

# POTENTIAL NEW INSECT PESTS OF FORAGE CROPS IN CALIFORNIA

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## 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.

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

## 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). Over two-thirds of all pesticides used on agricultural crops in California today are aimed at pests that originated from outside of the state (CDFA 2004). 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 in other areas of the world (Table 1).

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

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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	Palaearctic Region (Cool)	Blackman & Eastop 1984
Cowpea Aphid	Palaearctic 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

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Historically, many exotic pests have come from Europe and the Middle East. More recently, increasing human immigration from Asia and Australia has resulted in increased trade with these regions, leading to an increasing number of exotic pests discovered in California (CDFA 2004). Insects may arrive directly into California from offshore regions or may make their way here following their introduction into some other part of the United States. Currently, upwards of 7-8 injurious species of forages are poised to enter California at any time, most from within the U. S. 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. Because of our very long, hot summers and mild winters, many exotic pests may experience additional generations under our conditions. In addition, many established parasitoids and predators may not occur in California, giving any introduced pests an opportunity to become established and to flourish.

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. Reestablishment of some of these crops could result in a resurgence of these pests. They include the sorghum midge, *Contarinia sorghicola* (Coquillett), and the greenbug, *Schizaphis graminum* (Rondani).

Examples of all three groups, as they potentially affect forages, will be discussed in detail in the remainder of this paper. The insects discussed represent the best estimate by myself, other entomologists and farm advisors as to which species may become significant pests in California.

## **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. Additionally, it attacks over 250 other crops including sorghum, cotton, sugar beets and many vegetables (Capinera 2000) and thus poses a significant threat to a large number of California crops. Damage is done by the larvae which are light brown or pinkish gray in color, with a brown to black head. The body is marked with round dark spots on each body segment (Capinera 2000). <http://www.ent.iastate.edu/pest/cornborer/images> European corn borer is currently restricted to states east of the Rocky Mountains (Fig. 1), but it could easily cross that barrier at any time. In the midwest, European corn borer overwinters as late instar larvae in corn stalks. Following pupation in the spring, adults emerge and lay eggs on the underside of the leaf. Following hatch, the larvae feed on

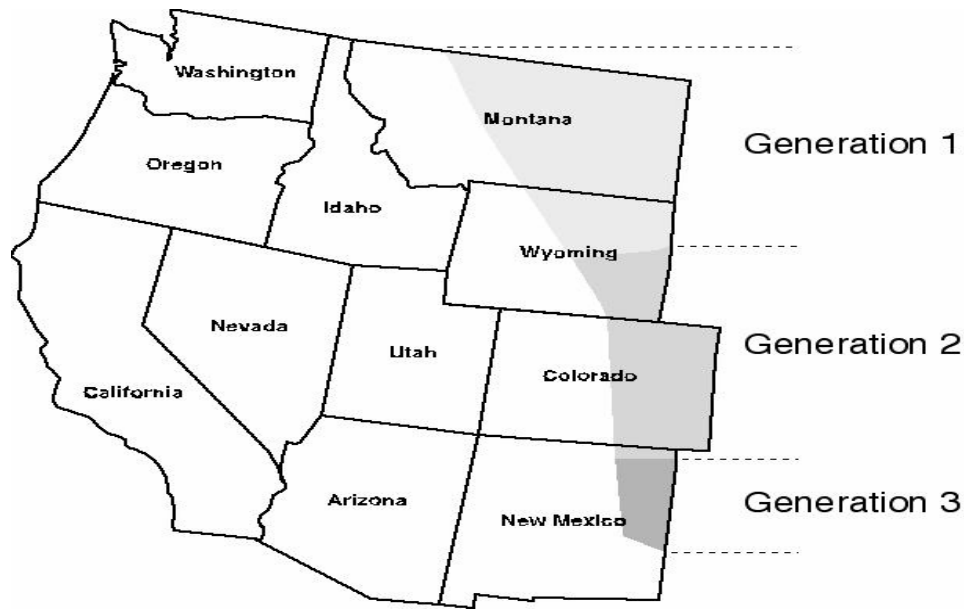


**Figure 1. Distribution of the European corn borer.**

the leaves and in the whorl. As the plant develops, later generation 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). Tunned stalks are extremely susceptible to lodging and tunneling in the ears and ear shanks may result in excessive ear loss. European corn borer infestations may increase the incidence of stalk rots (VanDyk 1996). European corn borer has up to four generations per year depending on location (Fig. 2). In most of California, we could expect at least four or five generations per year. See <http://www.ent.iastate.edu/pest/cornborer/images> for images of various damage.

