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Symptoms, Distribution and Abundance of the Stem-Boring Caterpillar, *Blastobasis repartella* (Dietz), in Switchgrass

Jarrad R. Prasifka
University of Illinois, prasifka@illinois.edu

Jeffrey Bradshaw
University of Nebraska-Lincoln, jbradshaw2@unl.edu

Arvid A. Boe
South Dakota State University

DoKyoung Lee
University of Illinois at Urbana-Champaign, leedk@illinois.edu

David Adamski
Smithsonian Institution

See next page for additional authors

Authors
Jarrad R. Prasifka, Jeffrey Bradshaw, Arvid A. Boe, DoKyoung Lee, David Adamski, and Michael E. Gray

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Symptoms, Distribution and Abundance of the Stem-Boring Caterpillar, *Blastobasis repartella* (Dietz), in Switchgrass

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Abstract A potential pest of switchgrass, *Panicum virgatum* L., was first detected in South Dakota in 2004, where death of partially emerged leaves was noted in a small proportion of tillers. Similar "dead heart" symptoms were observed in switchgrass in Illinois during 2008 and adults of a stem-boring caterpillar were collected and identified as *Blastobasis repartella* (Dietz). In 2009, a survey of the central United States was used to estimate the distribution and abundance of this insect. In eight northern states, *B. repartella* was consistently found in both cultivated plots and natural stands of switchgrass. In four southern states, *B. repartella* was not detected. However, because symptoms are conspicuous for a short period of time, failure to collect stem-borers on one survey date for each southern location does not necessarily define the limit of distribution for *B. repartella*. Sampling in four northern states showed the proportion of tillers damaged by *B. repartella* ranged from 1.0–7.2%. Unlike some caterpillars that feed on native grasses, it appears that the egg-laying behavior of adult moths may preclude the use of prescribed burns as an effective method to suppress this stem-boring caterpillar. As a potential pest of switchgrass planted for biomass production, near-term research needs include refining the geographic distribution of *B. repartella*, quantifying potential losses of switchgrass biomass, and determining whether switchgrass may be bred for resistance this and other stem-boring insects.

Keywords Biofuel · Coleophoridae · Microlepidoptera · Tallgrass prairie · Yield

J. R. Prasifka · J. D. Bradshaw
Energy Biosciences Institute, University of Illinois,
Urbana, IL, USA

A. A. Boe
Plant Science Department, South Dakota State University,
Brookings, SD, USA

D. K. Lee · M. E. Gray
Department of Crop Sciences, University of Illinois,
Urbana, IL, USA

D. Adamski
Department of Entomology, Smithsonian Institution,
Washington, DC, USA

J. R. Prasifka (✉)
Energy Biosciences Institute, Institute for Genomic Biology,
Room 1117, University of Illinois,
Urbana, IL 61801, USA
e-mail: prasifka@illinois.edu

Introduction

Perennial rhizomatous grasses, including switchgrass, *Panicum virgatum* L., are considered low-input crops for biomass production, in part because they should require little to no management for insect pests [11, 12]. However, observations of feeding by several orders of herbivorous insects suggest that rather than being pest-free, the identity of insect pests and their effects on harvestable biomass are simply not yet known [4, 8]. One potential pest was first detected near Pierre, South Dakota in May 2004, where death of partially emerged leaves was a conspicuous symptom in a small proportion of tillers of 'Dacotah' and 'Cave-In-Rock' switchgrass. Since some healthy lower leaves were present, damage to leaves was initially attributed to a late freeze. However, subsequent examination revealed caterpillars tunneling within the damaged tillers, and the insect was reported as an unidentified stem-borer [10]. Feeding by the caterpillars resulted in cessation of growth, preventing accumulation of additional biomass for infested tillers. Similarly, other stalk-boring caterpillars in maize, sorghum, rice and sugarcane produce conspicuous death of whorl leaves, a symptom often colloquially referred to as “dead heart” [5].

The death of emerging leaves and presence of holes in tillers just above soil level also suggested the presence of a stem-boring insect in ‘Cave-In-Rock’ switchgrass in Illinois during 2008. However, symptomatic tillers in Illinois contained only rotting tissue and larvae of insects that secondarily invade damaged and decaying plant tissues. After finding that the caterpillars in South Dakota are often collected inside the stem but below soil level, it was concluded that initial attempts to collect larvae in Illinois had been either too shallow or too late in the season. Accordingly, to catch adults of any insects responsible for the damage to ‘Cave-In-Rock’ tillers, small cages were placed over symptomatic tillers with the metal edges of each cage buried just below soil level. A small number of moths were collected from cages in Illinois and by collection in nets at night, allowing specimens to be submitted for identification.

