RUTGERS
New Jersey Agricultural Experiment Station

Managing Turfgrass Insects of the Northeast

Part 1.: IPM and Management Options

(updated 3/14/2022)

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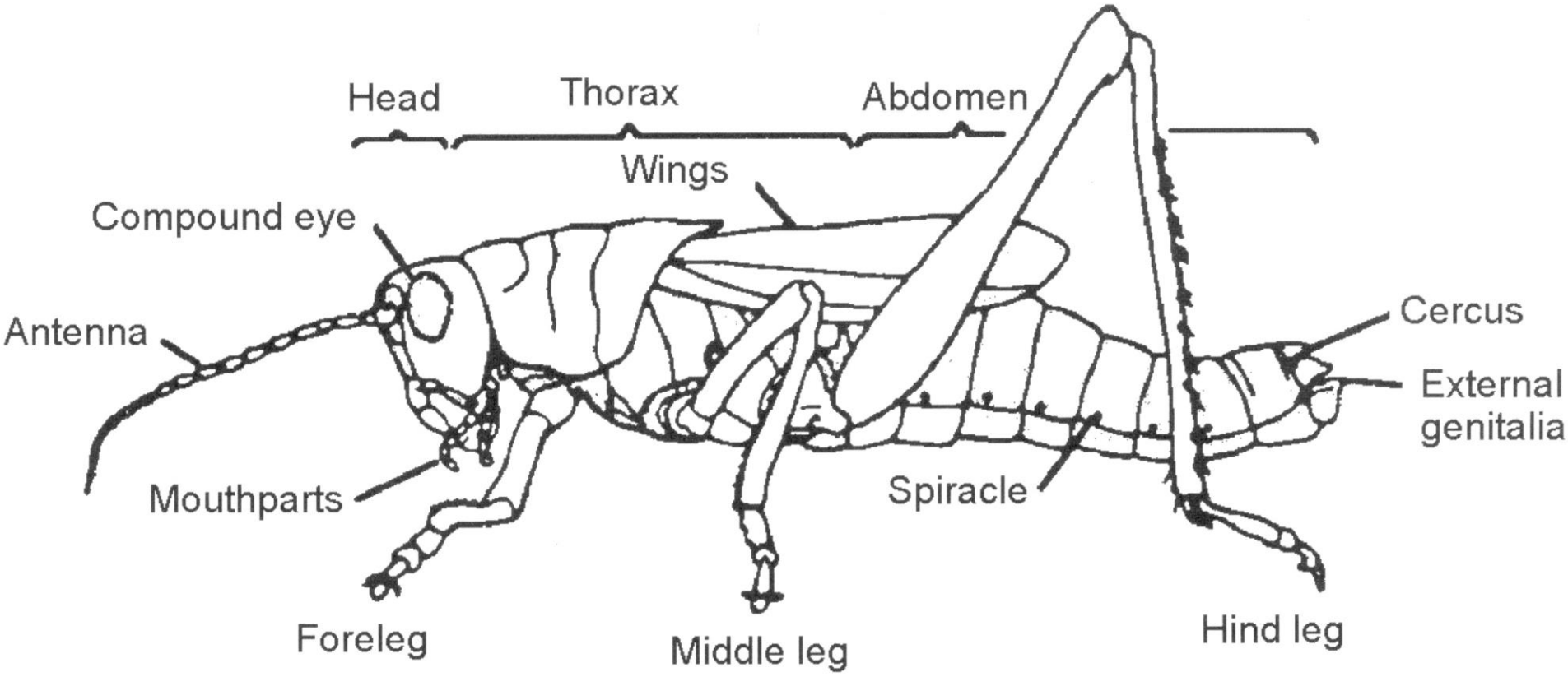
New Jersey Agricultural Experiment Station

