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Biology and Management of the Sugarcane Beetle (Coleoptera: Scarabaeidae) in Turfgrass

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ABSTRACT. The sugarcane beetle, *Euetheola humilis* (Burmeister), traditionally a pest of agricultural crops, has become a sporadic, but serious, pest of turfgrass on golf courses, athletic fields, home lawns, sod farms, and in pastures. Initially confined to the southeastern United States it has, in recent years, spread as far north as Maryland, west into Texas, and south into Florida. Little is known about sugarcane beetle ecology and behavior in turfgrass, including dispersal and feeding behaviors and the impact of damage to turf. Our research helped confirm previous ecological studies of this pest on sugarcane and other agronomic crops relative to life cycle, biology, and behavior to further develop better management approaches. Additional research concerning this insect is summarized and discussed relative to the current pest status of this insect and potential management strategies.

Key Words: sugarcane beetle, integrated pest management, turfgrass, *Euetheola*

Review of the Literature

The origin of the sugarcane beetle, *Euetheola humilis* (Burmeister), is not known; however, it is important to carefully review the literature, as nomenclature of this beetle has changed since its discovery in the United States. In 1847, the beetle was first identified by the German zoologist Hermann Burmeister as *Heteronychus humilis* from specimens collected on travels to Brazil and Argentina (Burmeister 1847). The first recorded observation of sugarcane beetles in the United States occurred in 1856, when entomologist John LeConte identified two adult beetles collected from a rice field in Georgia. LeConte placed the beetle in the genus, *Ligyrus*, following communications with Burmeister who indicated the beetle had originally been placed in the incorrect genus. LeConte also renamed the species, *rugiceps* (LeConte 1856), and subsequent papers referred to sugarcane beetles as *L. rugiceps* (LeConte) (Riley 1880, Comstock 1881, Howard 1888, Webster 1890, Titus 1905, Sherman 1914). In 1890, Henry Walter Bates, a British zoologist, proposed the genus, *Euetheola*, be created for the sugarcane beetle, asserting that *Heteronychus* was a misnomer (Bates 1890, Arrow 1911)—LeConte's earlier proposed genus name change of *Ligyrus*, published in the Proceedings of the Academy of Natural Sciences of Philadelphia, may not have reached the European scientific community. Bates, therefore, renamed the sugarcane beetle using the new genus name and Burmeister's original species name, *Euetheola humilis*. Bates also wrote that sugarcane beetle specimens had been recovered by various entomologists in both Mexico and Panama (Bates 1890). Before 1990, research papers and reports on sugarcane beetles published in the United States used the scientific name, *Eutheola rugiceps* (LeConte) (Phillips and Fox 1917, 1924; Osterberger 1931; Baerg and Palm 1932; Ingram and Bynum 1932; Lyle 1933; Ritcher 1944; Eden 1954; Scott 1956; Henderson et al. 1958; Holman 1968; Régnière et al. 1981; Riley 1986; White 1990), acknowledging Bates' genus name but retaining LeConte's original species name. Papers published in South America in that time, however, have maintained the name *Eutheola humilis* (Burmeister) (Hempel 1920, Guimaraes 1944, Abrahao 1970). Since 1990, papers have reverted to using *Euetheola humilis* (Burmeister) (Forschler and Gardner 1991, Forrest et al. 1995, Sanchez Soto 1997, Scavo and Joly 1998, Flanders et al. 2000, Buss 2006, Bernardi et al. 2008). Despite inconsistent naming, variations of *Euetheola* (*Ligyrus*) *humilis* (*rugiceps*) (Burmeister or LeConte) all refer to the sugarcane beetle.

Distribution and Pest Status

Since 1856, sugarcane beetle infestations have been recorded throughout the southeastern United States, north into Maryland and southern Ohio, as far west as Texas, and south into Florida (Brandenburg and Freeman 2012; Fig. 1). Although currently a sporadic issue in managed turfgrass, sugarcane beetles historically have been agricultural pests in the United States (Comstock 1881, Howard 1888). Also, they have been recorded as pests in buildings (Guimaraes 1944), rice (Hempel 1920, Ferreira 1998), and cotton (Abrahao 1970) in Brazil. They have also been collected in southeastern Mexico (Bates 1890, Sanchez Soto 1997), Panama (Bates 1890), and been found damaging rice, corn, sweet potato, and sugarcane in Venezuela (Scavo and Joly 1998).

