2008). In fact, yellow sticky traps are regularly used to monitor populations of the sharp-nosed leafhopper in blueberries (Tomlinson et al., 1950; Hopkins and Johnson, 1984; Meyer and Colvin, 1985). However, the potential of using colored sticky traps for monitoring blunt-nosed and sharp-nosed leafhoppers in cranberries has yet to be explored. In addition, trap height can affect the number of leafhoppers captured (Meyer and Colvin, 1985; Van Steenwyk et al., 1990; DeGooyer et al., 1998; Atakan and Canhilal, 2004; Pilkington et al., 2004); thus, height is an important factor that needs to be considered when monitoring with these traps. Because color can also influence the foraging behavior of natural enemies of pests (Maredia et al., 1992; Blackmer et al., 2008; Roubos and Liburd, 2008) and pollinators (Clare et al., 2000; Knight and Miliczky, 2003; Roubos and Liburd, 2008), attraction of these beneficials to colored traps needs to be addressed to minimize non-target effects.

The main objective of the present study was to develop a sticky trap sampling technique for leafhopper adults in cranberries. Specifically, we conducted field experiments in 2006–2010 in commercial cranberry bogs to: 1) examine the response of blunt-nosed and sharp-nosed leafhopper adults to colored sticky traps; 2) monitor the response of key natural enemies [e.g. lady beetles (Coleoptera: Coccinellidae), hoverflies (Diptera: Syrphidae), green lacewings (Neuroptera: Chrysopidae), minute pirate bugs (Hemiptera: Anthocoridae), spiders (Araneae), and parasitic wasps (Hymenoptera)] and honey bees, *Apis mellifera* L. (Hymenoptera: Apidae), to these traps in order to identify traps that are selective to leafhoppers, our target pest; 3) determine the effect of trap height on insect captures; and, 4) evaluate the effectiveness of commercially-available yellow sticky traps in capturing blunt-nosed and sharp-nosed leafhopper adults in relation to sweep net sampling.

2. Materials and methods

2.1. Colored sticky traps

Three field experiments were performed in separate years to examine the attraction of blunt-nosed and sharp-nosed leafhoppers to different color traps. All sites were cranberry bogs [a "bog" is a wetland with high water table and high acidic organic matter; because cranberries in New Jersey are grown in wet, marshy areas with acidic, sandy soils, these are called bogs (other terms include beds or marshes)] of at least 0.5 acres (0.202 ha), located in Burlington Co., New Jersey, selected based on prior history of leafhopper infestation. These sites had no broad-spectrum insecticides applied throughout the growing season.

2.1.1. Trap description

Colored sticky traps were made of 4 mm-thick flat Plexiglas (Laird Plastics; Bristol, PA, USA). Five or six colors were tested each year for attraction (see below). Traps were coated on both sides with sticky polymers (Tangle-Trap® Insect Trap Coating; The Tanglefoot Company, Grand Rapids, MI, USA), and attached horizontally with 2 screws to the top ends of 40-cm high metal poles. Poles were buried in fields such that trap bottoms were ~10 cm above the ground, i.e., just above canopy height.

2.1.2. 2006 experiment

This experiment was conducted in two commercial cranberry farms (Chatsworth, New Jersey) (farm A: Latitude 39.74°N, Longitude −74.43°W; farm B: Latitude 39.68°N, Longitude −74.49°W) from 7 June to 26 July 2006, to coincide with peak adult leafhopper flight activity. Five colors representing a wide wavelength range were tested for attraction: red (a mimic for cranberry fruit or that of senescing foliage; Cat. no. 2157; Laird Plastics), blue (a blueberry fruit mimic; Cat. no. 2114), green (a mature leaf mimic; Cat. no. 2108), yellow [a young leaf mimic or a color associated with insect or pathogen infestation; yellow traps were made by painting colorless clear Plexiglas with bright yellow (Painter's Touch multipurpose latex paint, Rust-oleum Corporation, Vemon Hills, IL, USA)], and white (a flower mimic; Cat. no. 3015). Traps were 20.5 cm (horizontal) × 30.5 cm (vertical) rectangles. Each set of five traps, one of each color, was replicated 7 times in a randomized complete block design, and blocked by site. Traps within each block were placed at least 10 m apart from each other, 20 cm away from the bog edge, following a straight-line arrangement, and rotated weekly to randomize their position relative to other traps, such that no trap of a particular color was placed in the same position twice during the experiment.

2.1.3. 2009–2010 Experiments

These experiments were conducted in two commercial cranberry farms from 26 June to 31 July (2009) and 28 June to 2 August (2010) [the farm used in the 2009 experiment was located in Chatsworth, New Jersey (farm A), while the farm in the 2010 experiment was located in Pemberton, New Jersey (farm C; 39.94°N, −74.48°W)] and