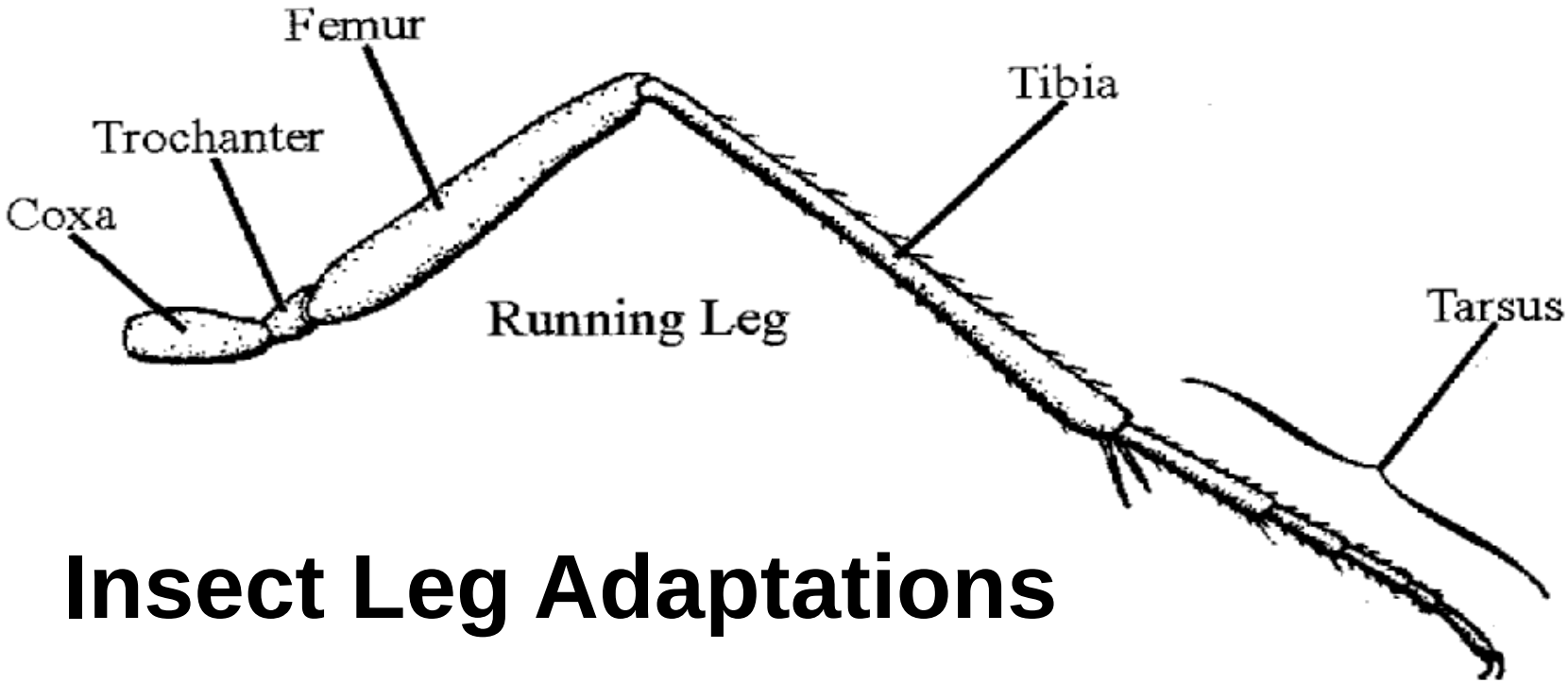
Outline

- **INTRODUCTION TO INSECTS (3-7)**
- **TURF INSECT PEST MANAGEMENT (8-45)**
  - **Overview of IPM (9-18)**
  - **Detection and monitoring (19-36)**
  - **Management options (37-45)**
- **TURFGRASS INSECTICIDES (46-83)**
- **BENEFICIAL INSECTS & INSECT PATHOGENS (84-109)**
- **BIORATIONAL, ORGANIC, MINIMUM RISK INSECTICIDES (110-115)**

