HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

White Grub (Coleoptera: Scarabaeidae) Population Density in Relation to Root Damage to Fraser Fir Seedlings in Transplant Beds[1]

R. Chris Williamson[2]
Department of Entomology, University of Wisconsin
246 Russell Labs, 1630 Linden Drive, Madison, WI 53706

Abstract

A field experiment was conducted in 2002 to evaluate the effect of five grub densities of second instar *Phyllophaga anxia* (LeCont) Glasgow larvae on feeding damage to roots of young seedlings of Fraser fir, *Abies fraseri* (Pursh) *Poir.*, Christmas trees in a transplant bed. Larval densities were equivalent to approximately 0, 31, 62, 93, and 124 larvae per m^2 (≈ 0, 3, 6, 9, and 12 larvae per ft^2). Larval survival and variations in larval and seedling weight were also evaluated. Regardless of the larval density, when *P. anxia* grubs were present, all Fraser fir seedlings experienced significant root damage as well as subsequent plant injury (i.e., decline or mortality). Larval density as low as one grub per 0.11 m^2 (≈ 3 larvae per ft^2) caused heavy to severe root damage to young, two-year-old, P2-0 Fraser fir seedlings. An inverse relationship was observed between plant weight and root damage.

Index words: *Phyllophaga*, larval damage, threshold, Christmas tree plantation.

Species used in this study: *Abies fraseri* (Pursh) *Poir*, Fraser fir; *Phyllophaga anxia* (LeConte) Glasgow, May/June Beetle.

Significance to the Nursery Industry

The results of this research will provide Christmas tree growers with an understanding of the damage threshold of May/June beetle, *Phyllophaga anxia* (LeConte) Glasgow, grubs in Christmas tree plantation transplant beds. This information will help nursery growers in implementing appropriate insecticide control strategies of *Phyllophaga* spp. grubs.

Introduction

White grubs of the genus *Phyllophaga* are below-ground, soil-dwelling insects that feed on the roots of numerous plants including coniferous and deciduous trees, annual and perennial grasses including turf, and other vegetation including various weed species. Grub damage to conifer seedlings in nurseries can be a serious problem (6, 9), causing losses in pine nurseries of 25–40% (3). Such losses are not only monetary, but also disrupt future planting programs (7). The larvae of *Phyllophaga* spp. and related beetles can severely damage young pine plantations in the Lake States Region (2). Damage to conifers occurs when the white grubs feed on the roots by cutting or stripping the roots of the tree. Typically, the lateral and taproots are girdled or chewed off (10), often resulting in plant injury or death (1). Plant damage symptoms are similar to that of drought injury. Survival of discolored seedlings depends on the original vigor, the nature and degree of injury, and weather conditions (9). Damage is more common and most extensive in plants that are less than two years old, especially in 1–0 and 2–1 seedling plant stock (1–0 and 2–1 represent 1 and 2 yr growth in seedling beds, plus 0 and 1 yr growth in transplant beds).

Approximately 30 larvae per m^2 (≈ 3–4 grubs/ft^2) is considered to be the damage threshold in turf (13), whereas Schwardt (6) suggested that relatively small populations, as few as one grub per ft^2 are potentially very destructive. Moreover, Shenefelt et al. (8) estimated that when as few as five grubs per m^2 (< 1 grub/ft^2) are present, control measures should be implemented. Based on these assumptions, recommendations for control measures have been made for white grub population densities (5, 8, 9, 12).

A study was conducted to accurately assess the larval density threshold of second instar *Phyllophaga anxia* (LeConte) Glasgow white grubs feeding on roots of young seedlings of Fraser fir, *Abies fraseri* (Pursh) *Poir.*, Christmas trees in transplant beds. This information is critical for determining and implementing integrated pest management (IPM) control recommendations.

Materials and Methods

The study was conducted in the summer and autumn of 2002 in Shawano County in northeastern Wisconsin. The field site was a Christmas tree plantation transplant bed that consisted of a sandy loam soil with overhead irrigation. Five white grub population densities were evaluated: 0, 31, 62, 93, and 124 larvae/m^2 (0, 3, 6, 9, and 12 larvae/ft^2). The treatments were arranged in a randomized complete block design (11) with five replications of each treatment. Individual P2–0 Fraser fir, *Abies fraseri* (Pursh) *Poir*., Christmas tree seedlings were planted in individual 4-liter or 1-gal (20.3 cm dia × 15.2 cm high; 8 in dia × 6 in high) plastic ice cream containers on July 25, 2002. Transplant beds typically have seedling populations closer to six plants per square foot; however due to the constraints and objective of this study, seedling population density was approximately three plants per ft^2.

