The Great Lakes Entomologist

Volume 25
Number 4 - Winter 1992 *Number 4 - Winter 1992*

Article 2

October 1992

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# SUITABILITY OF SELECTED BROAD-LEAVED WEEDS FOR SURVIVAL AND GROWTH OF TWO STALK-BORING *HYDRAECIA* SPECIES (LEPIDOPTERA: NOCTUIDAE)

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## ABSTRACT

Third instar hop vine borer (*Hydraecia immanis*) and potato stem borer (*H. micacea*) are new pest species on corn in the Midwest. Early instar larvae feed on small-stemmed grasses, and later instar larvae switch to broad-stemmed hosts to complete development. In order to assess potential suitability of various weeds of corn fields, larvae were reared on seven selected broad-leaved plants for 16–18 days under greenhouse conditions to determine their feeding behavior and performance. Domestic plants included hop (*Humulus lupulus*) and potato (*Solanum tuberosum*); weed species included curly dock (*Rumex crispus*), redroot pigweed (*Amaranthus retroflexus*), lambsquarters (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*) and giant ragweed (*A. trifida*). Larvae of both species survived best on corn, hop, and curly dock. While potato was an excellent host for the potato stem borer *H. micacea*, survival was poor for the hop vine borer, *H. immanis*. Red root pigweed, common ragweed, giant ragweed and lambsquarters were poor hosts for both moth species. While the potato stem borer, *H. micacea*, larvae were able to grow well and gain weight rapidly on several hosts, the hop stem borer, *H. immanis*, grew well only on hops. Larval feeding behavior and size, as well as plant phenology, stem thickness, and growth form, are all critical determinants as to whether or not a particular plant species can serve as a final host on which *H. immanis* and *H. micacea* can complete development.

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Both the hop vine borer, *Hydraecia immanis* (Guenée), and the potato stem borer, *H. micacea* Esper, belong to a small genus of noctuid moths whose members inhabit the temperate/boreal interface zones of the Nearctic and feed by boring into various herbaceous plants (Forbes 1954). The hop vine borer is native to North America and the potato stem borer was introduced from Europe into New Brunswick during the early 1900's (Gibson 1908, Brittain 1918). Neither species was considered an agricultural pest in North America until the mid-1970's when populations suddenly rose to damaging levels in corn fields across the Great Lakes region of the U.S. and Canada (Giebink et al. 1984).

Although related and very similar in appearance, the geographic origins and reported host ranges of these species are quite different. The hop vine borer (HVB) is a native North American insect previously associated only

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with hops (*Humulus lupulus*) and considered to be only a minor pest on that crop (Bethune 1873, Comstock 1883, Howard 1897, Sanderson 1902). Long considered a grass/hops specialist, this insect has successfully switched to corn, (*Zea mays*) with some local populations in Michigan, Iowa, Minnesota, Illinois, Wisconsin and New York causing significant economic damage (Hawley 1918, Giebink 1983, Giebink et al. 1984, Scriber and Hainze 1987).

The potato stem borer (PSB) is thought to be introduced from Europe (Brittain 1918), where it is widely distributed throughout all northern and central portions of that continent (Gibson 1908) as well as Scandinavia, Siberia and Japan. Accidentally introduced into Nova Scotia and New Brunswick in the early 1900's (McIntosh 1899, Gibson 1908), it has since become an occasional pest in North America on a variety of cultivated plants including corn, rhubarb (*Rheum rhaponticum*) and potatoes (*Solanum tuberosum*) (Jobin 1963, Deedat and Ellis 1983). The PSB is presumed to be much more polyphagous than HVB.

During late summer, the females of both species oviposit within the leaf sheaths of grasses. Eggs overwinter and hatch the following spring (Deedat and Ellis 1983, Giebink et al. 1984). Initially, larvae feed within grass stems, but eventually outgrow them and disperse to plants which have thicker above- and below-ground stems. During this active host-seeking period, early season crop plants such as corn may be attacked. Therefore, the importance of these stalk borers as pests is closely related to the composition of suitable weed populations in and around commercial crops. Both *Hydraecia* species typically complete their larval development and pupate below the soil surface (Hawley 1918, Zwolfer 1962, Jobin 1963, Giebink 1983, Deedat and Ellis 1983, Deedat et al. 1983, Giebink et al. 1984).

