UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

UC PLANT PROTECTION QUARTERLY

JANUARY 2006 VOLUME 16, NUMBER 1

Available online: www.uckac.edu/ppq

This newsletter is published by the University of California Kearney Plant Protection Group and the Statewide IPM Program. It is intended to provide timely information on pest management research and educational activities by UC DANR personnel. Further information on material presented herein can be obtained by contacting the individual author(s). Farm Advisors and Specialists may reproduce any portion of this publication for their newsletters, giving proper credit to individual authors.

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This material is based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project section 3(d), Integrated Pest Management

POTENTIAL NEW INSECT PESTS OF FORAGE CROPS IN CALIFORNIA.

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Key Words: forages, alfalfa, corn, cereals, exotic insect pests, pest introductions

Abstract

California provides an ideal habitat for many exotic invasive species. Forage crops are particularly susceptible to exotic pests due to their year around abundance and, in crops such as alfalfa, a relatively stable environment over several years. While a number of exotic pests arrive from off shore locations, California is surrounded by a number of serious pest species in adjacent states which could invade at any time. In addition, some species, present for many decades without causing injury, have suddenly become serious pests.

Introduction

California, with its mild Mediterranean climate, provides a perfect habitat for many exotic invasive species. It is estimated that a new invasive pest has arrived in California every 2 months during the past decade (Dowell 2002). An examination of the origin of the major alfalfa pests in California provides an interesting example of this. Fully 75% of the alfalfa pests requiring routine insecticide application originated from other areas of the world (Table 1).

IN THIS ISSUE

Table 1. Region of origin of the major insect pests of forage alfalfa in California.

Insect	Country/Region of Origin	Reference
Egyptian Alfalfa Weevil	Middle East	Wood et al. 1978
Blue Alfalfa Aphid	Asia	Blackman & Eastop 1984
Spotted Alfalfa Aphid	Middle East	Blackman & Eastop 1984
Pea Aphid	Paleartic Region (Cool)	Blackman & Eastop 1984
Cowpea Aphid	Paleartic Region (Warm)	Blackman & Eastop 1984
Beet Armyworm	Southeast Asia	Capinera 2004
Alfalfa Caterpillar	Native to California	Davis et al. 1979
Western Yellow Striped Armyworm	Native to Western North America	Hagen 1990

Currently, upwards of 7-8 species injurious to forages are poised to enter California at any time. In fact, some have been found in the state on numerous occasions and eradicated (Japanese Beetle (*Popillia japonica* Newman) while others, although found here in limited numbers, have apparently not become established (*Peregrinus maidis* Ashmead, maize planthopper). Others, such as European corn borer [*Ostrinia nubilalis* (Hubner)] and cereal leaf beetle [*Oulema melanopus* (L.)] are well established in neighboring states and could enter California at any time. In addition to newly introduced pests, some insects of long term residence in California that have never caused economic injury have suddenly become serious pests. Examples of these include the cowpea aphid, *Aphis craccivora* Koch, and the three cornered alfalfa hopper, *Spissistilus festinus* (Say). A third group consists of organisms that were at one time serious pests, but because of changes either in culture or in the crops grown, have become less serious over the years. Re-establishment of some of these crops could result in a resurgence of these pests. They include the sorghum midge, *Contarinia sorghicola* (Coquillett), and greenbug, *Schizaphis graminum* (Rondani).

Pests not known to be established in California

European Corn Borer. — *Ostrinia nubilalis* (Hubner) (Lepidoptera: Pyralidae). European corn borer is one of the most destructive pests of all types of corn in the U. S. It attacks over 250 other crops including sorghum, cotton, sugar beets and many vegetables (Capinera 2000). Damage is done by the larvae. http://www.ent.iastate.edu/pest/cornborer/images European corn borer is currently restricted to areas east of the Rocky Mountains (Fig. 1)

Figure 1. Distribution of the European corn borer.

Initially, larva feed in the whorls but, as the plant develops, larvae tunnel into the stalk and other structures such as cobs and ear shanks. Damage and yield loss result from leaf feeding, midrib feeding, stalk tunneling, leaf sheath, collar feeding and ear damage (VanDyk 1996). Tunneled stalks are extremely susceptible to lodging and tunneling in the ears and ear shanks may result in excessive ear loss. See http://www.ent.iastate.edu/pest/cornborer/images

Western Corn Rootworm. — *Diabrotica virgifera* LeConte (Coleoptera: Chrysomelidae). Western corn rootworm is primarily a pest of corn. Damage is done by the larvae, but some injury can be caused by the adults. The larvae are white slender worms with yellowish-brown heads and have three pairs of thoracic legs. The adult western corn rootworm is yellow and brown with brown stripes on the elytra. See http://www.nysaes.cornell.edu/ent/factsheets/pests/wcrw.html

Western corn rootworm is getting dangerously close to California (Fig. 2). In the western U. S., Western corn rootworm overwinters as eggs deposited in the soil. The most obvious damage symptom from corn rootworm feeding is "goose-necking" http://www.kingstonfeedandfarm.com/2003TFT7.htm of the more mature plants caused by larvae pruning the roots (Patrick & Stewart 2005). As the roots are pruned, the plants tend to fall over and the goose-necking occurs as they then grow upright again.

Figure 2. Distribution of the western corn rootworm in the western United States.

Cereal Leaf Beetle. — *Oulema melanopus* (L.) Coleoptera: Chrysomelidae. Cereal leaf beetle is a pest of small grains and grasses with oats, barley and wheat as preferred hosts (CDFA 2005a). It may also feed on corn (Parkinson et al. 2001). In California, all cereals, corn and winter forage are at risk. Damage incurred by feeding of both the adults and larvae can be substantial although adult feeding rarely causes economic losses. Mature larvae appear similar to slugs. Their integument (skin) is yellowish-brown and the body is covered with a mass of slimy, dark fecal material which protects the larvae from predators and parasitoids. This material rubs off on the clothing of individuals working in the field (Parkinson et al. 2001, Blodgett & Tharp 1999). This characteristic may be useful in spotting infestations. The adult beetle is approximately ¼ inch long with a metallic blue head and elytra (wing covers), red pronotum (thorax) and yellowish-orange legs. http://info.ag.uidaho.edu/Resources/PDFs/CIS0994.pdf

Cereal leaf beetle is currently found in much of the western U. S. (Fig. 3). Cereal leaf beetle overwinters as an adult in grass and debris, under bark or in woody or brushy locations (Parkinson et al. 2001). They appear to select shelter similar to adult Egyptian alfalfa weevils. Following emergence in the spring, they lay eggs singly or in small groups on the upper leaf surface near the mid-rib. Larvae feed on the upper leaf surface between veins removing all leaf material down to the lower cuticle resulting in an elongated "windowpane" in the leaf (Blodgett & Tharp 1999). Severely damaged fields appear "frosted".

Figure 3. Distribution of the cereal leaf beetle in the western United States.

Japanese Beetle. — *Popillia japonica* Newman (Coleoptera: Scarabaeidae). Japanese beetle is one of the most destructive insects ever introduced into the U. S. It has a host range of over 300 different plant species, many of which are important agricultural crops. Among the forages, crops such as alfalfa, clovers, corn, pasture and beans are favorite hosts (CDFA 2003, APHIS 1998). Japanese beetle, while not established in California, is found here on a routine basis. In 2004, Japanese beetles were trapped in Sacramento, Alameda, Fresno, Kings, Los Angles, San Bernardino, and San Diego counties.

