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THE DIFFERENTIAL GRASSHOPPER (ORTHOPTERA: ACRIDIDAE)—ITS IMPACT ON TURFGRASS AND LANDSCAPE PLANTS IN URBAN ENVIRONS

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ABSTRACT

The differential grasshopper, *Melanoplus differentialis* (Thomas) (Orthoptera: Acrididae), frequently migrates from highway rights-of-way, pastures, and harvested fields to feed in urban/suburban landscapes and retail/wholesale nurseries across the southern and southwestern U.S.A., as these areas dry down during hot dry summers. Nine selected turfgrasses and 15 species of landscape plants were evaluated for their susceptibility or resistance to this grasshopper. Grasshoppers were collected from stands of Johnsongrass, *Sorghum halepense*, which was used as a standard host for comparison in both experiments. Based on feeding damage, number of grasshopper fecal pellets produced, and their dry weight, *Zoysia matrella* cv. 'Cavalier' was the least preferred grass followed by *Buchloe dactyloides* cv. 'Prairie' and *Z. japonica* cv. 'Meyer'. *Festuca arundinacea* was significantly the most preferred host and sustained the most feeding damage, followed by *Poa pratensis* × *P. arachnifera* cv. 'Reveille' and 2 *Cynodon* spp. cultivars, 'Tifway' and 'Common'. Among the landscape plants, *Hibiscus moscheutos* cv. 'Flare', *Petunia violacea* cv. 'VIP', *Phlox paniculata* cv. 'John Fanick', *Tecoma stans* cv. 'Gold Star', and *Campsis grandiflora* were the least damaged or most resistant. *Plumbago auriculata* cv. 'Hullabaloo', *Glandularia hybrid* cv. 'Blue Princess', *Canna* × *generalis,* Johnsongrass, and *Cortaderia selloana* cv. 'Pumila' sustained the most damage. Based on the number of fecal pellets produced and their weights, *Canna* × *generalis* and *Glandularia hybrid* cv. 'Blue Princess' were the most preferred landscape plants tested.

Key Words: turfgrass, lawns, landscape plants, nursery plants, host plant resistance, *Melanoplus differentialis*

RESUMEN

El chapulín diferencial, *Melanoplus differentialis* (Thomas) (Orthoptera: Acrididae), frecuentemente emigra desde los derechos de vía, pasturas y terrenos cosechados hacia jardines urbanos y viveros comerciales en busca de alimento, principalmente donde las áreas comienzan a secarse en el verano del sur y sureste de Estados Unidos La susceptibilidad o resistencia a la alimentación de chapulines fue evaluada en nueve pastos para césped y otras quince plantas ornamentales. Los chapulines se colectaron en Johnsongrass, *Sorghum halepense*, el cual se uso como un hospedero estándar en ambos experimentos. Con base a los datos del daño al alimentarse, numero y peso de las heces fecales producidas, *Zoysia matrella* cv. 'Cavalier' es el menos preferido, seguido de *Buchloe dactyloides* cv. 'Prairie' y *Z. japonica* cv. 'Meyer'. El mas preferido significativamente, con el mayor daño al alimentarse fue *Festuca arundinacea* seguido de *Poa pratensis* × *P. arachnifera* cv. 'Reveille' y dos pastos de *Cynodon* spp. cv. 'Tifway' y 'Common'. En el grupo de plantas ornamentales, *Hibiscus moscheutos* cv. 'Flare', *Petunia violacea* cv. 'VIP', *Phlox paniculata* cv. 'John Fanick', *Tecoma stans* cv. 'Gold Star', y *Campsis grandiflora* presentaron la mayor resistencia. *Plumbago auriculata* cv. 'Hullabaloo', *Glandularia hybrid* cv. 'Blue Princess', *Canna* × *generalis*, Johnsongrass, y *Cortaderia selloana* cv. 'Pumila' presentaron el mayor daño significativamente. Con los parámetros de numero y peso de heces fecales, *Canna* × *generalis* y *Glandularia hybrid* cv. 'Blue Princess' fueron las plantas mas preferidas.

Translation provided by Carlos Campos, Texas A&M AgriLIFE Res. & Ext. Center, Dallas, TX