Although a number of plant hosts have been reported for *H. immanis* (Giebink 1983, Tietz 1972, Hawley 1918) and *H. micacea* larvae (Deedat 1980, Brittain 1918, Guenée 1852, Nordstrom et al. 1941, 1974, Seppanen 1970, West 1984, Zwolfer 1962), relatively little is known about their feeding behavior, survival, and growth performance across a range of potential weed hosts commonly found in plant communities in and around Midwestern corn fields. This study represents an analysis of the relative suitabilities of selected broad-leaved plants (which differ in phenology, stem thickness, growth form, and root system). This information is critical to understand the potential for continued geographic spread, local population densities, and phenological damage periods for HVB and PSB to susceptible crop plants in the northeast and north central states.

## MATERIALS AND METHODS

These host suitability studies consisted of seven thick-stemmed broad-leaved plants as no-choice treatments (two domestic and five midwestern wild or "weed" species) for each insect, with each host replicated five times for each insect species. The study, which was completely randomized and conducted under greenhouse conditions, was repeated twice.

Domestic plants included hop (*Humulus lupulus*) and potato *Solanum tuberosum*); weed species included curly dock (*Rumex crispus*), redroot pigweed (*Amaranthus retroflexus*), lambsquarters (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*) and giant ragweed (*A. trifida*). At the beginning of the study, plants were 56–63 days old. All of these "wide-stem" plants ranged from 4–9 mm in diameter.

Seeds for these plants were obtained from either wild plants or F & J Seed Service, P.O. Box 82, Woodstock, IL 60098. These were planted directly into plastic pots (21 cm diam. × 20 cm ht.) filled with autoclaved soil (equal parts compost, field soil, and sand), grown under Metalarc® high-intensity lamps (15L : 9D photoperiod), watered as necessary and fertilized every two weeks. Temperatures ranged from 14° C (early morning) to 30° C (late afternoon).

Larvae used in these studies were obtained from eggs deposited by one-generation laboratory-reared females on grasses in the greenhouse during late June through July the previous season. After remaining in the greenhouse for 3–4 weeks, these eggs were removed from the plants, chilled (5.6° C) for 8 or more weeks, and incubated at 21° C to promote egg hatch. Upon hatching, larvae were reared to the third instar on a modified navy bean diet (Shorey and Hale 1965) in the manner described by Giebink et al. (1985).

To ensure that introduced larvae did not escape from the test pot, a combination of screen cylinders and Teflon® coatings were used on each pot. The Teflon® coating (Phillips and Burkholder 1981), applied in a 3 cm band to the inside of the pot rim with a cotton-tipped applicator, prevented any larvae from crawling directly out of the pot; the screen cylinders (18 cm diam. x 50 or 80 cm ht.) kept all foliage directly above the pots, thereby preventing escapes via overhanging foliage.

At dusk, five larvae were introduced into each pot (i.e., 25 larvae per host treatment). Third instar larvae were used because it is this stage that typically disperses from grasses to seek out suitable thick-stemmed hosts (Giebink, pers. obs.). After the larvae had fed for 16 to 18 days, all plants were gently uprooted, placed in labeled plastic bags, refrigerated, and later examined for damage and dissected for larvae. Three larval parameters (survival, instar, and weight) were measured.

Using temperatures recorded by hygrothermographs placed at opposite ends of the study bench, centigrade degree-day accumulations (CDD's) were calculated with the sine-wave method (Allen 1976) and developmental thresholds (Giebink et al. 1985) of 4.9 (HVB) and 6.8° C (PSB). CDDs accumulated during these feeding periods were ca. 260 for HVB and 230 for PSB, or 13–16 CDDs per day, on average. Data were analyzed using SAS GLM procedures (SAS 1988).

