Weedy Host Plants of the Sugarcane Root Weevil (Coleoptera: Curculionidae) in Florida Sugarcane[1]

Dennis C. Odero, Ronald H. Cherry[2], and David G. Hall[3]

Everglades Research and Education Center, 3200 E. Palm Beach Road, Belle Glade, Florida 33430 USA

J. Entomol. Sci. 48(2): 81-89 (April 2013)

Abstract A greenhouse study was conducted to evaluate adult sugarcane root weevil (*Diaprepes abbreviatus* (L.)) residence (location), feeding damage, and oviposition choice on 4 sugarcane varieties and 5 weed species found in Florida sugarcane. Sugarcane varieties were CP 89 - 2143, CP 88 - 1762, CP 80 - 1743, and CP 78 - 1628. Weed species were common lambsquarters (*Chenopodium album* L.), spiny amaranth (*Amaranthus spinosus* L.), common purslane (*Portulaca oleracea* L.), sicklepod (*Senna obtusifolia* (L.) H.S. Irwin & Barneby), and coffee senna (*Senna occidentalis* (L.) Link). Adult residence was highest on coffee senna followed by spiny amaranth, sicklepod, and common purslane. Few adults were observed on sugarcane varieties and common lambsquarters. Adults caused feeding damage on all weed species. Coffee senna, spiny amaranth, and sicklepod had the highest feeding damage whereas common lambsquarters had the least damage. Little feeding damage was observed on sugarcane varieties. Oviposition of *D. abbreviatus* was observed on all sugarcane varieties and weed species with exception of common lambsquarters and sicklepod. Significantly more egg masses were found on sugarcane varieties compared with weed species. Weed surveys conducted in 3 locations in Florida sugarcane showed common lambsquarters, spiny amaranth, common purslane, and sicklepod as common broadleaf weeds in sugarcane fields. These results show that several weed species found in Florida sugarcane are suitable as food sources and oviposition sites for *D. abbreviatus*. However, sugarcane is generally more preferred for oviposition by *D. abbreviatus*. Preventing or removing weed hosts of *D. abbreviatus* from sugarcane fields will be an important defense against the weevil.

Key Words root weevil, sugarcane, weeds, Florida, *Diaprepes*

The sugarcane root weevil (*Diaprepes abbreviatus* (L.)) occurs naturally in the Lesser and Greater Antilles where it is considered an important pest of sugarcane and citrus, particularly in Barbados and Puerto Rico (Woodruff 1968). The weevil is native in the Caribbean and was first reported in Apopka, FL in 1964 (Woodruff 1964) from where it subsequently expanded its range across 17 counties (Hall 1995). *Diaprepes abbreviatus* is considered an important pest of citrus and ornamental plants in Florida (Simpson et al. 1996).

The presence and spread of *D. abbreviatus* in Florida during the 1970s and 1980s alarmed the sugar industry although no infestation in sugarcane had been reported. In the late 1990s and early 2000s, adult weevils were found in the vicinity of commercial sugarcane fields in association with weed species such as hemp sesbania (*Sesbania*

[1]Received 24 May 2012; accepted for publication 20 August 2012.
[2]Address inquires (email: rcherry@ufl.edu).
[3]U. S. Horticultural Research Laboratory, 2001 South Rock Road, Fort Pierce, FL 34945 USA.

herbacea (P. Mill.) McVaugh), sicklepod (*Senna obtusifolia* (L.) H.S. Irwin & Barneby), pigeon pea (*Cajanus cajan* (L.) Millsp.), Brazilian peppertree (*Schinus terebinthifolius* Raddi), and other plants growing near cane fields, but no larval infestations or signs of damage to sugarcane were found (Hall, pers. obs.). In 2010, *D. abbreviatus* larval damage was first observed in Florida sugarcane (Cherry et al. 2011). These were distinctly separate infestations located 50 km apart near Clewiston (Hendry Co.) and Pahokee (Palm Beach Co.) on sandy muck and muck soil, respectively. The occurrence of *D. abbreviatus* infestations in Florida sugarcane has consequently presented a potential major pest problem for commercial sugarcane in Florida, which currently is grown in over 150,000 ha (USDA 2011).

