Phenology, Abundance, Plant Injury and Effect of Temperature on the Development and Survival of *Leptodictya plana* (Hemiptera: Tingidae) on *Pennisetum* spp. Grasses[1]

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Abstract The lace bug, *Leptodictya plana* Heidemann, was sampled in the field on *Pennisetum purpureum* Schumach. from May through late October during 2008 and 2009. Highest population levels occurred in late August, which corresponded to the warmest temperatures of the season. Adults overwintered in ground litter/mulch and contributed eggs to as many as 4 overlapping generations in central Georgia, USA. Damage ratings on *P. purpureum* ornamental grasses averaged 20% for the entire 2008 and 2009 summer seasons, although individual plants expressed injury as high as 90% during midseason. When 2 ornamental grass standards were compared with each other, 'Princess' was more heavily damaged than 'Prince' during both sampling years. Decreased abundance observed in 2009 may have resulted from an increase in the amount of precipitation at the site. Mean duration of development ranged from 23.3 days at 30°C to 40.5 days at 25°C. Eggs hatched at 20, 25, 30 and 35°C, but not at 10 or 15°C. Complete development (egg to adult) was only successful at 25 and 30°C. The studies in this paper improve our understanding of this previously rare lace bug and suggest its potential as an emerging landscape and nursery pest.

Key words lace bug, Tingidae, ornamental pest, damage rating

Lace bugs are a family of small insects that are found on many different types of herbaceous plants, shrubs and trees. Damage to foliage caused by lace bugs detracts from the plant's aesthetic appeal, reduces its vigor and makes the plant more susceptible to damage by other insects and disease (Buntin et al.1996, Braman et al. 1992). In May 2008 lace bugs were found inflicting significant injury to *Pennisetum* spp. ornamental grasses in Griffin, GA. Identification by the USDA Systematic Entomology Laboratory as *Leptodictya plana* Heidemann established this as the first record of this lace bug in Georgia.

Leptodictya plana was originally described from a single male specimen collected in Oklahoma (Heidemann 1913). The adult has an elongate, oblong, extremely flat body, with a distinct narrowness across the elytra and opaque pronotal lateral margins, a yellow head, 3 characteristic low pronotal carinae, greenish-grey thorax and a light brown abdomen. *Leptodictya plana* is a relatively rare lace bug that is most commonly found in warm, dry habitats in the western United States (Wheeler 2008). It has been reported from Oklahoma, AZ, Alabama, FL, TX, KS, Mississippi, and New Mexico.

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The scarce literature indicates that this lace bug feeds and develops on panicoid grasses of the tribe Paniceae, subtribe Setariinae, and specifically grasses belonging to the bristle clade – *Pennisetum, Setaria,* and *Zuloagaea* (Wheeler 2008). Prior to our recent report (Carr et al. 2011), extensive damage to ornamental plants caused by large infestations of these lace bugs had not been documented.

Similarly to other species of lace bugs, *L. plana* nymphs and adults colonize the underside of the leaf blades and damage their host plants by piercing the leaf tissue and destroying the mesophyll which results in characteristic yellow chlorotic blotches that appear on the upper leaf surface (Schultz and Coffelt 1987, Braman et al.1992, Braman and Pendley 1993, Reinert et al. 2006). Severe infestation levels lead to leaf browning and wilting.

The state of *L. plana* as an emerging pest and lack of information on biology, ecology and host plant relationships prompted our study. Ornamental grasses are a staple in most landscapes and are used often due to their low maintenance and relatively pest -free nature. If *L. plana* feeds on common landscape varieties of ornamental grass, it could pose a substantial economic issue. Control strategies for managing lace bugs typically involve the use of chemical insecticides; however, numerous natural enemies have shown the potential to suppress various species (Braman et al.1992, Balsdon et al. 1993, Balsdon et al. 1996, Stewart et al. 2002).

The objectives of our research were to determine the seasonal activity of *L. plana* and evaluate damage on commercially available *Pennisetum purpureum* Schumach. cultivars, 'Prince' and 'Princess', to determine relative susceptibility of these grasses to this pest. Additionally, the effects of temperature on development and survival of *L. plana* were studied in the laboratory.

