is dorsoventrally flattened. The segments of the thorax are fused, and the thoracic spiracles located dorsally. The abdominal segments are distinct. The tarsi consist of only one segment, and there is only one large claw on each tarsus. Cerci are absent. Metamorphosis is incomplete (hemimetabolous development).

Biology

Sucking lice feed only on blood of mammals. Two (or three depending on how *Pediculus humanus* is treated) species affect humans, and about 12 species affect domestic animals. The families tend to contain lice with very similar feeding habits. For example, the echinophthiriids feed on seals, sea lions, walruses and river otter; the enderleinellids on squirrels; the haematopinids on ungulates such as pigs, cattle, horses and deer; the hoplopleurids on rodents and insectivores; the linognathids on even-toed ungulates such as cattle, sheep, goats, reindeer and deer, and on canids such as dogs, foxes and wolves; the pecaroecids on peccaries; the pediculids on the head and body of humans; the polyplacids on rodents and insectivores; and pthirids on gorillas and humans. The eggs generally are cemented to the hairs of the host. There are three nymphal instars in nearly all species.

► Human Lice

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Sugarcane Rootstock Borer Weevil

AU37

► Citrus Pests and Their Management

Sugarcane Pests and Their Management

ROBERT L. MEAGHER[1], MARIA GALLO[2]
[1]USDA, Agricultural Research Service, Gainesville, FL, USA
[2]University of Florida, Gainesville, FL, USA

Sugarcane is a tropical, perennial grass that evolved in Asia, most likely the South Pacific, probably the island of New Guinea. It is composed of six species in the genus *Saccharum* L. Two species are wild, *S. spontaneum* and *S. robustum*, and four species are cultivated, *S. officinarum*, *S. barberi*, *S. sinese*, and *S. edule*. All commercial sugarcane cultivars grown today are interspecific hybrids of *Saccharum*.

History of Sugarcane

Humans have cultivated sugarcane for at least the last two millennia. Traders and migrating populations hybridized and moved sugarcane from southeastern Asia through India and China, through the Middle East and northern Africa, and into the Mediterranean. Europeans introduced sugarcane into the islands off the west coast of Africa, and Columbus transported sugarcane from the Canary Islands to the Dominican Republic on

his second voyage in 1493. Sugarcane plantings and production spread during the next century into the other Caribbean islands and into Mexico, Central America, and South America.

Sugarcane Production in the USA

Sugarcane is grown commercially in four states in the USA, with over 900,000 acres harvested and a value of $754 million. Jesuit priests brought sugarcane into New Orleans, Louisiana, in 1751. Commercial-scale production in New Orleans began in 1795. Sugarcane is now grown on 435,000 acres in 24 parishes in southern Louisiana. The value of sugarcane production in Louisiana in 2005 was over $282 million.

Sugarcane has been grown in many locations in Florida since the arrival of the French and Spanish. Commercial production today is centered south, east, and west of Lake Okeechobee in the southern part of the state. The sugarcane industry expanded in Florida during the 1960s and harvested acres in 2006 reached 405,000. The value of sugarcane production in Florida in 2005 was almost $357 million.

Sugarcane has been grown in several locations in Texas, from the Houston area south to the Rio Grande Valley (Fig. 150). Sugarcane was introduced into the Rio Grande Valley in the early 1800s and by 1913 there were five sugar mills. However, due to economic hardships, the last mill closed in 1921. Research was conducted in the 1960s to determine the economic feasibility of growing the crop again and in 1973 a new sugar mill was completed in south Texas. In 2006 the harvest was 46,500 acres. The value of sugarcane production in Texas in 2005 was over $54 million.

Commercial sugarcane production started in Hawaii in 1837. However, because of increasing land values and poor economic returns, production has declined steeply since the mid-1980s. Final sugarcane harvests occurred in 1996 on the islands of Oahu and Hawaii, and in 2006, there were 22,300 acres harvested on Kauai and Maui.

Sugarcane Pests and Their Management, Figure 150 Sugarcane: a mature field of sugarcane (*above*), and recently planted (*below*).

The value of sugarcane production in Hawaii in 2005 was over $61 million.

Sugarcane Botany

Commercial sugarcane is vegetatively propagated by planting seed pieces. Seed pieces are sections of stalks that contain two or more nodes and internodes. A node is where the leaf attaches to the stalk but is also where the buds and root primordia are located. After planting, a primary shoot and two different types of roots emerge from the bud. Secondary shoots (tillering) emerge after the primary shoot and each shoot develops their own root system. Above ground, the sugarcane leaf is composed of a leaf sheath which surrounds the stalk and a leaf blade. Sugarcane stores sucrose

in the stalks with decreasing concentrations as you move up the stalk. Commercial production involves the use of plant cane fields and ratoon or stubble fields. Stubble fields have been harvested and the plants are allowed to regrow. The number of stubble crops depends on various factors such as sugarcane variety, plant diseases, soil type, and soil insect pressure.

Pest Descriptions

This section includes the important mite and insect species that attack sugarcane in the USA (Florida, Hawaii, Louisiana and Texas). Sugarcane insect pests are generally local insects that have adopted this plant as a host after its cultivation; however the movement of sugarcane has provided new geographical areas for these adopted pests. Many other insects inhabit sugarcane fields and act as predators or parasitoids. These insects are not mentioned here. Pest management considerations are discussed at the end of this section.

Acari

Although sugarcane may be infested by many different mite species, few are economic pests. Species within the genus *Oligonychus* (Tetranychidae) are occasional pests. *Oligonychus stickneyi* (McGregor) occurs in Hawaii and Florida and *O. pratensis* (Banks) is known to attack Florida sugarcane. A new mite, *O. grypus* Baker & Pritchard, was found infesting sugarcane in Florida greenhouses in 2002. This species, originally from Africa, was previously found in Cuba and Brazil. The mite *Steneotarsonemus bancrofti* (Michael) (Tarsonemidae) is rarely found in Hawaii and Florida.

Collembola

During the 1950s in Louisiana, control measures were taken against "small soil arthropods" although there was little evidence that they caused damage. *Lepidocyrtus cyaneus* Tullberg, *Onychiurus armatus* (Tullberg), *Proisotoma minuta* (Tullberg) and *Pseudosinella violentus* (Folsom) are soil-dwelling, whereas *Salina beta* Christiansen & Bellinger have been found on the underside of leaves in Florida.

