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ABUNDANCE AND SPATIAL DISTRIBUTION OF WIREWORMS (COLEOPTERA: ELATERIDAE) IN FLORIDA SUGARCANE FIELDS ON MUCK VERSUS SANDY SOILS

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ABSTRACT

Wireworms are important insect pests of Florida sugarcane. Our objective was to determine the abundance and spatial distribution of wireworms in Florida sugarcane on muck versus sandy soils. Fourteen commercial sugarcane fields were sampled for wireworms on farms in southern Florida. *Melanotus communis* (Gyllenhal) was the most abundant wireworm found in both soil types. Other less abundant wireworms found and discussed are *Conoderus* spp., *Ischiodontus* sp., and *Glyphonyx bimarginatus* Schaeffer. There were no significant differences in densities of *G. bimarginatus*, *M. communis*, or total wireworms of all species in muck versus sand fields. Significantly more *Conoderus* spp. were found in sandy fields and significantly more *Ischiodontus* sp. were found in muck fields. The spatial distribution of the wireworms within fields was similar in both soil types. In muck, wireworms in 4 fields were randomly distributed, aggregated in 3 fields, and uniformly distributed in no fields. In sand, wireworms in 3 fields were randomly distributed, aggregated in 4 fields and uniformly distributed in no fields.

Key Words: wireworm damage, pest, Elateridae, *Melanotus*

RESUMEN

Los gusanos alambres son plagas importantes de la caña de azúcar en la Florida. Nuestro objetivo fue el determinar la abundancia y distribución espacial de los gusanos alambres sobre caña de azúcar en suelos lodosos y arenosos en la Florida. Se realizo un muestreo de gusano alambre en catorce campos de caña de azúcar de fincas comerciales en el sur de la Florida. *Melanotus communis* (Gyllenhal) fue la especie mas abundante en las dos clases de suelo. Otras especies encontradas y discutidas menos abundantes fueron: *Conoderus* spp., *Ischiodontus* sp. y *Glyphonyx bimarginatus* Schaeffer. No hubo una diferencia significativa en la densidad de *G. bimarginatus*, *M. communis* o el total de las especies de gusanos alambres en campos lodosos versus campos arenosos. Un número significativamente mayor de *Conoderus* spp. fueron encontrados en campos arenosos y un numero significativamente mayor de *Ischiodonatus* sp. fueron encontrados en campos lodosos. La distribución espacial de los gusanos alambre dentro de cada campo fue similar en las dos clases de suelo. En campos lodosos, los gusanos alambre fueron distribuidos al azar en 4 campos, agregados en 3 campos y no distribuidos uniformemente en ninguno de los campos. En campos arenosos, los gusanos alambre fueron distribuidos al azar en 3 campos, agregados en 4 campos y no distribuidos uniformemente en ninguno de los campos.

The Everglades Agricultural Area (EAA) is a highly productive agricultural area located in southern Florida. The histosol soils of the EAA, commonly called muck soils, were formed over a 4,400 year period from partially decomposed remains of hydrophytic vegetation that accumulated under anaerobic wetland conditions resulting in highly organic soils (Rice et al. 2005). The EAA is bordered by less organic sandy soils. Sugarcane, vegetables, rice, and sod are the predominant crops grown on muck soils. These same crops are grown on sandy soils, and citrus and pastures also occur on sandy soils.

Wireworms in Florida are primarily a pest in newly planted sugarcane where the larvae attack the underground portions of the plant by feeding on the buds and root primordia during germination and on shoots and roots after germination. Although the insects are also found at higher densities in older ratoon sugarcane, they are rarely considered a pest in ratoon sugarcane because the sugarcane plants are large and well established. Of the different wireworm species found in Florida sugarcane, *Melanotus communis* Gyllenhal (Coleoptera: Elateridae) is the most important pest. Damage by this wireworm has been thoroughly documented in studies by Hall (1985, 1990). Cherry & Hall (1986) reported flight activity of *M. communis* in Florida sugarcane and Cherry (1988) noted distribution and abundance of the species in Florida sugarcane.

Detailed studies of wireworm biology are rare (Lefko et al. 1998). This paucity of information has resulted largely because most wireworms are difficult to collect in large numbers and have prolonged life cycles, thereby making them rather intractable for study (Keaster et al. 1975). However, understanding the role of soil type on wireworm abundance may be important in predicting expected wireworm damage. Gui (1935) stated that soil conditions have a marked influence on wireworms.

Florida sugarcane is grown in the EAA on soils ranging from sandy to highly organic muck. Several earlier studies (Sosa et al. 1994; Cherry & Hall 1986; Cherry 2007) reported different aspects of wireworm populations in Florida sugarcane. However, currently no data exist on actual wireworm densities and their spatial distribution in the different soil types where Florida sugarcane is grown. Moreover, some Florida sugarcane growers on sandy soils believe soil insecticides may be unnecessary at planting because of reduced wireworm populations inherent in sandy soils compared to muck. However, no data exist to substantiate this belief. Hence, our objective was to determine the abundance and spatial distribution of wireworms in Florida sugarcane fields on muck versus sandy soils. These data should be useful in predicting wireworm damage in these 2 soil types.