Diaprepes abbreviatus has a wide host range which includes 270 species in 157 genera in 59 plant families with associations ranging from adult and larval feeding to oviposition of egg masses (Simpson et al. 1996). Adults feed on plant foliage often leaving a characteristic pattern of notches around leaf edges which can result in severe plant defoliation (Simpson et al. 1996). Females oviposit by secreting a sticky substance that cements eggs between mature leaves for protection (Fennah 1942, Woodruff 1968, Adair et al. 1998). Whereas sugarcane may be a poor adult host, it is an excellent host of larvae (Simpson et al. 1996) which burrow through the soil and cause root damage resulting in fields showing stunted, lodged, and upturned plants (Cherry et al. 2011).

The objectives of this study were to compare different Florida sugarcane cultivars and weed species with respect to their attractiveness to adult *D. abbreviatus* for residence, feeding and oviposition. In addition, a survey of weed species associated with Florida sugarcane was conducted.

Materials and Methods

General procedures. A greenhouse study was conducted in 2011 at the Everglades Research and Education Center in Belle Glade, FL to evaluate various parameters of *D. abbreviatus* adults with 4 sugarcane varieties and 5 broadleaf weed species. Sugarcane varieties tested were CP 89 - 2143, CP 88 - 1762, CP 80 - 1743, and CP 78 - 1628. These varieties account for 81 and 61% of Florida sugarcane acreages grown on muck and sand soils, respectively (Rice et al. 2010). Weed species tested were common lambsquarters (*Chenopodium album* L.), spiny amaranth (*Amaranthus spinosus* L.), common purslane (*Portulaca oleracea* L.), sicklepod (*S. obtusifolia*), and coffee senna (*Senna occidentalis* (L.) Link). These are common broadleaf weed species in Florida sugarcane (Odero, pers. obs.).

Sugarcane stem cuttings (10 - 15 cm long from a single bud) of each variety were planted in 15-L (28-cm diameter) pots filled with Dania muck soil in August 2011. Seeds of the 5 weed species collected from sugarcane fields were planted in similar pots using Dania muck soil in September 2011. Pots were subsequently thinned to 1 plant per pot at 14 d after emergence. Plants were grown under natural light at a maximum temperature of 27°C, and watered as needed. Plants were allowed to establish for at least 1 month before release of *D. abbreviatus* adults.

Plants with no visible chewing insect damage were selected and moved to a completely sealed greenhouse under similar growing conditions. Wooden slats were placed between plants so that, besides flying, adults could easily walk between plants thus making this a free-choice test. Adults were obtained from the U. S. Horticultural Research Laboratory rearing facility in Fort Piece, FL. A male and a female adult were released into each pot in 11 November 2011. Sugarcane varieties and weed species were 40 and 20 - 45 cm tall, respectively. The experimental design was a randomized complete block with 5 replications of each sugarcane variety and weed species.

Adult residence. The number of adults present above ground on each plant species was recorded at 2, 3, 4, 5, and 6 wk after release in a free-choice test. Data were subjected to analysis of variance using the GLM procedure in SAS (2008). Means were separated using Fisher's Protected LSD ($\alpha = 0.05$). Single degree of freedom orthogonal contrasts were used to compare sugarcane varieties and weed species with regard to adult residence choice.

Feeding damage. Host plant feeding damage by adults was evaluated at 2, 3, 4, 5, and 6 wk after release. Other herbivorous insects with chewing mouthparts were not observed or removed thus ensuring that the damage was caused by *D. abbreviatus* adults. Plant foliage was considered damaged when characteristic notches along leaf margins were observed. A visual estimation of damage on each plant species was recorded on a scale of 0 - 10 with 0 being no damage and 10 being complete plant defoliation. Feeding damage data were subjected to statistical analysis as described previously.

Oviposition choice. Host plant preference for oviposition by adults was recorded at 2, 3, 4, 5, and 6 wk after release. Plants with characteristically cemented leaves were assessed for egg masses and recorded. Eggs were not counted because of egg hatching, mold, and damage. Each egg mass was removed after data recording. Oviposition data were subjected to statistical analysis as described previously.