Because few adults were available, the moths were tentatively identified as *Blastobasis repartella* Dietz (Lepidoptera: Coleophoridae), a species previously known only from two male specimens collected from Colorado in 1910 [7]. However, specimens from Illinois also closely resembled *Blastobasis graminea*, which has been described as a pest boring into stems of sugarcane, *Saccharum* spp. [1, 2], and smooth cordgrass, *Spartina alterniflora* Loisel [13]. Based on the ability of the stem-boring larvae to stop the growth of infested tillers, efforts in 2009 focused on conducting a survey to better determine the distribution of the *Blastobasis* species and sampling to obtain estimates of its prevalence within managed plots of switchgrass. Additional observations of the biology of *Blastobasis* infesting switchgrass were made, primarily from plots in Illinois.

Methods

While switchgrass is distributed throughout most of the United States, efforts to collect *Blastobasis* larvae focused on areas comprising the original tallgrass prairie. Southern states, including Texas, Oklahoma, Louisiana and Arkansas were surveyed during April 2009. Northern states of Illinois, Iowa, Nebraska, Wisconsin, Ohio, Michigan, South Dakota and North Dakota were visited during May and June 2009. Survey data for a single state, Ohio, came from a small roadside patch of switchgrass sampled en route to a seed production field in Michigan. In part, survey dates were selected in an attempt to visit fields when plants were 25–50 cm tall to make detection of dead, partially emerged leaves easier; unlike in regularly-spaced annual crops, the high density of tillers in switchgrass means that symptoms are more conspicuous when there is little or no height difference between infested and uninfested tillers.

At each survey location, a visual search was conducted for tillers with emerging leaves that were dead or dying. Because a late freeze or previous mechanical damage (e.g., from farm equipment or people walking though plots) may cause a similar appearance in emerging leaves, tillers were considered symptomatic only if a hole near the base of the stem also was visible (Fig. 1). For all locations where stem-boring larvae were present, a small number of larvae or pupae were collected to allow later examination of the specimens and storage as vouchers at the Illinois Natural History Survey insect collection. When time permitted, more intensive sampling was used to estimate the abundance of symptomatic tillers within a stand. To estimate the percentage of tillers lost to stem-borers, and *Blastobasis* in particular, five or ten points were arbitrarily selected within a plot; at each point, a subsample of 100 tillers was searched and each symptomatic tiller cut below soil level and placed into a clear plastic bag. Symptomatic tillers were later dissected by hand with tillers categorized as containing *Blastobasis*, other unidentified stem borers, or no stem-boring insects.

Additional observations were made using collections from field locations in Savoy, Illinois. Larvae were collected in May and June by removing symptomatic tillers from plots. Some of these larvae were confined with

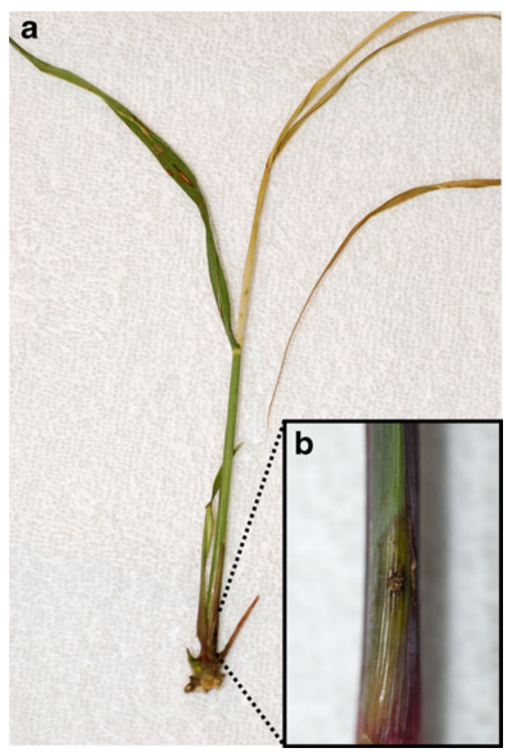

Fig. 1 Symptoms of *Blastobasis repartella* infestation. Switchgrass tiller **a** excised from field, and **b** with a detail of an entry wound

Table 1 Switchgrass field sites surveyed for *Blastobasis repartella*, 2009

Locations	Year established	Plot area (ha)	Cultivar	Sample date
B. repartella not collected				
Stephenville, TX[a]	1995	0.08	Alamo	April 6
Ardmore, OK	2007	0.23	lowland crosses	April 7
Homer, LA[ab]	2001	<0.01	Alamo	April 8
Booneville, AR	2002	1.01	Alamo	April 8
B. repartella collected				
Savoy, IL	2004	0.19	Cave-In-Rock	May 30
Ames, IA	2004	0.01	Cave-In-Rock	June 3
Mead, NE (1)	2006	23.10	Shawnee	June 4
Mead, NE (2)	2002	0.40	Shawnee Kanlow × Summer Summer × Kanlow Trailblazer	June 4
Arlington, WI[c]	2005	0.20	WS4U	June 16
Wauseon, OH[d]	unknown	<0.01	none	June 23
East Lansing, MI	1999, 2000	0.41	Southlow	June 24
Bristol, SD	2001	6.1	Trailblazer	June 30
Carrington, ND	2006	0.02	Sunburst Trailblazer	June 30

[a] Plot minimally maintained. Weedy with no cutting or burning of growth from previous year

[b] Planted as understory for loblolly pines, *Pinus taeda* L.