Materials and Methods

Phenology and abundance. Field plantings naturally invested with *L. plana* were sampled during 2008 and 2009. At the University of Georgia, Griffin Campus (Griffin, Spalding Co., GA), 21 accessions with 4 replications of *Pennisetum* interspecific and trispecific ornamental grasses (3-years-old) in a contiguous randomized complete block arrangement were sampled approx. every 10 d from 2 May through 16 October 2008 and from 14 May through 20 October 2009. Grasses, which can reach heights of more than 2 m, die back to the ground after the first hard freeze in the fall. New growth is evident in late spring. Although adults were observed in the field as early as mid March on the few newly- emerged grass blades present at that time, sufficient plant material for repeated destructive sampling to evaluate number of eggs and other stages was not present until May.

Four leaf blades were randomly selected from each plant and placed in plastic bags corresponding to each plant. Leaf blades were then transported to the laboratory where the number of intact eggs, nymphs (first through fifth instars) and adult lace bugs per 4-leaf sample were counted with the aid of a steroscope. Additionally, eggs were checked for signs of parasitoid emergence by observing the state of the operculum.

Plant injury. *Pennisetum purpureum* cv 'Prince' and 'Princess' were evaluated for percent foliar damage caused by *L. plana* 3 times during the 2008 sampling season and twice during the 2009 season. Two independent observers made estimates of foliar damage, and the values for each plant were averaged. The rating system for whole plants ranged from 0 - 100, with zero indicating that no damage was observed

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and 100 meaning that all visible foliage was damaged. Injury was expressed as stippling, chlorotic bronzing, and wilting characteristic of lace bug feeding which was distinct from other potential insect injury. The combined average percent foliar damage inflicted was compared between 'Prince' and 'Princess' for the 2008 and 2009 seasons.

Temperature effects. Specimens for experiments were obtained from a colony initiated with adults collected from ornamental grass plantings of *Pennisetum* spp. hybrids in Griffin, GA. The colony was periodically supplemented with additional field-collected individuals. *Leptodictya plana* were maintained in cages in the laboratory at approx. 25°C and a 12:12 (L:D) photoperiod on pearl millet (*Pennisetum glaucum* L.) in liners planted into Sun Gro Metro-Mix 300 (Sun Gro Horticulture, British Columbia, Canada). Plants were hand watered daily. Supplemental *P. glaucum* was grown from seed as needed.

Female lace bugs were caged on individual seedlings, placed in environmental chambers (Percival Manufacturing Co., Boone, IA) and allowed to oviposit for 24 h at 25°C. Once oviposited, eggs were transferred to the experimental temperatures. At least 233 individual eggs were evaluated at each temperature (Table 1). Eggs and the emerging nymphs were monitored for development twice daily at each of 6constant temperatures: 10, 15, 20, 25, 30, 35°C. First instars were transferred individually to fresh seedlings extending through a plastic lid into a 32–ml plastic cup of water. A second cup was modified by replacing the bottom with mesh netting to allow for ventilation. That cup was inverted and placed over the seedling, and the union of the cups was secured with Parafilm M (American National Can, Greenwich, CT). Date and time of ecdysis were recorded for each developmental stage. The total hours required for oviposition and each subsequent developmental stage were recorded and compared among the experimental temperatures.

Statistical analyses. Percent damage data were transformed using an arcsine square root transformation to normalize data prior to analysis. The data presented in figures are untransformed values. Student's *t*-test was used to compare lace bug damage on 'Prince' and 'Princess' ornamental grasses.

Days to develop for each stage at each temperature were subjected to ANOVA and means were separated using a least significant difference (LSD) test (SAS Institute 2008).

Results

Phenology and abundance. Adults were present throughout the sampling period in both years and continually contribued eggs to the population, resulting in overlapping generations; therefore distinct generations were difficult to observe (Figs. 1, 2). When represented graphically, population peaks indicate that 3 - 4 generations occurred in Griffin, GA. Adults were observed in the field as early as mid March on newly- emerged grasses indicating that adults overwinter in the mulch/debris. By May, when sufficient foliage was available for sampling, first- generation eggs were abundant.