Symptoms of corn borer infestation include small pin holes seen in the leaves and fine sawdust-like frass scattered over the upper surface of the punctured leaves. There is a noticeable amount of frass and damaged leaves in the whorl. As the larvae enter the stalk, they leave visible, small, rounded holes with wet frass extruding from the holes. Excessive lodging may be seen in mature corn (Gesell & Calvin 2000). See <http://www.ent.iastate.edu/pest/cornborer/images> for damage photos.

Possible means of entering California include larvae in pieces of cob, larvae in fresh sweet corn brought into the state from infested areas and adults hitchhiking on various objects coming into the state. The California Department of Food and Agriculture maintains a series of pheromone traps across the state to monitor for the possible introduction of this pest (CDFA 2005b).

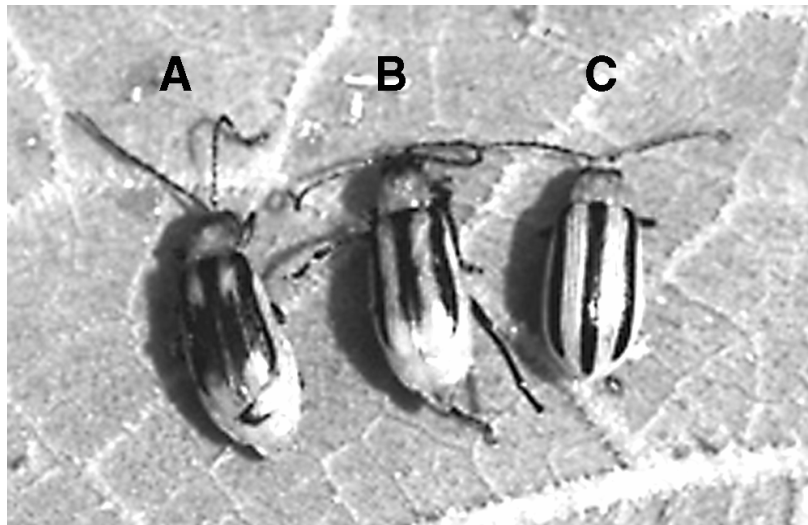


**Figure 2. Distribution of generation of the European corn borer in the western United States. A fourth generation occurs (not shown on map) in the southeastern United States.**

**Western Corn Rootworm.** — *Diabrotica virgifera* LeConte (Coleoptera: Chrysomelidae). Western corn rootworm has been called the “Billion-Dollar Bug” with estimates by the USDA of over \$1 billion in lost revenue each year. Western corn rootworm is primarily a pest of corn, threatening California’s extensive silage and grain crop as well as sweet corn production. Damage is done primarily 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. The adults look very similar to the striped cucumber beetle *Acalymma vittatum* (Fabricius), however, the stripes of the western corn rootworm do not reach the tip of the elytra (hard wing covering) while those of the striped cucumber beetle do (Fig. 3).

See <http://www.nysaes.cornell.edu/ent/factsheets/pests/wcrw.html> for photos of the adult and larvae.

Western corn rootworm is getting dangerously close to California (Fig. 4) with infestation occurring in Washington, Idaho, Utah and Arizona. In the western U. S., Western corn rootworm overwinters as eggs deposited in the soil. These eggs hatch in early spring (mid-May through June in Colorado) and the larvae seek out corn roots. Young larvae feed on the root hairs while larger larvae feed on and tunnel in the primary roots. Under heavy rootworm pressure, root systems can be completely destroyed. See <http://www.ent.iastate.edu/imagegal/plantpath/corn/rw/3936.52crwinj.html> The adults feed on the silk (see <http://www.utextension.utk.edu/publications/spfiles/SP341-Y.pdf> but this contribution to yield loss is not well documented (Peairs & Pilcher 2004). Western corn rootworm has a single generation throughout its range, but under California conditions, we might expect at least one additional generation, perhaps two per year.



**Figure 3.** Adults of the western corn rootworm on the left and an adult of the striped cucumber beetle on the right. Photograph by Whitney Cranshaw, Colorado State University. [www.forestryimages.org](http://www.forestryimages.org)



**Figure 4.** Distribution of the western corn rootworm in the western United States.

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. The presence of the western corn rootworm may also be determined by observation of the adults in the field. Any suspected individuals should be submitted to CDFA for positive identification.

