Frequency and Diversity of Fungal Genera Contaminating the External Body Parts of Leaffooted Bug, *Leptoglossus phyllopus* (Heteroptera: Coreidae)

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Abstract: Coreid bugs and in particular species in the genus *Leptoglossus* are considered insects pests of economic importance and have been shown to vector plant pathogens especially fungi. Leaffooted bugs, *Leptoglossus phyllopus* (L.), were collected from pecan, *Carya illinoinénsi*s (Wangenheim) K. Koch, *Gaura parviflora* Dougl., pomegranate, *Punica granatum* L., and *Sorghum bicolor* (L.) Moench, fields in Brazos and Burleson counties, Texas in 2008 and 2009. A number of genera of fungi, including *Alternaria* spp., *Bipolaris* spp., *Claviceps* spp., *Colletotrichum* spp., *Curvularia* spp., *Fusarium* spp., *Fusicladium effusum*, *Aspergillus* spp., *Rhizopus* spp., smut and several unidentified spores were found adhering to the external body parts of these insects. Several of these fungal genera contain species that are pathogenic to sorghum and pecan on which leaffooted bugs are considered pests. In both years, *Alternaria* spp. was the most frequently recovered fungal species. In collection areas such as pecan orchards or from *G. parviflora* growing close to pecan trees, higher amounts of *Fusicladium effusum*, causal agent of pecan scab, a very economically important disease, were found contaminating the external body parts of these bugs. Thus, these mobile insects have the potential to passively transmit fungal diseases from plant-to-plant, between fields or orchards and different crops, plant hosts, and habitats.

Keywords: *Leptoglossus phyllopus*, pomegranate, fungal pathogens, fungal spores, pecan, sorghum, pecan scab.

INTRODUCTION

Fungal pathogens which incite various diseases of plants can significantly impact both the crop yield and quality. A major obstacle to implementing efficient disease control strategies in several pathosystems is our incomplete knowledge of the mechanisms involved for spreading spores of different fungal pathogens from field to field, plant to plant, and from different crops, plant hosts or habitats by mobile insects.

Insects belonging to the family Coreidae are commonly called leaffooted bugs because of leaf-like dilations of the hind tibiae in some species [1]. They are primarily phytophagous and gregarious, especially as nymphs. Coreid pests of interest are "pod sucking" because they feed on the reproductive parts of plants and cause direct injury to fruits and developing seeds depending on the stage at which these are attacked. Pecans fed on by the leaffooted bug, *Leptoglossus phyllopus* (L.), at the liquid endosperm stage develop black pit and are aborted, but those fed on later develop kernel discoloration and do not drop from the tree [2]. Leaffooted bugs are considered important pecan pests in Texas [3] and other pecan-growing areas. The feeding activity of insect pests such as leaffooted bugs on pecan fruits causes significant losses in both nut yield and kernel quality [2]. Losses of up to $3.5 million due to insect damage on pecan have been reported in Georgia [2]. In her review of the literature on Heteroptera as vectors of plant pathogens, Mitchell [4] stated that coreids predominantly are associated with the transmission of fungi and seven of the 13 coreids that she cites as associated with pathogens belong to the genus *Leptoglossus.*

A number of sorghum [*Sorghum bicolor* (L.) Moench] diseases have been shown to be transmitted by insects from different orders and families [5-9]. Insects, including leaffooted bug (*L. phyllopus*) that feed on head and panicles have been shown to frequent sorghum panicles from flowering to hard-dough stages of development [10, 11], a period when the plant is most susceptible to fungal pathogens. The mechanical injuries to the panicles, grains, and other plant parts resulting from insect feeding provide easy avenues for infection and colonization by various fungal, bacterial, and viral pathogens [9]. Thus, this communication documents the frequency and diversity of fungal genera from the exterior

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body parts of leaffooted bugs collected from different plants, including sorghum and pecan {*Carya illinoinensis* (Wagenheim) K. Koch}.

