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This publication includes lecture notes of papers presented at the 2001 New Jersey Turfgrass Expo. Publication of these lectures provides a readily available source of information covering a wide range of topics and includes technical and popular presentations of importance to the turfgrass industry.

This proceedings also includes research papers that contain original research findings and reviews of selected subjects in turfgrass science. These papers are presented primarily to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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Dr. Ann Brooks Gould, Editor
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TURFGRASS INSECT CONTROL: CHOICES AND TIMING FOR LAWN AND LANDSCAPE TURF

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WHITE GRUBS

White grubs, the root-feeding larvae of scarab beetles, are important pests of turfgrass, pastures, and many crops throughout the world. At least 10 species cause significant damage to turfgrasses in the United States. In the northeastern United States, a complex of primarily introduced white grub species comprises the major turfgrass insect pests. Among these, the Japanese beetle, *Popillia japonica*, has until recently been regarded as the key species, but other white grub species are becoming more important. These other species include the oriental beetle (*Exomala* (=*Anomala*) *orientalis*), the European chafer (*Rhizotrogus majalis*), and the Asiatic garden beetle (*Maladera castanea*).

Surveys have indicated that the oriental beetle has become the most important white grub species in New Jersey and some neighboring areas. Thus, the average white grub species composition in New Jersey home lawns in the fall of 2001 (5 counties, 61 sites, in primarily the central part of the state) was 63% oriental beetle, 14% Asiatic garden beetle, 9% masked chafers, 8% Japanese beetle, 4% May/June beetle (*Phyllophaga* spp.), and 2% green June beetle (Koppenhöfer et al., *unpublished data*). However, species composition can vary considerably among sites. Because these species can vary significantly in susceptibility to different control agents, proper species identification can be critical. The safest way to identify white grub species in the larval stage is to examine the raster pattern just in front of the anal slit on the grub's underside. Identification is the easiest when the grubs are big, fat, and sassy 3rd instar larvae, but at this point, the damage is often already done or impending. Therefore, identification should be done when grub populations are being monitored to determine whether curative treatments are necessary (i.e., in mid-August).

Although the general life cycle of the important white grub species is very similar, the egg-laying period (major target for preventive treatments) and accordingly the occurrence of the voracious 3rd larval stage can vary by a few weeks between species; another reason for obtaining knowledge about the prevalent species in a turf site. Adult beetles emerge between June and August, mate, and the females return into the soil to lay eggs (total of about 20 to 60) in several batches over a period of 2 to 4 weeks. The egg, 1st larval, and 2nd larval stages each last about 3 weeks so that through September most of the grubs will molt to the 3rd and last larval stage. The voracious feeding of these large grubs, when combined with host and dry conditions, can result in quick and extensive loss of turf from late August through mid-October. As the soil temperatures cool down, the grubs move to deeper soil layers to stay below the frost line. During this time most species are more or less inactive. As the soil temperatures warm up in spring, the grubs come up to the root zone to feed for another 4 to 6 weeks in April and May before they pupate in the soil. Spring applications against white grubs are often ineffective because of the large size of the larvae and the cool soil temperatures. In addition, cool-season grasses can generally outgrow the grub feeding in spring.

Special control considerations by white grub species

The egg-laying period of the oriental beetle (Table 1) is between late June and late July. Most of the grubs molt into the 3rd stage during September. Effective curative control agents are Dylox and Diazinon.

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Dylox kills more quickly than Diazinon and may be more effective later in the year and in spring. Merit and MACH2 persist for long periods in the soil and are applied as preventives. MACH2 has a shorter persistence than Merit and should not be applied before June. However, the oriental beetle is not very susceptible to MACH2 (average control rate has been below 70%) and should be applied as close to the egg laying period as possible for maximum efficacy.

