White Grub Populations, Phyllophaga Spp., in Relation to Damaged Red Pine Seedlings in Michigan and Wisconsin Plantations (Coleoptera: Scarabaeidae)

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WHITE GRUB POPULATIONS, PHYLLOPHAGA SPP., IN RELATION TO DAMAGED RED PINE SEEDLINGS IN MICHIGAN AND WISCONSIN PLANTATIONS (COLEOPTERA: SCARABAEIDAE)

Richard F. Fowler and Louis F. Wilson[1]

INTRODUCTION

White grubs (Coleoptera, Scarabaeidae), the larvae of May and related beetles, are destructive pests in some young pine plantations in the Lake States Region. They live in the soil and feed on roots of trees and other vegetation. Larvae chew off the smaller and girdle the larger roots of pine seedlings, and consequently reduce growth, weaken, and kill the seedlings.

Recommendations against planting or for control measures have been made for grub population densities ranging from 4.4/ft.^{2}, 2.0/ft.^{3}, 2.0/ft.^{2}, down to 0.5 grubs/ft.^{2} of soil surface (Stone and Schwardt, 1943; Rudolf, 1950; Speers and Schmiege, 1961; Shenefelt *et al.*, 1954).

A study was carried out to accurately assess or predict grub-caused mortality and damage to seedlings from a given grub population density. This information is necessary for making control recommendations.

METHODS AND MATERIALS

White grub populations and the degree of root damage on red pine seedlings were studied in 16 recent plantations located on the Hiawatha National Forest, Michigan, and Chequamegon and Nicolet National Forests, Wisconsin. Four of these plantations were established in the spring of 1967 and eight in the spring of 1968. The white grub population estimates were made in the summer, and root damage estimates in the fall of 1968.

White grub populations were sampled with a cubic metal frame, 12 inches on a side, driven into the ground to facilitate removal of a 1 ft.^{3} soil sample. The soil inside the frame was removed and sifted through a 1/4 inch hardware-cloth screen to retrieve the grubs. In each of 12 plantations, four samples per line were taken at regular intervals along four parallel lines across the plantation. The four other plantations were sampled more intensively. There thirty soil samples were taken along five parallel lines within a 4-acre block.

Root damage was determined by excavating red pine seedlings from the vicinity of the soil sample holes. In 12 plantations, 20 seedlings were dug near each of the 16 soil sample holes (320 seedlings/plantation). In each of the four other plantations, 90 seedlings were dug from five 4-acre plots (450 seedlings/plantation). Roots of living as well as dying and recently dead seedlings were scored for feeding injury according to a Damage Index modified from Johnston and Eaton (1939) as follows:

Score 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; also included seedlings completely stripped of fibrous roots but which had grown some new root tips.
5 - 100% of fibrous roots destroyed or tap root severed above all fibrous roots.

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An average Damage Index was computed for each plantation. A DI of 1.00 means there was no injury and a DI of 5.00 means all seedlings were destroyed.

Six genera, *Phyllophaga, Serica, Diplotaxis, Dichelonyx, Aphodius,* and *Geotrupes,* were identified from larvae in the plantations on 12 ranger districts. Adults are needed for species identifications (Böving 1937). *Phyllophaga* accounted for 56% of all grubs, *Serica* 31%, and other genera 13%.

Phyllophaga spp. includes some of the largest and most destructive white grubs, but not all species are equally damaging. Graham (1958) reports 78%, 48%, and 3% red pine seedlings killed by three separate species of *Phyllophaga.* The members of this genus have a 3-5 year life cycle in the Lake States.

Serica spp. are smaller than *Phyllophaga* and less important in pine plantations (Craighead 1950, Graham 1958, Ives and Warren, 1965). Graham (1958) reported 13% and 18% of his seedlings killed by these grubs which have a 2-3 year life cycle.

Diplotaxis spp., and *Dichelonyx* spp., both with small larvae and 2-3 year life cycles, are uncommon in Lake States plantations, but have caused some injury (Craighead 1950, Graham 1958). *Aphodius* spp. and *Geotrupes* spp are dung feeders, although some *Aphodius* spp. may feed on living roots.