MATERIALS AND METHODOLOGY

Insect

Leaffooted bugs were arbitrarily collected from *Gaura parviflora* Dougl., pecan, pomegranate, and sorghum fields in Brazos and Burleson counties in Texas. Collections were conducted at bi-weekly intervals from May to July, a time when sorghum, pecan, weeds, and other plants are in different development stages (flowering to seed set). The locations where the bugs were collected were recorded for each collection. Insects were individually placed in vials and stored at -7°C until ready for examination.

Assessing the Amount of Fungal Spores Contaminating the Insects

The protocol previously described by Prom and Perumal [12] was used in this study. Briefly, 2.5 ml sterilized water was added to vials containing the leaf-footed bugs. Fungal spores were dislodged from the exterior body parts of the insect by shaking each vial using a vortex shaker for 30 s and then the insect was discarded. Identification of the fungal genera was based on the conidia descriptions provided by Ellis [13] and Navi *et al.* [14] and confirmed by reference cultures stored in the laboratory. The concentration of spores in each vial was quantified using a hemacytometer. A total of 105 and 100 insects were assessed in 2008 and 2009, respectively.

Statistical Analysis

The different fungal spore concentrations across locations were analyzed using the command PROC UNIVARIATE (Statistical Analysis 9.2, SAS Institute, Cary, NC) to provide summary of the data per insect.

RESULTS

The primary purpose of this work was to document the frequency and diversity of fungal genera contaminating leaffooted bugs collected in Brazos and Burleson counties, Texas. Spores from several fungal pathogens, including *Alternaria* spp., *Bipolaris* spp., *Claviceps* spp., *Colletotrichum* spp., *Curvularia* spp., *Fusarium* spp., *Fusicladium effusum* G. Winter (syn. *Cladosporium caryigenum*, *Fusicladosporium effusum*), *Aspergillus* spp., *Rhizopus* spp., smut and unidentified spores were found on the external body parts of leaffooted bugs collected from *G. parviflora*, pecan, pomegranate, and sorghum fields in 2008 and 2009 (Tables **1** and **2**).

In both years, spores from *Alternaria* spp. were the most recovered per insect, followed by smut spores (Tables **1** and **2**). Spores belonging to *F. effusum* and *Bipolaris* spp. were the third and fourth most observed per insect in 2008 (Table 1); whereas *Colletotrichum* spp.with one spore per insect was the third most abundant species observed in 2009 (Table **2**). In 2008, 54% of the *Curvularia* spp. spores, 47% of the *Fusarium* sp. spores, and 14% of the *F. effusum* spores were recovered from insects collected from the Brazos Bottom near sorghum plants, while 40% of *Curvularia* spp. spores, 53% of the *Fusarium* spp. spores and 81% of *F. effusum* spores were obtained from insects collected from pecan orchards or *G. parviflora* growing near pecan trees. In 2009, 64% of the *Curvularia* spp. spores, 55% of the *Fusarium* spp. spores, and 27% of the *F. effusum* spores were recovered from insects collected from the Brazos Bottom near sorghum plants, while 36% of *Curvularia* spp. spores, 45% of the *Fusarium* spp. spores and 73% of *F. effusum*

Table 1. Fungal Spores Recovered from External Body Parts of Adult Leaf-Footed Bugs Collected from May to July Around Brazos and Burleson Counties, Texas, in 2008[a]

Fungal genera	Mean[b]	N[c]	ANI[d]	Max[e]	Min[f]	SE[g]
Alternaria spp.	15.6	105	102	171	0	3.0
Aspergillus spp.	0.1	105	10	3	0	0.04
Bipolaris spp.	0.5	105	39	5	0	0.09
Claviceps spp.	0.03	105	2	2	0	0.02
Colletotrichum spp.	0.01	105	2	1	0	0.01
Curvularia spp.	0.4	105	26	8	0	0.1
Fusarium spp.	0.1	105	13	2	0	0.02
Fusicladium effusum 1.0	105	42	11	0	0.2	
Smut	1.3	105	17	11	0	0.2
Unidentified	0.1	105	30	10	0	0.1

[a] Adult leaf-footed bugs were collected from *Carya illinoinensis*, *Gaura parviflora*, *Punica granatum*, and *Sorghum bicolor* fields.
[b] = mean concentration of spores per insect.
[c] N = number of insects evaluated.
[d] ANI = the number of insects carry spores of the fungal species.
[e] Max. = maximum number of spores recovered.
[f] Min. =minimum number of spores recovered.
[g] SE = standard error of the spore concentration mean.