The egg-laying period of the Japanese beetle (Table 2) is between early July and mid-August. Most of the grubs molt into the 3rd stage during September. Dylox is similarly effective against Japanese beetle as against oriental beetle but Diazinon is not effective. However, unlike many other white grub species Japanese beetle grubs can be effectively controlled with the insect-parasitic nematode *Heterorhabditis bacteriophora*. Merit is similarly effective against Japanese beetle as against oriental beetle. The Japanese beetle is among the most MACH2 susceptible white grub species and this product can be applied very effectively from June through mid-August. Japanese beetle is also the only species against which the commercially available 'milky spore' powder can provide slow acting but long term suppression.

The egg-laying period of masked chafers (Table 3) (the common species in New Jersey is the northern masked chafer) is earlier and more concentrated than for most other white grub species, i.e., from mid-June to mid-July. Accordingly, most of the larvae molt into the 3rd stage earlier, i.e., from mid-August to early September and serious damage may occur earlier if this species dominates. Effective curatives are Dylox and Diazinon. Masked chafer grubs can also be controlled with *H. bacteriophora*, although not as effectively as Japanese beetle grubs. Masked chafers are less susceptible to Merit than oriental and Japanese beetle and the product should be applied as close to the egg-laying period as possible and at the highest allowed label rate. MACH2 is highly effective against masked chafers.

The egg-laying period of the Asiatic garden beetle (Table 4) is from July to mid-August and most of the larvae will molt to the 3rd stage during September and early October. Observations on susceptibility of this species are very limited. Dylox and Diazinon should provide control of this species. However, both preventives, Merit and MACH2, are ineffective even with optimal timing.

HAIRY CHINCHBUG

The hairy chinch bug (Table 5), *Blissus leucopterus hirtus*, is an important pest of cool-season grasses and zoysiagrass in the Northeast. Damage is caused by both the nymphs and the adults that suck juices from stems and crowns and inject saliva that clogs up the plants conductive tissues. Damage is most common during hot and dry periods in July to August and on sunny thatchy lawns. If the grass is in summer dormancy during this period, the damage often goes unnoticed until the grass does not recover after a good rain or irrigation. The hairy chinch bug has two generations per year. The overwintered adults become active in April and start laying eggs. The nymphs develop through 5 stages before the final molt into the adult stage in June to July. These adults lay eggs from early July through August and the next adult generation appears from early August through September.

The best way to control chinch bugs is through curative spot treatments in June if monitoring has detected potentially damaging population levels. Any labeled pyrethroid or Diazinon or Sevin can be applied. Preventive applications of the same insecticides in spring before the overwintered females start laying eggs should only be done if high chinch bug populations are detected at that time and if the areas have a history of chinch bug infestations. These preventive applications are often wasted because natural enemies such as big-eyed bugs and the insect-pathogenic fungus *Beauveria bassiana* often suppress chinch bug outbreaks. In addition, the preventive application will effectively 'control' those very natural enemies and also can encourage insecticide resistance. Rather, areas with perennial chinch bug problems should be overseeded with endophyte-enhanced grasses that are resistant to chinch bugs.

BILLBUGS

Billbugs (Table 6), *Sphenophorus* species, are among the most misdiagnosed turfgrass pests, their damage often being confused with symptoms of drought stress, diseases such as dollar spot or brown patch, or injury from green bugs or white grubs. Damage is done by larval feeding, inside the stem by the young smaller larvae, and later through external feeding on crowns, roots, or rhizomes by the mature larvae. Damage starts with scattered dead stems of a whitish-straw color that later grow together into patches of dead turf. The dead stems break off at the crown and are hollowed out or filled with sawdust-like material or frass. Damage is most common in mid- to late summer, especially during extended dry periods. Until recently it was assumed that the bluegrass billbug, *Sphenophorus parvulus*, was the only billbug causing damage in the Northeast, but recent studies at Rutgers have indicated that other species including the hunting billbug (*S. venatus vestitus*), the small billbug (*S. minimus*), and the uneven billbug (*S. inequalis*) may be similarly important.