Description

Sugarcane beetle eggs are white, shiny, and smooth (Titus 1905) and from oviposition until hatching, they almost double in size and triple in volume (Baerg and Palm 1932). The larvae are typical, "C-shaped" white grubs with red-orange head capsules (Phillips and Fox 1917). The raster pattern of sugarcane beetle larvae consists of an irregular median double row of bristles (Baerg 1942), but can be confused with that of masked chafers (*Cyclocephala* spp.; Fig. 2). As a result, sugarcane beetle larvae are often difficult to distinguish from other white grub species in the field (Watschke et al. 2013).

Sugarcane beetle adults are dull black, ≈15 mm (0.6 in) in length, and have distinct rows of striae extending along the length of the abdomen (Fig. 3). Adults can often be confused with three common beetles within the same subfamily of rhinoceros beetles (Dynastinae): rice beetles (*Dyscinetus morator* F.) (Casey 1915) and carrot beetles (*Tomarus gibbosus* (DeGeer) (Comstock 1881, Hayes 1917) and *Tomarus subtropicus* (Gordon and Anderson 1981)). Adults of sugarcane and rice beetles are black and similar in size and shape. However, rice beetles have a smooth, broad head that lacks clypeal teeth and has a rectangular clypeus, separated from the epicranium by a distinct suture, distinct characteristics in sugarcane beetle adults (Phillips and Fox 1924; Fig. 3). Rice beetle adults can sometimes be larger than sugarcane beetles and range from 15 to 19 mm. Carrot beetles tend to have a reddish-brown tint to the head, thorax, and elytra, and the ventral sides of the thorax and abdomen are covered with tiny hairs. Carrot beetles also have a median depression close to the anterior margin of the pronotum, in front of which is a blunt spine (Phillips and Fox 1924). Another species that may be mistaken for sugarcane beetle is the lamellicorn beetle (*Diplotaxis liberta* Germar).

Fig. 1. Map of sugarcane beetle distribution (Brandenburg and Freeman 2012).

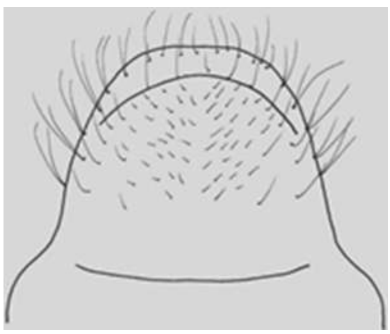

Fig. 2. Sugarcane beetle raster pattern (Carroll 2013). Referenced from Ritcher 1944.

Fig. 3. Sugarcane beetle adult.

These beetles are in a different subfamily (Melolonthinae) but are black and similarly shaped to sugarcane beetles. Lamellicorn beetles tend to be smaller (≈9–10 mm) than sugarcane beetles and have a smooth head that is similar to the rice beetle, although the anterior edge of the head capsule curves upward toward the dorsal side. Larvae of *D. liberta* feed on coniferous seedlings (Craighead 1950); thus, adult catches of lamellicorn beetles in light traps are typically higher near coniferous trees. All five species of adult beetles are attracted to light sources at night (Forschler and Gardner 1991, Flanders et al. 2000, Buss 2006), so it is common to find specimens of any of these five species in a light trap throughout the year. Although there are other morphological traits unique to each beetle species, examination of the head is the most easy and reliable method to identify adults in the field.

Life Cycle

Sugarcane beetles are univoltine. Although previous work suggests that females lay their eggs in the soil in May and June (Ingram and Bynum 1932), dissections of female beetles in the spring in North Carolina indicate that they contain eggs from April through October. The eggs are white, smooth, and ≈0.75 mm in diameter (Titus 1905). Eggs hatch within 8–10 d, dependent on available soil moisture (Baerg and Palm 1932). Larvae are present in the soil June through August, and the next generation of adults begins emergence in September. Adult activity continues throughout October and November. Our observations of overwintering behavior indicate that adults begin to burrow deeper (>10 cm) into the soil as temperatures decrease below 10°C (50°F) in late fall. In laboratory studies, sugarcane beetles were reared from oviposition to adult, incubated at an average of 33°C (91°F) and 80% relative humidity. The total time of development was 53 d for an approximate total of 2,230 DD (Baerg and Palm 1932). Earlier work suggests that relatively harsh winters (2–3 wk with low temperatures below 0°C; White 1990) and low soil moisture are conducive to sugarcane beetle development (Holman 1968, White 1990). Light trap catches from North Carolina are consistent with these findings and suggest that, in the southeast United States, harsh winters are often followed by larger sugarcane beetle overwintering populations, which subsequently result in higher fall adult numbers.