Regression analyses were run to see if Damage Index and percentage of trees damaged were related to white grub population levels. The relationship between Damage Index and percentage of trees damaged was also examined.

RESULTS

The Damage Index was found to be related to 1) mean numbers of *Phyllophaga* per $ft.^3$; 2) mean numbers of *Phyllophaga* and *Serica* per $ft.^3$; and 3) mean numbers of white grubs of all genera per $ft.^3$. The addition of numbers of grubs in genera other than *Phyllophaga* to the grub count did not improve the precision of making damage estimates. Thus, in the plantations used in this study, data of *Phyllophaga* alone were sufficient to make damage predictions (Fig. 1). This was true even though the count of *Serica* grubs far exceeded *Phyllophaga* in one instance.

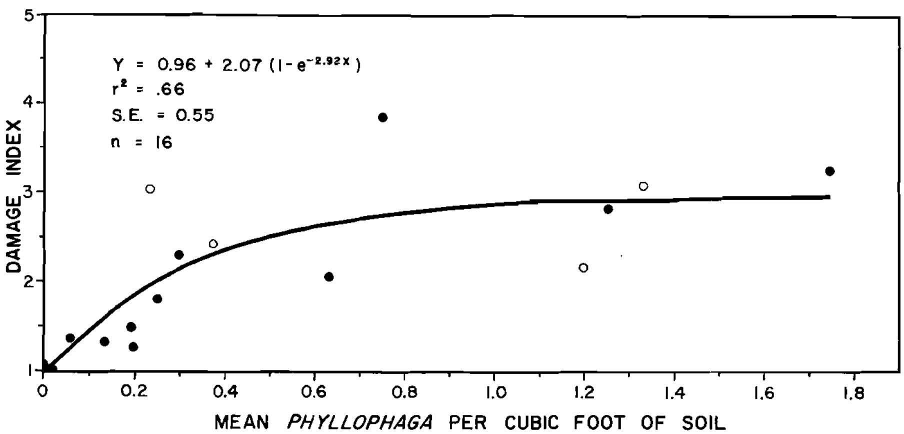

Fig. 1. Relationship between mean number of *Phyllophaga* larvae per cubic foot of soil and degree of damage to red pine seedlines. White discs are 1967 plantings, black discs 1968.

In order to improve the relationship between Damage Index and the *Phyllophaga* population, larval size should be considered because large larvae eat more than small ones. Head capsule widths were therefore measured and plotted in a frequency histogram to separate grubs by instars. The following Feeding Index was formulated to adjust for larval size: $FI=[N_1 + 2N_2 + 4N_3 + 8N_4]/n$ where N_1, N_2, etc., are the numbers of larvae in instars 1, 2, etc., and n is the mean number of larvae collected per plantation. We assumed that the amount of feeding damage doubled for each instar. Hence the factors 1, 2, 4, 8, based on observations of sawflies by Wilson (1966). A closer relationship between the Damage Index and the *Phyllophaga* population resulted (Fig. 2).

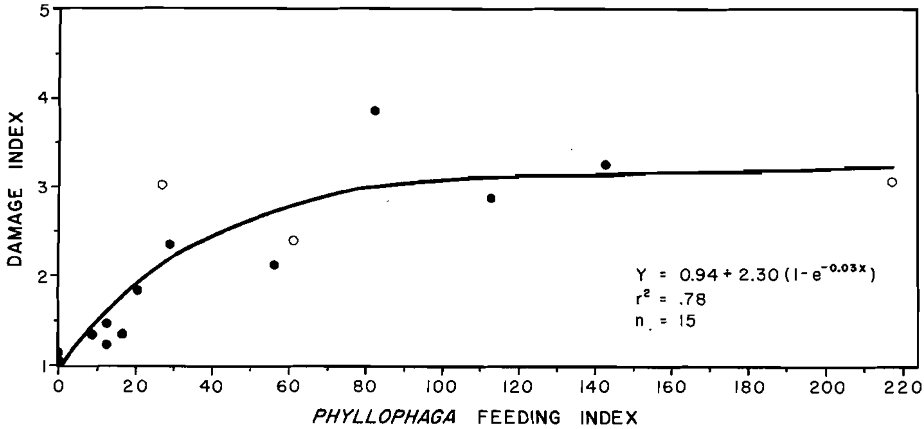

Fig. 2. Relationship between mean number of *Phyllophaga* larvae per cubic foot of soil adjusted for larval size (feeding index) and degree of damage to red pine seedlings. White discs are 1967 plantings, black discs 1968.