Billbugs have one generation per year. The bluegrass billbug overwinters in the adult stage. The adults become active again in late April to mid-May when they can be seen dispersing from their overwintering quarters over sidewalks or similar exposed surfaces to turf areas. Females will lay up 200 eggs each in May through early July inside grass stems. The eggs hatch in about 6 days. As the growing larvae become too big to stay inside the stems, larvae become abundant in the soil from early July to early August. After pupation in the soil, the emerging next generation of adults is abundant in late summer and fall before seeking out overwintering quarters. The seasonal distribution of the other billbug species in New Jersey is not well understood but is probably similar. However, the presence of larvae is likely to be more extended over the growing season than if only the bluegrass billbug were present, making optimal timing of control measures more difficult.

The best time for curative treatments is when the larvae are starting to move from the stems into the soil around mid-June. Diazinon, Sevin, and the insect-parasitic nematodes *Steinernema carpocapsae* or *H. bacteriophora* are effective at this time. In high-risk areas where high adult numbers were observed migrating in spring or areas with perennial infestation, larvae can be controlled preventively with applications of Merit or MACH2 from late April into June. Alternatively, preventive treatments of any labeled pyrethroid or Diazinon can be applied in spring before the adults start laying eggs. The optimal timing for adult treatments can be pinpointed through monitoring with pit-fall traps.

SOD WEBWORMS

More than 20 species of sod webworm (Table 7) can cause damage to turf in the USA with typically two or three species having the potential to cause damage in a given area. Common species in New Jersey include the bluegrass sod webworm, *Parapediasia teterrella*, and the larger sod webworm, *Pediasia trisecta*. Damage is caused by the larvae that feed at night from silken tunnels woven in the thatch or surface soil and chew off leaves and stems just above the crown. Damage begins as general thinning, followed by patches of brown, closely cropped grass. Weak or drought stressed grass may die due to sun exposure of crowns.

Sod webworms have two or three generations per year. They overwinter as partially grown larvae in the soil or thatch and resume feeding in spring, typically pupating in May to June in the soil. The females drop several hundred eggs on the wing into the turf that hatch in about 7 days. Larval development through six to eight larval stages takes 4 to 7 weeks. Sod webworms can be treated curatively on an as needed base using the insect parasitic nematodes *S. carpocapsae* and *H. bacteriophora*, the biorationals MACH2 and Conserve, or Diazinon, Dylox, Sevin, and Address/Orthene.

ARMYWORMS

Although quite spectacular when they occur, armyworm (Table 8) outbreaks are very rare in the Northeast because the armyworms do not overwinter well and have to immigrate as moths every year from more southern latitudes by hitchhiking on large storm systems. In addition, armyworms generally prefer small grain, corn, or pastures to turfgrasses as hosts. The larvae feed in large groups and mow the grass down to the crown. With adequate irrigation, fertilization, and patience, the grass will generally recover well. Armyworms cannot be controlled preventively, but once detected, they are easy to control. If they are already large, any labeled pyrethroid, Sevin, Diazinon, or Address/Orthene should be used to quickly kill them. If they are detected while still small, they can also be controlled with the slower acting control agents such as the nematode *S. carpocapsae* or the biorationals Conserve, Bt-products, or MACH2.

MULTIPLE TARGETS

Because of their long persistence, the preventives Merit and MACH2 can be used to control more than one insect pest in a given growing season (Tables 9 and 10). However, keep in mind that while more than one insect pest usually can be found in a given turfgrass area, rarely does more than one of them cause damage in 1 year in the same location. Tables 9 and 10 show for Merit and MACH2, respectively, how the windows of application to control different insect pest overlap for each of the two products. If the turfgrass manager has reason to believe that more than one insect pest has the potential to cause problems in a given area, the application time should be chosen to optimize the control of all targets. If, however, generally only one pest causes regular and significant damage, the turfgrass manager should carefully weigh the benefits of potentially controlling more than the major target versus compromising optimal control of the major pest problem.