[c] Source population detailed in Crop Sci 46:998–999

[d] Sample taken from roadside patch if switchgrass

uninfested 'Sunburst' tillers in potted plants in attempt to induce burrowing into stems without *Blastobasis*. Adults were collected at night in July using headlamps and sweep-nets. Adults were subsequently caged on potted 'Sunburst' switchgrass in an attempt to induce egg-laying, as eggs have not been observed previously for any *Blastobasis* species. Because switchgrass fields where prescribed burns are used still harbor *Blastobasis* populations, it seemed likely that eggs were being deposited in a sheltered location, possibly just beneath the soil surface. One week later plants and soil were inspected for evidence of eggs.

Results

Neither symptomatic tillers nor *Blastobasis* larvae were found at locations in Texas, Oklahoma, Louisiana and Arkansas. However, *Blastobasis* larvae were found in cultivated switchgrass at seven northern states; in Ohio, the eighth northern state sampled, examination of a small roadside patch of switchgrass produced one pupa from two symptomatic tillers (Table 1). *Blastobasis* larvae, pupae and adults (emerged from pupae) from these collections were examined and confirmed as *B. repartella* based on comparisons to museum specimens.

The degree of infestation by stem-borers was estimated to range from 1.0–7.2%, with both the highest and lowest values occurring in plots near Mead, Nebraska. Among the five locations where the percentage of tillers lost to stem-borers was assessed, survey locations varied considerably in size (<1–23 ha) and age (2–14 years). Assuming about 600 tillers / m^2 [3], the data from five fields in four states suggest from 6–40 symptomatic tillers may be present in one square meter. Excluding Savoy, Illinois, the only location where another, unidentified stem-boring caterpillar (family Crambidae) was found, over 70% of the symptomatic tillers contained *B. repartella* (Table 2). In general, the symptomatic tillers that contained no larvae

Table 2 Estimated percentages of switchgrass tillers infested with *Blastobasis repartella*, 2009

Location	Symptomatic tillers (%±SE)	Tillers with *Blastobasis* (%)
Savoy, IL	3.2±0.8	1.3±0.4[a]
Mead, NE (1)	1.0±0.6	0.8±0.5
Mead, NE (2)	7.2±1.0	5.0±1.3
Arlington, WI	3.0±1.1	2.4±1.0
Bristol, SD	3.6±1.1	2.3[b]

[a] Sample included another unidentified stem-boring caterpillar

[b] Estimated from a single sample (n=50) of symptomatic tillers in field

contained frass (insect fecal material) indicative of insect feeding and appeared to be among the smallest tillers collected (height<10 cm).

From hundreds of symptomatic tillers collected from Savoy, Illinois during May and June, it appears no more than one *B. repartella* larva is found within a single tiller and the larval location within the stem seems to change. Just after symptoms appear larvae often are found above the hole near the base of the tiller; later in the season larvae are more likely to be found below soil level, as the larvae usually pupate within the most basal part of infested tillers. The larval entry hole near the base of the stem for *B. repartella* is generally within 3 cm of the soil surface, while entry holes for the unidentified stem-borer in Illinois are almost always found at a height greater than 3 cm above soil level. While larvae were sometimes successfully induced to burrow into small stems of 'Sunburst,' they seemed unable to enter more mature (i.e., thicker-stemmed) tillers in the same pot. The dissection of switchgrass plants caged with adult *B. repartella* revealed eggs deposited at the base of stems, but concealed beneath the desiccated sheath at the base of each tiller. Eggs were present on both currently growing switchgrass and stubble from previously cut tillers. The location of eggs and the subsequent life stages of *B. repartella* are shown in Fig. 2.