## RESULTS AND DISCUSSION

Larvae of both species survived most successfully on corn, followed closely by hop and curly dock (Table 1). While potato plants were excellent for the PSB, HVB survival on potato plants was poor (only 4%, Table 1). Lambsquarters, common ragweed, giant ragweed and redroot pigweed were generally poor hosts for both moth species with larval survival less than 20% (Table 1). Larvae of both species initiated feeding on all plant species except lambsquarters.

HVB larvae grew very fast on hop compared to all other broad-leaved plant species tested. On hops, HVB larvae attained weights 4–5x greater than those on corn and curly dock and 10x those of surviving larvae on potato, both ragweed species, pigweed and lambsquarters (Table 1). This supports the theory that the HVB does in fact appear physiologically better adapted for survival and growth on its preferred host rather than other plants in the cornfield community.

In contrast, PSB appears to grow rapidly on several hosts (including corn, curly dock, potato and hop; Table 1). Growth rates on redroot pigweed and giant ragweed is less than that observed on the four previously mentioned hosts, but still was enough to produce pupae (although smaller) at about the same time as the best four hosts (see developmental index, Table 1).

Table 1.—A comparison of the larval growth of hop vine borer and potato stem borer larvae reared on broadleaf plants in the greenhouse.

| Grass species | % Larval survival[1] | Developmental index[2,3] | Larval weight (mg)[3] | Total no. surviving larvae |
|---|---|---|---|---|
| | | Hop Vine Borer[4] | | |
| Corn | 52.0±12.0a | 4.9±0.1ab | 82.4± 7.8 b | 13 |
| Hop | 44.0± 7.5ab | 6.4±0.2a | 465.8±75.0a | 11 |
| Curly dock | 30.0± 6.1abc | 4.7±0.3ab | 106.4±27.5 b | 15 |
| Common ragweed | 16.0± 6.5 bcd | 4.0±0.2 b | 23.8± 5.6 b | 8 |
| Redroot pigweed | 14.0± 3.0 bcd | 4.4±0.2 b | 37.5±37.5 b | 7 |
| Giant ragweed | 10.0± 3.3 cd | 4.3±0.2 b | 31.3± 5.5 b | 5 |
| Potato | 4.0± 2.7 cd | 4.5±0.5 b | 50.8±24.4 b | 2 |
| Lambsquarters | 0 d | – | – | 0 |
| | | Potato Stem Borer[4] | | |
| Corn | 56.0± 7.5a | 6.0±0.0ab | 483.2±50.5a | 14 |
| Curly dock | 40.0± 7.3a | 6.3±0.2a | 390.5±32.9ab | 20 |
| Potato | 36.0± 7.5a | 6.9±0.1a | 554.4±37.3a | 9 |
| Hop | 28.0± 4.9a | 6.6±0.2a | 392.6±14.0a | 7 |
| Redroot pigweed | 6.0± 3.0 b | 5.0±0.0 b | 128.3± 3.4 b | 3 |
| Giant ragweed | 2.0± 2.0 b | 7.0±0.0a | 168.0± 0.0 b | 1 |
| Common ragweed | 0 b | – | – | 0 |
| Lambsquarters | 0 b | – | – | 0 |

[1]Means followed by the same letter within a column are not significantly different ($P < 0.05$; Scheffe arc sine sq. rt (%/100) transformation). Values are combined overall results of both spring and fall experiments. For HVB, values are averages of 10 replications of 5 larvae each for all treatments except hops (spring only) and corn (fall only) which are averages of 5 replications: for PSB, values are averages of 10 replications of 5 larvae each for all treatments except hops, potatoes (spring only) and corn (fall only).

[2]For calculations of the developmental index, a numerical assignment was made for each stage (e.g.. 1–6 = larval instars and 7 = pupa, with molting larvae assigned the mean value of the two instars).

[3]Values are averages of the number of replications (10 or less) with surviving larvae (i.e., replications with no surviving larvae were excluded from the calculations; means followed by the same number within a column are not significantly different ($P < 0.05$; Scheffe's test).

[4]After feeding for 16–18 days on 8-week-old plants, centigrade degree day (CDD) accumulations were 260 and 230 for hop vine borer and potato stem borer, respectively. Data are presented as a mean ± SE.