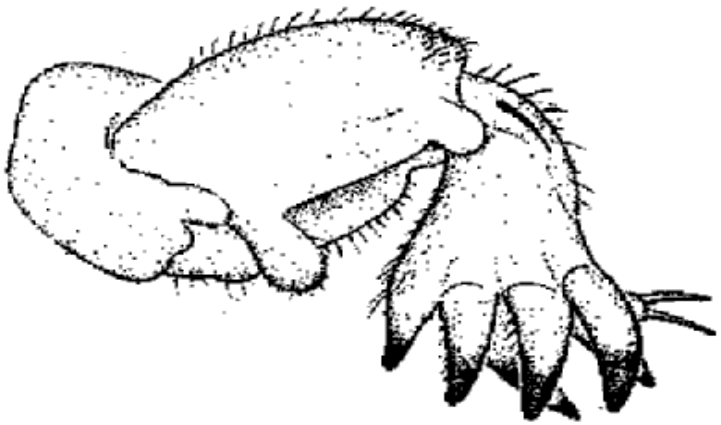
Insect General Body Plan



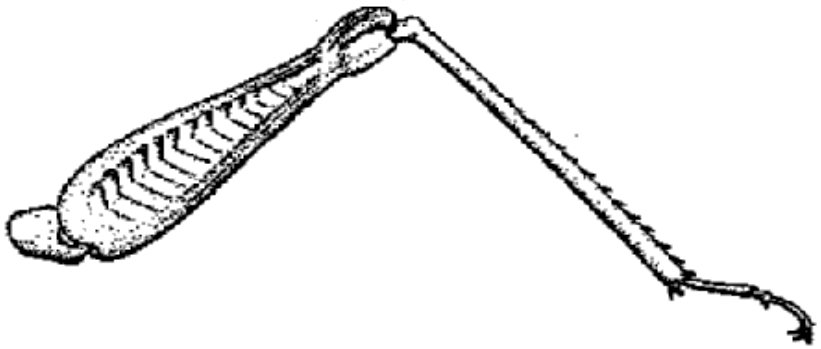
from Potter 1998



Insect Leg Adaptations



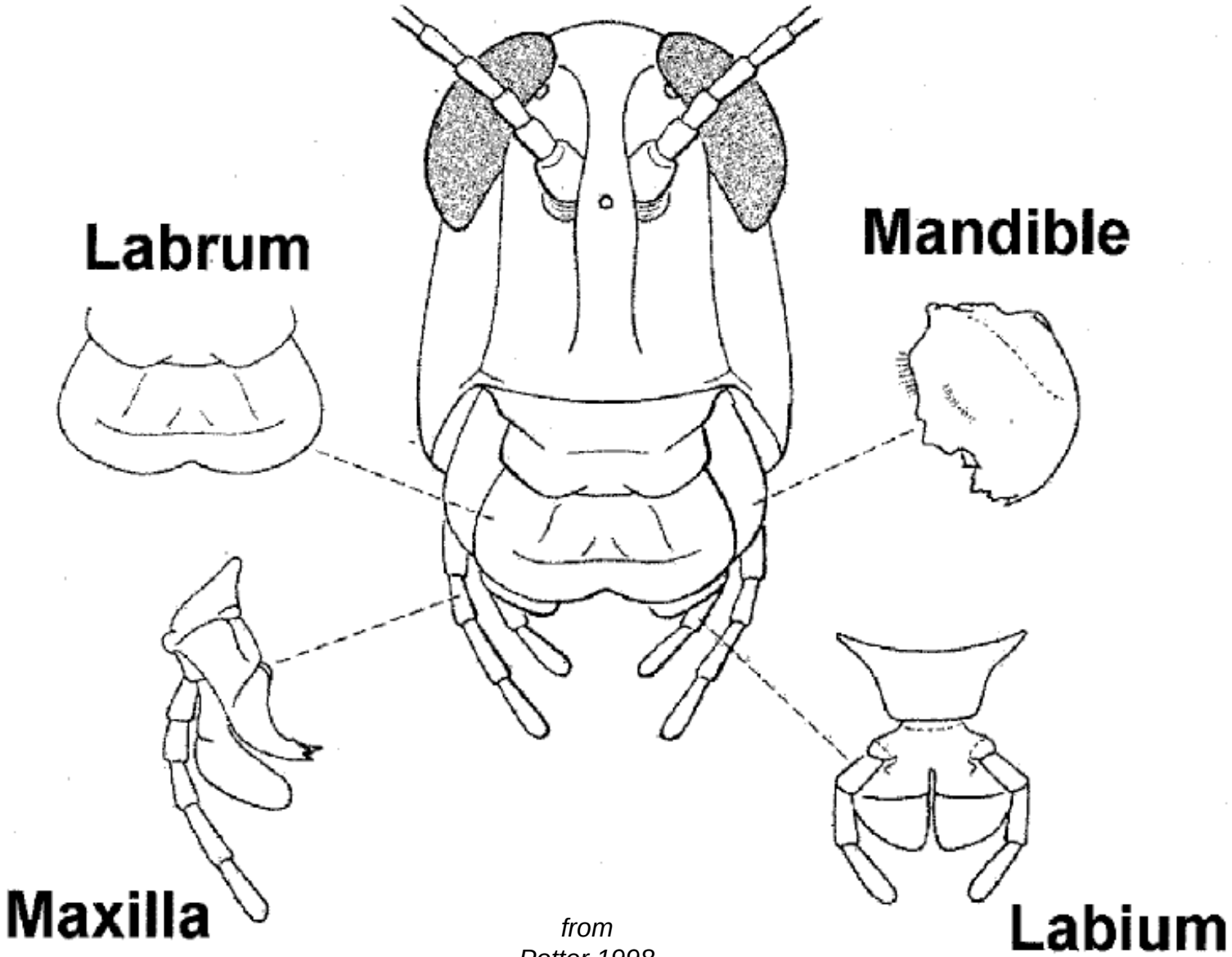
Digging Leg



