Orchardgrass, *Dactylis glomerata* L. (Cyperales: Poaceae), is a cool season grass, cultivated throughout the United States as a high-value forage crop. Larval feeding by two weevil species (Coleoptera: Curculionidae), the bluegrass billbug, *Sphenophorus parvulus* Gyllenhal, and the hunting billbug, *Sphenophorus venatus vestitus* Chittenden, has caused widespread economic damage to orchardgrass stands in Virginia. The cryptic feeding habits of these species, combined with a lack of effective systemic insecticides, make billbug control extremely difficult in orchardgrass. Here, we present an overview of the biology of orchardgrass and its associated billbug pests, and review the control options for these pests.

**Orchardgrass**

Orchardgrass is a cool season bunch-type grass, cultivated as a high-value forage crop in the United States. In Virginia, the production value of orchardgrass in 2011 was estimated as US$188,772,000, or ~35% of the total production value of grass hay for the state (National Agricultural Statistics Service [NASS] 2012). The bluegrass billbug, *Sphenophorus parvulus* Gyllenhal, and hunting billbug, *Sphenophorus venatus vestitus* Chittenden, are important pests of orchardgrass in Virginia. A survey conducted in 2005 on over 324 ha (800 ac) of orchardgrass in northern Virginia showed losses of 40–100% attributed to billbugs (R.R.Y., unpublished data). The sheltered feeding habits of these species, combined with the lack of effective systemic insecticides for orchardgrass, make billbug control extremely difficult in orchardgrass. Here, we present an overview of billbug ecology, and control options for these pests in orchardgrass.

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**Key Words:** hunting billbug, bluegrass billbug, Curculionidae, *Sphenophorus* spp., orchardgrass

Orchardgrass, *Dactylis glomerata* L. (Cyperales: Poaceae), is a cool season bunch-type grass, cultivated as a high-value forage crop in the United States. In Virginia, the production value of orchardgrass in 2011 was estimated as US$188,772,000, or ~35% of the total production value of grass hay for the state (National Agricultural Statistics Service [NASS] 2012). The bluegrass billbug, *Sphenophorus parvulus* Gyllenhal, and hunting billbug, *Sphenophorus venatus vestitus* Chittenden, are important pests of orchardgrass in Virginia. A survey conducted in 2005 on over 324 ha (800 ac) of orchardgrass in northern Virginia showed losses of 40–100% attributed to billbugs (R.R.Y., unpublished data). The sheltered feeding habits of these species, combined with the lack of effective systemic insecticides for orchardgrass, make billbug control extremely difficult in orchardgrass. Here, we present an overview of billbug ecology, and control options for these pests in orchardgrass.

**Orchardgrass**

Orchardgrass is a cool season bunch grass used for forage throughout the world. Native of Eurasia and northern Africa, it was first described by Linnaeus in 1753 (Peeters 2004). Cultivation of orchardgrass began after its introduction into the United States, presumably in the 1750s, and in 1763, an improved variety from Virginia was reimported to England (Christie and McElroy 1995). Named for its propensity to grow in shady areas such as orchards, orchardgrass is also called cocksfoot in Europe for the likeness of its inflorescence to the foot of a rooster (Balasko and Nelson 2003). In the United States today, various cultivars of orchardgrass are found in every state, including Alaska and Hawaii, as well as Puerto Rico (Natural Resources Conservation Service [NRCS] 2010); however, it is predominant in the northeastern, north-central, and Pacific Northwest regions of the United States (Christie and McElroy 1995). Orchardgrass has a few marked characteristics that make it easy to distinguish from other grasses (Fig. 1). As a bunch-type grass, orchardgrass plants grow in tight, round clusters (Smith et al. 1986). The leaves of these clusters are limp, somewhat curly, and green to blue-green in color. Each leaf is folded longitudinally at its base within the bud and has a cross-sectional “V”-shape (Christie and McElroy 1995). Stems can reach 20–120 cm in height (Peeters 2004).

Orchardgrass became widely accepted as a forage grass in the United States in the 1940s and is now used for pasture, hay, silage, and green chop (Miller 1984, Christie and McElroy 1995). Key features of this grass include easy and rapid establishment, early maturation, high productivity, shade tolerance, heat tolerance, drought tolerance, and moderate winter-hardiness (Miller 1984). Orchardgrass responds well to nitrogenous fertilizers, by application of animal manure, or by planting with a legume, such as alfalfa, *Medicago sativa* L., or ladino clover, *Trifolium repens* L. (Miller 1984, Christie and McElroy 1995).