Orthoptera

In other regions of the world where sugarcane is grown, grasshoppers can be serious pests. In the USA, several species of grasshoppers and field crickets may inhabit but usually don't economically damage sugarcane. These include the grasshopper *Schistocerca obscura* (F.) and the field crickets *Gryllus assimilis* (F.) and *G. firmus* Scudder. Two species of mole crickets, *Scapteriscus borellii* Giglio-Tos and *S. vicinus* Scudder, sometimes attack young sugarcane plants.

Isoptera

Termites can be major pests of sugarcane, especially in parts of Australia, China, and India. In the USA, *Coptotermes formosanus* Shiraki in Hawaii and *Reticulitermes flavipes* (Kollar) in Florida are considered minor pests.

Psocoptera

Few species of Psocoptera have been identified in sugarcane. *Ectopsocopsis cryptomeriae* (Enderlein) was found in Florida and perhaps consumes sugarcane rust fungus (*Puccinia melanocephala* H. & P. Syd).

Hemiptera

At least 11 families have been documented to cause plant injury to sugarcane. Injury is caused by feeding from xylem or phloem tissues or by

vectoring a plant pathogen which causes disease. Results of these types of injury can cause economic damage through a reduction in sugar production or plant death. Management tactics for hemipteran species include varietal resistance and the use of natural enemies.

Acleridae

This very small family of scale insects has two representatives from Louisiana, *Aclerda holci* Teague and *A. sacchari* Teague. Neither species is important economically.

Aphididae

Several aphid species are considered serious pests of sugarcane, while several other species are probably incidental inhabitants. Aphids cause injury by direct feeding and by vectoring plant diseases.

The sugarcane aphid, *Melanaphis sacchari* (Zehntner) is a widely distributed species. It was reported in Hawaii in 1896, Florida in 1977, and Louisiana in 1989. It was not found in Texas in a survey conducted in 1990. Large populations can sometimes be present and it is known to vector sugarcane yellow leaf virus (SCYLV). Although large numbers of aphids can be present, natural enemies can keep the aphids under economic control.

The yellow sugarcane aphid, *Sipha flava* (Forbes), occurs in Florida, Louisiana, and Texas. In 1989, it was found to be established in Hawaii. It is a serious pest of sugarcane and can cause premature yellowing and death of sugarcane leaves. Young plants are sometimes killed by large populations, and if the plant survives, there is a reduction in sugar yield. Natural enemies, such as predators, and varietal resistance are the two strategies used for control, although in Florida chemical control is common in some years.

Five aphid species are known vectors of the potyvirus mosaic virus: *Acyrthosiphon pisum* (Harris), *Hyperomyzus* (= *Nasonovia*) *lactucae* (L.), *Hysteroneura setariae* (Thomas), *Rhopalosiphum maidis* (Fitch), and *Uroleucon* (= *Dactynotus*) *ambrosiae* (Thomas). *Rhopalosiphum maidis* also transmits SCYLV and the phytoplasma causal organism of grassy shoot disease, which is not currently in the Western Hemisphere.

Cercopidae

Froghoppers or spittlebugs are serious pests of sugarcane in many areas of Mexico, Central and South America. These insects can attack sugarcane roots and also feed from leaf or stem tissues. Important genera include *Aeneolamia*, *Mahanarva*, *Sphenoclypeana*, *Sphenorhina*, and *Tomaspis*. Only one species, *Prosapia bicincta* (Say), is present in Louisiana and Florida. Surveys taken in Texas failed to find this species.

Cicadellidae

Many species of leafhopper can be found in sugarcane but it is doubtful that they cause economic damage. *Draeculacephala portola* Ball is a common species found in sugarcane and was once thought to be a vector of the sugarcane disease chlorotic streak. Other species collected in US sugarcane include *D. mollipes* (Say) (Hawaii, Louisiana), *Balclutha caldwelli* Blocker (Florida), *B. rosea* (Scott) (Texas), *Graminella nigrifrons* (Forbes) (Florida, Texas), *G. plana* (DeLong) (Texas), *G. sonora* (Ball), *Homalodisca insolita* (Walker) (Florida, Texas), and *Oncometopia lateralis* F. (Louisiana).

Cixiidae

Two cixiid planthopper species have been found in US sugarcane and have been reported in other sugarcane-producing areas of the New World. *Myndus crudus* Van Duzee, the American palm

cixiid, is a serious pest of palms and is known to vector the palm disease lethal yellowing. Nymphs develop on the roots of grasses and adults feed on the foliage of palms. *Oliarus texanus* Metcalf is a species found in Texas and is not considered to be an economic pest.

Coccidae

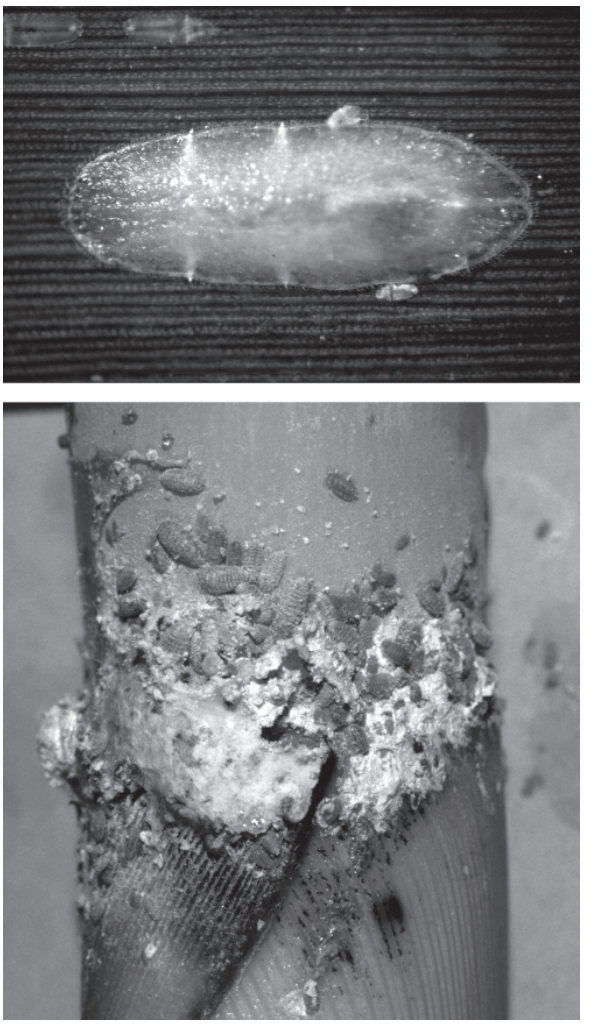
One species of soft scale, *Pulvinaria elongata* Newstead, has been found in Florida (Fig. 151), Hawaii, Louisiana, and Texas. It is a serious pest of sugarcane through its feeding, but also has been shown to vector a disease called sugarcane yellow leaf luteovirus. Natural enemies, including parasitoids and predators, can be effective in controlling populations.