A P2–0 Fraser fir seedling is a plant plug that has two flushes of growth (equivalent to 2 years) and no time in a

[1]Received for publication December 16, 2003; in revised form February 27, 2004. I thank Dan Hanauer, Jr., Hanauer Tree Farms (Shawano, WI) for providing the research site and support of this study. I also thank Seung Cheon (Steve) Hong for his technical assistance and D. Mahr and S. Myers (University of Wisconsin) for their critical review of this manuscript. This study was supported by the University of Wisconsin-Madison College of Agricultural and Life Sciences.

[2]Assistant Professor, Department of Entomology, University of Wisconsin-Madison, 246 Russell Laboratories, 1630 Linden Drive, Madison, WI 53706. Email: rcwillie@entomology.wisc.edu.

transplant bed. The Fraser fir seedlings were obtained from Itasca Greenhouse (Cohaffet, MN); the ice cream containers from Schoep's Ice Cream Company (Madison, WI). Six 0.5 mm (0.02 in) diameter holes were made in the bottom of each plastic container to allow water drainage. Seedlings were selected for similarity of size, well-developed root system, and healthy appearance. The native sandy loam soil was collected from the transplant bed, and approximately 4850 cm^3 (≈ 296 in^3) of soil added to each plastic container. Respective containers were labeled and inserted into the soil profile of the transplant bed to a depth that allowed the top of the plastic container to extend approximately 2.5 cm (≈ 1 in) above the soil surface. Containers were equally spaced 40.6 cm (≈ 16 in) apart within each block, and blocks were 1 m (≈ 3 ft) apart.

Immediately following insertion of the containers into the soil, approximately 0.64 cm (≈ 0.25 in) of water was applied to promote seedling establishment. Thereafter, seedlings were watered every 3 to 4 d or as needed. All weed species including monocotyledons and dicotyledons were physically removed from containers on an as needed basis. The Christmas tree seedlings were allowed to acclimate for 14 d. During this acclimation period, unidentified second instar *Phyllophaga* larvae were collected from the endemic population inhabiting nearby Christmas tree fields. Once collected, larvae were returned to the laboratory for identification. A taxonomic key as described by Kriska (4), was used to accurately identify the larvae. After identification, *Phyllophaga anxia* larvae were weighed and placed into plastic containers with soil and a Fraser fir seedling on August 8, 2002. Treatments included 0, 1, 2, 3, and 4 larvae per container.

On September 26, 2002, all plastic containers were removed from the transplant bed and respective plastic containers were evaluated for grub survival, larval weight (g) and seedling weight (g). Roots were scored according to a Root Damage Index (RDI) modified from Johnston and Eaton (3) and Fowler and Wilson (2) as follows: 1 = no grub injury, 2 = up to 33% of fibrous roots destroyed by grubs, 3 = 34–66% of fibrous roots destroyed by grubs, 4 = 67–99% of fibrous roots destroyed by grubs, and 5 = 100% of fibrous roots destroyed by grubs.

Larval survival was determined by counting the number of larvae alive in each plastic container. Larvae and seedlings were weighed with an Ohaus Scout II portable balance (Florham Park, NJ).

Larval and seedling weight, and RDI were tested by 1-way ANOVA using Statixtica 6.1 (10), with means of the different larval densities compared to the treatment without any *P. anxia* larvae at an experimentwise error rate of 0.05 (11).

Results and Discussion

All treatment densities of *P. anxia* larvae caused significant root damage and subsequent lower plant weight compared to the treatment without grubs (Table 1). An inverse relation between RDI and plant weight occurred (Table 1). This result is likely due to the consumption and complete destruction of fibrous or succulent root tissue when more grubs were present.

As presumed by Shenefelt et al. (8), results confirm that merely one second instar larva has the potential to destroy the roots of a young Fraser fir seedling. Despite the fact that this study used only one plant density (i.e., approximately 3 plants per square foot), and a typical seedling density in a Christmas tree transplant bed is closer to six seedlings per square foot, when grub population densities approximate 31 grubs/m^2 (≈ 3–4 grubs/ft^2) extensive seedling damage will likely result. Subsequently, when white grub populations in transplant beds reach the aforementioned threshold, curative or corrective insecticide treatments should be applied to transplant beds to reduce seedling damage.