A similar relationship exists between percentage of trees damaged by grubs and mean number of *Phyllophaga* (Fig. 3). This relationship likewise improves when larval size (as a feeding index) is included (Fig. 4).

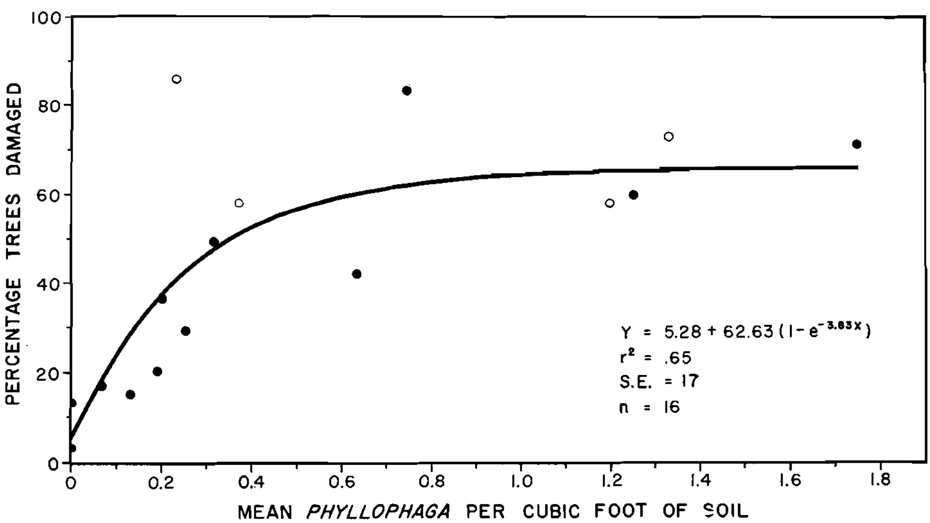

Fig. 3. Relationship between mean number of *Phyllophaga* larvae per cubic foot of soil and percentage red pine seedlings damaged. White discs are 1967 plantings, black discs 1968.

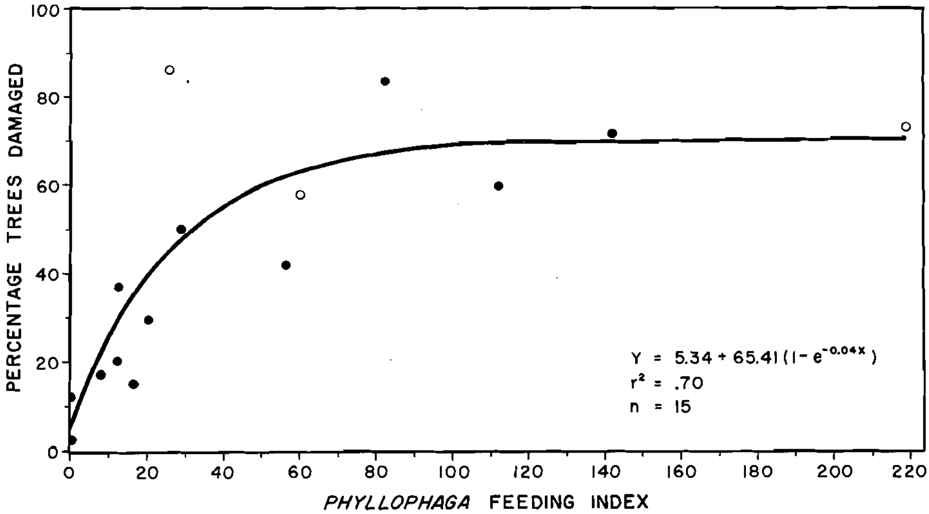

Fig. 4. Relationship between mean number of *Phyllophaga* larvae per cubic foot of soil adjusted for larvae size (feeding index) and percentage red pine seedlings damaged. White discs are 1967 plantings, black discs 1968.