Cydnidae

Burrower bugs attacking sugarcane are found in several areas in South America (Brazil and Venezuela) and southeastern Asia (Indonesia, Myanmar, Philippines, and Taiwan). In Florida, *Cyrtomenus ciliatus* (Palisot de Beauvois) and *Pangaeus bilineatus* (Say) are sometimes found at low populations levels, and in Louisiana, *P. bilineatus* and *Sehirus cinctus* (Palisot) can be abundant during spring and early summer.

Delphacidae

Two species of delphacid planthopper are potentially important pests to sugarcane in the USA. *Perkinsiella saccharicida* Kirkaldy, the sugarcane delphacid, was found in Florida in 1985, Texas in 1991, Louisiana in 1994, and Hawaii in the early 1900s. This pest can cause severe economic damage and is a vector of *Fijivirus* sp., causal agent of Fiji disease of sugarcane. Currently the disease is restricted to southeastern Asia, Madagascar, and the southern Pacific. *Saccharosydne saccharivora*



Sugarcane Pests and Their Management, Figure 151 A sugarcane-feeding soft scale, *Pulvinaria elongata* Newstead (*above*), and pink sugarcane mealybug, *Saccharicoccus sacchari* (Cockerell) (*below*).

(Westwood) is found in Florida, Louisiana, and Texas. This species has the potential to build up large populations on some varieties, but it usually doesn't cause economic damage in the US. However, reports from Cuba have recently (2005) identified this species as a vector of sugarcane yellow leaf phytoplasma, a plant pathogen that inhabits the phloem sieve tubes of infected plants. Surveys in Florida and Texas have documented several other delphacid species on sugarcane, but it is not believed that they are breeding on the host plant.

Diaspididae

Several species of armored scales are important pests of sugarcane. They congregate on the stalks under the leaf sheaths and can produce several generations during a season. Large populations can reduce sugar production. Two species, *Aulacaspis tegalensis* (Zehntner) and *Melanaspis glomerata* (Green), are not present in the US, but are serious pests in other sugarcane areas.

Several species do occur in the US but are not considered serious pests. *Aspidiella sacchari* (Cockerell) and *Odonaspis saccharicaulis* (Zehntner) are found in Florida, Hawaii, and Texas. *Aspidiotus destructor* Signoret is a serious pest of coconuts but is only casually found in sugarcane. *Duplachionaspis divergens* (Green) was discovered on *Miscanthus* sp. in Florida in 2000 and on sugarcane in a greenhouse in 2003. It has been reported as a minor sugarcane pest but as of yet has not been found infesting Florida sugarcane in the field. Sugarcane is noted as being a host plant for three other species, *Diaspis bromeliae* (Kerner), *Hemiberlesia cyanophylli* (Signoret), and *Selenaspidus articulatus* (Morgan).

Pseudococcidae

Mealybugs infest sugarcane in all production areas of the world. In the USA, several common species are found, although none are considered economic pests. *Dysmicoccus boninsis* (Kuwana), the gray sugarcane mealybug, is a common species found in all sugarcane-producing states. *Saccharicoccus sacchari* (Cockerell), the pink sugarcane mealybug, is present in Florida, Hawaii, and Texas. It was found in Florida in 1944 but was not found in sugarcane until 1995. Both species attack sugarcane by feeding on the stalks behind leaf sheaths. *Dysmicoccus brevipes* (Cockerell), the pineapple mealybug, is found in Florida and Hawaii and attacks roots and stalks near the ground. The Rhodesgrass mealybug, *Antonina graminis* (Maskell), is a pest of rangeland grasses along the US Gulf Coast and is seldom found in sugarcane. *Birendracoccus* (= *Pseudococcus*) *saccharifolii* (Green) was noted to be in Florida and is a disease vector. It has not been found in surveys. Two other species, *Chorizococcus rostellum* (Lobdell) and *Pseudococcus longispinus* (Targioni-Tozzetti), have been noted as attacking sugarcane in Hawaii. Natural enemies and healthy seedcane programs (using uninfested cane for planting) appear to keep populations managed.

Tingidae

The sugarcane lacebug, *Leptodictya tabida* (Herrich-Schaeffer) was documented in Texas sugarcane as early as 1910, being known as a common species in Mexico, Venezuela, and the Caribbean. When the sugarcane mills shut down in the 1920s, sugarcane lacebug disappeared until its rediscovery in 1989. This species was discovered on Maui in 1985 and in Florida in 1990. Although having the potential to produce large populations, it has not yet created economic damage.

Thysanoptera

Several thrips species have been documented in Hawaiian sugarcane but few have been noted in sugarcane in the continental US. However, many of the species listed from Hawaii are cosmopolitan in distribution and have been reported from other plants in Florida, Louisiana, and Texas. Therefore, the species is listed below where there is a historical reference to being found in sugarcane. Thrips appear not to cause economic damage to sugarcane.

One species from the family Phlaeothripidae, *Haplothrips halophilus* Hood, has been documented in Louisiana sugarcane. Eight species from the family Thripidae have been documented either from Florida, Hawaii, or Louisiana. Most of these species are cosmopolitan in distribution

and probably occur in Texas. The grass thrips, *Anaphothrips obscurus* (Müller), and the Hawaiian grass thrips, *A. swezeyi* Moulton, are pests in turf grasses but also can be found in sugarcane. Four species, *Arorathrips* (= *Chirothrips*) *mexicanus* (Crawford), *A.* (= *Chirothrips*) *spiniceps* (Hood), *Chirothrips sacchari* Moulton, and *Thrips saccharoni* Moulton, have only been documented in sugarcane in Hawaii. *Hercinothrips femoralis* (Reuter), the banded greenhouse thrips, has a world-wide distribution both in greenhouses and in the field in subtropical and tropical areas. It is probably present in all US sugarcane areas, but has only been documented in Hawaii and Florida. *Bregmatothrips venustus* Hood has been found in Louisiana sugarcane.