Materials and Methods

Fourteen commercial sugarcane fields were sampled for wireworms on farms in southern Florida. Fields were selected from different areas and different sugarcane growers in order to obtain a representative sample of wireworm populations present. Seven fields were located on muck soils (>40% organic matter) and 7 on sandy soils (<13% organic matter) to compare wireworm population differences in these 2 soil types. Newly planted sugarcane has few wireworms present due to discing and soil insecticide application at planting. Hence, all fields sampled were second ratoon (approximately 2 years old) to keep crop age constant between fields and allow wireworm populations to accrue since soil insecticides are not applied after planting.

Mature sugarcane is a very difficult crop in which to sample insects (Southwood 1969), and Florida sugarcane may be 3 to 4 m high before harvest. Therefore, all fields were sampled after harvest for easy access. All sampling was conducted during a 2-month period to reduce the possibility of seasonal variation in wireworm numbers (Cherry 2007) affecting counts between fields. Eight fields (4 muck, 4 sand) were sampled during Feb-Mar 2006 and six fields (3 muck, 3 sand) during Feb-Mar 2007. Sugarcane fields ranged from 8 to 16 ha in size.

Sugarcane plants (stools) were used for sample units since most soil dwelling pests of sugarcane become aggregated around sugarcane plants (Southwood 1969) as occurs with Florida sugarcane grubs (Cherry 1984) and wireworms (Cherry 2007). Each field was divided into 8 equal size plots (4×2 configuration). Five random samples were taken for wireworms within each plot. Each sample consisted of a soil sample ($40 \times 40 \times 20$ cm deep) dug around a sugarcane stool and examined for wireworms for 10 min by 1 person. Examination time was 5 min if 2 people were present. After collection, wireworms were brought to the laboratory and identified via microscope. Soil samples were taken from plots, mixed, and the % organic matter of soil in the field was determined by the methods of Mylavarapu & Kennelly (2002).

The relative abundance of different wireworms in the 14 fields was determined. To determine if soil type influenced wireworm populations, *t* tests (SAS 2007) were conducted on the total number of wireworms found in a field for each of the different wireworms in muck versus sandy soil. Data were transformed before *t* tests by log 10 (y + 1) transformation (Steel & Torrie 1980), Untransformed data are presented in tables. A variance to mean ratio ($s^2/\bar{x}$) was determined for wireworms (total number of all species) per plot throughout each sugarcane field. The ratio is a simple index for aggregation and was tested for departure from randomness at alpha = 0.05 with a χ^2 test where χ^2 (n -1 df) = s^2 (n -1)/$\bar{x}$ (Southwood & Henderson 2000). The variance to mean ratio was used in this study because it is the most fundamental of the various indices of aggregation (Taylor 1984) and has the advantage of being easy to compute and readily understandable (Myers 1978). Aggregation analysis was restricted to total wireworms combined for all species rather than individual wireworm species. This was done because when sampling sugarcane, growers do not differentiate between wireworm species.

Results and Discussion

Melanotus communis was the most abundant wireworm found in both soil types with more being found in muck soils (Tables 1 and 2). These data are consistent with Cherry & Hall (1986), who reported that more adult *M. communis* were caught in light traps from Florida sugarcane fields on muck soils than on sandy soils. However, there was no significant difference (t = 1.1, df = 12, $P > 0.05$) in *M. communis* population densities in muck versus sand fields in this study, which is partially explained by the extreme variability found in *M. communis* between fields in both soil types. Hall (1988) reported that *M. communis* is an important soil pest of Florida sugarcane and that insecticides are routinely applied at planting time for control.

TABLE 1. ABUNDANCE OF WIREWORMS IN FLORIDA SUGARCANE FIELDS IN MUCK SOILS.

		Wireworms/field[b]				
Field #	% OM[a]	*Conoderus* spp.	*G. bimarginatus*	*M. communis*	*Ischiodontus* sp.	Total
1	82	6	2	151	12	171
2	81	1	4	163	2	170
3	82	1	7	146	2	156
4	82	1	5	131	0	137
5	51	2	2	23	15	42
6	40	0	1	9	2	12
7	82	5	1	104	20	130
Total		16	22	727	53	818

[a]Percentage organic matter of soil.
[b]Total wireworms in 40 samples in each field.

Conoderus spp. were the second most abundant wireworms found in both soil types with 6 times as many being found in sandy soils. There were significantly more ($t = 4.5, df = 12, P < 0.05$) *Conoderus* spp. in sandy fields than muck fields. Hall (1988) reported 4 *Conoderus* species commonly associated with Florida sugarcane. However, *Conoderus* species were not determined in this study. *Conoderus* have been reported to be pests of sugarcane in Louisiana (Bynum et al. 1949) and Hawaii (Stone 1976).