**Billbugs (Sphenophorus spp.)**

The weevils (Coleoptera: Curculionidae) currently belonging to the genus *Sphenophorus* (known as “billbugs”), have a long and confusing nomenclature history, explained in detail by Vaurie (1951) and O’Brien and Wibmer (1982). The genus currently known as *Sphenophorus* was originally described as *Calendra* Clairville and Shellenberg, but was spelled as *Calandra* (with an “a”) in one figure (Schellenberg and Clairville 1798). This caused years of confusion, as different authors used one spelling over the other (e.g., Schoenherr 1838, Pierce 1925). In 1959, the matter was finally settled when the International Commission on Zoological Nomenclature (ICZN), following recommendations of specialists around the world, suppressed the names *Calendra* and *Calandra* in favor of the name *Sphenophorus* (ICZN 1958, 1959). The last major revision of the genus was made by Vaurie (1951).

Several taxonomic keys have been written for the identification of various life stages of weevils to the genus- and species-level of *Sphenophorus*. Anderson (1948) provided a generic key to larvae of the curculionid subfamily, Calendrininae (now Dryophthorinae), which included *Calendra*. It should be noted that no species-level key for the larvae of *Sphenophorus* yet exists; however, Satterthwait (1931b) devised a species-level key to the pupae of *Calendra* in the United States. Species-level keys for *Sphenophorus* adults were written by Blatchley and Leng (1916) for Rhynchophora (now Curculionoidea) of eastern North America, Vaurie (1951) for *Calendra* of the United States, Johnson–Cicalese et al. (1990) for those species in this genus that are pests of turfgrass in the United States, and Downie and Arnett (1994) for beetles of the United States. Vaurie (1951) also included a key to differentiate the five *S. venatus* subspecies.

**Bluegrass Billbug.** The bluegrass billbug, *S. parvulus*, was described by Leonard Gyllenhal in 1838 (Schoenherr 1838). Since that time, it
Johnson–Cicalese 1988, Watschke et al. 1995). Although there are many publications that associate this species with injury to various grasses and plants, few authors have connected the bluegrass billbug to orchardgrass. Satterthwait (1931b) included orchardgrass as a potential host plant for the bluegrass billbug; Turner (1955) reported it to orchardgrass. Satterthwait (1931b) also reported the bluegrass billbug to be feeding on orchardgrass. The bluegrass billbug is currently found in nearly every state of the continental United States, and in particular corn, Zea mays L., and Kentucky bluegrass, Poa pratensis L. (Bruner 1890, Webster 1892, Forbes 1902, Blatchley and Leng 1916, Tashiro and Personius 1970, Lindgren et al. 1981). Additional hosts include barley, Hordeum vulgare L., wheat, Triticum aestivum L., rye, Secale cereale L., ryegrass, Lolium spp., bentgrass, Agrostis spp., and yellow nutsedge, Cyperus esculentus L. (Satterthwait 1931b, Johnson–Cicalese 1988). 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Host species include Timothy hay, Bermuda grass, zoysiagrass, reported in orchardgrass (Kamm 1969, Kuhn et al. 2013). The hunting billbug adults are nocturnal, and that eggs may be deposited in or around feeding “notches” created by the female on grass stems. The adult feeding at the folded base of a leaf, and then unfurls into a mirrored pair as the leaf grows. These holes are a diagnostic feature evident in dry than well-watered grass, despite being equally infested with billbug adults. Larvae feed within the stems and roots in midsummer and damage appears as irregularly shaped patches of brown grass (Watschke et al. 1995). Damage caused by larvae is often more evident in dry than well-watered grass, despite being equally infested (Bruner 1890). Later in the growing season, infested stems break off easily and the larval frass, which resembles sawdust, spills out of these hollowed stems (Tashiro and Personius 1970). Feeding by larvae in later instars causes the most damage (Turner 1955).

Several methods have been devised to sample for billbugs. To extract billbug eggs from turfgrass, Tashiro (1987) used a blender to break up the turfgrass material and a series of stacked sieves to filter out the resultant turfgrass fragments, leaving the eggs. Larvae can be found by examining the upper layers of soil cores or square-foot samples (Watschke et al. 1995). Adult billbugs may be found in turfgrass by drenching the grass with water (Vittum et al. 1999), monitoring sidewalks and pavement for adults (Watschke et al. 1995, Vittum et al. 1999), using “suction or vacuum samplers” (Watschke et al. 1995), and using pitfall traps (Johnson–Cicalese et al. 1990, Watschke et al. 1995, Vittum et al. 1999). In addition, Doskocil (2010) found several commercial blends of aggregation pheromones from four non-Sphenophorus weevil species to be effective attractants for hunting billbug adults in a laboratory setting.