Coleoptera

Beetle pests of sugarcane either tunnel within the stalks or infest the roots and seed pieces. There are a couple of families where only a few species are found in association with sugarcane in the US. These include Alleculidae (*Lobopoda* sp.), Cerambycidae [*Prionus* sp. and *Prosoplus bankii* (F.)], Nitidulidae [*Carpophilus humeralis* (F.)], and Tenebrionidae (*Eutochia lateralis* Boheman). Most of these species are only casually associated with sugarcane and may not feed on any plant tissue.

Buprestidae

One species, *Aphanisticus cochinchinae seminulum* Obenberger, was found in Florida sugarcane in 2000. This species is a leafmining insect, as larvae tunnel between the upper and lower leaf epidermal layers. This feeding injury results in dead tissue. Adults are small and elongated in shape and feed on leaf tissue. This beetle is native to Malaysia and southeastern Asia and was reported in Hawaii in 1984 and Texas in 1994. It is not considered an economic pest.

Chrysomelidae

Two flea beetle species, the desert corn flea beetle *Chaetocnema ectypa* Horn and *C. pulicaria* Melsheimer, can be found feeding on sugarcane leaves. The desert corn flea beetle was found injuring sugarcane leaves in Florida in 2000 and is a common species being recorded from a variety of grass hosts. It is probably not an economic pest in sugarcane. *Diabrotica* spp. (rootworms) have been reported in Florida sugarcane and are probably present in Louisiana and Texas.

Curculionidae

The Diaprepes root weevil, *Diaprepes abbreviatus* (L.), is native to the Caribbean and is an important pest of sugarcane on some of the islands. It was found in central Florida near Apopka in a nursery in 1964. Populations have moved south and adults were found in sugarcane in 2002. These weevils were associated with alternate host plants such as hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. Ex A.W. Hill] and sicklepod (*Cassia obtusifolia* L.). Thus far it has not been a problem in sugarcane but is a major concern to the citrus industry.

The silky cane weevil, *Metamasius hemipterous sericeus* (Olivier), is a subspecies of the West Indian cane weevil, *Metamasius hemipterous* (L.). It was first reported in southern Florida in 1984 but not reported infesting sugarcane until the mid-1990s. It is distributed throughout the Caribbean, Central, and South America. Females are attracted to sugarcane stalks that are cracked or have other types of injury. Larvae tunnel in the stalks and cause damage so severe that stalks may lodge or break. Pheromone trapping technology is available for monitoring, and varietal resistance (especially varieties that don't produce growth cracks) appears to be the best management approach. This insect is also an important pest of nursery palms and banana plantings.

Southern blue-green citrus root weevil adults, *Pachnaeus litus* (Germar), have been found in

sugarcane fields but there has been no observed injury to sugarcane leaves or roots. It is not known if they can complete development on sugarcane host plants.

The New Guinea sugarcane weevil or sugarcane weevil borer, *Rhabdoscelus obscurus* (Boisduval), is currently one of the three most important pests to sugarcane in Hawaii. This species has a wide distribution throughout the western Pacific, including Australia, and was documented in Hawaii in the 1880s. Females lay eggs either into bored holes or into stalks previously injured by insects or rodents. Larvae tunnel extensively in the stalks. A tachinid fly, [*Lixophaga sphenophori* (Villeneuve)], was imported from New Guinea into Hawaii in the early 1910s and again in the early 1970s. This parasitoid appears to be an important mortality agent.

Xyleborus kraatzi Eichhoff is only casually associated with sugarcane and is not thought to cause damage.

A complex of billbug species are occasionally found associated with sugarcane. These include *Sphenophorus cariosus* (Olivier), *S. coesifrons* Gyllenhal, *S. maidis* Chittenden, and *S. venatus vestitus* Chittenden. These insects are pests of forage and turf grasses and are not generally considered to be economic pests of sugarcane.

Elateridae

Wireworms, the larval stage of click beetles, are considered one of the most important pest groups attacking sugarcane. Many species are found in the sugarcane growing regions of the US, but *Melanotus communis* (Gyllenhal) and various species of *Conoderus* are the most serious pests. Wireworms feed on the buds and root primordia of newly planted seed pieces and on the young shoots and roots after germination. Wireworms are seldom pests of stubble sugarcane. The death of buds or young shoots leads to stand reductions. Chemical control is the most common management technique, although cultural controls such as change in planting date (Louisiana) or flooding (Florida) have had some success. Sampling for larvae is tedious and difficult; therefore, researchers in Florida have developed baits composed of rolled oats as a monitoring tool.

Scarabaeidae

This is a large family of beetles that are serious pests of sugarcane in many parts of the world, especially India and Australia. Scarabaeidae is separated into several subfamilies which in the literature may be given family status, including Cetoniinae (flower beetles), Dynastinae, Melolonthinae (May or June beetles), and Rutelinae (shining leaf chafers). Most scarab species damage sugarcane by feeding on roots and underground stems of stubble crops, especially around field edges. Some species will attack buds and root primordia of newly planted sugarcane and the apical meristem of growing plants [sugarcane beetle, *Euetheola humilis rugiceps* (LeConte)]. In Louisiana the white grub *Phyllophaga latifrons* (LeConte) is a pest, while in Florida *Tomarus* (= *Ligyrus*) *subtropicus* (Blatchley) is the most serious (Fig. 152) grub pest. Studies in Florida have shown that high infestations of *T. subtropicus* caused yield reductions in tonnage of 39%. Chemical control tactics are not always effective against white grubs in the US, but are successful in other sugarcane areas. Biological controls (parasitoids, milky disease *Bacillus popilliae*, and the fungal disease *Metarhizium anisopliae*) occur naturally and may have positive benefits to lowering populations. Cultural practices such as disking, reducing the number of stubble crops, and flooding are also used against these pests, and have reduced the impact of *T. subtropicus* in Florida.

Diptera

Few fly species are noted as pests in sugarcane. In Florida adults of the otitid *Euxesta stigmatias* Loew (cornsilk fly) are found in sugarcane fields but no injury has been recorded.