Flight Behavior

Sugarcane beetle adults exhibit significant flight behavior at two distinct times of the year: mid-late spring and mid-fall. When adults emerge in the spring, beetles fly to light sources, and flight activity is typically at its highest level at this time of year (Fig. 4). Fall flight activity is less predictable, with some years having moderate adult flight activity (200–500 beetles per weekly trap catch), as measured by black-light traps, and other years with little to no flight activity (0–80 beetles per weekly trap catch; A.C. Murillo and R.L.B., unpublished data). They can also be seen walking across the turf surface at night throughout the spring, summer, and fall. Nighttime beetle activity is highest ≈1 h after sunset before air temperatures fall below 18°C (64°F). Adults are also frequently observed walking across the turf early in the morning, but typically burrow down into the soil to avoid predation and exposure to direct sunlight. Adult flight activity decreases in June and July, and flight activity for the new generation begins in early September. Sugarcane beetle and carrot beetle flight behaviors seem greatly influenced by nighttime air temperatures (Forschler and Gardner 1991). One possible explanation is that sugarcane beetle adults rely more on ambient air temperature to reach a threshold for wing muscle locomotion, which allows them to fly and mate.

Damage in Turfgrass

Sugarcane beetles have most frequently been reported as a pest of warm-season turfgrasses. Although corn and sugarcane were originally thought to be the primary hosts, adult sugarcane beetles were often recovered in pasture areas and wild fields feeding exclusively on *Paspalum* spp. grasses, and especially *Juncus effuses* L. As historical surveying efforts continued, entomologists discovered that although *Paspalum* were preferred hosts, sugarcane beetles could survive for long periods of time on Bermuda grass (*Cynodon dactylon* L.) when the former was not present (Phillips and Fox 1924). Due to the irregular and infrequent occurrence of adult beetle infestations, concern regarding sugarcane beetle issues waned during the latter half of the 20th century. In the past two decades, beetle activity in managed turfgrass has increased in the Southeast, and infestations have been recorded in both Bermuda grass and zoysiagrass (*Zoysia* spp.). Sugarcane beetle preference to warm- and cool-season grasses has been examined, and adults appear not to have a significant preference for

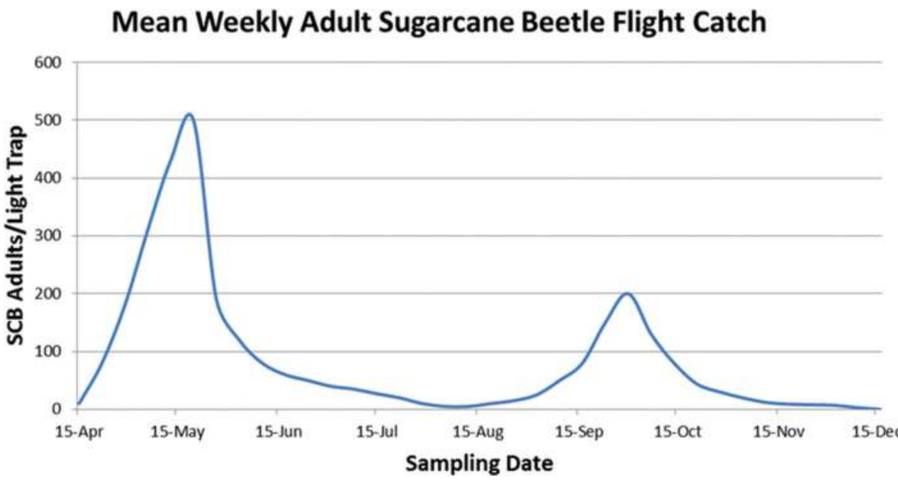

Fig. 4. Mean weekly adult sugarcane beetle UV-black light trap catch in Wake Co., NC (2009–2012).

either under laboratory conditions (Murillo and Brandenburg 2011, unpublished data). These observations indicate that the incidence of warm-season sugarcane beetle infestation may be a reflection of beetle distribution in the southeastern United States, where warm-season turfgrasses are predominant. Recently, sugarcane beetles have been recorded as a pest in established tall fescue in South Carolina (T.L.B., unpublished data). Most likely, adults are initially attracted to areas with an abundant food source and their northward distribution is restricted by winter minimum temperatures.