The larvae (grubs) occur underground where they feed on the roots. Young plants are usually killed. The larvae are typical white grubs. The adults are skeletonizers; they eat the leaf tissue between the veins. The leaf looks like lace and soon withers and dies (Shetlar 2000). Adults are a brilliant, metallic green color (thorax) and the wing covers (elytra) are a copper-brown color. The abdomen has a row of five tufts of white hairs on each side which are diagnostic of the species (Shetlar 2000). See http://www.pueblo.gsa.gov/cic_text/housing/japanese-beetle/jbeetle.html Aircraft inspection discovered Japanese beetle adults in Sacramento, San Joaquin, Alameda, Santa Clara, San Mateo, San Francisco, Fresno, Los Angeles, San Bernardino, Orange, and San Diego counties during 2004 (CDFA 2005b). Japanese beetle has been eradicated from California (Sacramento and San Diego counties) several times in the past few years.

Maize Planthopper. — *Peregrinus maidis* (Ashmead) (Homoptera: Delphacidae). The maize planthopper has greater significance as a disease vector than as a pest in its own right. It is the vector of maize stripe virus and maize mosaic virus, two serious diseases of corn. The adult planthoppers are yellowish-brown with darker brown markings along the edges of the body segments. See http://www.ars.usda.gov/is/graphics/photos/may05/D083-1.htm The maize planthopper is established in Florida and Hawaii (CDFA 2005b). In 2004, one specimen of *P. maidis* was found in Los Angeles County (CDFA 2005b). It is not known if the maize planthopper has become established in California.

Southwestern Corn Borer. — *Diatraea grandiosella* Dyar (Lepidoptera: Pyralidae). Southwestern corn borer occurs across much of the southwest and southern plains (Fig. 4). It occurs throughout much of Arizona and is present in the Yuma area, just across the border from California. It attacks a few species of wild or cultivated grasses, with corn as its primary host (Chippendale & Sorenson 1997). http://www.ent.iastate.edu/imagegal/lepidoptera/swcb The larvae overwinter in cells in the stalk crown of the plants (Chippendale & Sorenson 1997). Its habits are similar to that of European corn borer, feeding in the whorl and tunneling into the stalk. Feeding reduces plant vigor and ear production may be retarded due to limited uptake of water and nutrients. As larger larvae tunnel into the stalk, the weakened stalks are more prone to lodging making harvesting more difficult.

Lucerne Leaf Beetle. — *Gonioctena fornicate* Brüggemann (Coleoptera: Chrysomelidae). This leaf beetle is one of the most serious pests of alfalfa in some parts of Europe. In addition to alfalfa, this insect attacks black medic and clover. In many cases, the larvae have caused complete crop loss (Pest Alert 2001). With only a cursory glance, the adult may easily be mistaken for a Coccinelid (lady bird beetle). http://www.pestalert.org/Detail.CFM?recordID=58 The larvae are yellowish to orange with black spots. *Gonioctena fornicate* has been consistently detected in the U. S.

Figure 4. Distribution of the southwestern corn borer in the western United States.

Insects currently established in California which are emerging as pests.

This group of insects has been established in California for a number of years. These insects are commonly found in various crops, but normally have never been major pests. For reasons as yet poorly understood, many of them appear to have suddenly become pests of economic importance in various locations throughout the state.

Soldier Blister Beetle. — *Tegrodera* spp., *Lytta* spp. (Coleoptera: Meloidae). Blister beetles are narrow and elongated and the covering over the wings is soft and flexible. They may be solid colored (black or gray) or striped (usually orange or yellow and black) and are among the largest beetles likely to be swept from alfalfa. http://elib.cs.berkeley.edu/cgi/img_query?query_src=&enlarge=1335+3153+0214+0048 Blister beetles contain a chemical, cantharidin, which is toxic to livestock. Cantharidin is contained in the hemolymph (blood) of the beetles and may contaminate forage directly by beetles killed during harvest and incorporated into baled hay, or indirectly by transfer of the hemolymph from crushed beetles onto forage. Blister beetles have been a serious problem in alfalfa in the northern United States, the mid-west and the south for many years, but until recently have not been a problem in California. Alfalfa contaminated with blister beetles in the extreme southern Owens Valley has been linked to the death of several dairy cows. At this point, it is not known if blister beetles are widespread or confined to the Owens Valley.

Three Cornered Alfalfa Hopper. — *Spissistilus festinus* (Say) (Homoptera: Membracidae). The three cornered alfalfa hopper is commonly found in desert alfalfa where it has bordered on being a pest for several years. During the fall of 2005, it appears to have reached that status in the low desert and Palo Verde valley. Sweep net samples (2005) show populations of 29 adults per 20 inch sweep. (i.e. The sweep net is in contact with alfalfa over a 20 inch arc. While also commonly found in the Central Valley it is not considered a pest although numbers in the San Joaquin Valley have increased substantially in recent years, but still only average only 2-3 per 180º sweep. Adults are light-green, thick-bodied, triangular insects about ¼ inch long. http://homepages.ius.edu/RHUNT01/research/PicFiles/Spissistilus.jpg Nymphs are grayish-white, soft bodied, with saw-toothed spines on their backs. http://insects.tamu.edu/images/insects/common/images/a-txt/aimg85.html Populations build up in the spring and persist into the fall. Adult female treehoppers girdle stems by depositing eggs, causing the stem and leaves to turn red, purple or yellow above the girdle.

Cowpea Aphid. — *Aphis craccivora* Koch (Homoptera: Aphididae). Cowpea aphid is the newest aphid pest of alfalfa in California. It is easily distinguished from the other alfalfa aphids since it is the only black aphid found in alfalfa. Individuals may be shiny black or a dull, slate black in color. They have white legs with dark bands at the joints. http://www.ipm.ucdavis.edu/PMG/A/I-HO-ACRA-AD.004.html Although cowpea aphid has historically been present in alfalfa for many years in very low numbers, it rarely, if ever, has reached population levels that cause damage or yield loss. However, during the winter and spring of 1998, elevated populations of cowpea aphid were common in alfalfa in the low desert (Imperial County) and were also found in higher than normal numbers in the high desert (San Bernardino, Riverside and Los Angeles counties). By the fall of 1999, cowpea aphid was found infesting alfalfa throughout the Central Valley from Kern to Glenn County. During the summer of 2000 it was found throughout the intermountain counties of Shasta, Siskiyou and Modoc.

Like the spotted alfalfa aphid, cowpea aphid injects a very powerful toxin into the plant during feeding and under severe aphid pressure, cowpea aphids can kill plants. Cowpea aphid is a prolific honeydew producer and the alfalfa becomes sticky and covered with sooty molds at relatively low aphid densities.

Pea Aphid—Pink Biotype. — *Acyrthosiphon pisum* (Harris) (Homoptera: Aphididae). On 13 May, 2005 the pink biotype of the pea aphid was discovered in an alfalfa field at the Kearney Research and Extension Center, Parlier, Fresno County, California. This is the first report of its occurrence in California. The pink biotype is identical in appearance to the green biotype except for the color. http://www.ipm.ucdavis.edu/TOOLS/KEYAPHID/peapink.html In addition to alfalfa, the pink biotype has been found on several species of clover in other parts of the U. S. and thus clover in California may also become infested. In some cases, clover appears to be a better host than is alfalfa.

The pink biotype apparently differs from the green biotype in a number of important ways. Several studies have suggested that the pink biotype shows signs of partial resistance to the parasitoid *Aphidius ervi* Haliday (Li et al. 2002). The pink biotype may also circumvent some of the pea aphid resistance bred into many alfalfa cultivars. The pink biotype was readily recovered in surveys conducted in Fresno, Kings, and Tulare counties (Summers 2005). It has also been reported from Yolo and Sacramento counties (Rachael Long, Jodi Azulai: Personal Communication).