Currently, CDFA does not conduct any formal surveys for the presence of western corn rootworm in California (CDFA 2005b).

**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> Adults are strong fliers and can move over great distances (Blodgett & Tharp 1999). This characteristic and cereal leaf beetle's proximity to California increases the threat of invasion.

Cereal leaf beetle is currently found in much of the western U. S. (Fig. 5). Only California, Arizona and New Mexico appear free from infestation at this point. 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. Following hatching, 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". (See link above.) Cereal leaf beetle has one generation per year. Under California conditions, we might reasonably expect more than one.



**Figure 5. Distribution of the cereal leaf beetle in the western United States.**

California conducts routine sweep net surveys in 48 counties for the detection of cereal leaf beetle (CDFA 2005b). California also maintains a quarantine alert with infested states <http://pi.cdffa.ca.gov/pqm/manual/hm/321.htm> to prevent the importation of cereal leaf beetle into the state. Small grains, hay (not alfalfa unless it is infested with grass), straw, grasses (including ornamentals), some species of pines, used harvesting equipment and other potential hosts are prohibited entry into California unless they have been properly treated and certified as clean. See the above link for specific items in the quarantine. These are the most likely avenues of entry into the state.

**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. Figure 6 shows the counties where Japanese beetles were trapped during 2004.



Figure 6. Location of Japanese beetles caught in traps 2004.

Fig. 7 shows those counties in which aircraft inspection discovered Japanese beetle adults in 2004 (CDFA 2005b). Japanese beetle has been eradicated from California (Sacramento and San Diego counties) several times in the past few years.

The larvae (grubs) occur underground where they feed on the roots. Young plants are usually killed. The larvae are typical white grubs. They can be separated from other soil dwelling white grubs by the presence of a V-shaped series of bristles on the raster (Shetlar 2000). 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 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 [www.pueblo.gsa.gov/.../jbeetle.html](http://www.pueblo.gsa.gov/.../jbeetle.html) There is one generation per year, but as noted previously, more may occur in California.



**Figure 7. Counties in which Japanese beetle were intercepted in aircraft during 2004.**



CDFA has a detection program in place for Japanese beetle. In addition to Japanese beetle traps located throughout the state, with particular attention paid to areas around airports, there is an active inspection of aircraft which originate from infested states at many California airports. These inspections include passenger, cargo and military aircraft.

**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. Antennae are elbow-like and usually face backward. There is a large flattened spur at the apex of the hind tibia (Nuessly et al. 1999). 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. The individual found in Los Angeles County is thought to have originated from Hawaii (Ray Gill personal communication).

**Southwestern Corn Borer.** — *Diatraea grandiosella* Dyar (Lepidoptera: Pyralidae). Southwestern corn borer occurs across much of the southwest and southern plains (Fig. 8). 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). The larvae show seasonal polymorphism with summer forms of white with black pinacula and winter forms uniformly light yellow due to pigment free pinacula (Chippendale & Sorenson 1997). <http://www.ent.iastate.edu/imagegal/lepidoptera/swcb>



**Figure 8. Distribution of the southwestern corn borer in the western United States.**

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.

The insect has three complete generations per year, but as frequently mentioned, there may be more in California. Currently there is no program for the detection and intervention of southwestern corn borer.

**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. on ceramic and quarry tiles originating from Italy. Climatic conditions are suitable for development in many parts of North America.

The adult beetle feeds only on leaves, but the larvae will feed on petioles and young stems. This insect currently occurs in Germany, Poland, Czech Republic, Austria, Hungary, Italy, Yugoslavia, Greece, Romania, Bulgaria, Turkey, Syria, Iraq, U.S.S.R, Great Britain, and North Africa (Pest Alert 2001).

### INSECTS CURRENTLY ESTABLISHED IN CALIFORNIA WHICH ARE EMERGING AS PESTS

This group of insects has been established in California for a number of years. The 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](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. As the name implies, handling these insects may result in blisters, similar to a burn, on the hands or fingers. Blister beetles have been a serious problem in alfalfa in the northern United States, the midwest 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. Likewise, it is not known if the problem is likely to spread and hence become a common occurrence in California alfalfa. In the mean time, growers and PCAs are advised to be on the lookout for blister beetles and to contact their Farm Advisor for advice if these insects are found. To reduce the incidence of blister beetles in alfalfa, hay should be cut before bloom. If beetles are found, remove the conditioner wheels from the swather in order to prevent crushing beetles. Also, these beetles are often found on the edge of the field or congregated in groups within the field. Such areas should be skipped when cutting or the bales from these areas picked up separately and isolated from bales picked up from the rest of the field.