Injury caused by sugarcane beetles can be seen in turfgrass as early as May and, unlike other white grub species, sugarcane beetles can damage turfgrass both in the larval and adult life stage. In June, July, and August, larvae primarily feed on decaying plant material in the soil but may incidentally feed on turfgrass roots, weakening a turf stand when larval populations are high. April through November, adults cause direct damage to the turfgrass by attacking the stem of the plant at the soil surface and either cut off the stem completely or sever it so that the plant wilts and dies (Phillips and Fox 1924). Over the course of a few weeks, adults can consume large portions of above-ground plant material which causes a thinning of the grass canopy (Fig. 5). Indirect damage to the turfgrass may also occur by adult beetles tunneling and burrowing through the soil during the day. This tunneling behavior, ≈12–50 mm (0.5–2 in) below the soil surface, weakens the plant root system and creates an uneven turf surface. Adult beetles cause the majority of damage following overwintering emergence in April and May and after the fall emergence in late September and early October. Following overwintering, sugarcane beetles are initially attracted to light sources at night. On golf courses and athletic fields, damage tends to be most severe directly underneath a light source and spreads radially from there.

Sugarcane beetle larvae and adults can cause secondary damage to turf, by attracting mammals such as moles, raccoons, armadillos, and birds to an infested area (Buss 2006). Damage is not limited to the spring and fall, when the adults are feeding, but can also occur from mammals foraging for adults and larvae anytime the insect is active. As a result, a sugarcane beetle infestation could lead to a nearly year-long damage control issue.

Damage in Agricultural Crops and Ornamentals

Sugarcane beetles are recorded as pests of many other plant species, including sugarcane (Comstock 1881, Titus 1905, Philips and Fox 1917, Philips and Fox 1924, Osterberger 1931, Baerg and Palm 1932, Ingram and Bynum 1932, White 1990, Smith 2006), corn (Howard 1888; Titus 1905; Sherman 1914; Phillips and Fox 1917, 1924; Baerg 1942), wild grasses (Sherman 1914; Phillips and Fox 1917, 1924), eucalyptus (Bernardi et al. 2008), rice (Osterberger 1931, Ingram and Bynum 1932), roses (Lyle 1933), strawberries (Baerg 1942), tobacco (Scott 1956), potato (Sherman 1914), and sweet potato

Fig. 5. Symptomatic thinning turfgrass damage caused by sugarcane beetle adults.

(Smith 2006). This polyphagous feeding behavior increases the difficulty of predicting sugarcane beetle outbreaks because they are able to survive and reproduce on plants commonly found across systems. Damage in sugarcane and corn is similar. Adults bore into the stalk at (sugarcane) or below (corn) the soil surface and consume the plant material. Once they reach the apical meristem or "heart," the plant lodges and the roots decay, providing soft plant material for larval feeding (Titus 1905). Recent work has suggested that adult beetles have a positive olfactory response to both beetle-injured and mechanically injured roots and are more likely to become a pest in stressed sugarcane stands (Smith 2006). In roses, strawberries, and tobacco, adults feed on plant stems just below the soil surface, causing wilting and yield loss. Adults also burrow into the ground to feed on the roots of sweet potatoes. To date, larvae have not been reported feeding directly on these host plants, and are most likely consuming organic matter and root materials in the soil.

Sampling

Adult sugarcane beetles are attracted to light sources at night. Bucket black-light traps equipped with 22-W, AC-powered circular black-light bulbs (BioQuip, Rancho Dominguez, CA) are used as an effective tool to monitor for sugarcane beetle adults throughout the spring, summer, and fall.

Placing UV–black light traps in areas with a history of sugarcane beetle activity in late March and April can aid in early detection. Light traps should be placed in an area adjacent to a turfgrass stand and should be monitored weekly throughout the spring, summer, and fall. Sugarcane beetle damage thresholds are not currently established due to discrepancies between adult count numbers and associated turfgrass injury. Successful monitoring of sugarcane beetles includes keeping accurate records of areas that have sustained past injury and corresponding light trap beetle numbers. If light trap beetle numbers approach a level at which injury has occurred in that particular area in the past, treatment may be necessary. Although trap catch numbers can be a good indication of sugarcane beetle presence and timing of flight activity, they are generally not an accurate representation of the relative abundance of the beetle population. The best way to determine the spatial distribution of a sugarcane beetle population is to walk a turfgrass stand an hour after sunset with a flashlight or headlamp. Adults walk across the turf surface throughout late spring, summer, and fall, although light trap catch numbers are lowest in the middle of the summer.