Weed surveys. Surveys of weed species in Florida sugarcane were conducted in 3 locations near Belle Glade, FL between February and March 2012. This is typically the period for most postemergence weed control programs in Florida sugarcane. Forty sugarcane rows (61 m) wide by 76 m long were randomly selected in each field. Fields were surveyed using the inverted "W" pattern (Thomas 1985). Five equally spaced points were sampled along each arm of the pattern giving a total of 20 sampling points per field. All weed species present were identified and recorded using a 0.25-m^2 quadrat at each of the 20 sampling points. The frequency of each weed species was calculated as a percentage of the total number of sampling points in which a weed species occurred (Thomas 1985). All fields were sugarcane less than 1 year old and had not received any herbicide treatments or cultivation for weed control.

Results and Discussion

Adult residence. Adult residence within plants from 2 - 6 wk after release was not significantly different ($P > 0.05$) (Table 1). This shows that the residence response to the plants was consistent over time. Few adults were observed on sugarcane varieties, common lambsquarters, and common purslane. Adult residence was significantly different between species at each evaluation timing ($P < 0.01$). Overall, adult residence was highest on coffee senna followed by spiny amaranth and sicklepod. Adult residence was not significantly different among sugarcane varieties on any observation date. Single degree of freedom orthogonal contrasts showed that there were significant differences in adult residence on weed species and sugarcane. Overall, adult residence was highest on weed species compared with sugarcane varieties.

Feeding damage. Feeding damage was characterized by circular notches along leaf margins. There was little to no damage by adults to any sugarcane cultivar and, similarly, little damage was observed to common lambsquarters (Table 2). Damage

Table 1. Adult *Diaprepes abbreviatus* residence (location) on sugarcane and weed species.

	Weeks after adult release*				
	2	3	4	5	6
Sugarcane varieties					
CP 78 - 1628	0.4Ab	0.2Ac	0.2Ac	0.0Ac	0.0Ac
CP 80 - 1743	0.2Ab	0.4Ac	0.6Ac	0.4Ac	0.0Ac
CP 88 - 1762	0.2Ab	0.0Ac	0.2Ac	0.2Ac	0.0Ac
CP 89 - 2143	0.6Ab	0.0Ac	0.0Ac	0.0Ac	0.4Ac
Weed species					
Spiny amaranth	2.0Ab	3.2Aab	2.4Ab	3.0Aab	1.4Abc
Sicklepod	0.8Ab	0.5Abc	0.5Ac	1.5Abc	1.7Abc
Coffee senna	5.6Aa	5.8Aa	4.4Aa	4.8Aa	4.8Aa
Common lambsquarters	0.2Ab	0.0Ac	0.0Ac	0.0Ac	0.0Ac
Common purslane	0.0Ab	0.0Ac	0.0Ac	0.4Ac	0.0Ac
Significance of contrasts					
Sugarcane varieties versus weed species	0.021	0.008	<0.001	<0.001	<0.001

*Means followed by the same upper case letter in a row are not significantly different (α = 0.05) using a LSD test (SAS 2008); means followed by the same lower case letter in a column are not significantly different (α = 0.05) using a LSD test (SAS 2008).

over time was not significantly different within each sugarcane variety ($P > 0.05$). Damage to spiny amaranth increased with time ($P < 0.01$). By 5 wk after adult release, more than half of each spiny amaranth plant had been defoliated. Similarly, damage to sicklepod was significant and increased over time ($P = 0.03$). At 6 wk after adult release, half of each sicklepod plant had been defoliated. Damage to coffee senna was significant and increased over time ($P < 0.01$). By 4 wk after adult release, more than half of each coffee senna plant had been defoliated. Damage to common purslane was also significantly and increased over time ($P = 0.04$).

There were significant differences in feeding damage when compared across species at all evaluation times ($P < 0.05$). At 2 wk after adult release, damage was only observed in spiny amaranth, sicklepod, and coffee senna although these were not significantly different. By 3 wk after adult release, damage was highest in coffee senna. A similar trend was observed until 6 wk when there were no significant differences in damage among these 3 weed species.

These results show that feeding damage was closely related to adult residence. Highest feeding damage occurred in species that had highest adult residence. Single degree of freedom orthogonal contrasts showed that there were significant differences

Table 2. *Diaprepes abbreviatus* adult feeding damage on sugarcane and weed species.