**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. Twenty inch sweeps are used as they fit across the beds on which alfalfa is grown in the region.) Numbers would be significantly larger if 180° sweeps were used (Mike Rethwisch, personal communication). 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 2-3 per 180° 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> Nymphs are confined to the lower portions of the plant and may not be picked up in a sweep net. Populations build up in the spring and persist into the fall. They feed by inserting their needle-like mouth parts into stems, sucking out juices. 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.

Historically, cowpea aphids have occurred during the hot summer months and have disappeared as temperatures cooled in the fall. The cowpea aphid currently infesting alfalfa, however, appears to thrive in cool as well as hot temperatures. In the Central Valley, populations generally reach highest numbers from February to April and in the desert, numbers peak from October to January. In the San Joaquin Valley, populations have also reached treatable levels in August and September. 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.** — *Acyrtosiphon 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> Another “pink” aphid associated with alfalfa, *Macrosiphum creelii* Davis, but generally considered rare, has been reported from several western states and British Columbia (Blackman and Eastop 1984, Pike et al. 2003). However, it has not been found in the desert southwest, including California (Pike et al. 2003). 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). Similar results were found by Michaud and Mackauer (1994) working with pink and green biotypes of *M. creelii* and *A. pisum*. Females of *A. ervi*, *A. pisivorus* Smith and *A. smithi* Sharma and Subba Rao selected hosts by sight and showed a preference for the green biotype over the pink biotype. The pink biotype may also circumvent some of the pea aphid resistance bred into many alfalfa cultivars. Kugler and Ratcliffe (1983) found that the pink (red) biotype of *A. pisum* introduced into the U. S. from Europe easily overcame resistance in a number of U. S. cultivars with the exception of CUF 101.

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). The pink biotype appears predominate in all three San Joaquin Valley counties over the course of the late spring and early summer. The significance of the pink biotype to California alfalfa, its distribution in California and its pest potential remain to be seen. Further evaluations are needed.

**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).

Most mealybugs are foliage feeders, but there is a group of mealybugs that feed exclusively on the roots. 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. Its form is elongated, with sides nearly parallel (McKenzie 1967). Ground mealybug is restricted to the heavier soils of the Sacramento Valley and it is not found in the San Joaquin or Imperial Valleys. Feeding interacts with stressful environmental conditions resulting in greatly reduced plant growth that is particularly evident during the summer. There are three generations per year with populations peaking in the early winter, spring and mid-summer periods (Godfrey & Pickle 1998). The eggs, nymphs and adults all occur in the soil. Infestations in alfalfa fields generally occur in “circular” patches and spread slowly. Crop rotation may help in management, but this pest appears to survive on several crop plants and weed species: there is differential survival across species so rotation to a less preferred host may aid in management. In a greenhouse study, greatest survival was on potato, tomato, safflower and alfalfa, followed by cotton, cantaloupe, dry land rice, sugarbeets and wheat (Godfrey & Pickle 1998). Strawberry also appears to be a good host. There was only slight survival on field corn and kidney beans. However, there were no plant species without some level of survival.

**Garden Centipede.** — *Scutigera immaculate* (Newport) (Symphyla: Scutigerales).

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). Infested areas include the southern California counties of Orange, Los Angeles, Riverside, San Bernardino and San Diego.

(<http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7487.html>) In the Central Valley, infestations are found in Fresno, Kern, Madera, Merced, Sacramento and Stanislaus counties (CDFA 2005b). While every effort is being made to eradicate this pest, caution must still be taken to guard against further establishment. Currently infestations appear to be most common in nursery stock, almonds and golf courses. Imported fire ant is a threat to crops, humans, pets and livestock. They are extremely aggressive and when disturbed attack with a vengeance. They attack seeds (corn, sorghum and soybeans), young saplings and seedlings (citrus and nut trees) and destroy buds and developing fruit (citrus and stone fruit). Bites and stings produce large raised welts that have a burning sensation, hence the name. Some individuals are allergic to the stings and may go into anaphylactic shock if the attack is severe enough. Young animals and birds are often killed by attacking red imported fire ants. They raise havoc with the environment by upsetting the ecological balance of an area by killing and driving out other species. 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 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: Noctuididae). 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. Finding the larvae is difficult and requires persistent searching. Control has proven to be extremely difficult.