The differential grasshopper, *Melanoplus differentialis* (Thomas) (Orthoptera: Acrididae), does not fly long distances like the migratory grasshopper, *Melanoplus sanguinipes* (Fabricius) (Shotwell 1930). However, as highway rights-of-way, pastures, and harvested fields dry down during hot dry summers, *M. differentialis* adults fly from them to nearby urban/suburban landscapes and retail/wholesale nurseries to consume the foliage of turfgrasses and many landscape plants across the Southern U.S.A. Based on limited surveys during summers and autumns since 1998, we have recorded the differential grasshopper as the most frequently encountered species occurring in urban areas of Dallas, Texas. *M. differentialis* is also 1 of the most important grasshopper species causing economic injury to corn, wheat, alfalfa, and several other field crops (Anonymous 1994; Isely 1944; Harvey & Thompson 1993). A single adult of this species feeding on a small potted or landscape plant can defoliate it practically overnight, and the invasion of many adults can devastate an entire landscape after just a few days and nights of feeding. Such sudden damage to nursery production can render the planting stock unsellable for the remainder of the season. The extremely hot and dry summers in the Southern and Southwestern U.S.A. create ideal conditions for extensive outbreaks across many states. Dense migrating populations do not occur every year, but when conditions are right, large and quite devastating populations do occur across the region. As pastures and field crops are either harvested or desiccated from drought in late summer and early autumn, *M. differentialis* readily disperse into plant nurseries and the urban landscapes in search of food (Reinert et al. 2001). As a result, extensive damage is common on many landscape plant species, and effective grasshopper control strategies for the urban landscape, and especially plant nurseries, are often required to protect valuable plants that contribute significantly to high property values (Merchant & Cooper 2010; Reinert et al. 2001; Royer & Edelson 2004).

Several studies have been conducted to determine the feeding preferences of selected species of grasshoppers on various grasses and herbaceous plants; however, most of them have dealt with range or pasture grasses, weeds, and cultivated field crops. Isely (1938) determined that the short-horned grasshoppers (Acrididae), including *M. differentialis*, have mandible patterns possessing both graminivorous and forbivorous characteristics, which allows them to readily feed on both grasses and forbs.

Specific host feeding studies have also been conducted with *M. differentialis*. Isely (1944) fed nymphs of *M. differentialis* on 2 native grasses (*Andropogon saccharoides* Swartz and *Sprorobolus heterolepis* A. Gray) and on Johnosongrass, *Sorgham halepense* (L) Pers; bermudagrass, *Cynodon dactylon* L. Pers; and corn, *Zea mays* L. He also fed them on 5 weeds: *Helianthus annuus* (L.) (Asteraceae); common sunflower, *Ambrosia aptera* (DC) (Asteraceae); giant ragweed, *Lactuca virose* (L.) (Asteraceae); wild lettuce, *Gaillardia pulchella* (Four.) (Asteraceae); and *Parthenium hysterophorus* (L.) (Asteracaeae) that were commonly present in stands of Johnsongrass. Isely (1944) did not report on the preference of 1 grass or herb over another, but only that *M. differentialis* matured an average of 12 d faster in cages with forbs than in cages with only grasses. In another set of studies with 12 species of plants in Maryland, *M. differentialis* showed a strong preference for common dandelion, *Taraxacum officinale* F. H. Wigg. (Asteraceae). *Plantago rugellii* Dcne. (Plantaginaceae); *Dactylis glomerata* L.; and *Cyperus strigosus* L. (Cyperaceae) also served as good hosts (Kaufmann 1968). Goldenrod, *Solidago altissima* L. (Asteraceae), was only nibbled by the grasshoppers (Kaufmann 1968). Kaufmann also showed that this grasshopper could develop and reproduce by feeding only on species of Poaceae; but development was slower and adults were smaller than when they fed on both grasses and forbs.

M. differentialis also showed a preference for some corn hybrids over others in choice field experiments (Brunson & Painter 1938; Harvey & Thompson 1993). Even though under field conditions *M. differentialis* feeds heavily on alfalfa, *Medicago sativa* L. (Fabaceae), it was found to be an inadequate host for complete development (Barnes 1963). *M. differentialis* showed strongest preference for the common sunflower, *Helianthus annuus* L. (Asteraceae) compared to the following offered food plants: fava bean, *Faba vulgaris* Moench. (Fabaceae); kale, *Brassica oleracea* L. (Brassicaceae); and tomato, *Solanum Iycopersicum* L. (Solanaceae) (Howard 1995). However, in another test *M. differentialis* preferred giant ragweed, *Ambrosia trifida* L. (Asteraceae), over sunflower (Lewis 1984). Host preference has also been shown with other *Melanoplus* species (Bailey & Mukerji 1976; Fielding & Brusven 1992; Hinks et al. 1990; Hinks & Olfert 1993; Johnson & Mündel 1987; Porter & Redak 1997). Damage to seedlings in a pine nursery was reported by Feaver (1985), but no other literature on the preferences of *M. differentialis* for either turfgrasses or landscape plants has been found.

Mulkern (1967) reviewed the literature on preference for food plants by grasshoppers and concluded that they are selective feeders with definite preferences, especially in choice experiments when they are confined on 2 or more species of plants. Only limited published documentation exists on grasshopper damage to urban landscapes and gardens. Lists of the preferred plants based upon landscape observations when *M. differentialis* nymphs and adults were feeding, and control strategies have been developed by Cooperative Extension Specialists in Texas (Merchant & Cooper 2010), Oklahoma (Royer & Edelson 2004), and Kansas (Bauernfeind 2005).