	Weeks after adult release*†				
	2	3	4	5	6
Sugarcane varieties					
CP 78 - 1628	0.0Ab	0.0Ac	0.0Ad	0.0Ad	0.0Ac
CP 80 - 1743	0.0Ab	0.2Ac	0.0Ad	0.0Ad	0.0Ac
CP 88 - 1762	0.0Ab	0.7Ac	0.0Ad	0.4Ad	0.2Ac
CP 89 - 2143	0.0Ab	0.0Ac	0.0Ad	0.0Ad	0.0Ac
Weed species					
Spiny amaranth	1.6Ca	3.2BCb	4.6ABab	5.3Aab	5.5Aa
Sicklepod	1.6Ca	2.8BCb	3.5ABb	3.6ABb	5.2Aa
Coffee senna	1.9Ba	5.0Aa	5.5Aa	5.7Aa	6.1Aa
Common lambsquarters	0.0Ab	0.2Ac	0.2Ad	0.0Ad	0.0Ac
Common purslane	0.2Bb	1.2ABc	1.8Ac	1.8Ac	1.8Ab
Significance of contrasts					
Sugarcane varieties versus weed species	<0.001	<0.001	<0.001	<0.001	<0.001

* Damage is on a scale of 0 - 10 with 0 being no damage and 10 being complete plant defoliation.

† Means followed by the same upper case letter in a row are not significantly different ($\alpha = 0.05$) using a LSD test (SAS 2008); means followed by the same lower case letter in a column are not significantly different ($\alpha = 0.05$) using a LSD test (SAS 2008).

in adult feeding between weed species and sugarcane. Overall, weed species had higher feeding damage compared with sugarcane varieties.

Sugarcane has been previously reported as a host known to support the entire life cycle of *D. abbreviatus* including adult feeding (Fennah 1942, Simpson et al. 1996). Our study shows that the main Florida sugarcane varieties are not preferred adult feeding choices. Weed species such as spiny amaranth, sicklepod, coffee senna, and common purslane prevalent in Florida sugarcane can serve as *D. abbreviatus* adult feeding hosts. Both sicklepod and spiny amaranth have been previously reported as host plants upon which *D. abbreviatus* adults feed (Armstrong 1987, Simpson et al. 1996). However, common lambsquarters, which is an important weed species in Florida sugarcane, was not a preferred food source.

Oviposition choice. The rate of egg masses being laid within plants from 2 - 6 wk after release was not significantly different ($P > 0.05$) (Table 3). Although adult feeding damage to sugarcane was minimal, adults oviposited on all sugarcane varieties. CP 80 - 1743 sugarcane variety had the highest number of egg masses. Oviposition was observed on coffee senna, spiny amaranth, and common purslane, but not on common lambsquarters or sicklepod. Simpson et al. (1996) reported sicklepod as an adult feeding host but not an oviposition host. During wk 4, 5, and 6, one or two sugarcane varieties had significantly more egg masses laid than the 5 weed species. Single degree of freedom orthogonal contrasts showed that there were significant differences in oviposition between weed species and sugarcane in wk 5 and 6. These data show that sugarcane was preferred for oviposition when compared with weed species and that preference for oviposition was not related to adult residence or feeding.

Weed field survey. Weed surveys are useful in determining the occurrence of species associated with crop production systems (Thomas 1985, McCully et al. 1991) including sugarcane. Eleven weed species were identified in the survey at 3 locations in Florida sugarcane (Table 4). These weed species included forbs, grasses, and sedges from 8 plant families. Forbs in the survey with the highest frequency were common lambsquarters (70%), spiny amaranth (63%), and common purslane (37%). Common lambsquarters and common purslane are forbs that had not previously been investigated as potential hosts of *D. abbreviatus*. However, spiny amaranth, common ragweed, and sicklepod are forbs that were previously reported to have associations with *D. abbreviatus* (Armstrong 1987, Simpson et al. 1996). Similarly, yellow nutsedge which had a frequency of 67% had been reported as a food host of *D. abbreviatus* larvae (Simpson et al. 1996). Fall panicum, goosegrass, and bermudagrass were the most common grasses in the fields surveyed. Fall panicum had the highest frequency of 67%. The suitability of these grasses as hosts of *D. abbreviatus* was not known. Spiny amaranth, alligatorweed, American blacknightshade, yellow nutsedge, bermudagrass, goosegrass, and fall panicum are weed species that have been reported as common in Florida sugarcane (Webster 2000, 2004, 2008).