Ischiodontus sp. was the third most abundant wireworm found in both soil types with almost all (95%) being found in muck soils. As expected, there were significantly more ($t = 3.1, df = 12, P < 0.05$) *Ischiodontus* sp. in muck fields than sandy fields. Similarly, Gui (1935) reported that organic matter content of soils had a positive relationship with wireworm populations of *Agriotes mancus* Say in Ohio. Furthermore, Pill et al. (1976) noted that the wireworm *Limonius dubitans* Leconte was a pest only in higher organic soils. Hall (1988) reported that localized populations of this wireworm are sometimes encountered in Florida sugarcane which is consistent with the highly variable distribution observed among fields in this study. Little is known of the biology or economic impact of *Ischiodontus* sp. in Florida sugarcane.

Glyphonyx bimarginatus Schaeffer were the least abundant wireworms found in the sugarcane fields with equal population densities found in both soil types. Obviously, there was no significant difference ($t = 0.9, df = 12, P > 0.05$) in *G. bimarginatus* in muck versus sandy fields. It is probable that *G. bimarginatus* are more numerous in Florida sugarcane than shown here because they were the smallest wireworm species found in this study and were probably underestimated in visual samples. Hall (1988) reports that *G. bimarginatus* is a small wireworm often present in Florida sugarcane. Little is known of the biology or economic impact of *G. bimarginatus* in Florida sugarcane.

There were 37% more wireworms of all species in muck fields than in sandy fields. However, variability in total wireworm population densities be-

TABLE 2. ABUNDANCE OF WIREWORMS IN FLORIDA SUGARCANE FIELDS IN SANDY SOILS.

		Wireworms/field[b]				
Field #	% OM[a]	*Conoderus* spp.	*G. bimarginatus*	*M. communis*	*Ischiodontus* sp.	Total
1	2	17	0	32	0	49
2	12	13	11	2	1	27
3	3	6	0	125	0	131
4	2	8	0	115	2	125
5	3	9	7	116	0	132
6	3	33	4	0	0	37
7	3	6	0	92	0	98
Total		92	22	482	3	599

[a]Percentage organic matter of soil.
[b]Total Wireworms in 40 samples in each field.

TABLE 3. SPATIAL DISTRIBUTION OF WIREWORMS IN FLORIDA SUGARCANE FIELDS.

Field	Variance	Mean[a]	Ratio	Chi-square[b]	Distribution
		Muck soil			
1	77.4	21.4	3.61	25.3	Aggregated
2	44.9	21.3	2.11	14.7	Aggregated
3	34.8	19.5	1.78	12.5	Random
4	25.0	17.1	1.46	10.2	Random
5	14.4	5.3	2.72	20.2	Aggregated
6	1.7	1.5	1.13	7.9	Random
7	27.0	16.3	1.66	11.6	Random
		Sandy Soil			
1	14.4	6.1	2.36	16.6	Aggregated
2	2.9	3.4	0.85	5.9	Random
3	68.9	16.4	4.20	29.4	Aggregated
4	26.0	15.6	1.73	11.7	Random
5	54.8	16.5	3.32	23.2	Aggregated
6	3.6	4.6	0.78	5.5	Random
7	44.9	12.3	3.65	25.5	Aggregated

[a]Mean of all wireworms in a plot.
[b]Chi-square = Variance (n-1) divided by mean.

tween fields was high in both soil types and more wireworms were found in some sandy fields than muck fields. These data resulted in there being no significant difference ($t = 0.5, df = 12, P > 0.05$) in total wireworm densities in muck versus sandy fields. These data show that soil type alone cannot be used accurately to predict wireworm densities in Florida sugarcane fields.

Overall, spatial distribution patterns of wireworms were similar in both soil types (Table 3). In muck, wireworms in 4 fields were randomly distributed and aggregated in 3 fields. In sand, wireworms in 3 fields were randomly distributed and aggregated in 4 fields.

Reasons for the aggregation of wireworms in some of the fields are not known. However, we observed minor soil type differences within some fields, especially in sandy soils. Sandy soils are subject to rapid soil transitions and also may contain small areas called "muck pockets". Salt & Hollick (1946) noted that soil type affected wireworm distribution in pastures and hence this may have caused the wireworm aggregation we observed in some fields. Also, we observed minor soil moisture differences within some fields due to low areas with wetter soil. Lefko et al. (1998) noted that soil moisture may be important in affecting wireworm distribution and this may have been a factor in wireworm aggregation in some fields.

As a last note, Sosa et al. (1994) reported that wireworm populations were greater towards field centers in Florida sugarcane although only a weak correlation ($r = 0.16$) was shown. However, since sampling methods between the former study and our study were quite different, it is not possible to directly compare results of the 2 studies. Moreover, Southwood & Henderson (2000) have noted that sampling method and sample size may affect the apparent distribution of an organism. Since we used the same methodology in both soil types, our main conclusions that the wireworm spatial distribution patterns were similar in both soil types remains valid.

In summary, our data show that soil type alone cannot be used to accurately predict total wireworm densities in Florida sugarcane fields. Hence, sugarcane growers on both muck and sand soils face similar wireworm pressure which may necessitate soil insecticide application at planting. Also, our data show high inter-field variability in total wireworm densities in both soil types. These latter data suggest that some sugarcane fields with low wireworm densities could be planted without a soil insecticide if sampling methodology existed to determine this. Currently, we are developing sampling methods to determine when soil insecticides are necessary for wireworm control when planting Florida sugarcane.

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