Knowing the host feeding preferences for this frequent pest in urban landscapes can help the nurseryman and landscape manager determine which plants will serve as good indicators as they develop monitoring strategies for their pest management program. Additionally, this information can serve as a guide for plant selection for landscape plantings in areas with a higher potential for *M. differentialis* invasion and outbreaks.

This study was initiated to test our hypothesis that some turfgrasses and landscape plants are more preferred than others by *M. differentialis*, and secondly to determine if any of the commonly planted turfgrasses or landscape plants exhibit resistance to this pest. A diverse selection of landscape plants from 13 plant families and 9 turfgrasses was chosen to help identify preferences among the plant groups used in the urban landscape.

Materials and Methods

A representative collection of 9 of the most commonly used cultivars and species of turfgrasses (family Poaceae) in the arid Southwestern U.S.A. and 15 species of landscape plants (in 13 families) found either growing in the landscape or in container nurseries at the Texas AgriLIFE Research & Extension Center, Dallas, Texas was selected for this study. Two no-choice feeding experiments were conducted, the first compared 9 selected turfgrasses and a second study compared 15 species of landscape plants (Table 1). Johnsongrass, *S. halepense*, was included in both experiments as a standard host plant, since the grasshoppers used in these experiments were collected from this host. Johnsongrass is a common food source for *M. differentialis* (Isely 1944), and because it is fairly drought resistant, this grasshopper species tends to aggregate on it as the other plant materials begin to desiccate during the summer heat and drought stress period.

For each test plant in each replicate, leaves or terminal shoots were clipped from the grasses or landscape plant and transported to the laboratory in a cooled ice chest. Adequate plant material

Table 1. Turfgrasses and landscape plants evaluated in feeding study for host preference/resistance to the differential grasshopper.

Plants Family	Plant/Cultivar	Genus and Species
	Turfgrasses (Experiment 1)	
Poaceae	'Common' Bermudagrass	*Cynodon dactylon* (L.) Pers.
Poaceae	'Tifway' Bermudagrass	*Cynodon dactylon* × *C. transvaalensis* Burtt-Davy
Poaceae	'Prairie' Buffalograss	*Buchloe dactyloids* (Nutt.) Engelm
Poaceae	'Raleigh' St. Augustinegrass	*Stenotaphrum secundatum* (Walt.) Kuntze
Poaceae	'Meyer' Zoysiagrass	*Zoysia japonica* Steud
Poaceae	'Cavalier' Zoysiagrass	*Zoysia matrella* (L.) Merr.
Poaceae	'Tejas' Texas Bluegrass	*Poa arachnifera* Torr.
Poaceae	'Reveille' TX x KY Bluegrass	*Poa pratensis* L. × *P. arachnifera* Torr.
Poaceae	Tall Fescue	*Festuca arundinacea* Schreb.
Poaceae	Johnsongrass	*Sorghum halepense* (L.) Pers.
	Landscape Plants (Experiment 2)	
Apocynaceae	'Hardy Red' Oleander	*Nerium oleander* L.
Bignoniaceae	Chinese Trumpet Vine	*Campsis grandiflora* K. Schum
Bignoniaceae	'Gold Star' Esperanza	*Tecoma stans* (L.) Juss. ex Kunth
Cannaceae	Red Canna	*Canna * generalis* L. H. Bailey
Convolvulaceae	'Marguerite' Ornamental Sweet Potato	*Ipomoea batatas* (L.) Lam.
Lythraceae,	Crape Myrtle	*Lagerstroemia fauriei* Koehne
Malvaceae	'Flare' Perennial Hibiscus	*Hibiscus moscheutos* L.
Nyctaginaceae	Bougainvillea	*Bougainvillea spp.* Comm. ex Juss.
Poaceae	'Pumila' Dwarf Pampas Grass	*Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn.
Poaceae	Johnsongrass	*Sorghum halepense* (L.) Pers
Polemoniaceae	'John Fanick' Perennial Phlox	*Phlox paniculata* L.
Plumbaginaceae	'Hullabaloo' Blue Plumbago	*Plumbago auriculata* Lam.
Rosaceae	'Climbing Pinkie' Rose	*Rosa* sp.
Solanaceae	'VIP' Petunia	*Petunia violacea* Lindl.
Verbenaceae	'Blue Princess' Perennial Verbena	*Glandularia hybrida* (Groenland & Rümpler) G. L.Nesom & Pruski (formerly V*erbena hybrida*)
Verbenaceae	Lantana	*Lantana horrida* Kunth (Synonym of *Petunia integrifolia* (Hook.) Schinz & Thell.)