Management

Cultural practices such as appropriate fertilizer use and infrequent, deep irrigation will result in a vigorous turf stand that is more tolerant of insect pests and may help alleviate some damage issues. Eliminating any unnecessary light sources that may attract adult beetles to the turf area may be beneficial also.

Earlier research has shown that sugarcane beetle larvae, similar to other white grubs, can be susceptible to parasitism by several parasitoids. Specifically, four different families of parasitic flies have been recorded ovipositing inside sugarcane beetle larvae including asilids and dexiids (Phillips and Fox 1924, Osterberger 1930, Baerg 1942) and sarcophagids and tachinids (Ingram and Bynum 1932). An unidentified species of wasp, similar to *Tiphia inornata* which is known for attacking *Phyllophaga* spp. larvae, also lays eggs inside sugarcane beetle grubs. The wasp larvae feed on the dorsal side, immediately behind the head capsule (Phillips and Fox 1924).

Although not capable of attacking adult beetles, foraging thief ant (*Solenopsis molesta* Say) populations will feed on scarab eggs placed in the soil, reducing the number of larvae and adults present (Zenger and Gibb 2001). The red imported fire ant (*Solenopsis invicta* Buren) has been examined as a potential predator of scarab beetle adults and larvae in the southeastern United States, but research has shown no apparent susceptibility of sugarcane beetle adults to fire ant population activity. It is possible that fire ant activity in an area may increase scarab egg predation. However, proximity of egg lay location to ant foraging tunnels may be necessary for ant populations to have much of an impact (Barden et al. 2011).

Although not known to have feeding habits that negatively impact beetle larval populations, saprophytic mites, *Rhizoglyphus phylloxserae* Riley, have been found attacking field collections of sugarcane beetle larvae in the laboratory, resulting in a lower survival rate (Phillips and Fox 1924). Our observations indicate that adult sugarcane beetles captured at night carry several species of mites that may have an impact on sugarcane beetle survival. Mite specimens recovered from these adults belong to the Mesostigmata order, and the relationship between these mites and sugarcane beetles is not yet known. Mesostigmatid mites can be either predaceous or phoretic, but generally form a parasitic relationship with nesting insects (Hunter and Rosario 1988). Sugarcane beetles with significant mite activity, typically exhibit weakened, convulsive walking behavior and seem unable to fly, suggesting that mite presence has a negative impact on adult and larval survival.

Effective chemical control requires a different approach for sugarcane beetles compared with that of other scarabs (*Popillia japonica* Newman, *Cyclocephala* spp., and *Phyllophaga* spp.), which targets early larval instars. Unlike other white grub species that overwinter in the larval stage, the sugarcane beetle spends the majority of its life cycle as an adult. Sugarcane beetle adults, once emerged, do not fly very far before mating and ovipositing. Therefore, larval populations in the soil are larger in areas where adult flight activity is greatest. Overwintered sugarcane beetle adults also have a sporadic distribution, higher numbers than fall populations, and great damage potential, thereby requiring control products for the adults to be applied as quickly as possible once adults are observed. Historically, organochlorines (Henderson et al. 1958) and organophosphates (Riley 1986) provided excellent control of sugarcane beetle adults. Recent work suggests that the pyrethroid insecticides may be the most successful against adults although there is variability in efficacy among the active ingredients in this class. Adult sugarcane beetles are more susceptible to the active ingredient z-cypermethrin over others (chlorpyrifos or bifenthrin; Smith 2006). Research in North Carolina has shown higher efficacy against the overwintered adults that emerge in spring and early summer and significantly lower control against fall-emerging adults. Low winter temperatures could have fitness costs to the overwintering adult populations that may contribute to higher insecticide efficacy. Insecticide performance may be improved by targeting the more susceptible adult beetle population. Additional research is needed to examine insecticide efficacy against both overwintering and fall-emerging adults to classify active ingredient success between two temporally distinct adult populations.

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