Sugarcane Pests and Their Management, Figure 152 An important sugarcane-feeding white grub species, *Tomarus* (= *Ligyrus*) *subtropicus* (Blatchley): larva (above) and adults (below).

Lepidoptera

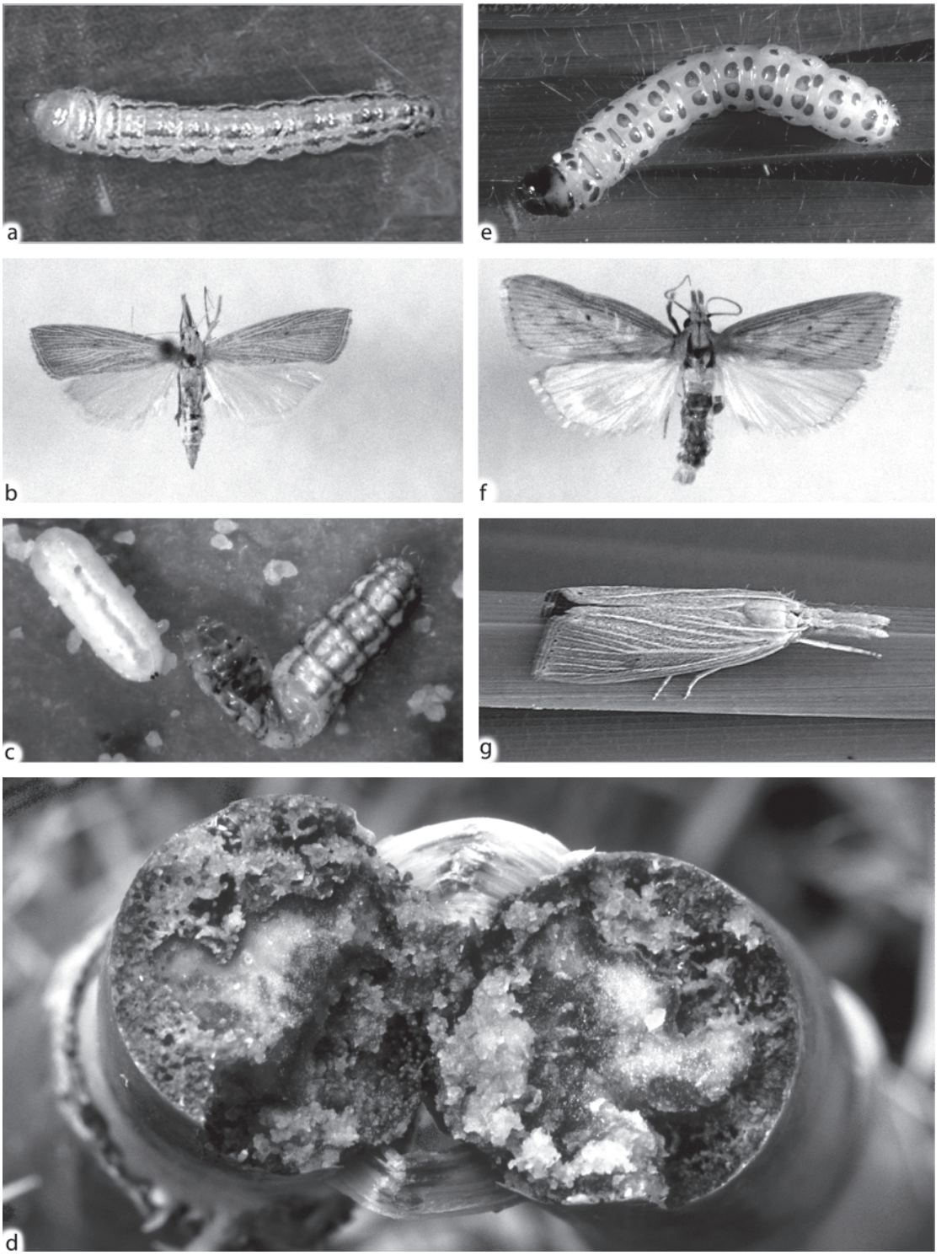
Moth species attack both above- and below-ground portions of the sugarcane plant. Many of the families we have listed (Elachistidae, Noctuidae, and Oecophoridae) contain species that are only casual occupants in sugarcane. One exception is fall armyworm (FAW) [*Spodoptera frugiperda* (J.E. Smith)], a sporadic pest that can, under certain conditions, defoliate a field of newly planted sugarcane.

Crambidae and Pyralidae

The most important group of moth pests is the crambid and pyralid stalkborers. Species in these groups are found everywhere that sugarcane is grown, and in many locations, a stalkborer species is the most important insect pest in that region. In the USA, sugarcane borer (SCB) [*Diatraea saccharalis* (F.)] is the species of concern in Florida and Louisiana. In Texas, the Mexican rice borer (MRB) [*Eoreuma loftini* (Dyar)] surpassed SCB as primary pest (Fig. 153). In Hawaii few stalkboring species are present but the lesser cornstalk borer [*Elasmopalpus lignosellus* (Zeller)] has invaded and is a serious pest.

Stalkborers lay eggs on sugarcane leaves (SCB) or in dried leaf material at the base of plants (MRB). The first few instar larvae feed or mine in the leaves, midribs, and leaf sheaths. The resulting injury appears as "pinholes" or "window-panes." In young plants, feeding within the inner whorl of leaves can cause "deadhearts," where the central growing shoot is killed. Older instar larvae enter and tunnel within stalks, creating injury defined as a "bored internode." Tunnels constructed by SCB larvae are cleaner and more linear than tunnels created by MRB larvae. Sugarcane borer larvae may tunnel in stalk sections between internodes, whereas MRB larvae generally meander within one internode. Pupation is completed within the stalk and adults emerge through their tunnels. Stalkborer feeding weakens the stalks so that they break or lodge more easily. Also, feeding allows entry for saprophytic red rot fungi [*Glomerella tucumanensis* (Speq.) Arx & E. Müller (= *Colletotrichum falcatum* Went.) and various secondary insect pests (Nitidulidae).