(leaves or shoots) to support 1 adult grasshopper for at least 2 d of feeding on the turfgrasses and 3 d on the landscape plants was initially caged with each adult *M. differentialis* in a 9 cm diam × 20 mm deep plastic feeding chamber (Petri dish). Each feeding chamber was provided with 2 water-saturated, 7 cm diam filter paper discs to maintain plant turgidity. Both feeding studies consisted of 1 grasshopper per feeding chamber, with 3 chambers per experimental unit and 8 replications for a total of 24 grasshoppers per test plant. These chambers were observed daily for feeding activity and the weight and production of fecal pellets was recorded.

After 2 d exposure to the test turfgrasses, each grasshopper was moved to a new feeding chamber and several parameters were assayed to determine feeding activity: a) the amount of feeding was rated on a scale of 1-5, 1 = little or no feeding, and 5 = near complete consumption of the plant material; b) fecal pellets were counted; and c) fecal pellets were oven dried (72 h at 70°C) and weighed. The grasshoppers tested on the turfgrasses were again placed on fresh samples of the respective grasses for an additional 6 d (8 d total) of feeding. Grasshoppers were held initially for 3 d on the test landscape plants before these parameters were assayed. Grasshoppers held on the landscape plants were reestablished in the test chambers for an additional 11 d (14 d total) of feeding on each plant species. For both experiments, cages were opened every 2-3 d, so that fecal pellets and decaying plant material could be removed and fresh plant material added to insure that the grasshoppers always had adequate fresh plant material on which to feed. After feeding for 8 and 14 d on turfgrasses and landscape plants, respectively, all remaining fecal pellets were counted, oven dried, and weighed.

Adult differential grasshoppers for these studies were individually collected with a sweep net from large stands of Johnsongrass growing wild in highway and railroad rights-of-ways in Denton, County, Texas, U.S.A. and stored in cooled ice chests for transport to the laboratory. Grasshoppers were held with no food and only water for 72 h to allow them to eliminate any waste from plants on which they had been feeding. Grasshoppers that appeared healthy were then used to establish the tests. Female grasshoppers were randomly chosen for all 8 replicates with the turfgrasses. For the landscape plant experiment, females were used for the first 7 replicates; but since there were not enough females to complete replicate 8, only males were used for this last replicate.

Statistical Analysis

Data for the following parameters were recorded: feeding damage, number, and weight of fecal pellets after 2 d of feeding on each of the turfgrasses; the same 3 parameters after 3 d of feeding on each of the landscape plants; the number and weight of fecal pellets produced after 8 d of feeding on each of the turfgrasses; and the same 2 parameters after 14 d of feeding on each of the landscape plants and they were analyzed by Analysis of Variance (ANOVA) (PROC GLM) for a randomized complete block design to test the differences between test plants. Means were compared at the 5% level of significance using Waller-Duncan k-ratio (k = 100) t test (SAS Institute 2009).

Results and Discussion

Turfgrasses

The feeding response by the differential grasshopper on 9 turfgrasses is presented in Figs. 1 and 2. *Zoysia matrella* cv. 'Cavalier' was the least preferred cultivar of turfgrass with a mean damage rating of 0.79 on the scale of 1 to 5, with 1 = little or no damage, and 5 = near complete consumption of the plant material (Fig. 1). *Buchloe dactyloides* cv. 'Prairie' and *Z. japonica* cv. 'Meyer' were the next 2 least damaged grasses with damage ratings of 1.17 and 2.13, respectively. *Festuca arundinacea* (tall fescue) sustained the most feeding damage and was the most preferred grass (rating of 4.62), followed with significantly less feeding damage by *Poa pratensis* × *P. arachnifera* cv. 'Reveille', *Cynodon dactylon* × *C. transvaalensis* cv. 'Tifway', *C. dactylon* cv. 'Common' (each with damage ratings ≥3.50) (Fig. 1). Feeding on Johnsongrass was also high with a damage rating of 3.24.

When the number of fecal pellets and their weight were compared for each grass after 2 d of feeding, the response among the various grasses was very similar to the results for actual feeding damage ratings (Fig. 2). Grasshoppers feeding on *Zoysia* cv. 'Cavalier' only produced an average of 5.33 fecal pellets (Fig. 2A) during the first 2 d at a weight of 15.57 mg (Fig. 2B). The weight of fecal pellets (24.79 mg) produced on *Buchloe* cv. 'Prairie' was not significantly different from that produced on *Zoysia* cv. 'Cavalier'. In contrast, grasshoppers feeding on *F. arundinacea* produced an average of 29.62 fecal pellets at a mean weight of 80.32 mg. Significantly fewer fecal pellets (21.91, 22.85, 20.15, and 17.78) were produced by grasshoppers feeding on *P. pratensis, P. arachnifera* cv. 'Reveille', *Cynodon* cv. 'Tifway', *Cynodon* cv. 'Common', and *P. pratensis* cv. 'Tejas1', respectively than on *F. arundinacea* (Fig. 2A) and the 2-d fecal pellet weight produced on each of these grasses exceeded 54 mg (Fig. 2B). The number of fecal pellets produced during the first 2 d on *Zoysia* cv. 'Meyer' was not much greater than produced on *Buchloe* cv. 'Prairie';