South American Bean Thrips. — *Caliothrips phaseoli* (Hood) (Thysanoptera: Thripidae). This is another insect that has become more important in recent years and has been implicated in causing injury in alfalfa, particularly in the low desert and Palo Verde valley (Mike Rethwisch, personal communication) and treatments have been necessary on seedling stands (Natwick 2002). Adult bean thrips are black with white bands on the wings while the nymphs are yellow with pinkish or reddish markings. http://www.viarural.com.ar/viarural.com.ar/agricultura/frutales/plagas/caliothrips-phaseoli01.htm Feeding by bean thrips results in whitened areas on the tops of the leaves as a result of chlorophyll removal (Rethwisch 2004). There are also copious small dark deposits of fecal material (Rethwisch 2004). Damage caused by the feeding of bean thrips should not be confused with feeding by the western flower thrips, *Frankliniella occidentalis* (Pergande) which general results in leaf distortion. While the former species has been shown to cause economic injury and in some cases requires chemical intervention, the latter species has never been shown to cause significant damage. This points up the necessity of being sure of the identity of the insect present before making decisions on control measures.

Ground Mealybug. — *Rhizoecus kondonis* Kawana (Homoptera: Pseudococcidae). The ground mealybug feeds on alfalfa roots and can cause severe damage to alfalfa. The insect is a small, white oval shaped individual with a mealy appearance due to a covering of powdery wax. Ground mealybug is restricted to the heavier soils of the Sacramento Valley. Feeding interacts with stressful environmental conditions resulting in greatly reduced plant growth that is particularly evident during the summer. Infestations in alfalfa fields generally occur in "circular" patches and spread slowly.

Garden Centipede. — *Scutigerella immaculate* (Newport) (Symphyla: Scutigerallidae). This organism is also referred to as the Garden Symphylan. It is not an insect but is more closely related to the millipedes and centipedes. Adults are approximately ½ inch long with 15 body segments and 11-12 pairs of legs. They are slender, white in color and have prominent antennae. http://www.ipm.ucdavis.edu/PMG/r108500111.html Garden centipedes are soil dwelling organisms. They feed on small roots and root hairs and plants attacked are either killed or severely weakened. On older plants, they may pit the root phloem providing an entryway for pathogens. In recent years, they have become an important pest of seedling alfalfa in the Delta.

Red Imported Fire Ant. — *Solenopsis invicta* Buren (Hymenoptera: Formicidae). The red imported fire ant, a serious pest in both urban and rural environments in the southeast, has been present in California since the late 1990s (Dowell et al. 1997). (http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7487.html) Fire ants construct huge mounds that may be 24 inches in diameter and 18 inches in height. http://fireant.tamu.edu/materials/graphics/photo/img37.html These may seriously interfere with alfalfa harvesting. Undisturbed areas such as pastures and alfalfa fields are an ideal setting for red imported fire ant to establish colonies and hence nesting mounds. These mounds may seriously damage harvesting equipment and operators may be attacked by disturbed colonies.

Granulated Cutworm. — *Feltia subterranea* (F.) (Lepidoptera: Noctudidae). Most commonly a pest of seedling alfalfa, in the past few years the granulated cutworm has become a serious pest of established stands. Reports from both the Central Valley and the High and Low Desert indicate that growers are having increasing problems with this insect. Damage is done by the larval stage. Full grown larvae have a pale brown head, a dark brown to gray body with pale longitudinal stripes. The skin surface is covered with small, black, conical granules which are observable with a 10X hand lens. The larvae curl up in a familiar “C” shape when disturbed. Cutworms cut off new shoots at or below ground following harvest. Since the larvae feed primarily at night and hide in the crowns or under plant debris, it is sometimes difficult to tell that damage has been done until it is noticed that there is little or no regrowth.

Pests currently established in California but presently not causing serious damage.

These insects are present in California and in previous years caused severe damage to some crops. Changes in cropping patterns have reduced the seriousness of the insects, but they could easily re-emerge as pests with only minor changes in cropping patterns.

Sorghum Midge. — *Contarinia sorghicola* (Coquillett) (Diptera: Cecidomyiidae). The sorghum midge was a serious pest of grain sorghum throughout the southern San Joaquin Valley during much of the 1960s through the 1980s. As grain sorghum was phased out around 1985 (Steve Wright, Personal Communication) as a crop in this area, damage caused by the sorghum midge also faded and the insect has not been seen since the mid-1980s. However, with the increase in acreage of forage sorghum grown for silage, sorghum midge may well return as a serious pest. The adult is a small fly with a bright orange abdomen.
http://lubbock.tamu.edu/focus/2003/july_25/ImagesPest/SorghumMidge.jpg
It is most often found hovering around sorghum heads, particularly those in bloom. Eggs are laid at the base of the ovary. Damage is caused by the larvae feeding on the internal contents of the developing ovary (Summers et al. 1976). The damaged ovary fails to develop, resulting in an empty spikelet producing little or no grain. http://comp.uark.edu/~pjmcleod/grainsorghum/midge.html

Greenbug. — *Schizaphis graminum* (Rondani) (Homoptera: Aphididae). This insect, like sorghum midge, was a serious pest of grain sorghum as well as many winter cereals, particularly wheat, from the 1960s through the early 1980s throughout the southern San Joaquin Valley. When grain sorghum was phased out as a commercial crop, serious greenbug problems were drastically reduced. This was likely due to removal of the summer bridge host (sorghum) that drastically curtailed the population of greenbugs available to move into fall planted cereals. Green bug is a small green aphid with a dark green strip down its back. http://www.ipm.ucdavis.edu/TOOLS/KEYAPHIDGRAIN/greenbug.html It can be distinguished from the Russian wheat aphid by the lack of a supracaudal process and from the rose-grain aphid by its uniformly dark antennae.

“Sleeper pests”

These are insects that currently occur in California as well as other areas of the U. S. They have caused no serious economic problems here, but need to be watched for potential outbreaks.

Corn Leafminer. — *Agromyza parvicornis* Loew (Diptera: Agromyzidae). This insect occurs throughout North America wherever corn is grown. The adult is a small fly which lays its eggs on the leaf surface. As they hatch, the larvae tunnel into the corn leaves where they feed between the upper and lower leaf surface leaving behind transparent tunnels or mines (Wright 1998) http://www.ag.uidaho.edu/news/Photos/Fig-1b.JPG . Generally only the lower leaves are attacked. Leaves above number seven to 10 are rarely attacked because the cuticle becomes too thick for the larvae to penetrate

Clover Root Curculio. — *Sitona hispidulus* F. (Coleoptera: Curculionidae). The clover root curculio is a recognized alfalfa pest in the eastern half of the U. S. Clover root curculio is apparently more common in sandy soils of the San Joaquin Valley than in the heavier soils of the Sacramento Valley. The adults are slightly smaller than alfalfa weevil adults and are a mottled gray-brown with no distinct patterns. The damage from clover root curculio is done by the legless white grub-like larvae. These larvae feed on alfalfa roots and leave gouges in the tap root. This damage has been shown to be detrimental to alfalfa yield and stand longevity in the eastern U. S. as well as to facilitate root rot diseases by providing entry points for fungi.

Russian Wheat Aphid. — *Diuraphis noxia* (Kurdjumov) (Homoptera: Aphididae). The Russian wheat aphid was first found in the U. S. in Texas in 1986. It was discovered in California in 1988. Russian wheat aphid is a green aphid that can be distinguished from all other aphids by the presence of a second tail-like process (supracaudal process) located directly above the cauda. http://www.ipm.ucdavis.edu/PMG/D/I-HO-DNOX-AD.011.html It is the only aphid in California with this characteristic. Damage is caused by feeding and the injection of a toxin. The toxin is responsible for many of the symptoms the most characteristic of which are white, longitudinal streaks on the leaves.