In 2008 and 2009, highest population levels occurred in early August, which corresponded with the highest seasonal temperatures. All plants had approximately the same life stages and relative number of individuals present; therefore, there were no differences observed between the plant accessions in terms of lace bug phenology. No evidence of parasitism was observed in the field. Field-collected eggs showed no

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Table 1. Mean ± SEM duration of development in days, and number of corresponding individuals completing each stage, of *L. plana* on *Pennisetum glaucum* seedlings.

Temp,		Instar					Total	
°C	Egg	1	2	3	4	5	nymphal	Total
10	NE (449)	ND**	ND	ND	ND	ND	ND	ND
15	NE (381)	ND	ND	ND	ND	ND	ND	ND
20	39.4 ± 0.1A (359)	2.9 ± 0.3B (62)	ND	ND	ND	ND	ND	ND
25	15.1 ± 0.1B (416)	5.0 ± 0.1A (220)	3.4 ± 0.2A (82)	4.1 ± 0.3A (69)	4.8 ± 0.1A (54)	8.1 ± 0.3A (45)	25.4 ± 0.4A (32)	40.5 ± 0.2A (32)
30	8.5 ± 0.1C (584)	3.5 ± 0.2B (266)	2.8 ± 0.3B (112)	2.2 ± 0.1B (92)	2.9 ± 0.2B (63)	4.0 ± 0.3B (48)	15.2 ± 0.2B (27)	23.7 ± 0.3B (27)
35		ND	ND	ND	ND	ND	ND	ND

Means within a column followed by the same letter are not significantly different ($P < 0.05$; LSD test); values in parentheses are numbers of individuals entering each stage.

* No live emergence from egg.

** No development occurred.

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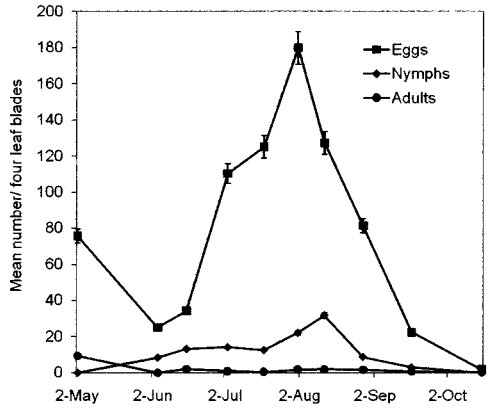

Fig. 1. Mean (± SEM) number of *L. plana* eggs, nymphs, and adults per 4 leaf blade sample from *Pennisetum* interspecific and trispecific hybrid ornamental grasses in Griffin, GA from May through October 2008.

evidence of parasitoids having emerged through the lace bug operculum as has been observed for other lace bug species (Braman et al. 1992).

Approximately 30% fewer insects were collected in 2009 than in 2008. According to the Georgia Automated Environmental Monitoring Network Station located on the Griffin Campus, there was 64% more rainfall received in 2009 than 2008 during our sampling period (May-October). This lace bug is more common in arid regions of the United States, suggesting the possibility that the wetter year could have inhibited population growth although no evidence of insect pathogens was observed.

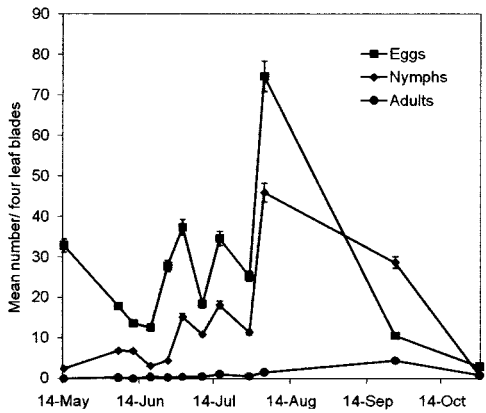

Fig. 2. Mean (± SEM) number of *L. plana* eggs, nymphs, and adults per four leaf blade sample from *Pennisetum* interspecific and trispecific hybrid ornamental grasses in Griffin, GA from May through October 2009.