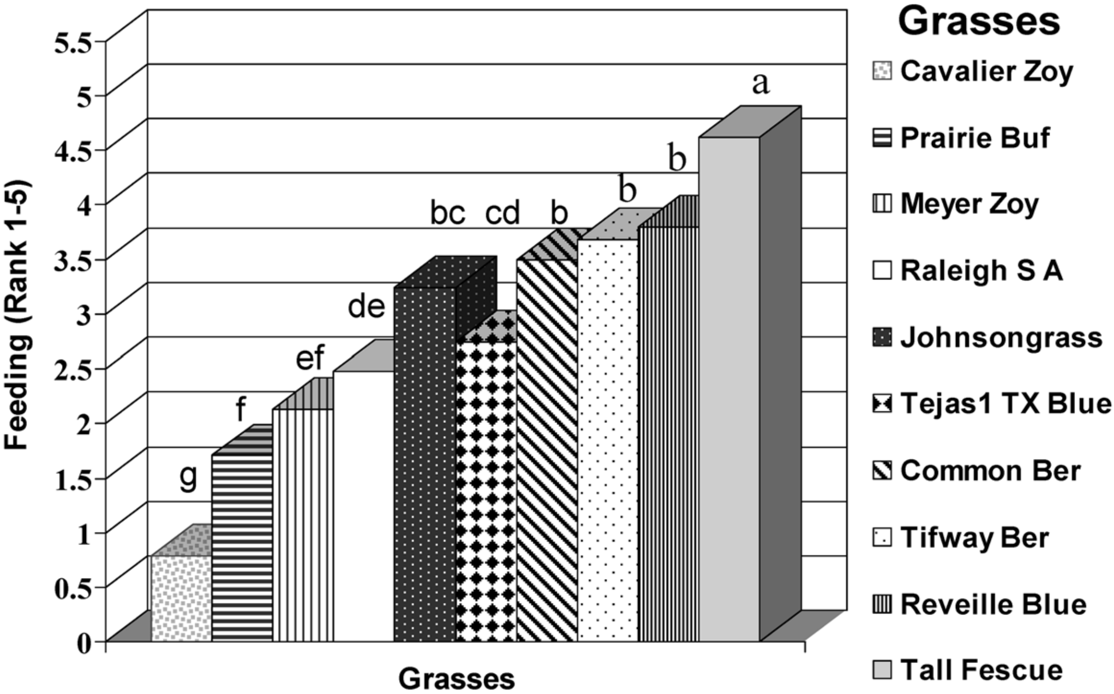

Fig. 1. Feeding damage by differential grasshoppers on 9 turfgrass cultivars and Johnsongrass during the first 2-d feeding period. Damage was rated on a scale of 1-5; where 1 = little or no feeding, and 5 = near complete consumption of the available plant material. The order of cultivars listed at the right side of the graph corresponds to the bars from left to right. Bars for each plant with the same letters above them are not significantly different by Waller-Duncan k-ratio (k = 100) t test (P = 0.05).

however, their weight was more than doubled at 50.76 mg. Even though the damage rating was relatively high on Johnsongrass, the number of fecal pellets (11.96) and their weight (29.94 mg) was unexpectedly low compared to the number and weight of fecal pellets produced on the less damaged *Zoysia* cv. 'Meyer' and *Stenotaphrum secundatum* cv. 'Raleigh'. Production on Johnsongrass was considerably lower than the number and weight of pellets produced on 'Reveille' hybrid bluegrass or on *Cynodon* cvs. 'Tifway' or 'Common', which had similar damage ratings.

After 8 d of feeding, *Zoysia* cv. 'Cavalier' and *Buchloe* cv. 'Prairie' were still significantly the most resistant with the lowest mean number of fecal pellets produced per day (2.05 and 2.78, respectively) (Fig. 2C) and mean weights of 5.78 and 6.77 mg, respectively (Fig. 2D). The number of pellets and their weight were ca. one-half that of the next 2 grasses, *Zoysia* cv. 'Meyer' and *Stenotaphrum* cv. 'Raleigh' with numbers of pellets >5 and weights >12 mg. Johnsongrass continued to be in the midrange of damage with a mean of 5.57 fecal pellets weighing 13.72 mg per day. Isely (1944) also reported Johnsongrass as a good host, especially when it was growing in mixed stands with common sunflower, giant ragweed, and wild lettuce. Tall fescue continued to be significantly the most preferred host with the highest average number of fecal pellets (12.24) and highest weight (31.39 mg) per day over the 8-d feeding period. Regardless of the grass, *M. differentialis* produced more fecal pellets weighing more per day during the first 2 d of feeding than they did daily during the remaining feeding period. This higher level of feeding is probably due to the fact that we starved the grasshoppers for a 72-h period before the initial 2-d feeding period. No literature was found that characterized the preferential feeding behavior of *M. differentialis* for one turfgrass in preference to another.