Acknowledgments

I appreciate the input from Carol Frate, Mick Canevari, Rachael Long, Les Ehler, Larry Godfrey, Mick Rethwisch, Eric Natwick, Dave Byrne, Glenn Fisher, Frank Peairs, Tim Hays, Steve Wright, Jim Rains, Lee Jackson and Victoria Yokoyama. I greatly appreciate the editorial assistance provided by Lois Strole.

Literature cited

APHIS. 1998. Pest detection and management programs. Japanese beetle. http://www.aphis.usda.gov/ppq/ispm/jb/background.html

Blackman, R. L., and V. F. Eastop. 1984. Aphids on the world's crops—An identification guide. Wiley & Sons. New York. 466 p.

Blodgett, S., and C. Tharp. 1999. Cereal leaf beetle. http://scarab.msu.montana.edu/ipm/clb.html

Capinera, J. L. 2000. European corn borer. http://creatures.ifas.ufl.edu/field/e_corn_borer.htm

Capinera, J. L. 2004. Beet armyworm. http://creatures.ifas.ufl.edu/veg/leaf/beetarmyworm.htm

CDFA. 2003. Pest detection/emergence projects branch. Japanese beetle pest profile. http://www.cdfa.ca.gov/phpps/pdep/japanese_beetle_profile.htm

CDFA. 2005a. Cereal leaf beetle. http://www.cdfa.ca.gov/phpps/ipc/biocontrol/biocontrol_hp.htm

CDFA. 2005b. Plant health and pest prevention services annual report 2004. http://www.cdfa.ca.gov/phpps/pdfs/PHPPS_2004_Report.pdf

Chippendale, G. M., and C. E. Sorenson. 1997. Biology and management of the southwestern corn borer. http://ipmworld.umn.edu/chapters/chippen.htm

Davis, D. W., S. C. Hoyt, J. A. McMurtry, and M. T. AliNiazee. (eds.). 1979. Biological control and insect pest management. University of California Division of Agricultural Sciences. Publ. 4096. 102 p.

Dowell, R. V. 2002. Exotic invaders and biological control in California. Proc. 3rd Calif. Conf. Biol. Control. p. 47-50.

Dowell, R. V., A. Gilbert, and J. Sorenson. 1997. Red imported fire ant found in California . California Plant Pest and Disease Report 16(3-4) June-September: 50-55.

Hagen, K. S. 1990. Biological control of insect pests of hay. *In:* 20th California Alfalfa Symposium, 6-7 December, 1990, Visalia, California, Department of Agronomy and Range Science Cooperative Extension, University of California, Davis, CA 95616.

Li, S., P. L. Falabella, S. Giannantonia, P. Fanti, D. Battaglia, M. C. Digilio, W. Volkl, J. J. Solggett, W. Weisser, and F. Pennacchio. 2002. Pea aphid clonal resistance to the endophagous parasitoid *Aphidius ervi*. J. Insect Physiol. 48: 971-980.

Natwick, E. T. 2002. Insect management. Yuma County Cooperative Extension Alfalfa Report. Nov. 4, 2002.

Parkinson, S. C., R. L. Stoltz, J. Karren, and M. E. Cooper. 2001. Cereal leaf beetle. University of Idaho Cooperative Ext. Publ. CIS 994. University of Idaho, Moscow, ID.

Patrick, C. R., and S. Stewart. 2005. Insects—Western corn rootworm. University of Tenn. Extension Bull. SP341-Y.

Pest Alert. 2001. http://www.pestalert.org/Detail.CFM?recordID=58

Rethwisch, M. 2004. Minor insect pests of alfalfa: Are treatments economical? *In:* Proceedings, National Alfalfa Symp, 13-15 December, 2004, San Diego, CA: UC Cooperative Extension, University of California, Davis, CA 95616. http://alfalfa.ucdavis.edu

Shetlar, D. J. 2000. Japanese beetle. Ohio State University Extension Fact Sheet. HYG-2504-91. Ohio State University, Columbus, OH.

Summers, C. G. 2005. Pink biotype of the pea aphid found in California. UC Plant Protection Quart. 15(2 & 3): 6-7.

Summers, C. G., R. L. Coviello, W. E. Pendery, and R. W. Bushing. 1976. Effect of sorghum midge on grain sorghum production in the San Joaquin Valley relative to date of planting and plant spacing. Hilgardia. 44: 127-140.

VanDyk, J. 1996. European corn borer ecology and management. http://www.ent.iastate.edu/pest/cornborer/intro/intro.html

Wood, K. A., E. J. Armbrust, D. P. Bartell, and B. J. Irwin. 1978. A bibliography of the alfalfa weevil, *Hypera postica* (Gyllenhal), and the Egyptian alfalfa weevil, *Hypera brunneipennis* (Boheman) (Coleoptera: Curculionidae). Special Pub. 54, Agric. Expt. Station, College of Agriculture, University of Illinois, Urbana-Champaign, IL. 92 p.

This paper was originally published in the Proc. 35th California Alfalfa & Forage Symposium, Visalia CA. December 12-14, 2005. The present paper in (UC PPQ) is an abstracted version of the original. Please see the following web site for the full version of this paper. http://alfalfa.ucdavis.edu

DEVELOPING A PHEROMONE BASED MATING DISRUPTION PROGRAM FOR THE VINE MEALYBUG.

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Abstract

Mating disruption for the vine mealybug was tested using a sprayable, microencapsulated formulation of the synthetic sex pheromone. Compared with a no-pheromone control, there were significantly lower season-long trap catches of adult males, lower season-long mealybug densities (2003 only), and less crop damage in mating disruption blocks. Two critical factors impact the effectiveness of the tested mating disruption program. First, mating disruption was most effective when the mealybug density was low, suggesting that for best results a combination of an insecticide application and mating disruption may be necessary, at least initially. Second, the current microencapsulated formulation had a relatively short effective lifetime, indicating that repeated applications of the tested formulation would be necessary.

Introduction

The vine mealybug, *Planococcus ficus* (Signoret), has become a primary insect pest of vineyards in

California (Daane et al. 2005). When left uncontrolled, the vine mealybug can build to levels capable of destroying the crop and even killing the vines. Besides infesting the grape clusters, the mealybugs excrete large quantities of honeydew that encrusts the leaves, canes, and clusters, resulting in further crop damage, defoliation, and the growth of sooty molds and bunch rots. Moreover, *P. ficus* is a vector of grape leafroll diseases and therefore is considered an economic pest even at low densities. Because of the serious consequences of vine mealybug infestations, tolerance levels are low. Insecticide treatments include a delayed-dormant application and / or post harvest application of an organophosphate (chlorpyrifos), and one or more in-season applications of an organophosphate (dimethoate), carbamate (methomyl), insect growth regulator (buprofezin), or neonicotinoid (imidacloprid) (Bentley et al. 2004).

Effective, species-specific, and environmentally safe management strategies that will work in combination with or as an alternative to insecticide programs need to be developed (Daane et al. 2006). We are evaluating the use of a pheromone-based mating disruption program for the vine mealybug. The mealybug sex pheromone, which is produced by the female to attract the adult winged males, was initially identified by Hinkens et al. (2001) and successfully employed in pheromone-baited monitoring traps (Millar et al. 2002, Walton et al. 2004). While most successful mating disruption programs have targeted Lepidoptera (Cardé and Minks 1995, Welter et al. 2005), researchers in Israel have suggested that this technique may be effective for *Planococcus* species (Franco et al. 2004). We have tested mating disruption programs in coastal and San Joaquin Valley vineyards, including the use of two different delivery methods – a sprayable formulation and plastic dispensers. Here, we present results on the commercial potential of a sprayable, microencapsulated formulation of the synthetic sex pheromone for mealybug management. Our objective is the commercial development of an effective and economical control for vine mealybug, which can be used singularly or in combination with less-disruptive insecticides and as an alternative to chlorpyrifos.