Table 1. Seasonal distribution of oriental beetle life-stages, occurrence of damage, and timing and choices of insecticides.[1]

Pest	Stage	April	May	June	July	Aug.	Sept.	Oct.
Oriental beetle	Pupa							
	Adult							
	Egg							
	Larva (L1-3)							
Damage	**(L2) L3**							
Insecticide	**Type / Target**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**
Dylox	Curative / L2-3							
Diazinon	Curative / L2-3							
Merit	Preventive / E-L2							
MACH2	Preventive / E-L2							

[1] High abundance of life stage, high risk of damage, and optimal timing of insecticide application.

Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

Table 2. Seasonal distribution of Japanese beetle life-stages, occurrence of damage, and timing and choices of insecticides.[1]

Pest	Stage	April	May	June	July	Aug.	Sept.	Oct.
Japanese beetle	Pupa	□□□□	□□□▒	■■■■	□□□□	□□□□	□□□□	□□□□
	Adult	□□□□	□□□□	□□□▒	■■■■	■▒□□	□□□□	□□□□
	Egg	□□□□	□□□□	□□□□	□▒■■	■■▒□	□□□□	□□□□
	Larva (L1-3)	■■■■	■■■■	▒□□□	□□□□	▒■■■	■■■■	■■■■
Damage	**(L2) L3**	□□▒▒	▒▒▒▒	□□□□	□□□□	□□▒▒	■■■■	■■▒▒
Insecticide	**Type / Target**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**
Dylox	Curative / L2-3	□□▒▒	▒▒▒▒	□□□□	□□□□	□■■■	■■■▒	▒▒□□
H. bacteriophora	Curative / L2-3	□□□□	□□□□	□□□□	□□□□	□■■■	■■■■	▒▒▒□
Merit	Preventive / E-L2	□□□▒	▒▒■■	■■■■	■■■■	■■▒▒	□□□□	□□□□
MACH2	Preventive / E-L2	□□□□	□□□□	▒▒■■	■■■■	■■▒▒	▒□□□	□□□□

[1] ■ High abundance of life stage, high risk of damage, and optimal timing of insecticide application.
▒ Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

Table 3. Seasonal distribution of masked chafer life-stages, occurrence of damage, and timing and choices of insecticides.[1]

Pest	Stage	April	May	June	July	Aug.	Sept.	Oct.
Masked chafers	Pupa							
	Adult							
	Egg							
	Larva (L1-3)							
Damage	**(L2) L3**							
Insecticide	**Type / Target**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**
Dylox	Curative / L2-3							
Diazinon	Curative / L2-3							
H. bacteriophora	Curative / L2-3							
Merit	Preventive / E-L2							
MACH2	Preventive / E-L2							

[1] High abundance of life stage, high risk of damage, and optimal timing of insecticide application.

Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

Table 4. Seasonal distribution of Asiatic garden beetle life-stages, occurrence of damage, and timing and choices of insecticides.[1]

Pest	Stage	April				May				June				July				Aug.				Sept.				Oct.			
Asiatic garden beetle	Pupa						░	▓	▓	▓	▓	░																	
	Adult											▓	▓	▓	▓	▓	░	░	░										
	Egg												░	▓	▓	▓	▓	▓	▓	░									
	Larva (L1-3)	▓	▓	▓	▓	▓	▓	░	░						░	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
Damage	**(L2) L3**			░	░	░	░	░												░	░	▓	▓	▓	▓	▓	▓	░	░
Insecticide	**Type / Target**	**April**				**May**				**June**				**July**				**Aug.**				**Sept.**				**Oct.**			
Dylox	Curative / L2-3			░	░	░	░	░											▓	▓	▓	▓	▓	▓	░	░	░		
Diazinon	Curative / L2-3																		▓	▓	▓	▓	▓	░	░	░			

[1] ▓ High abundance of life stage, high risk of damage, and optimal timing of insecticide application.

░ Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

Table 5. Seasonal distribution of hairy chinch bug life-stages, occurrence of damage, and timing and choices of insecticides.[1]

Pest	Stage	April	May	June	July	Aug.	Sept.	Oct.
Hairy chinch bug	Pupa							
	Nymph (N1-5)							
	Adult							
Damage	**N3-A**							
Insecticide	**Type / Target**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**
Pyrethroids	Preventive / A							
Diazinon / Sevin	Preventive / A							
Pyrethroids	Curative / N1-A							
Diazinon / Sevin	Curative / N1-A							

[1] (dark shading) High abundance of life stage, high risk of damage, and optimal timing of insecticide application.

(light shading) Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

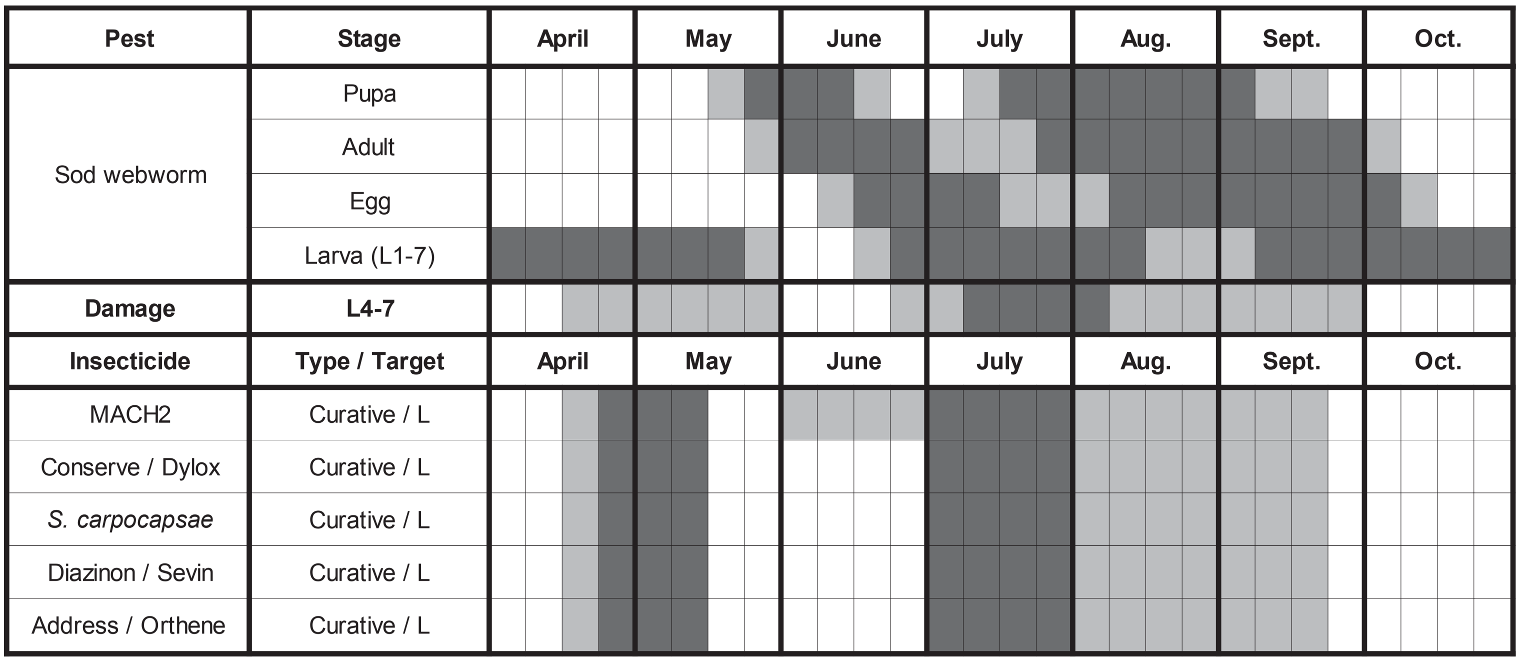
Table 6. Seasonal distribution of bluegrass billbug life-stages, occurrence of damage, and timing and choices of insecticides.[1]