Table 2. Fungal Spores Recovered from External Body Parts of Adult Leaf-Footed Bugs Collected from May to July Around Brazos and Burleson Counties, Texas, in 2009[a]

Fungal Genera	Mean[b]	N[c]	ANI[d]	Max[e]	Min[f]	SE[g]
Alternaria spp.	14.2	100	96	82	0	2.1
Bipolaris spp.	0.5	100	21	4	0	0.1
Claviceps spp.	0.03	100	2	1	0	0.02
Colletotrichum spp.	1.2	100	13	65	0	0.7
Curvularia spp.	0.2	100	14	2	0	0.04
Fusarium spp.	0.13	100	17	3	0	0.04
Fusicladium effusum	0.21	100	11	3	0	0.07
Smut	2.1	100	34	41	0	0.6
Unidentified	0.4	100	91	10	0	0.1

[a] Leaf-footed bugs were collected from Carya illinoinensis, Gaura parviflora, Punica granatum, and Sorghum bicolor fields.
[b] = mean concentration of spores per insect.
[c] N = number of insects evaluated.
[d] ANI = the number of insects carry spores of the fungal species.
[e] Max = maximum number of spores recovered.
[f] Min = minimum number of spores recovered.
[g] SE = standard error of the spore concentration mean.

spores were obtained from insects collected around pecan trees or from *G. parviflora* growing near pecan orchards.

DISCUSSION

A number of sorghum grain-molding fungal genera (*Alternaria* spp., *Bipolaris* spp., *Colletotrichum* spp., *Curvularia* spp., and *Fusarium* spp.) were recovered from the external body parts of the leaffooted bugs. Prom and Perumal [12] also recovered similar grain-molding fungi genera from external body parts of this insect. Finding spores of *Claviceps* spp. on leaffooted bugs reinforces earlier reports by Prom and Lopez [6] and Prom *et al.* [7] that insects play an important role in dissemination of spores of diseases like sorghum ergot by feeding on ergot honeydew or on infected sorghum panicles. Other insects in the heteroptera group have been associated with a number of fungal diseases on plants either by providing infection courts or as spore dispersal agents [15]. The leaffooted bug *L. gonagra* has been shown to transmit the citrus fruit disease stigmatomycosis caused by *Nematospora coryli* [15]. Yamoah *et al.* [16] noted that the adult light brown apple moth, gorse seed weevil, gorse podmoth, and gorse thrips have the capacity to carry and deposit spores of the fungus *Fusarium tumidum* Sherb. Bumblebees also have been shown to passively transmit the anther smut, *Ustilago violacea* spores from diseased *Viscaria vulgaris* (Röhl.) Bernh. to healthy flowers [17]. Leaffooted bugs collected from pecan orchards or from *G. parviflora* growing close to pecan trees exhibited higher amounts of *Fusicladium effusum,* causal agent of pecan scab than those collected from other areas. Although the causal pathogen of pecan scab was found on the external parts of leaffooted bugs, the fact that these insects feed on developing nuts allows for spore entry in shuck tissues through feeding puncture, thereby providing infection courts for fungal pathogens. Pecan scab disease is the most economically important disease of pecans in the southeastern U.S, causing significant losses in nut yield and kernel quality [18].

CONCLUSION

In conclusion, the results of this study indicate that leaffooted bugs can carry on their external body parts diverse genera of fungi some of which are pathogenic to sorghum and pecan. Furthermore, *G. parviflora,* a very common weed that grows along fence lines, uncultivated fields, and semi-cultivated areas such as pecan orchards also may act as a reservoir for the pecan scab pathogen.