Materials and Methods

Field sites and treatment application. Trials were conducted in commercial vineyards located near Del Rey, Sanger, and Fowler, Fresno County, California. In each vineyard, we established two treatment-plots for either the microencapsulated pheromone or a no-pheromone control. In 2003, plot size varied from 1.5–2.2 ha per treatment plot (20–35 vine rows by 50–100 vines), and in 2004 plot size varied from 0.15–0.29 ha per treatment plot (5–10 vine rows by 25–50 vines). Plots were separated by a buffer (ca. 20–120 m). Trials were conducted in 2003 and 2004, with five replicates in each trial. The synthetic pheromone used was racemic lavandulyl senecioate, produced by Kuraray Fine Chemicals (Tokyo, Japan) and microencapsulated by Suterra Inc. (Bend, OR). The formulation was mixed with water (1 ml: 7.6 liter) and applied using a air-blast sprayer.

In 2003, the sprayable pheromone was applied between 12–15 May (depending on vineyard), which was before any adult male mealybugs were caught in pheromone traps, 19 June, and again between 2–4 August (depending on vineyard). In addition to the pheromone applications, a delayed dormant application of an organophosphate (chlorpyrifos) was applied (full label rate, 4 pints per acre), uniformly to all plots (application dates varied among vineyard blocks, but were from 17–25 February 2003). In 2004, applications dates were 20 April, 19 May, 16 June, and 19 July. In addition to the pheromone applications, an in-season application of an insect growth regulator (buprofezin) was applied at 50% of the full label rate, 6 oz per acre, uniformly to all plots between 10–16 June 2004.

Insect sampling. Pherocon Delta IIID sticky traps with sex-pheromone lures (Suterra, Bend, OR) were used to monitor male mealybug flight periods. Mealybug population densities were determined using a timed visual count, based on methodology developed for the grape mealybug, *Pseudococcus maritimus* (Ehrhorn) (Geiger et al.

2001). In each plot, 2–4 vines were randomly selected in each of 3–5 rows (10 vines per plot per sample date, vines and rows on the plot edges were not sampled). On each vine, a 3 min search was conducted and all visible mealybugs were recorded by the following developmental categories: crawlers and first instars, second and third instars, adults, ovisacs; and the following vine locations: ground (from 5 cm below the soil line to 30 cm above on the trunk), trunk, cordon, old canes, new canes, leaves, and grape bunches (when present). . To determine the effect of the mating disruption treatment on mealybug egg production, we collected ca. 100 female mealybugs from each treatment plot every 2 – 4 wk (3 June to 8 October 2003 and 15 April to 26 July 2004). Collected mealybugs were isolated in gelatin capsules. The number of unhatched eggs and crawlers were recorded for each female, as well as numbers of parasitoids that emerged.

Crop Damage. Mealybug crop damage was rated using a 0–3 scale, as described by Geiger and Daane (2001), where 0 indicates no mealybug damage, 1 equals a grape bunch with honeydew (an indication of mealybug presence), 2 is a bunch with honeydew and mealybugs, where at least part of the bunch is salvageable, and 3 represents a total loss of the sampled bunch. Crop damage was evaluated by inspecting 950 and 500 clusters per treatment in 2003 and 2004, respectively.

Effect of Mealybug Density. In 2004 we also evaluated pheromone-treatment effects on different mealybug population densities. On 7 April, before treatments were applied, we classified vines as having low, medium, or high level mealybug densities based on the following criteria. *Low* infested vines had no visible mealybug infestation and, additionally, these vines were treated with buprofezin at the full label rate (12 oz per acre) on 12 April. *Medium* infested vines had no ant activity and < 10 mealybugs found during a 3-min visual search. *Highly* infested vines had tending ant activity, honeydew or sooty mold, and >10 mealybugs found during a 3-min visual search. In each treatment plot, we selected 4 vines of each category. There after, every 2 wk two basal leaves on each vine were sampled and all mealybug densities were recorded.

Pheromone Residue. The microencapsulated formulation starts emitting sex pheromone immediately upon exposure to the atmosphere. The small size of these capsules may cause rapid depletion of the pheromone due to evaporation and degradation by exposure to heat and sunlight. To determine the effective field life of the microcapsules, we treated vines with the pheromone or water (control) (10 July 2003). We randomly collected 10 leaves at 1, 7, 14, 21, 28, 35, and 42 d after application. The leaves were placed individually onto the sticky surface of a Pherocon Delta IIID sticky traps and then randomly placed at 1–3 m distances from a mealybug colony inside an insectary room for 24 hr. Adult males were then counted on each trap.

Statistical Analysis. Season-long treatment effects are compared using Repeated Measures Analysis of Variance (ANOVA) (Systat 2000). Data were transformed (log[x +1]) as needed to stabilize the variance. To compare egg production between treatments, we used a *t*-test for each sample date, as collected mealybugs were independent of population density. For cluster damage, as measured by the rating scale, treatment effects were compared in a 2 × 2 contingency table with treatments separated using Spearman's rank order test. To compare mealybug densities from leaf samples on vines categorized as low, medium, or high densities, we used Repeated Measures ANOVA to compare mealybug density in each category in the control treatments and to validate the accuracy of our preseason categorization of mealybug density. The data were transformed (log[x +1]) to stabilize the variance and pairwise comparisons were made of three possible categorical combinations, with alpha set at P = 0.0167 (0.05 / possible combinations) (Systat 2000). An assessment of treatment impact in each density category was then made using Tukey's HSD test on the per capita change of the mealybug density in the mating disruption treatment as compared with corresponding control plots.

Results

Mealybug Male Flight. In both 2003 and 2004, male flight activity, as recorded by the pheromone-baited traps, was first detected in May, with numbers peaking in late July, and steadily declining thereafter (Figs. 1A and 1B). Season-long trap catches were significantly lower in the mating disruption plots than in the control plots in 2003 (Fig. 1A) and 2004 (Fig. 1B). However, catches of male mealybugs in the traps were not completely shut down and while numbers were lower overall, the seasonal flight pattern was similar to that in the controls.

Mealybug Population Density. In 2003 and 2004, mealybug populations were detected throughout the sampling period (April through October), reflecting the year-round presence of the mealybug in the tested vineyards. In 2003, there was no season-long treatment impact on the density of settled mealybugs (2nd instar to adult mealybugs) (Fig. 2A), whereas in 2004, there were significantly fewer mealybugs in the mating disruption treatment than the control (Fig. 2B).

Egg Production. In 2003, average egg production from field-collected adult mealybugs was 46.8 ± 1.7 eggs per female across all treatments and sample dates. During the sample dates when the sprayable pheromone was newly applied (3 June to 29 July 2003) and excluding parasitized mealybugs, there were 32.7 ± 3.4 (n = 174) and 55.0 ± 2.6 (n = 299) eggs per female in the mating disruption and control treatments, respectively (t = 5.09, df = 471, $P < 0.001$). The greatest impact on egg production was that 32.7% of collected mealybugs from the mating disruption treatment did not produce eggs, whereas only 9.0% of mealybugs from the control treatment did not produce eggs. In 2004, average egg production was 23.2 ± 0.8 eggs per female across all treatments and sample dates. During the sample dates when the sprayable pheromone was newly applied (3 May to 26 July 2004), there were 22.2 ± 1.3 (n = 863) and 24.2 ± 1.3 (n = 859) eggs per female in the mating disruption and control treatments respectively ($P < 0.05$).