The normal feeding behavior of HVB and PSB larvae is to feed initially on small-stemmed grasses, then switch to larger small-stemmed grasses or broad-leaved plants. Without these grasses the survival of larvae to the third instar would be much less successful (Hawley 1918, Giebink et al. 1984). Our study standardized the rearing conditions for the first three larvae instars in order to analyze the importance of differential suitability of the final hosts for these two stalk-boring species. It is important to realize that the early instar feeding on grasses will also vary according to their differential suitability (Giebink et al. in prep.). We still do not know if previous hosts (for early instars) differentially affect survival or growth performance on subsequent broadleaved hosts and corn.

Among other things, phenology, larval feeding behavior, and stem size are all critical determinants as to whether or not a plant species can serve as host for these *Hydraecia* spp. When HVB and PSB larvae begin feeding in late April, very few host plants are available. This temporal isolation, in itself, drastically limits the number of potential host plants. Typically, the only available hosts are early developing perennials including grasses (Giebink et al. 1984). Once feeding has been initiated on a particular plant host, feeding behavior and larval size usually dictate how long feeding on a particular plant continues. Feeding behavior of *Hydraecia* sp. larvae proceeds in two steps. Initially, larvae feed above-ground within grass stems. But by the fourth instar they outgrow these stems, with the majority feeding either within or beside stems/roots of the secondary host below the soil surface. This behavior differs considerably from other stalk borers, such as *Papaipema nebris* Guenée, which feed exclusively within the host above the soil surface and may even pupate within it (Alvarado 1985, Decker 1931).

Most primary hosts (grasses), however, have neither the stem thickness nor root mass to sustain larval development beyond the third or fourth instar. Consequently, larvae are often forced to disperse to other available hosts that have these characteristics (e.g., corn, hops, or potatoes). Such interplant movement is often, but not always, necessary; a number of perennial grass species (primarily sedges, reeds and several aquatic grasses) in marsh or swamp habitats have thick, fleshy culms, rhizomes, or underground roots capable of sustaining *H. micacea* larvae to pupation.

As with the grass hosts, the known wild broad-leaved hosts of these stalk borers are also exclusively perennials. For PSB, most of these hosts inhabit swampy or marshy areas. They include several members of the iris family and several docks (buckwheat family) as well as hops. For the stenophagous HVB hosts include *Silphium* spp., *Lupinus microcarpus* (Tietz 1972), and of course, *Humulus lupulus*. Known as rosinweed, *Silphium* spp. comprise a group of ca. 20 species of coarse perennial herbs (e.g., compass plant, cup plant, and prairie dock) native to eastern North America. *Lupinus microcarpus*, a member of the lupine family, resides in western N. America.

As frequent residents of marsh habitats, the polyphagous PSB has been reported feeding on a wide variety of these wild plants in Europe (Seppanen 1970, Zwolfer 1962) and Canada (Jobin 1963). In Wisconsin, thus far PSB has only been reported on quackgrass (*Agropyron repens*), reed canary grass (*Phalaris arundiancea*), and corn—usually adjacent to marshy, low lying habitats. However, over 200 sedge species inhabit the state (Fassett 1976) and the possibility exists that endemic PSB populations are already established on these plants.

Both HVB and PSB, particularly HVB, exhibit many characteristics associated with "K" specialists: both are univoltine; both have relatively long larval periods; both depend on relatively reliable resources (e.g., perennials or continuous corn); and the sedentary females oviposit close to the pupation site. As such, the composition of the plant community has important implications with regard to cultural controls such as crop rotation (Southwood 1977). For these reasons, and in view of our findings with broad-leaved hosts, crop rotation should be able to locally eliminate HVB and perhaps even the generalized PSB larvae from corn fields, except perhaps along field edges near swampy or marshy areas.

## ACKNOWLEDGMENTS

This research was supported by the Colleges of Agriculture of the University of Wisconsin, Madison (Hatch Project 5134) and Michigan State University (MAES Projects #16448072 and 8051), Regional Research Projects NC-180 and NC-205 and in part by the "Agroecology" LTER Project at Kellogg Biological Station (NSF-BSR-02332). We are grateful for assistance from Phil Pellitteri and Jeffrey Beehler.

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