Chemical, biological, and plant resistance techniques are used to manage stalkborer populations. Insecticides applied that are targeted to the adult and young larval stages can be effective, but once larvae enter the stalks control is difficult. *Cotesia flavipes* Cameron, a parasitoid of *Chilo* spp. in India and Pakistan, was initially brought to the Caribbean for SCB control. It is now the main natural enemy of SCB in Florida and Texas. In Florida, augmentative releases of this parasitoid are made in some areas. In Louisiana, predation by the red imported fire ant, *Solenopsis invicta* Buren, provides good biological control. The search for effective natural enemies of MRB continues in



Sugarcane Pests and Their Management, Figure 153 **Some important Lepidoptera affecting sugarcane: Mexican rice borer, *Eoreuma loftini* (Dyar) larva (a), adult (b), larva from which a tachinid parasitoid has emerged (d), and tunneling damage in cane stalks; and sugarcane borer, *Diatraea saccharalis* (F.) larva (e) and adults (f, g).**

several states of western Mexico. Certain varieties of sugarcane have natural tolerance (ability to produce high sugar yields under stalkborer pressure) or confer resistant characters (tough leaves or rind hardness) that reduce populations. New techniques such as the production of plants with insecticidal proteins are showing positive results.

The lesser cornstalk borer (LCB) is native to the southeastern US and is a pest of sugarcane on sandy soils. It is a relatively new pest in Hawaii, being first recorded in 1986. Lesser cornstalk borer is a more serious pest to young sugarcane plants under dry conditions. Eggs are laid just below the soil surface and larvae feed from silken tunnels at or below the soil level. Larvae kill the primary shoots causing deadhearts. Cultural controls, such as regulating irrigation, insecticides, introduction and conservation of parasitoids, and varietal resistance are some of the management techniques that are used for control.

Sugarcane Pest Management

Management Strategies

Growers use a variety of approaches to control insect and mite pests of sugarcane. Cultural control is defined as using agronomic techniques to reduce the likelihood of pest problems. These techniques include planting clean seed pieces (i.e., planting uninfested cane pieces), the use of irrigation or flooding, disking or tillage of fields, reduction of the number of ratoon crops, and sanitation of infested plant material.

Biological control is another management strategy that has been very successful with some sugarcane pests. The introduction of insect pathogens (for beetle and stalkborer pests) and predators (for aphid, scale insect, and mealybug pests) has had varying degrees of success. However the introduction and conservation of parasitoids has had the most success in controlling insect pests. Insect species within families of Diptera (Tachinidae) and Hymenoptera (Bethylidae, Braconidae, Eulophidae, Ichneumonidae, Scelionidae, and Trichogrammatidae) have been released in large numbers to control various hemipteran and lepidopteran pests. For example, 17 species in six parasitoid families have been introduced into Texas sugarcane for biological control of the crambid pest MRB. Continued research into the requirements of these parasitoids and the conditions which promote their establishment and population growth will guarantee success of biological control.

Chemical control, especially against soil pests, is used in USA sugarcane production. In Florida and Louisiana, two materials are registered for wireworm and other soil insect control. Insecticides are also labeled for SCB, LCB, and aphid control in Florida and Louisiana. To maintain the presence of biological control agents, insecticide applications are made to <1% of the sugarcane acreage in Hawaii and Texas.

Varietal resistance through classical breeding has been an important management strategy against stalkborers. There is variability in the number of bored internodes among the commercial and non-commercial sugarcane clones when tested against SCB and MRB. Resistance can be separated into leaf and stalk components. Young larvae must be able to become established within the leaves, midribs, and leaf sheaths and obtain sufficient nutrients before entering stalks. Leaf sheath appression and leaf midrib hardness have been shown to be resistant characters. Stalk resistance involves the ability of larvae to enter and tunnel. Rind hardness (an interior section of the stalk), stem diameter, and physical attributes of the interior part of the stalk are mentioned as possible resistant characters.

However, classical breeding for sugarcane improvement is labor intensive as well as time consuming, and is often limited by genetic complexity and low fertility. Unlike many other grasses, sugarcane tissue culture and transformation is, for the most part, genotype independent. Consequently, elite sugarcane cultivars can be genetically engineered for improved traits like insect resistance.

Sugarcane plants have been genetically engineered through the biolistic method of transformation (using a "gene gun" to insert genes into the tissue) using embryogenic callus as the target tissue derived from young plant tissue. Additionally, *Agrobacterium*-mediated transformation has been successful using meristematic sections and axillary buds of the sugarcane plant. A lectin-encoding gene (*Galanthus nivalis* agglutinin) from the snowdrop lily was used to transform sugarcane, and experimental results showed less feeding by larvae and fewer eggs placed on these plants by MRB and SCB. Partial resistance to SCB was also observed in transgenic sugarcane plants expressing genes encoding soybean proteinase inhibitors. However, the most common genes used for insect resistance in sugarcane have been modified *Bacillus thuringiensis* (Bt) endotoxin protein genes. Transgenic sugarcane plants expressing these Bt genes have displayed resistance to the LCB, SCB, and FAW.

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Sugarcane Pests and Their Management, Table 27 **Sugarcane arthropod pests, geographical area affected, and site of injury**

Taxa scientific/Common name	USA geographic area	Site of injury
Acari		
Tetranychidae		
Oligonychus stickneyi (McGregor)	Hawaii, Florida	leaves
O. grypus Baker & Pritchard	Florida	leaves
O. pratensis (Banks)	Florida	leaves
Tarsonemidae		
Steneotarsonemus bancrofti (Michael)	Hawaii, Florida	leaves
Collembola		
Entomobryidae		
Lepidocyrtus cyaneus Tullberg	Florida	
Pseudosinella violentus (Folsom)	Florida, Louisiana	roots
Salina beta Christiansen & Bellinger	Florida	leaves
Isotomidae		
Proisotoma minuta (Tullberg)	Louisiana	roots
Onychiuridae		
Onychiurus armatus (Tullberg)	Florida, Louisiana	roots
Orthoptera		
Acrididae		
Schistocerca obscura (F.)	Florida	leaves

Sugarcane Pests and Their Management, Table 27 Sugarcane arthropod pests, geographical area affected, and site of injury (Continued)