Parasitoid Activity. In 2003, of 2654 mealybugs isolated in gelatin capsules, 41.4 ± 1.0% were parasitized across all treatments. The mealybug developmental stage isolated influenced percentage parasitism, with the third and second instars more commonly parasitized (51.1 ± 1.7 and 56.3 ± 2.1%, respectively) than the first instar and adult stages (29.0 ± 2.5 and 28.7 ± 1.4%, respectively). Of the parasitoids reared to the adult stage (n = 593), *Anagyrus pseudococci* (Girault) was the most common (86.3 ± 1.4%), followed by *Allotropa* sp. (Platygastridae) (11.5 ± 1.3%) and *Leptomastidea abnormis* (Girault) (Encyrtidae) (2.2 ± 0.6%). There were no treatment differences in levels of parasitoid activity, as measured by either numbers of mummies counted during the 5 min search on vines, or the percentage of mummies obtained from mealybugs collected and isolated in gelatin capsules. In 2004, of 4390 mature mealybugs (third instar and adults) isolated in gelatin capsules, only 2.8 ± 0.3 were parasitized, all by *A. pseudococci*. There was no significant difference in parasitism levels between mating disruption and control treatments on any sample date (n = 9). Similarly, there was no season-long difference in levels of parasitoid activity, as measured by numbers of mummies counted during the 5 min search of vines.

Crop Damage. Significantly lower crop damage ratings were recorded in mating disruption than control treatments in 2003 and 2004 (Fig. 3). Of key interest to vineyard managers is that fewer grape clusters were rated as having “moderate” or “severe” damage in mating disruption blocks (3.1 and 4.0% in 2003 and 2004, respectively) compared with the controls (9.1 and 11.8% in 2003 and 2004, respectively).

Effect of Mealybug Density. Mealybug density had a significant impact on the effectiveness of the mating disruption treatment. Mealybug densities were reduced by 86.3 ± 6.3% on vines that were categorized as having a low mealybug density in the pre-treatment application survey (Fig. 4). In contrast, mealybug densities were reduced by only 9.0 ± 35.7% on vines that were previously categorized as having a high mealybug density in the pre-treatment survey (Fig. 4).

Effective Field Life of Microencapsulated Pheromone. From 1-28 d after the microencapsulated pheromone was applied to leaves, significantly more male mealybugs were caught in pheromone traps baited with a leaf with adhering microcapsules than in traps baited with a water-sprayed leaf (Fig. 5). The initial trap catches (day 1) were low, which may have been a reflection of the colony size rather than treatment impact. Differences between treated and control leaves were most pronounced on days 1, 7, and 14, less so on days 21 and 28, and there was no difference by day 35. The results indicate that the pheromone release rates decline after 3 wk, and are no longer effective after 5 wk.

Discussion

To test the feasibility of developing a commercial mating disruption program for vine mealybug, we applied a microencapsulated pheromone formulation to sections of commercial vineyard blocks, in combination with insecticide applications. We observed a significant reduction in the number of male mealybugs caught in traps in plots treated with the pheromone. This result is an indication of the pheromone effects, but does not necessarily signify successful mating disruption. In fact, when we later measured mealybug population density on the vines, we found that the level of mealybug reduction as measured by pheromone trap catches (Figs. 1A and 1B) was much greater than that recorded by visual counts of mealybugs (Figs. 2A and 2B). Most important was the significant reduction of crop damage in combination of mating disruption and insecticide treatments, compared with insecticide treatment alone.

In both 2003 and 2004, there were significantly fewer ovisacs produced, as a proportion of the mealybug population, in the mating disruption treatment than in the controls. Of greater interest is the proportion of ovisacs and the number of eggs per ovisac. Vine mealybug egg production in South African vineyards reportedly ranges from 150-700 eggs per female (Walton 2003). In our 2003 trials, the overall egg production per female was <70 eggs per female, across all treatments; a significant number of mealybugs did not produce eggs, especially in the mating disruption treatment. In the 2004 trials, the proportion of mealybugs producing an ovisac was <40%, with only 23 eggs per female produced across all treatments. Two factors may have decreased egg production. First, in-season application of insect growth regulator (IGR) insecticide should have retarded egg production. Second, plot size might also be an issue, where pheromone drift between plots may have affected overall egg production.

Parasitism levels were not disrupted by the mating disruption treatment. In earlier studies with the *P. ficus* pheromone showed that the parasitoid *A. pseudococci* was attracted to the pheromone traps (Millar et al. 2002), and we saw an increase in parasitism levels in mating disruption trials in South Africa (Walton and Daane, unpublished). In the current study, two factors may have influenced parasitism, reducing the difference between treatments. First, in 2003 trials the vineyards had high levels of parasitism in both treatments (data not shown), a result of reduced insecticide use and inoculative release of *A. pseudococci* in adjacent vineyards from 2001–2003. Second, in 2004 trials the vineyards received an in-season application of the insect growth regulator in June, which is a critical period for the overwintered *A. pseudococci* to locate and oviposit in exposed hosts (Daane et al. 2004). We suggest that the application of the insect growth regulator killed most of the mealybugs available to the foraging adult parasitoids.

For commercialization of a sprayable formulation to be adopted, the effective field life of the formulations must be improved. The efficacy of the sprayable formulation used in our studies clearly declined after only 3 wk, with the pheromone totally depleted after 5 wk. The short field lifetime of the formulation may explain, in part, the better performance of the mating disruption program in 2004, where there were four applications, as compared with 2003, when only three applications were made. The effective life of microencapsulated materials is dependent on the microcapsule porosity and coating composition, which can be controlled, and ambient temperature, rainfall, and sunlight exposure, which cannot be controlled. We suggest that problems with effective lifetime can be overcome with better formulation of the microencapsulated particles. Improvement of the effective field life is clearly required in order to develop a robust and reliable control program. There are several advantages to a microencapsulated formulation as compared with other types of dispensers (discussed in Trimble et al. 2004). Of particular importance for control of small insects such as *P. ficus* is the fact that the sprayable formulation provides relatively complete coverage, with the microencapsulated pheromone in numerous point sources on each vine. Additionally, the sprayable formulation has the advantage of being amenable to mixes with other pesticide applications or pheromones (Cardé and Minks 1995).

Our research identifies several key factors requiring further improvement for a commercially successful mating disruption program for vine mealybug. Most evident was the effect of mealybug density on the effectiveness of mating disruption: the proportional reduction of mealybug density was much greater on vines with low initial mealybug densities. It is well known that the performance of mating disruption can decline with increased pest population density (Cardé and Minks 1995). For this reason, a combination of control tactics may prove more effective than a single tactic, as revealed in other pest systems; for example, mating disruption combined with insecticide applications controlled the oriental fruit moth (Trimble et al. 2004). Our results suggest that commercialization of this program may include some use of insecticides or other practices to lower the initial mealybug density to a level at which the mating disruption is effective. Further study and manipulation of the formulation to lower costs and enhance longevity may show that mating disruption is an effective, economical, and sustainable tool to be implemented as part of a mealybug management program. This work, with a more complete discussion of the result, has been submitted to the *Journal of Economic Entomology*.

Acknowledgments

Lee Martin coordinated field research and Doug Middleton, Josh Woods, Juan Sanchez, Glenn Yokota, and Rodney Yokota provided field and laboratory help, and their efforts are greatly appreciated. Funding was provided by the California Table Grape Commission, the California Raisin Marketing Board, and the American Vineyard Foundation, and is gratefully acknowledged. We thank Suterra Inc. for the microencapsulated pheromone, and the vineyard owners and farm managers for field support and use of vineyards.

References Cited

Bentley, W. J., F. G. Zalom, J. Granett, R. J. Smith, L. G. Varela, and A. H. Purcell. 2004. Univ. Calif. IPM Pest Management Guidelines: Grape, Insects and Mites. Univ. California, Agricul. Natr. Resc. Publ. 3448. Oakland, CA.