Table 1. Root damage index (RDI) and plant weight of Fraser fir seedlings and larval weight and survival of *Phyllophaga anxia* grubs in containers.[z]

Density of *P. anxia* larvae/m^2 (10.8 ft^2)	Post-Treatment			
	RDI	Plant wt. (g)	Larval wt. (g)	No. larvae surviving (%)
0	1.0 ± 0.0a[y]	10.9 ± 0.7a	—	—
31	4.6 ± 0.2b	5.2 ± 0.5b	10.2 ± 0.4a	5/5 (100.0)
62	4.6 ± 0.2b	4.4 ± 0.7bc	10.1 ± 0.9a	7/10 (70.0)
93	5.0 ± 0.0b	3.9 ± 0.4bc	8.9 ± 1.8b	10/15 (66.7)
124	5.0 ± 0.0b	3.1 ± 0.4c	10.5 ± 1.4a	13/20 (65.0)

[z]Plant density was 31 plants/m^2 (3/ft^2).

[y]Within columns, means followed by the same letter are not significantly different ($P < 0.05$; ANOVA; LSD). Values (except number surviving) are means ± SEM.

As the number of *P. anxia* larvae per unit area increased, larval survival decreased slightly. This was likely due to cannibalism; as food resources were depleted, larvae began preying on each other. This phenomenon is common with several species of white grubs. Furthermore, it is unlikely that other vegetation such as weeds had any effect on the damage threshold since all weed species were immediately removed throughout the duration of this study.

To confound the difficulty of managing white grubs in Christmas tree plantations, population densities of white grubs are often highly variable to sporadic (9). As a result, white grubs can be quite difficult to predict; thus very careful observations must be made when sampling grub populations (9). Due to the development and commercialization of preventative (i.e., prior to egg hatch or before grubs begin feeding) white grub insecticides such as imidacloprid (Bayer®) and thiamethoxam (Syngenta®), Christmas tree growers have an alternative white grub management strategy. Such preventive insecticides enable Christmas tree growers who experience perennial problems with white grubs to protect their nursery beds before grub populations reach the damaging threshold.

Literature Cited

1. Chamberlin , T.R., C.L. Flueke, and J.A. Callenbach. 1943. Species, distribution, flight, and host preferences of June beetles in Wisconsin. J. Econ. Entomol. 36:674–680.

2. Fowler, R.F. and L.F. Wilson. 1971. White grub populations, *Phyllophaga* spp., in relation to damaged red pine seedlings in Michigan and Wisconsin plantations. Michigan Entomol. 4:23–28.

3. Johnston, H.R. and C.B. Eaton. 1939. White grubs in forest nurseries of the Carolinas. U.S. Dept. Agric., Bur. Entomol. Plant Quaran. E–486.

4. Kriska, N.L. 2000. The Scarabaeoidea (Coleoptera) of Wisconsin: Species inventory, taxonomic keys, natural histories, and distributions. M.S. Thesis. Univ. Wisconsin, Madison. 571 pp.

5. Rudolf, P.O. 1950**.** Forest plantations in the Lake States. U.S. Dept. Agric. Tech. Bull. No. 1010. 171p.

6. Schwardt, H.H. 1942. Control of native white grubs in young hemlocks. J. Econ. Entomol. 35:176–177.

7. Shenefelt, R.D. and H.G. Simkover. 1950. White grubs in Wisconsin forest tree nurseries. J. Forestry 48:429–434.

8. Shenefelt, R.D., H.R. Liebig, and R.C. Dosen. 1954. Protecting machine planted trees from white grubs. Univ. Wisc. Forest Res. Notes 17. 3 p.

9. Speers, C.F. and D.C. Schmiege. 1961. White grubs in forest tree nurseries and plantations. U.S. Dept. Agric. Forest Serv., Forest. Pest Leafl. 63:1–4.

10. StatSoft, Inc. 2003. Statistica 6.1. Data Analysis, Data Mining, and Quality Control. StatSoft, Tulsa, OK.

11. Steel, R.G.D. and J.H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill, N.Y.

12. Stone, E.L. and H.H. Schwardt. 1943. White grub injury to plantations in New York. J. Forestry 41:842–844.

13. Vittum, P.J., M.G. Villani, and H. Tashirio. 1999. Turfgrass Insects of the United States and Canada. Second Edition. Cornell Univ. Press, Ithaca, N.Y.