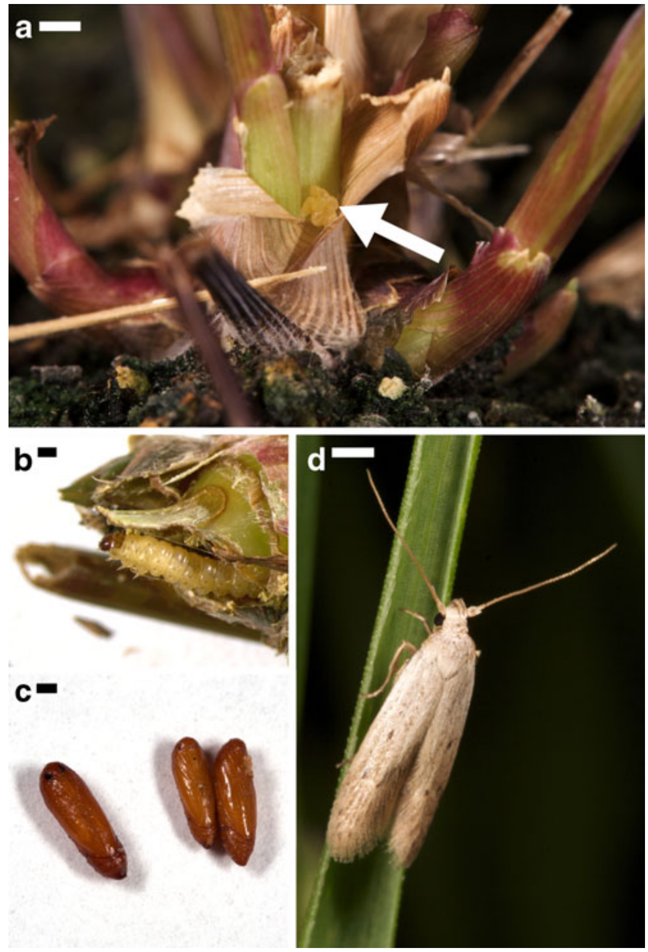

Fig. 2 Life stages of *Blastobasis repartella*. Photographs include **a** eggs, **b** larva, **c** pupae, and **d** adult. All plant parts are of switchgrass. Scale bars (each≈1 mm) are positioned next to figure letters

Discussion

Results suggest that in the north central United States, *B. repartella* may be ubiquitous in established stands of switchgrass, as it was found in all eight northern states in the survey. Though no locations were included for Indiana or Minnesota, *B. repartella* is almost certainly present in both states, which are bordered with three or four states where the stem-borers have been collected. However, fields in Texas, Oklahoma, Louisiana and Arkansas all failed to show evidence of stem-borers during one early-season visit (Table 1).

The four southern states are part of the native distribution for switchgrass, making it unclear whether the insect is not present, or if it was not detected for another reason. For example, a small proportion of infested tillers could go unnoticed because of less-than-ideal timing. Plots may be infested but not show the dead heart symptom because larvae have not yet consumed enough tissue to kill emerging leaves. Also, based on observations in Wisconsin, it appears that plots with little regular management (i.e., weed control or harvest) may harbor fewer larvae. Since another *Blastobasis* species is known from Louisiana [13], additional sampling would be needed to have confidence in the absence of *B. repartella* in the United States.

Based on more intensive sampling, the occurrence of symptomatic tillers of switchgrass was estimated to be modest (< 10%) across five locations in four states (Table 2). Some tillers with dead heart and an entry hole did not contain caterpillars; such symptomatic tillers without larvae may have been once infested but abandoned, or larvae may have died from predation, parasitism or pathogens. However, because symptomatic tillers without *B. repartella* remain stunted, the proportion of tillers with dead heart and visible holes just above soil level (i.e., symptomatic tillers) may be a more accurate measure of activity by *B. repartella* where no other early-season stem borers are known.

Interestingly, the locations with the highest and lowest percentage of symptomatic tillers were located within 4 km of each other near Mead, Nebraska. Other than size, the primary difference between the locations is the number of years since plot establishment. If new switchgrass plantings are colonized by moths from nearby wild switchgrass or more distant fields, there may be a positive correlation between the age of fields and degree of infestation. However, since the percentage of tillers lost to *B. repartella* was accurately measured in only five locations, more research would be required to examine any relationship between stand age and degree of infestation.

Because the injury by *B. repartella* occurs early, it seems possible that switchgrass could compensate for the loss of some tillers. However, under a scenario where the area of switchgrass grown for bioenergy greatly expands, it is possible that stem-borer abundance could also increase and become problematic; control of other internal feeders is often a challenge because larvae are protected by feeding within the plant, requiring precisely timed insecticide applications [9]. Stem-borers of native grasses that deposit eggs on leaves can be controlled by burning [6], but the sheltered location of eggs and the presence of above-average infestation in a location that was burned early in 2009 (Bristol, South Dakota; Table 2) suggest this may not be an effective technique to suppress *B. repartella*.

As a potential pest of switchgrass planted for biomass production, much of the desired biological information for *B. repartella* is not yet known. For example, based on the relatively late emergence of adults in Illinois (June into July) and an apparent inability of larvae to tunnel into mature switchgrass stems, the insect is presumed (but not known) to have one generation per year. Besides better understanding the life-history of the insect, there are also near-term needs to refine the geographic distribution of *B. repartella*, to quantify potential losses of switchgrass biomass, and to determine whether switchgrass may be bred for resistance to this and other stem-boring insects.

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