Landscape Plants

Feeding responses of *M. differentialis* on the 15 landscape plants compared with Johnsongrass are presented in Figs. 3 and 4. The ratings of feeding damage during the first 3 d the grasshoppers were confined on the plant material show that the least visual feeding damage occurred on *Hibiscus*

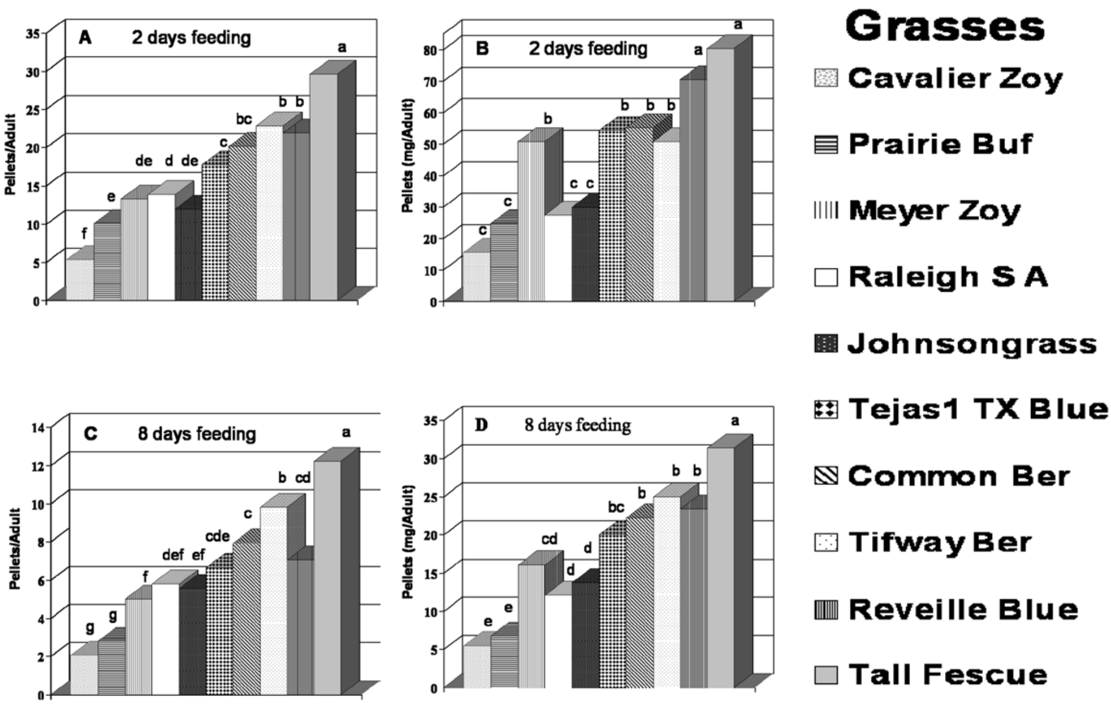

Fig. 2. Number of fecal pellets (A) and their dry weight (B) produced by differential grasshoppers feeding on 9 turfgrass cultivars and Johnsongrass during the first 2-d; Number of fecal pellets (C) and their dry weight (D) after the 8-d feeding period. The order of grass cultivars listed at the right side of the graph corresponds to the bars from left to right. Bars for each plant with the same letters above them are not significantly different by Waller-Duncan k-ratio (k = 100) t test (P = 0.05).

moscheutos cv. 'Flare' (1.96), *Petunia violacea* cv. 'VIP' (2.02), *Phlox paniculata* cv. 'John Fanick' (2.00), *Tecoma stans* cv. 'Gold Star' (2.46), and *Campsis grandiflora* (2.48) (Fig. 3). Conversely, the highest amount of feeding per adult *M. differentialis* occurred on *Plumbago auriculata* cv. 'Hullabaloo' (3.83), *Glandularia hybrida* cv. 'Blue Princess' (3.77), red *Canna* × *generalis* (3.67), Johnsongrass (3.45), and *Cortaderia selloana* cv. 'Pumila' (3.43), with these 5 plants grouped in the top statistical separation. Since *M. differentialis* normally feeds on both grasses and herbs, it was no surprise that Johnsongrass and pampas grass along with several of the landscape plants were among the test plants showing the most feeding damage. When the number and dry weight of fecal pellets per grasshopper for the first 3-d feeding period were examined, *Ipomoea batatas* cv. 'Marguerite', *Bougainvillea* sp*.,* and *Lantana horrida* were also grouped in the same statistical separation of least fed upon plants (nonpreferred) (Fig. 4). Based on these 2 parameters, red *Canna* and *Glandularia* cv. 'Blue Princess' were the most preferred hosts with the highest number of fecal pellets (*Glandularia* = 25.5; *Canna* = 21.75) (Fig. 4A) and the highest fecal pellet weights (*Canna* = 62.0 mg; *Glandularia* = 41.56 mg) (Fig. 4B).