Pitfall traps, which are often used to capture surface-dwelling arthropods, are the most common method for sampling billbug adults. A basic pitfall trap comprises a container buried in the soil so that its rim is flush with the soil surface. The container is partially filled with a killing solution, such as soapy water, ethanol, or ethylene glycol, to both prevent captive arthropods from escaping and to preserve them from decay until the traps can be checked. Several modifications have been made to the basic trap idea. Linear pitfall traps use a piece of buried PVC pipe with a slit cut dorsally along its length to funnel surface-dwelling arthropods into a collection can at one end (Lawrence 1982), while in a barrier pitfall trap (Hansen and New 2005, Laub et al. 2008), a barrier wedged into the ground diverts arthropods into pitfall traps on either of its ends. In the latter method, multiple pitfall traps may be connected by several barriers, or multiple barriers may be used around a single pitfall trap, increasing the area covered by the trap (Hansen and New 2005).

Although a number of cultural, biological, and chemical control methods have been suggested for billbugs in turfgrass and corn, there has been little focus on control in orchardgrass. Tashiro (1987) and Watschke (1995) reviewed billbug-resistant varieties of turfgrass, but no billbug-resistant varieties of orchardgrass have been reported.

Predators of billbugs include the adults and larvae of carabid beetles (Bruner 1890); a tachinid fly, Mysophasia metallica (Townsend); as well as the American toad, alligators, and 26 species of birds (Satterthwait 1932). Natural parasites and parasitoids include the entomopathogenic fungus, Beauveria sp. (Kamm 1969); entomopathogenic nematodes of the genus Mermis Dujardin or Gordius L. (Bruner 1890); mites (Acari) (Forbes 1902); a braconid wasp, Vipio belfragei (Cresson) (Satterthwait 1932); and the mymarid wasp, Anaphes (Patasson) calendris (Gahan) (Satterthwait 1931a, Beardsley 2000).

Billbug augmentative biological control has been attempted and has included the introduction of A. calendris into Hawaii in 1928 and 1963. The second introduction was successful, as individuals of A. calendris were found in 1995; however, efficacy against the target weevil species is unknown (Beardsley 2000). For controlling billbug adults and larvae, Watschke et al. (1995) recommended application of various entomopathogenic nematodes (Steinernema carpocapsae Weiser, Steinernema glaseri Steiner, and multiple Heterorhabditis spp.), and moistening turfgrass in the spring to augment the entomopathogenic, soil-borne fungi, Beauveria spp.

Watschke et al. (1995) reported that the most effective means of chemical control for billbugs is to target the egg-laying spring adults. Larvae may also be targeted as they leave the stem and drop to the soil to feed on the roots of the plant; however, some larvae remain within the plant and are therefore never exposed to contact or soil insecticides (Watschke et al. 1995). In turfgrass, systemic insecticides are effective for controlling billbug larvae and adults; however, these insecticides are not available for orchardgrass. There are only five insecticides currently registered for grass hay and pasture, which includes orchardgrass: β-cyfluthrin, carbaryl, λ-cyhalothrin, malathion, and...
ξ-cypermethrin (Youngman et al. 2013). Of these, however, only λ-cyhalothrin is currently labeled for use on billbugs in grass hay and pasture in Virginia.

Billbugs in Orchardgrass: A Poorly Understood Problem

Billbugs are a major pest of orchardgrass in Virginia; however, most of our current understanding of them is based on studies of their interactions with turfgrass. Further investigations are warranted to verify the life histories of the bluegrass and hunting billbugs on orchardgrass. In addition, other billbug species have been reported in orchardgrass fields, including the southern corn billbug, *Sphenophorus castaneus* (Olivier), lesser billbug, *Sphenophorus minimus* (Hart), and Timothy billbug, *Sphenophorus zeae* (Walsh) (Kuhn et al. 2013). Feeding studies are needed to determine whether these species regularly feed on orchardgrass and, if so, how likely they are to become pests. Finally, the current measures available for control of billbugs in orchardgrass are extremely limited. New management tools, insecticides or otherwise, are required to effectively control this pest.

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