Our results show that several weed species found in Florida sugarcane are suitable as food sources and oviposition sites for *D. abbreviatus*. However, sugarcane is generally more preferred for oviposition by *D. abbreviatus*. Based on these results, a front-line defense against *D. abbreviatus* in Florida sugarcane is elimination of weed species used by adult weevil as host plants. There is limited information relating to controlling the weevil in sugarcane using insecticides. However, in citrus and other crops, foliar insecticide sprays against adult weevils and granular insecticides applied to the soil to kill neonates can help limit infestations (Duncan et al. 2011). In addition, natural control of *D. abbreviatus* may be boosted by entomopathogenic nematodes

Table 3. Number of egg masses of *Diaprepes abbreviatus* on sugarcane and weed species.

	Weeks after adult release*				
	2	3	4	5	6
Sugarcane varieties					
CP 78 - 1628	0.0Aa	0.8Aa	0.8Aa	0.2Abc	0.4Aab
CP 80 - 1743	0.0Aa	0.4Aa	0.4Aab	0.8Aab	1.0Aa
CP 88 - 1762	0.0Aa	0.6Aa	0.0Ab	1.0Aa	0.2ABab
CP 89 - 2143	0.0Aa	0.2Aa	0.2Aab	0.4Aabc	1.0Aa
Weed species					
Spiny amaranth	0.0Aa	0.4Aa	0.0Ab	0.0Ac	0.0Ab
Sicklepod	0.0Aa	0.0Aa	0.0Ab	0.0Ac	0.0Ab
Coffee senna	0.0Aa	1.0Aa	0.2Aab	0.0Ac	0.0Ab
Common lambsquarters	0.0Aa	0.0Aa	0.0Ab	0.0Ac	0.0Ab
Common purslane	0.0Aa	0.2Aa	0.0Ab	0.0Ac	0.0Ab
Significance of contrasts					
Sugarcane varieties versus weed species	1.000	0.533	0.061	0.002	0.002

* Means followed by the same upper case letter in a row are not significantly different ($\alpha = 0.05$) using a LSD test (SAS 2008); means followed by the same lower case letter in a column are not significantly different ($\alpha = 0.05$) using a LSD test (SAS 2008).

Table 4. Family, common name, scientific name, and frequency of weed species in three Florida sugarcane fields near Belle Glade, FL.*

Family	Common name	Scientific name	Mean frequency (± SE)
Amaranthaceae	Alligatorweed	*Alternanthera philoxeroides* (Mart.) Griseb.	21.7 (16.9)
	Spiny amaranth	*Amaranthus spinosus* L.	63.3 (13.0)
Asteraceae	Common ragweed	*Ambrosia artemisiifolia* L.	8.3 (8.3)
Chenopodiaceae	Common lambsquarters	*Chenopodium album* L.	70.0 (14.4)
Cyperaceae	Yellow nutsedge	*Cyperus esculentus* L.	66.7 (18.8)
Fabaceae	Sicklepod	*Senna obtusifolia* (L.) Irwin & Barneby	13.3 (13.3)
Poaceae	Bermudagrass	*Cynodon dactylon* (L.) Pers.	15.0 (8.7)
	Goosegrass	*Eleusine indica* (L.) Gaertn.	43.3 (21.7)
	Fall panicum	*Panicum dichotomiflorum* Michx.	66.7 (3.3)
Portulacaceae	Common purslane	*Portulaca oleracea* L.	36.7 (10.9)
Solanaceae	American blacknightshade	*Solanum americanum* P. Mill.	10.0 (5.0)

*Survey of weed species was conducted between February and March 2012.

(Duncan et al. 2011) and insect parasitoids (Jacas et al. 2005, Castillo et al. 2006). However, once a sugarcane field is infested by large numbers of weevil larvae, there may be limited management options. Under laboratory conditions, flooding has been shown to be an effective control measure against weevil larvae depending on temperature (Shapiro et al. 1997), but no research on flooding has been conducted in a field situation where flood waters might not reach all larvae boring into a cane stool. Ultimately, there may be no choice but to repeatedly disk an infested field to kill the *D. abbreviatus* and replant.