Taxa scientific/Common name	USA geographic area	Site of injury
Gryllidae		
Gryllus assimilis (F.) – Jamaican field cricket	Florida	leaves
G. firmus Scudder – sand field cricket	Florida	leaves
Gryllotalpidae		
Scapteriscus borellii Giglio-Tos – southern mole cricket	Florida	roots, shoots
S. vicinus Scudder – tawny mole cricket	Florida	roots, shoots
Isoptera		
Rhinotermididae		
Coptotermes formosanus Shiraki – Formosan subterranean termite	Hawaii	roots
Reticulitermes flavipes (Kollar) – eastern subterranean termite	Florida	roots
Psocoptera		
Ectopsocidae		
Ectopsocopsis cryptomeriae (Enderlein)	Florida	leaves
Hemiptera		
Acleridae		
Aclerda holci Teague	Louisiana	leaves
A. sacchari Teague	Louisiana	leaves
Aphididae		
Acyrthosiphon pisum (Harris) – pea aphid	cosmopolitan	leaves
Hyperomyzus lactucae (L.) – sowthistle aphid	cosmopolitan	leaves
Hysteroneura setariae (Thomas) – rusty plum aphid	all sugarcane-producing states	leaves
Melanaphis sacchari (Zehntner) – sugarcane aphid	Florida, Hawaii, Louisiana	leaves
Rhopalosiphum maidis (Fitch) – corn leaf aphid	cosmopolitan	leaves
Sipha flava (Forbes) – yellow sugarcane aphid	all sugarcane-producing states	leaves
Uroleucon ambrosiae (Thomas) – brown ambrosia aphid	Louisiana	leaves
Cercopidae		
Prosapia bicincta (Say)	Florida, Louisiana	roots, leaves
Cicadellidae		
Balclutha caldwelli Blocker	Florida	leaves
B. rosea (Scott)	Texas	leaves

Sugarcane Pests and Their Management, Table 27 **Sugarcane arthropod pests, geographical area affected, and site of injury (Continued)**

Taxa scientific/Common name	USA geographic area	Site of injury
Draeculacephala mollipes (Say)	Hawaii, Louisiana	leaves
D. portola Ball	Florida, Louisiana, Texas	leaves
Graminella nigrifrons (Forbes) – blackfaced leafhopper	Florida, Texas	leaves
G. plana (DeLong)	Texas	leaves
G. sonora (Ball)	Texas	leaves
Homalodisca insolita (Walker)	Florida, Texas	leaves
Oncometopia lateralis F.	Louisiana	leaves
Cixiidae		
Myndus crudus Van Duzee – American palm cixiid	Florida	roots, leaves
Oliarus texanus Metcalf	Texas	leaves
Coccidae		
Pulvinaria elongata Newstead	all sugarcane-producing states	leaves
Cydnidae		
Cyrtomenus ciliatus (Palisot de Beauvois)	Florida	roots
Pangaeus bilineatus (Say)	Florida, Louisiana	roots
Sehirus cinctus (Palisot)	Louisiana	roots
Delphacidae		
Perkinsiella saccharicida Kirkaldy – sugarcane delphacid	all sugarcane-producing states	leaves
Saccharosydne saccharivora (Westwood)	Florida, Louisiana, Texas	leaves
Diaspididae		
Aspidiella sacchari (Cockerell)	Florida, Hawaii, Texas	stalks
Aspidiotus destructor Signoret	Florida, Hawaii	stalks
Diaspis bromeliae (Kerner) – pineapple scale	Florida, Hawaii	stalks
Duplachionaspis divergens (Green)	Florida in U.S; cosmopolitan	stalks
Hemiberlesia cyanophylli (Signoret)	Florida, Hawaii	stalks
Odonaspis saccharicaulis (Zehntner)	Florida, Hawaii, Texas	stalks
Selenaspidus articulatus (Morgan)	Florida	stalks
Pseudococcidae		
Antonina graminis (Maskell) – Rhodesgrass mealybug	all sugarcane-producing states	stalks
Birendracoccus saccharifolii (Green)	Florida?	leaves
Chorizococcus rostellum (Lobdell)	Hawaii	stalks

Sugarcane Pests and Their Management, Table 27 Sugarcane arthropod pests, geographical area affected, and site of injury (Continued)

Taxa scientific/Common name	USA geographic area	Site of injury
Dysmicoccus boninsis (Kuwana) – gray sugarcane mealybug	all sugarcane-producing states	stalks
D. brevipes (Cockerell) – pineapple mealybug	Florida, Hawaii	roots/stalks
Pseudococcus longispinus (Targioni-Tozzetti) – longtailed mealybug	Hawaii	stalks
Saccharicoccus sacchari (Cockerell) – pink sugarcane mealybug	Florida, Hawaii, Texas	stalks
Tingidae		
Leptodictya tabida (Herrich-Schaeffer) – sugarcane lacebug	Florida, Hawaii, Texas	leaves
Thysanoptera		
Phlaeothripidae		
Haplothrips halophilus Hood	Louisiana	leaves
Thripidae		
Anaphothrips obscurus (Müller) – grass thrips	Hawaii	leaves
A. swezeyi Moulton – Hawaiian grass thrips	Hawaii	leaves
Arorathrips (= Chirothrips) mexicanus (Crawford)	Hawaii	leaves
A. (= Chirothrips) spiniceps (Hood)	Hawaii	leaves
Bregmatothrips venustus Hood	Louisiana	leaves
Chirothrips sacchari Moulton	Hawaii	leaves
Hercinothrips femoralis (Reuter) – banded greenhouse thrips	Florida, Hawaii	leaves
Thrips saccharoni Moulton	Hawaii	leaves
Coleoptera		
Alleculidae		
Lobopoda sp.	Florida	roots?
Buprestidae		
Aphanisticus cochinchinae seminulum Obenberger	Florida, Hawaii, Texas	leaves
Cerambycidae		
Prionus sp.	Florida	stalks?
Prosoplus bankii (F.)	Hawaii	stalks?
Chrysomelidae		
Chaetocnema ectypa Horn – desert corn flea beetle	Florida, Louisiana, Texas	roots, leaves
C. pulicaria Melsheimer	Florida, Louisiana	roots, leaves

Sugarcane Pests and Their Management, Table 27 **Sugarcane arthropod pests, geographical area affected, and site of injury (Continued)**