Cardé, R. T., and A. K. Minks. 1995. Control of moth pests by mating disruption – successes and constraints. Annu. Rev. Entomol. 40: 559–585.

Daane, K. M., R. Malakar-Kuenen, and V. M. Walton. 2004. Temperature development of *Anagyrus pseudococci* (Hymenoptera: Encyrtidae) as a parasitoid of the vine mealybug, *Planococcus ficus* (Homoptera: Pseudococcidae). Biol. Control 31: 123-132.

Daane, K. M., R. H. Smith, K. M. Klonsky, and W. J. Bentley. 2005. Organic vineyard management in California. Organic-Research Com. 5: 37-55.

Daane, K. M., W. J. Bentley, V. M. Walton, R. Malakar-Kuenen, G. Y. Yokota, J. G. Millar, C. A. Ingels, E. A. Weber, and C. Gispert. 2006. Sustainable controls sought for the invasive vine mealybug. Calif. Agric. 60: 31-38.

Franco, J. C., P. Suma, E. B. da Silva, D. Blumberg, and Z. Mendel. 2004. Management strategies of mealybug pests of citrus in

Mediterranean countries. Phytoparasitica 32: 507-522.

Geiger, C. A., and K. M. Daane. 2001. Seasonal movement and sampling of the grape mealybug, *Pseudococcus maritimus* (Ehrhorn) (Homoptera: Pseudococcidae) in San Joaquin Valley vineyards. J. Econ. Entomol. 94: 291-301.

Geiger, C. A., K. M. Daane, and W. J. Bentley. 2001. Sampling program for grape mealybugs improves pest management. Calif. Agric. 55(3): 19-27.

Hinkens, D. M., J. S. McElfresh, and J. G. Millar. 2001. Identification and synthesis of the sex attractant pheromone of the vine mealybug, *Planococcus ficus*. Tetrahedron Let. 42: 1619-1621.

Millar, J. G., K. M. Daane, J. S. McElfresh, J. Moreira, R. Malakar-Kuenen, M. Guillen, and W. J. Bentley. 2002. Development and optimization of methods for using sex pheromone for monitoring the mealybug *Planococcus ficus* (Homoptera: Pseudococcidae) in California vineyards. J. Econ. Entomol. 95: 706-714.

Systat. 2000. SYSTAT Version 10.0. Evanston, IL, SPSS Inc.

Trimble, R. M., D. J. Pree, E. S. Barszcz, and N. J. Carter. 2004. Comparison of a sprayable pheromone formulation and two hand-applied pheromone dispensers for use in the integrated control of the oriental fruit moth. J. Econ. Entomol. 97: 482-489.

Walton, V. M., K. M. Daane, and K. L. Pringle. 2004. Utilizing the sex pheromone of *Planococcus ficus* to improve pest management in South African vineyards. Crop Prot. 23: 1089-1096.

Welter, S. C., C. Pickel, J. Millar, F. Cave, R. A. Van Steenwyk, and J. Dunley. 2005. Pheromone mating disruption offers selective management options for key pests. Calif. Agric. 59: 16-22.

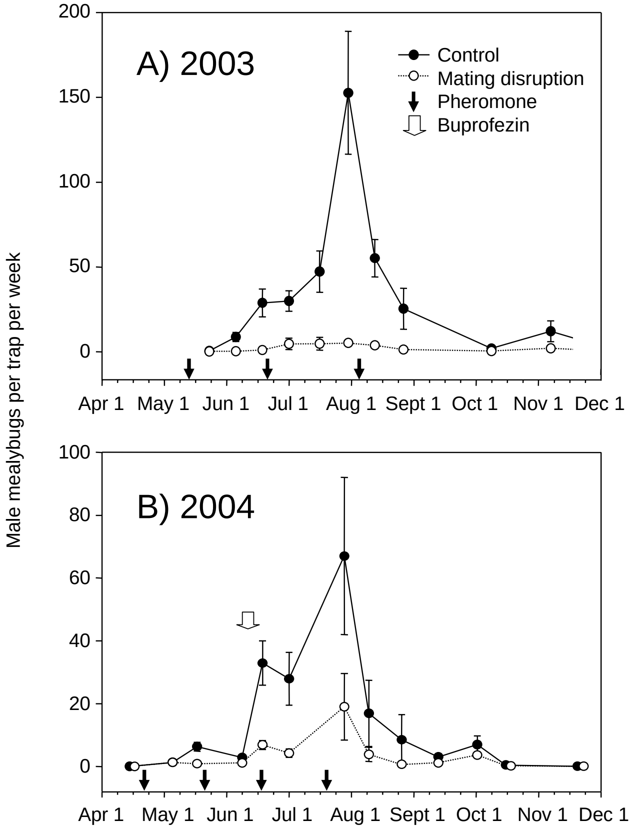

Figure 1. Season-long counts of male *P. ficus* (mean ± SEM) caught in pheromone-baited Delta traps. Counts were significantly lower in mating-disruption treatment blocks, as compared with the control, in the (A) 2003 season (F = 83.24, df = 1,8, $P < 0.001$) but (B) not in the 2004 season (F = 4.08, df = 1,8, $P = 0.078$). Data used for the Repeated Measures ANOVA analyses were from May through August collections in both 2003 and 2004. Solid arrows indicate application dates for the sprayable pheromone, and the open arrow indicates the application date of buprofezin in 2004.

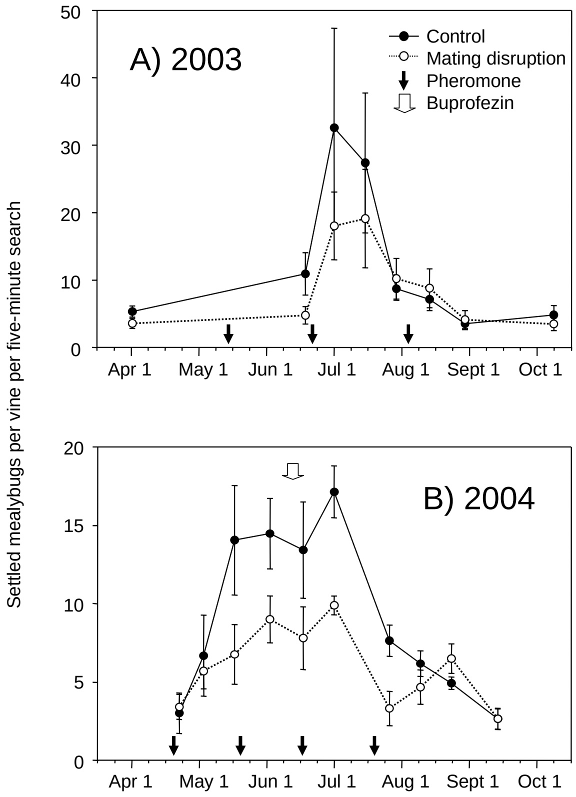

Figure 2. Season-long density of settled (second instar to adult) *P. ficus* (mean ± SEM), as measured by timed counts on randomly sampled vines, in mating-disruption and the control plots in the (A) 2003 season (F = 0.19, df = 1,6, $P = 0.68$) and (B) 2004 season (F = 5.77, df = 1,8, $P = 0.04$). Solid arrows indicate application dates for the sprayable pheromone, and the open arrow indicates the application date of buprofezin in 2004.