After 14 d of continual feeding, the same 5 cultivars continued to exhibit the least feeding (resistant) based on the number and dry weight of fecal pellets per grasshopper per day of feeding (Fig. 4C and 4D). Red *Canna*, *Glandularia* cv. 'Blue Princess', *Plumbago* cv. 'Hullabaloo', and *Cortaderia* cv. 'Pumila' continued to be among the preferred hosts. The number and weight of fecal pellets produced on red *Canna* during the last 11 d of the trial were significantly reduced compared to the feeding exhibited during the first 3 d. The lower number on red *Canna* can partially be explained by the large amount of fluids present in the *Canna* leaves which caused the grasshoppers to produce very watery fecal pellets that were difficult to distinguish and did not hold together.

Nerium oleander cv. 'Hardy Red' emerged as the most preferred host with nearly 8 fecal pellets (weighing 15 mg) produced per grasshopper per day. Conversely, *M. differentialis* feeding on the 5 aforementioned resistant plants produced fewer than 4 fecal pellets and less than 6 mg of dry pellet weight per day of feeding. The strong feeding

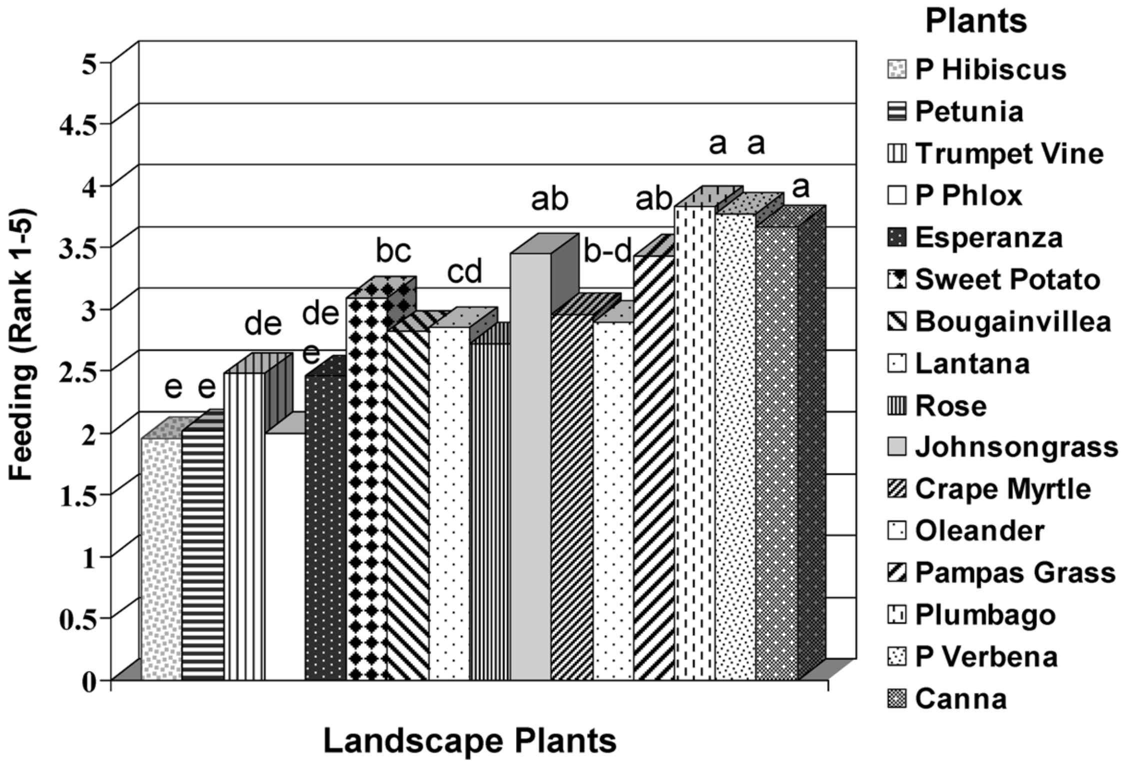

Fig. 3. Feeding damage by differential grasshoppers on 14 landscape cultivars and Johnsongrass during the first 3-d feeding period. Damage was rated on a scale of 1-5; where 1 = little or no feeding, and 5 = near complete consumption of the available plant material. The order of landscape cultivars listed at the right side of the graph corresponds to the bars from left to right. Bars for each plant with the same letters above them are not significantly different by Waller-Duncan k-ratio (k = 100) t test (P = 0.05).

preference by the grasshoppers for *Nerium* was unexpected, because the presence of glucosides in both fresh and dry foliage of *Nerium* makes it extremely toxic to man and animals (Muenscher 1948). This was the first report of the ability to tolerate glucosides expressed by an Orthopteran. The ability of *M. differentialis* to detoxify plant secondary metabolites was first reported by Snyder et al. (1998). He showed that *M. differentialis* can tailor its detoxification enzymes (a variety of microsomal cytochrome P450s and several cytosolic detoxification enzymes) to the profile of secondary metabolites in its diet. All previous work with Orthoptera had dealt with detoxification of synthetic pesticides. This phenomenon had been well documented for several species of Lepidoptera (Berenbaum 1991).