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Plant injury. The overall average percent damage observed in the field for both sampling seasons was approximately 20% among all cultivars. Percent damage to plants ranged from 5 - 90% during peak infestation levels. In both sampling years, 'Princess' was more heavily damaged than 'Prince' (Fig. 3).

In addition to damage caused by lace bug feeding and defecation, we observed low numbers of grasshoppers and two-lined spittlebugs, *Prosapia bicincta* Say, late in the season. Only minor damage could be attributed to these insects. Toward the end of the season, as lace bug numbers began to naturally decline, the ornamental grasses in the field plots were able to outgrow most of the damage inflicted by the lace bugs. New growth appeared in the center of the plant and spread outwards, with uninjured, healthy new foliage.

Temperature effects. Successful total development occurred at 25 and 30°C (Table 1). At 20°C, 62 nymphs emerged and underwent ecdysis but died shortly after reaching the second instar. Nymphs (103) attempted to emerge at 35°C; however, no further development occurred. Duration of development from oviposition to ecdysis to the adult stage ranged from 23.3 d at 30°C to 40.5 d at 25°C. About one third of the total developmental period was spent in the egg stage. Among nymphal stages, time required for development of the second instar was the least, whereas fifth instars required the longest time. Mean days to develop were significantly different for total development at all temperatures for all stages and ages within a stage.

Discussion

The temperature range suitable for *L. plana* development was narrow when compared with some species of lace bugs, such as *Stephanitis pyrioides* Scott (Neal and Douglass 1988, Braman et al.1992). However, there are some lace bugs that have similarly narrow ranges such as *Corythucha cydoniae* Fitch, which is also typically more abundant in hot, dry weather (Braman and Pendley 1993). Our data suggest that

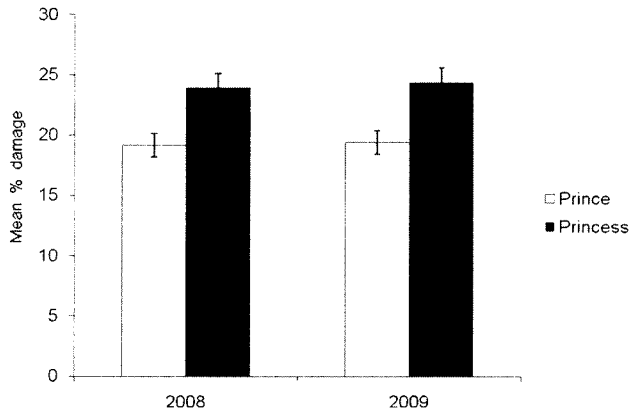

Fig. 3. Mean (± SEM) percent foliar damage inflicted to two ornamental grass standards, *Pennisetum purpureum* 'Prince' and 'Princess', by *Leptodictya plana* in a field plot in Griffin, GA during 2008 and 2009.

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L. plana thrives under weather conditions that are common during the summer months in central Georgia.

Our reports (Carr et al. 2011 and herein) are the first evidence of this lace bug occurring on ornamental grasses or of it occurring on *P. purpureum*. Additionally, it was successfully reared in the greenhouse on *P. glaucum*, pearl millet, and was found naturally infesting *Pennisetum* spp. interspecific and trispecific hybrid ornamental grasses in the field. This suggests the possibility that *L. plana* could become a substantial economic pest. Therefore, *L. plana* should be viewed as an emerging pest and considered as a potentially serious problem. The specific origins of this lace bug in Georgia are unknown, but it is likely that this pest has been sustained in a local population at low levels and was able to use a large planting of a suitable host material.

With the appearance of this lace bug in central Georgia, indicating an expansion in habitat distribution, there is a greater importance to further study this insect to determine how its occurrence might affect the ecology of the region. From our studies, it is apparent that this insect causes significant damage and thrives in our climate. It would be useful to understand how this insect originated in our area and what other potential host plants might exist. Ornamental grasses are a staple in many southern US landscapes and are used often due to their low maintenance requirements and relative pest free nature. If *L. plana* feeds on other varieties of ornamental grass, it could pose a substantial economic issue. Additional research is needed to determine the most effective ways to minimize its impact and potential range expansion.

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