Pest	Stage	April	May	June	July	Aug.	Sept.	Oct.
Bluegrass billbug	Pupa	□□□□	□□□□	□□▒■	■■■■	■■▒▒	▒▒▒▒	▒□□□
	Adult	■■■■	■■■■	■▒▒▒	▒▒▒■	■■■■	■■■■	■■■■
	Egg	□□□□	▒▒■■	■■■▒	▒▒□□	□□□□	□□□□	□□□□
	Larva	□□□□	□□▒▒	▒■■■	■■■■	■▒▒▒	▒▒▒□	□□□□
Damage	**L**	□□□□	□□□□	□□□▒	▒■■■	■■▒□	□□□□	□□□□
Insecticide	**Type / Target**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**
S. carpocapsae	Curative / L	□□□□	□□□▒	■■■■	▒▒▒□	□□□□	□□□□	□□□□
H. bacteriophora	Curative / L	□□□□	□□□▒	■■■■	▒▒▒□	□□□□	□□□□	□□□□
Diazinon / Sevin	Curative / L	□□□□	□□□▒	■■■■	▒▒▒□	□□□□	□□□□	□□□□
Pyrethroids	Preventive / A	□▒■■	■■▒□	□□□□	□□□□	□□□□	□□□□	□□□□
Diazinon	Preventive / A	□▒■■	■■▒□	□□□□	□□□□	□□□□	□□□□	□□□□
Merit	Preventive / L	□□□■	■■■■	▒▒□□	□□□□	□□□□	□□□□	□□□□
MACH2	Preventive / L	□□□■	■■■■	■■▒▒	▒□□□	□□□□	□□□□	□□□□

[1] ■ High abundance of life stage, high risk of damage, and optimal timing of insecticide application.

▒ Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

Table 7. Seasonal distribution of sod webworm life-stages, occurrence of damage, and timing and choices of insecticides.[1]



[1] (dark shading) High abundance of life stage, high risk of damage, and optimal timing of insecticide application.
(light shading) Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

Table 8. Seasonal distribution of common armyworm life-stages, occurrence of damage, and timing and choices of insecticides.[1]

Pest	Stage	April	May	June	July	Aug.	Sept.	Oct.
Common armyworm	Pupa							
	Adult							
	Egg							
	Larva (L1-8)							
Damage	**L4-8**							
Insecticide	**Type / Target**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**
Conserve	Curative / L							
MACH2	Curative / L							
S. carpocapsae	Curative / L							
Address / Orthene	Curative / L							
Diazinon	Curative / L							

[1] (dark shading) High abundance of life stage, high risk of damage, and optimal timing of insecticide application.

(light shading) Low abundance of life stage, low risk of damage, and sub-optimal timing of insecticide application.

Table 9. Overlap of windows for application of Merit against important turfgrass insect pests.[1]

Insecticide	Pest	April	May	June	July	Aug.	Sept.	Oct.
Merit	Oriental beetle							
Merit	Japanese beetle							
Merit	Masked chafer							
Merit	Bluegrass billbug							

[1] Optimal timing of insecticide application.
Sub-optimal timing of insecticide application.

Table 10. Overlap of windows for application of MACH2 against important turfgrass insect pests.[1]

Insecticide	Pest	April	May	June	July	Aug.	Sept.	Oct.
MACH2	Oriental beetle							
MACH2	Japanese beetle							
MACH2	Masked chafer							
MACH2	Bluegrass billbug							
MACH2	Sod webworm							

[1] Optimal timing of insecticide application.
Sub-optimal timing of insecticide application.