The regression line of Damage Index over percentages of trees examined appears to give a good estimate of the Damage Index when more than 10% and less than 90% of the seedlings are damaged (Fig. 5). This relationship is useful in certain types of surveys where seedlings can be dug but time does not permit root scoring.

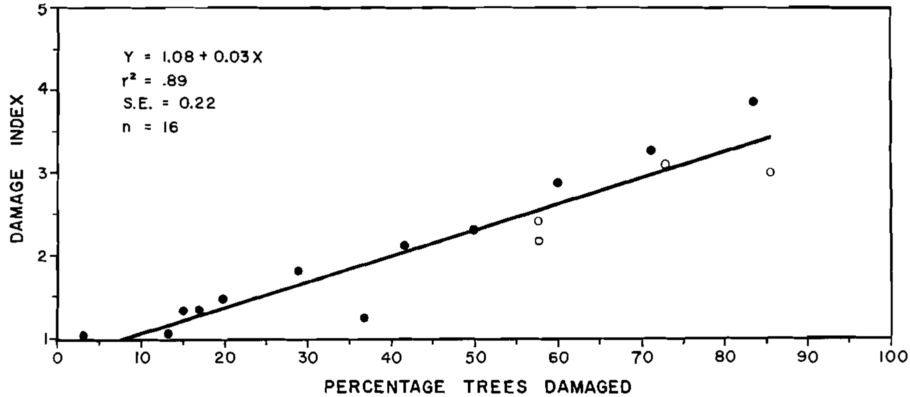

Fig. 5. Relationship between degree of larval *Phyllophaga* damage and percentage of red pine seedlings damaged. White discs are 1967 plantings, black discs 1968.

DISCUSSION AND CONCLUSIONS

The results indicate that a reasonable seedling damage estimate from *Phyllophaga* grubs can be made before planting or in a freshly planted stand. After estimating the larval population from a survey, the damage can be estimated from Figures 1-4. Percentage of trees damaged can also be used to arrive at a Damage Index from Figure 5 when *Phyllophaga* injury is suspected.

The most serious result of grub feeding is seedling mortality which may extend beyond the fourth growing season. From the data collected, a reasonable estimate of seedling mortality into the second growing season can be made. If we assume nonsurvival of seedlings scored 4 and 5 (67-100% root-killed) by the second growing season that appeared alive during the first season in addition to the actual first year mortality from all agents, a graph can be constructed showing minimum (score 5) and maximum (score 4 and 5) predicted mortality for various grub populations (Fig. 6). A plantation with 0.5 grubs/ft.^{3} would lose between 16 and 34% of its seedlings by the second growing season after planting, including non-grub mortality estimated to be about 4% by that time.

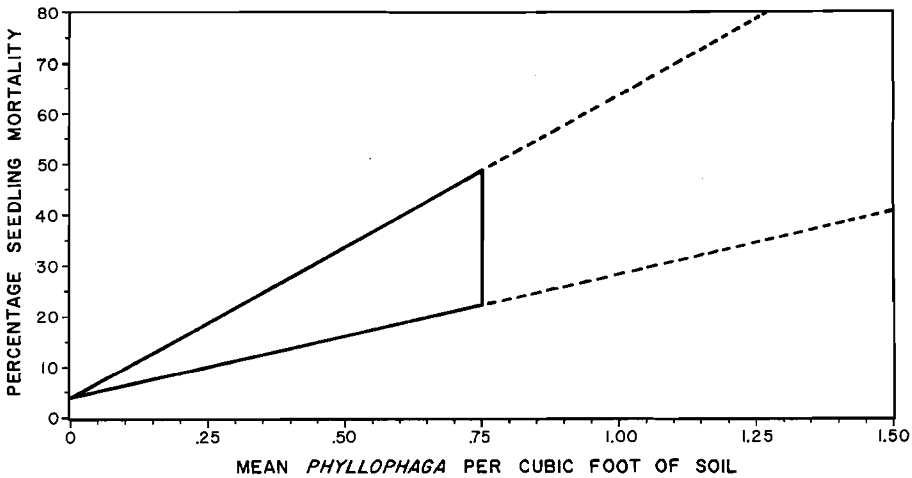

Fig. 6. Estimated mortality (within triangle) of red pine seedlings from *Phyllophaga* feeding one year after planting including initial 4% mortality from other agents.