Most previous research showed that several plants in the Asteraceae were good hosts for *M. differentialis* (Howard 1995; Isely 1944; Kaufmann 1968; Lewis 1984). However, these previous works provide little insight as to which other families of herbaceous plants that was tested in this experiment (Table 1) would serve as hosts for this grasshopper. This experiment shows that *M. differentialis* will feed on a wide range of herbaceous plants from a diverse group of plant families.

The differential grasshopper is a significant pest of several field crops but it also causes significant economic damage in urban/suburban landscapes and in plant nurseries. This paper characterizes the level of damage for a select group of turfgrasses and landscape plants commonly used in Southern landscapes. Knowing which plants are most susceptible to damage should be useful information for home owners and managers of parks and other public and private grounds to aid them in choosing plants that are less likely to be damaged. This knowledge can be especially important to nursery plant growers and for wholesale and retail nurseries to more closely monitor certain plant species that are more subject to damage, or to simply avoid handling these species; especially during *M. differentialis* outbreak years. This type of information is necessary for the development of comprehensive IPM programs for urban landscapes and plant nurseries.

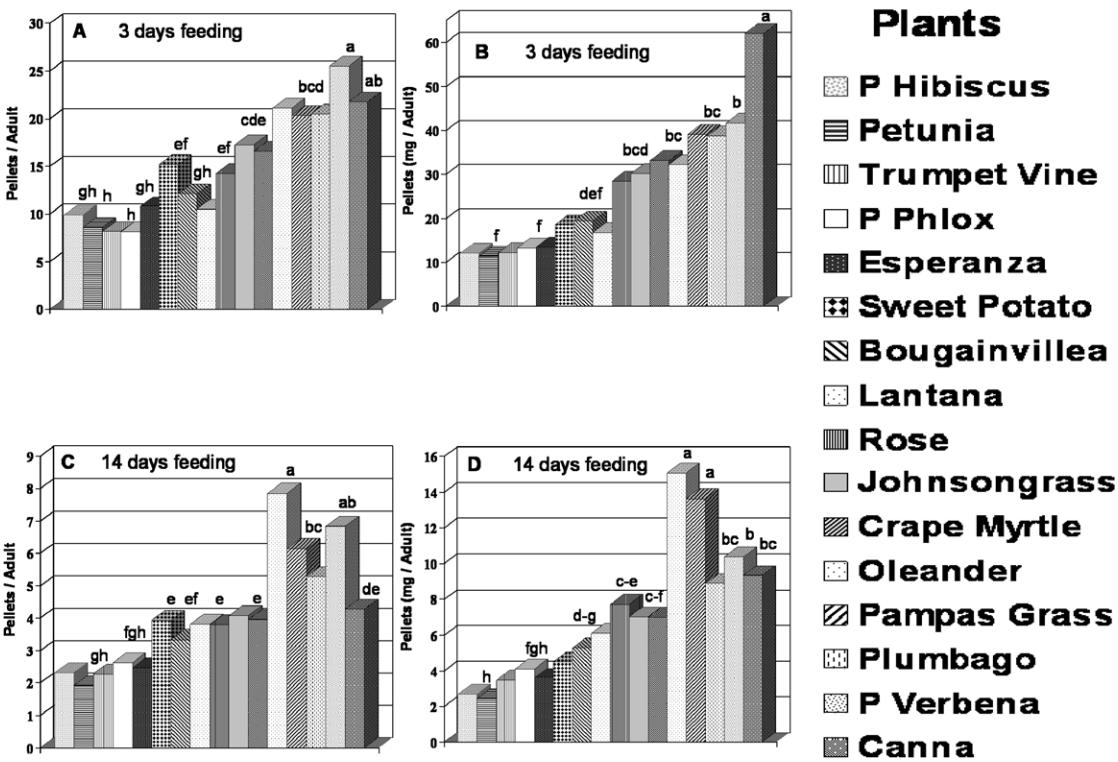

Fig. 4: Number of fecal pellets (A) and their dry weight (B) produced by differential grasshoppers feeding on 14 landscape cultivars and Johnsongrass during the first 3-d; Number of fecal pellets (C) and their dry weight (D) after the 14-d feeding period. The order of landscape cultivars listed at the right side of the graph corresponds to the bars from left to right. Bars for each plant with the same letters above them are not significantly different by Waller-Duncan k-ratio (k = 100) t test (P = 0.05).

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