#### **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 reemerge as pests with only minor changes in cropping patterns once again.

**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](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. This condition is called “blast” or “blight” of the spikelet, and severely damaged heads produce little or no grain (Summers et al. 1976).

<http://comp.uark.edu/~pjmcleod/grainsorghum/midge.html>

Although grain sorghum acreage is now severely curtailed, johnsongrass serves as an alternate host for sorghum midge. Populations of the midge are maintained at low levels in johnsongrass from late spring to mid-summer. A slow buildup occurs during early August, and numbers capable of causing severe yield reductions are reached after mid-August (Summers et al. 1976). Planting made before 15 June will likely escape injury, while those made after 30 June risk severe midge infestations and yield reductions (Summers 1976).

Forage sorghum is becoming more popular, particularly late in the season, as a replacement for corn to avoid corn stunt disease. Since sorghum midge has likely maintained itself in johnsongrass and in the minimal acreage of grain sorghum that is still being planted, it could once again become a serious problem in late planted forage sorghum, destroying much or all of the grain in the heads. Such destruction would significantly lower the nutritional quality of the silage and perhaps negate its use as a substitute for corn to evade the corn leafhopper and corn stunt disease.

Sorghum midge is extremely difficult to control using chemicals. The best control measures available are early plantings so sorghum matures before midge becomes a problem (Summers et al. 1975, Summers et al. 1976). Plantings of forage sorghum, particularly those planted late in the season, should be monitored for the presence of sorghum midge.

**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.

Greenbugs cause injury by sucking sap from the plant and also by injecting a toxin into the plant during the feeding process. This toxin may cause distorted plants and curled leaves. Feeding symptoms most commonly appear as small, reddish spots of the upper surface of infested leaves. As feeding continues, the leaf turns yellow. As population densities increase, the entire plant may become yellow. Damage is usually more severe if feeding occurs before tillering.

As is the case with sorghum midge, the increase in acreage of forage sorghum may result in a resurgence of greenbug. If this occurs, not only will forage sorghum be impacted, but also winter forages, which are primarily wheat and cereals grown for grain.

### “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. On the occasion that it does, mining takes place only on the upper or lower surface which reduces injury (Wright 1998). Corn leafminer only rarely reaches damaging levels and is not considered a pest through its range. It is, however, an insect that needs to be watched closely.

**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., but information on this pest in California is extremely limited. 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 life cycle is similar to alfalfa weevil in that the adults leave the alfalfa fields and spend the summer in protected areas. 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. In California, clover root curculio populations have been associated with alfalfa stand decline in some cases.



**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. Heavily infested plants are stunted and exhibit a flattened appearance. During cold weather, the plants may show a purple color. Infested leaves curl up like a soda straw and remain in a rigid upright position. The awns may be trapped in the curled flag leaf and the head assumes a fish hook appearance.

Upon its first arrival, it caused serious injury and considerable losses statewide. After only a few years, aphid populations declined significantly throughout the Central Valley and the Intermountain Region. The high desert, however, remains a hot spot for Russian wheat aphid with periodic outbreaks of damage. Russian wheat aphid continues to be a significant pest throughout much of the midwest and plains states. It could still become a major player in California and needs to be watched closely.

### SUMMARY COMMENTS

This represents my best effort at identifying some of the potential arthropod pests that we may be facing in forage crops in the coming years. The purpose of this paper is to bring them to your attention so you can continue your vigilance in watching for these encroaching pests. Having said that, however, I am reminded of the words of the Scottish poet Robert Burns in his poem “To a Mouse.”

*“The best-laid plans o’ mice an’ men  
Gang aft a-gley,  
An’ lea’e us nought but grief an’ pain  
For promised joy.”*

Having tried to determine the most likely invaders, it is very possible, indeed likely, that something “off the wall” will be our next major insect pest in California rather than the species so eloquently discussed above. After all, of the six exotic pests of alfalfa listed in Table 1, none were anticipated in advance of their invasion of the state.

### LINKS

All links provided within the text and the Literature Cited section were checked and found to be working correctly as of 25 October, 2005.

## ACKNOWLEDGMENT

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.

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