Several authors have suggested that a population of 0.5 grubs (per ft.^{2} or ft.^{3}) or more is a "damaging" population. Second season mortality predictions suggest that control should be considered at levels lower than 0.5 grubs, especially since mortality in third and fourth years could substantially increase that presently predicted. A reasonable grub population level for which control would always be necessary cannot be given until actual third and fourth year mortality has been determined, but it would most likely be less than 0.25 grubs/ft.^{2} if the maximum acceptable seedling mortality were 20%.

ACKNOWLEDGEMENT

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LITERATURE CITED

Böving, A. G. 1937. Keys to the larvae of 4 groups and 43 species of the genus *Phyllophaga.* USDA Bur. Entomol., Plant Quar. E-417. 9 p.

Craighead, F. C. 1950. Insect enemies of eastern forests. U.S. Dep. Agr. Misc. Publ. 657. 679 p.

Graham, S. A. 1958. Problems caused by insects in the Lake States. 10th Int. Congr. Entomol. 1956 Proc. 4: 261-274.

Ives, W. G. H. and G. L. Warren. 1965. Sequential sampling for white grubs. Can. Entomol. 97: 596-604.

Johnston, H. R. and C. B. Eaton. 1939. White grubs in forest nurseries of the Carolinas. U.S. Dep. Agr. Bur. Entomol., Plant Quar. E-486. 9 p.

Rudolf, P. O. 1950. Forest plantations in the Lake States. U.S. Dep. Agr. Tech. Bull. 1010. 171 p.

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

Speers, C. F. and D. C. Schmiege. 1961. White grubs in forest tree nurseries and plantations. U.S. Dep. Agr. Forest Pest Leafl. 63. 4 p.

Stone E. L., Jr. and H. H. Schwardt. 1943. White grub injury to young plantations in New York. J. Forest. 41: 842-844.

Wilson, L. F. 1966. Effects of different population levels of the European pine sawfly on young Scotch pine trees. J. Econ. Entomol. 59: 1043-1049.

ANNUAL VARIATION IN STARTING DATE OF SPRING FEEDING BY THE EUROPEAN PINE SHOOT MOTH IN A MICHIGAN PLANTING

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ABSTRACT

New tents spun in five successive springs by the European pine shoot moth (*Rhyacionia buoliana* [Schiff.]) in a Michigan planting of red pine (*Pinus resinosa* Ait.) occurred about 2 days later each year. This trend is believed due to habitat cooling as trees grow larger. In another planting feeding was more advanced on small trees than on large trees.

INTRODUCTION

Feeding in buds and elongating shoots, the European pine shoot moth (*Rhyacionia buoliana* (Schiff.)) disrupts the growth of young pines. It can be suppressed with contact poisons in the spring or summer at earliest signs of feeding. After wintering in or near injured buds, partly grown larvae turn to fresh buds in April. Before boring in, each larva spins a silken, tentlike anteroom. Tents are soon coated with resin and other debris. This makes them conspicuous and useful for accurately timing suppression treatments (Miller 1967). Pointing (1963) has described early spring larval activity in detail.

A study was done to learn more about how starting date of spring feeding varies from year to year. Few starting dates have been reported. In northeastern Ohio, three observations ranged from April 13 to 20 (Miller and Neiswander 1955). These were based on casual checks in a different pine planting each year. In southern Michigan, more rigorous studies yielded two starting dates: April 14 (Graham and Williams 1958) and April 17 (Haynes and Butcher 1962). Apparently, starting dates have not been reported for more than one year in the same planting.

A 5-year record of incipient tent spinning was made in a red pine (*Pinus resinosa* Ait.) planting near East Lansing, Michigan. Later, an observation in a different red pine planting tested whether starting date varied with tree size. In brief, results show that incipient spring feeding occurred later each year. It also appeared earlier on small trees than on larger ones.