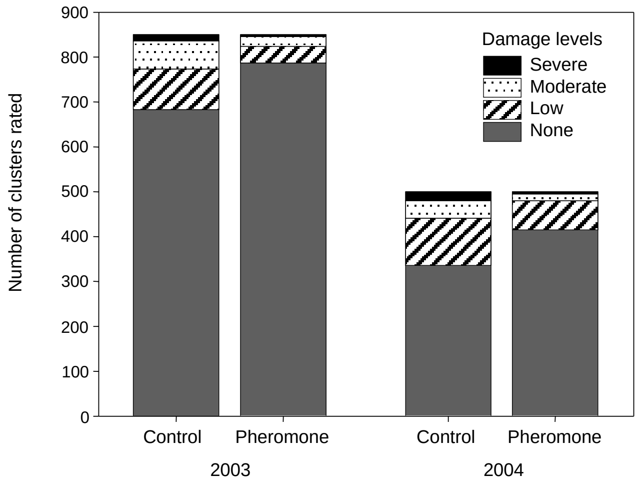

Figure 3. Percentage cluster damage ratings for insecticide and control treatments in 2003 and 2004, where 0 = no mealybug damage, 1 = honeydew (indicating the presence of mealybugs), 2 = honeydew and mealybugs but the cluster is harvestable, and 3 = unmarketable. There was significantly less damage in the mating disruption treatment in 2003 (Pearson Chi-square = 54.81, df= 3, $P < 0.001$) and 2004 (Pearson Chi-square = 37.39, df= 3, $P < 0.001$).

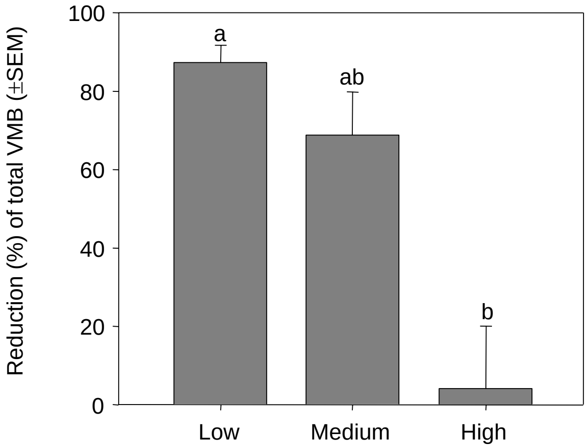

Figure 4. The percentage reduction of mealybugs varied significantly among mealybug density categories (F = 5.88, df = 2, 12, $P = 0.016$), and was greater in the low vs. high density category (the medium vs. high density category was $P = 0.069$).

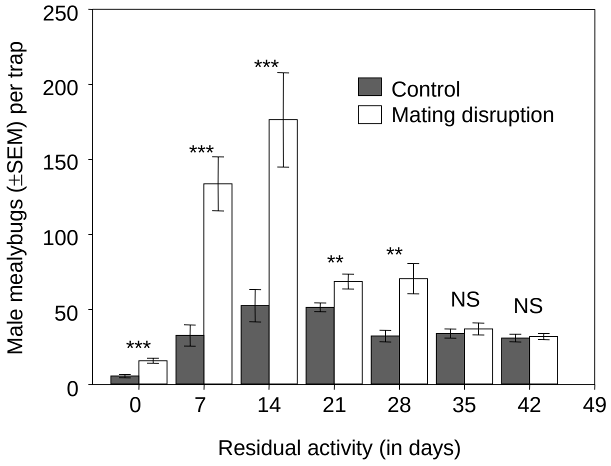

Figure 5. Numbers of adult male *P. ficus* (mean ± SEM) caught in Delta traps baited with vine leaves treated with the microencapsulated pheromone versus a water-sprayed control leaf on day 1 ($t = 5.02$, $P < 0.001$), day 7 , ($t = 5.23$, $P < 0.001$), day 14 ($t = 3.73$, $P = 0.001$), day 21 ($t = 2.99$, $P =$

0.008), day 28 ($t = 3.53$, $P = 0.002$), after which there was no significant difference ($P > 0.05$). Codes above each pair of bars denote alpha values at NS = not significant, * < 0.05, ** < 0.01, *** < 0.001.

ABSTRACTS

35th CALIFORNIA ALFALFA & FORAGE SYMPOSIUM, December 12-14, 2005, Visalia, California

<u>Sclerotinia in alfalfa: Biology and control in the Central Valley</u>

C.A. Frate, UCCE Tulare County, and R.F. Long, UCCE Yolo County

Sclerotinia stem and crown rot of alfalfa can be a significant disease in California's Central Valley in wet and/or foggy winters. Previous studies have failed to demonstrate significant control with cultural and weed control measures. Planting in September has numerous advantages in terms of stand establishment, seedling survival, and subsequent yields compared to the more traditional planting times of November through February. However, in years conducive to Sclerotinia crown and stem rot, growers feel the advantages of early seeding are negated by stand loss due to this disease. No fungicides are currently registered for controlling this disease in California. Because moisture and humidity favor disease, one management strategy has been to minimize canopy by burning back plant and weed growth with paraquat (Gramoxone Max). Two trials in the winter of 2004/2005 evaluated unregistered fungicides in addition to cultural and weed control measures. The fungicides Pristine (boscalid + pyraclostrobin) and Endura (boscalid) reduced disease ratings and increased yields in the first cutting compared to untreated controls, early mowing, and paraquat application

2006 BELTWIDE COTTON CONFERENCES, January, 2006, San Antonio, Texas

<u>Measuring Localized Movement of *Lygus hesperus* into San Joaquin Valley Cotton Fields</u>

P.B. Goodell and B. Ribeiro, Kearney Agricultural Center

Lygus hesperus populations develop both externally and internally to the San Joaquin Valley in California. In certain years, weed hosts are favored by precipitation patterns and these can provide extended habitat on which *Lygus* population can build. In 2005, tarweed, *Hemizonia kelloggii*, was abundant and widely distributed. *Lygus* populations were sampled weekly from tarweed on uncultivated rangeland and in the adjoining cotton. Both Pima and Acala upland cottons were sampled. In addition to tarweed, almonds (bearing and non-bearing), pistachios, onions and highway frontage were bordering cotton. Tarweed allowed population development into July before soil moisture was depleted and plants senesced. Cotton bordering tarweed did not show a *Lygus* population increase until this time. Other bordering crops and situations acted as substantial sources for *Lygus* adults illustrating the annual problem of pest buildup on internal crops as opposed to the infrequent movement from rangeland areas.

<u>Areas-wide approach to the management of *Lygus hesperus* in San Joaquin Valley cotton</u>

P.B. Goodell, Kearney Agricultural Center

Lygus hesperus is a key pest on cotton and other crops in the San Joaquin Valley of California. Within the San Joaquin Valley (SJV), cultivated and uncultivated plants can act as sources (movement out of a field) or sinks (movement into a field). This complex mosaic of plants creates unique challenges and opportunities for the management of *Lygus*. Because of the SJV's Mediterranean climate and lack of summer rainfall, most weedy plants senesce and do serve as sources for *Lygus* after early June. Thus, most of the migration will occur from neighboring crops, usually as the field is prepared for harvest. Examples of major sources of migration include safflower, sugar beets and alfalfa seed. Alfalfa forage is the key sink in the landscape. This crop is produced for its vegetative product rather than its reproductive parts and never is allowed to senesce. Thus, properly managed, alfalfa fields can act as important sinks for *Lygus* during the critical fruiting period from June until August.

There are no formal area wide management approaches to *Lygus* in cotton. Individual farms have used strip cutting alfalfa to preserve source habitat with great success. Interplanting alfalfa and cotton is utilized by a few farmers who are moving toward a more biological intensive IPM system. Some large farms with management authority over a large area have modified rotational schemes to consolidate critical sources and minimize the border effect on surrounding cotton. In some areas, farmers have joined together to coordinate management of *Lygus* in safflower by timing area wide applications for maximum effectiveness.