References Cited

Adair, R. C., H. N. Nigg, S. E. Simpson and L. Lefevre. 1998. Ovipositional preferences of *Diaprepes abbreviatus* (Coleoptera: Curculionidae). Fla. Entomol. 81: 225-234.

Armstrong, A. 1987. Distribution of adult *Diaprepes abbreviatus* L. (Coleoptera: Curculionidae) in north and northwest sugarcane areas of Puerto Rico. J. Agr. U. Puerto Rico 71: 411-413.

Castillo, J., J. A. Jacas, J. E. Peña, B. J. Ulmer and D. G. Hall. 2006. Effect of temperature on life history of *Quadrastichus haitiensis* (Hymenoptera: Eulophidae), an endoparasitoid of *Diaprepes abbreviatus* (Coleoptera: Curculionidae). Biol. Control 36: 189-196.

Cherry, R., D. G. Hall, A. Wilson and L. Baucum. 2011. First report of damage by the sugarcane root weevil *Diaprepes abbreviatus* (Coleoptera: Curculionidae) to Florida sugarcane. Fla. Entomol. 94: 1063-1065.

Duncan, L. W., M. E. Rogers, C. W. McCoy, S. H. Futch, J. H. Graham and H. N. Nigg. 2011. Florida citrus pest management guide: citrus root weevils. University of Florida IFAS Extension publication #ENY-611. http://edis.ifas.ufl.edu/cg006.

Fennah, R. G. 1942. The citrus pest's investigation in the Windward and Leeward Islands, British West Indies 1937-1942. Agr. Advisory Dept., Imp. Coll. Tropical Agr. Trinidad, British West Indies. pp. 1-67.

Hall, D. G. 1995. A revision of the bibliography of the sugarcane rootstalk borer weevil, *Diaprepes abbreviatus* (Coleoptera: Curculionidae). Fla. Entomol. 78: 364-377.

Jacas, J. A., J. A. Peña and R. E. Duncan. 2005. Successful oviposition and reproductive biology of *Aprostocetus vaquitarum* (Hymenoptera: Eulophidae): a predator of *Diaprepes abbreviatus* (Coleoptera: Curculionidae). Biol. Control 33: 352-359.

McCully, K. V., M. G. Sampson and A. K. Watson. 1991. Weed survey of Nova Scotia lowbush blueberry (*Vaccinium angustifolium*) fields. Weed Sci. 29: 180-185.

Rice, R., L. Baucum and B. Glaz. 2010. Sugarcane variety census: Florida 2009. Sugar J. July, 10-15.

SAS. 2008. SAS Version 9.2. Cary, NC: SAS Institute Inc.

Shapiro, J., D. G. Hall and R. E. Niedz. 1997. Mortality of the larval root weevil *Diaprepes abbreviatus* (Coleoptera: Curculionidae) in simulated flooding. Fla. Entomol. 80: 277-285.

Simpson, S. E., H. N. Nigg, N. C. Coile and R. A. Adair. 1996. *Diaprepes abbreviatus* (Coleoptera: Curculionidae): host plant associations. Environ. Entomol. 25: 333-349.

Thomas, A. G. 1985. Weed survey system used in Saskatchewan for cereal and oilseed crops. Weed Sci. 33: 34-43.

Webster, T. M. 2000. Weed survey – southern states. Grass crops subsection. Proc. Southern Weed Sci. Soc. 53: 261.

Webster, T. M. 2004. Weed survey – southern states. Grass crops subsection. Proc. Southern Weed Sci. Soc. 57: 416.

Webster, T. M. 2008. Weed survey – southern states. Grass crops subsection. Proc. Southern Weed Sci. Soc. 61: 234.

Woodruff, R. E. 1964. A Puerto Rican weevil new to the United States (Coleoptera: Curculionidae). Florida Dep. Agric. Div. Plant Ind. Entomol. Circ. 30: 1-2.

Woodruff, R. E. 1968. The present status of a West Indian weevil (*Diaprepes abbreviatus* (L.) in Florida (Coleoptera: Curculionidae). Florida Dept. Agri., Div. Plant Industry, Entomol. Circ. No. 77.

USDA. 2011. National Agricultural Statistics Service. Crop Values Summary. http://usda01.library.cornell.edu/usda/nass/CropValuSu//2010s/2012/CropValuSu -02-16-2012.pdf.