Taxa scientific/Common name	USA geographic area	Site of injury
Diabrotica spp.	Florida	roots, leaves
Curculionidae		
Diaprepes abbreviatus (L.) – Diaprepes root weevil	Florida, Texas	roots
Metamasius hemipterous sericeus (Olivier) – silky cane weevil	Florida	stalks
Pachnaeus litus (Germar) – southern blue-green citrus root weevil	Florida	roots
Rhabdoscelus obscurus (Boisduval) – New Guinea sugarcane weevil; sugarcane weevil borer	Hawaii	stalks
Sphenophorus cariosus (Olivier) – nutgrass billbug	Hawaii, Louisiana, Florida?, Texas?	roots
S. coesifrons Gyllenhal	Florida	roots
S. maidis Chittenden – maize billbug	Louisiana	roots
S. venatus vestitus Chittenden – hunting billbug	Florida, Louisiana	roots
Xyleborus kraatzi Eichhoff	Hawaii	stalks
Elateridae		
Aeolus dorsalis (Say)	Florida	buds, roots
Conoderus amplicollis (Gyllenhal) – gulf wireworm	Florida, Hawaii, Texas	buds, roots
C. exsul Sharp	Hawaii	buds, roots
C. falli Lane – southern potato wireworm	Florida	buds, roots
C. lividus (De Geer)	Florida, Louisiana, Texas	buds, roots
C. (= Aeolus) perversus Brown	Florida	buds, roots
C. rudis Brown	Florida	buds, roots
C. scissus (Schaeffer)	Florida	buds, roots
Glyphonyx bimarginatus Schaeffer	Florida	buds, roots
Ischiodontus sp	Florida	buds, roots
Melanotus communis (Gyllenhal) – corn wireworm	Florida	buds, roots
Neotrichophorus carolinensis (Schaeffer)	Florida	buds, roots
Orthostethus infuscatus (Germar)	Florida	buds, roots
Simodactylus cinnamomeus (Boisduval)	Hawaii	buds, roots
Nitidulidae		
Carpophilus humeralis (F.)	Florida	seed pieces
Scarabaeidae		
Cetoniinae		

Sugarcane Pests and Their Management, Table 27 Sugarcane arthropod pests, geographical area affected, and site of injury (Continued)

Taxa scientific/Common name	USA geographic area	Site of injury
Euphoria sepulcralis (F.)	Florida, Texas	roots
Dynastinae		
Cyclocephala borealis Arrow	listed as USA	roots
C. parallela (Casey)	Florida	roots
Dyscinetus morator (F.)	Florida, Texas	roots
Euetheola humilis rugiceps (LeConte) – sugarcane beetle	Louisiana	roots, buds
Tomarus (= Ligyrus) subtropicus (Blatchley)	Florida	roots
T. gibbosus (DeGeer)	Louisiana	roots
Melolonthinae		
Phyllophaga antennata (Smith)	listed as USA	roots
P. clypeata (Horn)	listed as USA	roots
P. congrua (LeConte)	listed as USA	roots
P. crassissima (Blanchard)	listed as USA	roots
P. latifrons (LeConte)	Louisiana, Florida	roots
Rutelinae		
Anomola marginata (F.)	Florida	roots
A. orientalis (Waterhouse)	Hawaii	roots
Tenebrionidae		
Eutochia lateralis Boheman	Hawaii	roots
Diptera		
Otitidae		
Euxesta stigmatias Loew – cornsilk fly	Florida	?
Lepidoptera		
Crambidae		
Diatraea crambidoides (Grote) – southern corn stalk borer	Florida, Louisiana, Texas	stalks
D. evanescens Dyar	Florida, Louisiana?	stalks
D. saccharalis (F.) – sugarcane borer	Florida, Louisiana, Texas	stalks
D. lineolata Walker	Texas	stalks
Eoreuma loftini (Dyar) – Mexican rice borer	Texas	stalks
Herpetogramma bipunctalis (F.) – southern beet webworm	Florida, Louisiana, Texas	leaves
Elachistidae		
Elachista saccharella (Busck)	Louisiana	leaves
Elachista (= Dicranoctetes) sp.	Florida	leaves

Sugarcane Pests and Their Management, Table 27 **Sugarcane arthropod pests, geographical area affected, and site of injury (Continued)**

Taxa scientific/Common name	USA geographic area	Site of injury
Noctuidae		
Agrotis crinigera (Butler)	Hawaii	leaves
A. dislocata (Walker)	Hawaii	leaves
A. ipsilon (Hufnagel) – black cutworm	all sugarcane-producing states	leaves, shoots
A. malefida Guenée – pale-sided cutworm	Florida, Louisiana, Texas	leaves, shoots
A. subterranea (F.) – granulated cutworm	Florida, Louisiana, Texas	leaves, shoots
Anicla infecta (Ochsenheimer) – green cutworm moth	Florida, Louisiana, Texas	leaves
Elaphria chalcedonia (Hübner)	Florida, Louisiana, Texas	leaves
E. nucicolora (Guenée)	Florida, Louisiana, Texas	leaves
Leucania latiuscula Herrich-Schaffer	Florida, Louisiana, Texas	leaves
L. scirpicola Guenée – scirpus wainscot	Florida, Louisiana, Texas	leaves
Meropleon cosmion Dyar	Florida, Louisiana, Texas	leaves
Mocis latipes (Guenée) – small mocis	Florida, Louisiana, Texas	leaves
Pseudaletia amblycasis (Meyrick)	Hawaii	leaves
P. pyrrhias (Meyrick)	Hawaii	leaves
P. unipuncta (Haworth) – armyworm	all sugarcane-producing states	leaves
Spodoptera dolichos (F.)	Florida (greenhouse)	leaves
S. frugiperda (J.E. Smith) – fall armyworm	Florida, Louisiana, Texas	leaves
S. eridania (Stoll) – southern armyworm	Florida, Louisiana, Texas	leaves
S. latifascia (Walker)	Florida (greenhouse)	leaves
Oecophoridae		
Autosticha pelodes (Meyrick)	Hawaii	leaves
Pyralidae		
Cryptoblabes aliena Swezey	Hawaii	stalks
Elasmopalpus lignosellus (Zeller) – lesser cornstalk borer	all sugarcane-producing states	tillers, shoots
Marasmia trapezalis (Guenée)	Florida	stalks
Tineidae		
Opogona apicalis Swezey	Hawaii	stalks, buds
O. aurisquamosa (Butler)	Hawaii	stalks, buds
O. omoscopa (Meyrick)	Hawaii	stalks, buds
O. purpuriella Swezey	Hawaii	stalks, buds
O. sacchari (Bojer) – banana moth	Florida, Hawaii	stalks, buds