DISCLAIMER

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendations or endorsement by the U.S. Department of Agriculture.

CONFLICT OF INTEREST

None Declared.

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REFERENCES

[1] Mitchell PL. Leaf-footed bugs (Coreidae), In: Schaefer CW, Panizzi AR, Eds. Heteroptera of economic importance. USA: CRC Press 2000; pp. 337-403.
[2] Yates IE, Tedders SL, Sparks D. Diagnostic evidence of damage on pecan shells by stink bugs and coreid bugs. J Am Soc Hortic Sci 1991; 116(1): 42-6.
[3] Knutson A, Ree B, Muggee M. Managing insect and mite pests of commercial pecans in Texas. TX, USA: Texas AgriLife Extension 2010.
[4] Mitchell PL. Heteroptera as vectors of plant pathogens. Neotrop Entomol 2004; 33(5): 519-45.
[5] Frederiksen RA, Odvody GN, Eds. Compendium of Sorghum diseases. 2nd ed. St. Paul, MN, USA: The American Phytopathological Society APS Press 2000.

[6] Prom LK, Lopez JD Jr. Viability of *Claviceps africana* spores ingested by adult corn earworm moths, *Helicoverpa zea* (boddie) (Lepidoptera: Noctuidae). J Econ Entomol 2004; 97: 764-7.

[7] Prom LK, Lopez JD Jr., Latheef MA. Transmission of *Claviceps africana* spores from diseased to non-infected sorghum by corn earworm moths, *Helicoverpa zea*. J Sustain Agric 2003; 21: 49-58.

[8] Showemimo FA. Effects of the head bug *Eurystylus oldi* (Poppius) (Hemiptera: miridae) on some bio-agronomic traits of sorghum. Crop Prot 2003; 22: 117-9.

[9] Ratnadass A, Butler DR, Marley PS, Bandyopadhyay R, Hess DE, Akintayo I. Sorghum head-bugs and grain molds in West and Central Africa: II. Relationships between weather, head-bug and mold damage on sorghum grains. Crop Prot 2003; 22: 853-8.

[10] Hall DG, Teetes GL. Alternate host plants of sorghum panicle-feeding bugs in southeast central Texas. Southwest Entomol 1981; 6: 220-8.

[11] McPherson JE, McPherson RM. Stink bugs of economic importance in America north of Mexico. New York: CRC Press 2000.

[12] Prom LK, Perumal R. Leaf-footed bug, *Leptoglossus phyllopus* (Hemiptera: Coreidae), as a potential vector of sorghum fungal pathogens. Southwest Entomol 2008; 33:161-4.

[13] Ellis MB. Dematiaceous hyphomycetes. Kew, Surrey, England: Commonwealth Mycological Institute 1971.

[14] Navi SS, Bandyopadhyay R, Hall AJ, Bramel-Cox P. A pictorial guide for the identification of mold fungi on sorghum grain. Patancheru, Andhra Pradesh, India: ICRISAT 1999.

[15] Mitchell PL. Heteroptera as vectors of plant pathogens. Neotrop Entomol 2004; 33(5): 519-45. Available from: <http://www.scielo.br/scielo.php?script=sci arttext&pid=S1519-566X2004000500001&1ng=en&nrm=iso>, http://dx.doi.org/10.1590/S1519-566X2004000500001. [cited 24th Feb 2012].

[16] Yamoah E, Jones EE, Suckling DM, Bourdot GW, Walter M, Steward A. Using insects as potential vectors of Fusarium tumidum to control gorse. N Z Entomol 2011; 34: 5-11.

[17] Jennersten O. Insect dispersal of fungal disease:effect of Ustilago infection on pollinator attraction in Viscaria vulgaris. Oikos 1988; 51: 163-70.

[18] Sanderlin RS, Pyzner JR. Pecan Scab disease. LA, USA: Louisiana Cooperative Extension Service 2000.

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