Jumping Leg

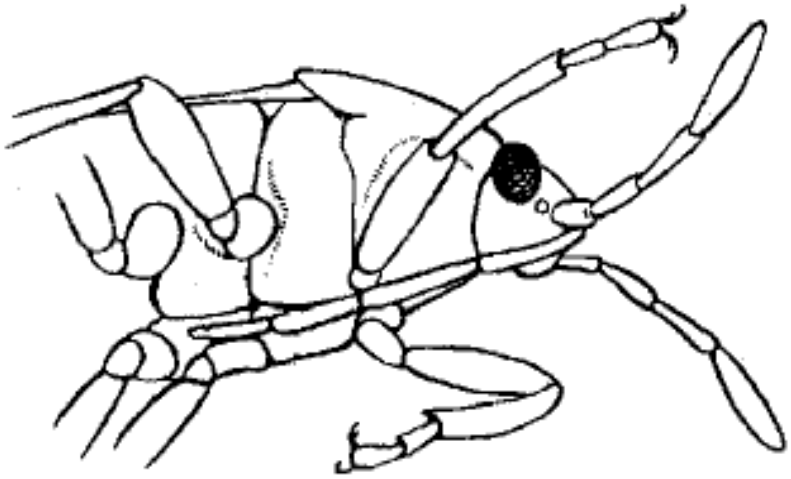
from
Potter 1998

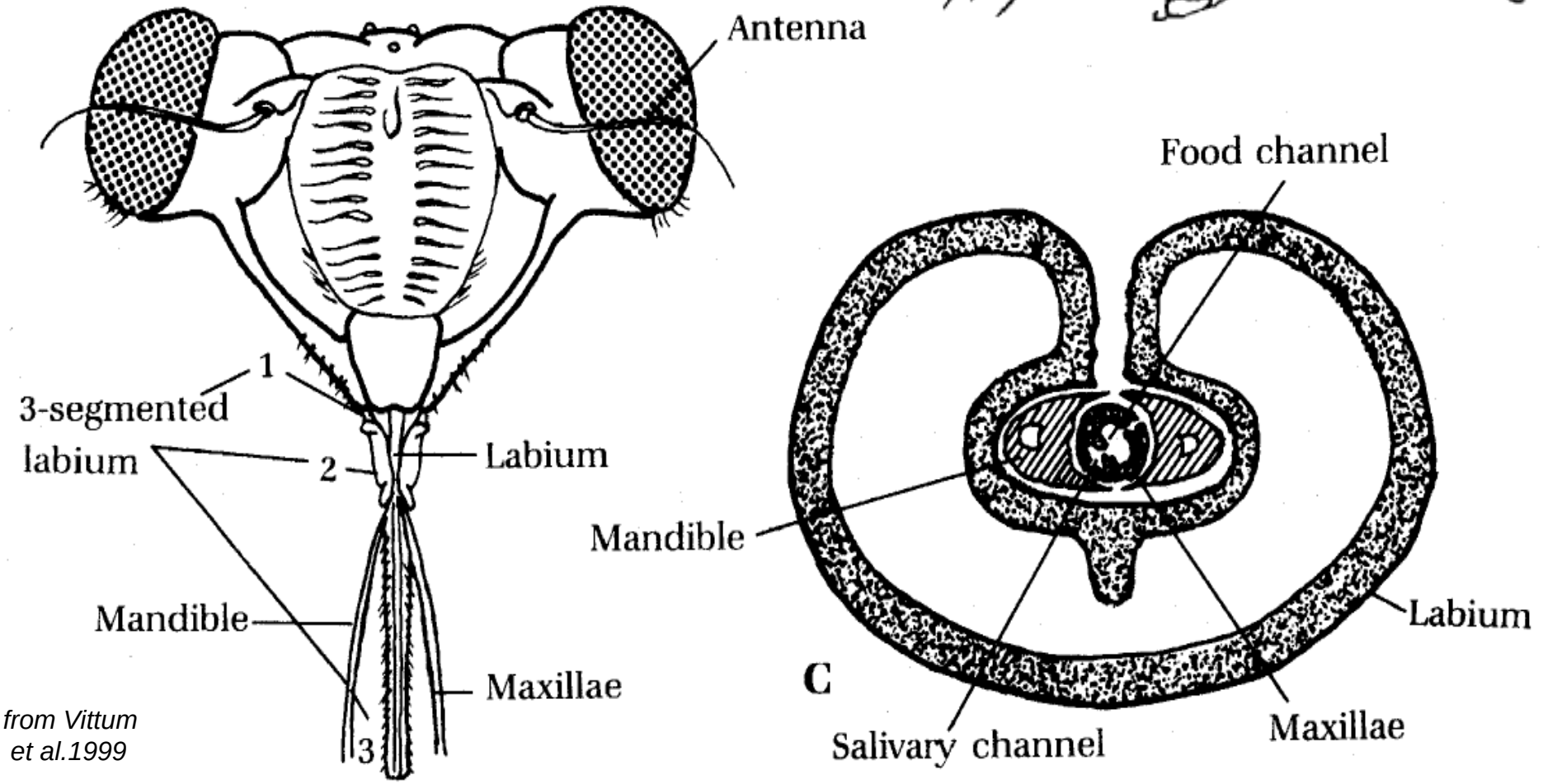
Insect Mouthpart – Chewing Type



from
Potter 1998

Insect Mouthpart - Sucking Type



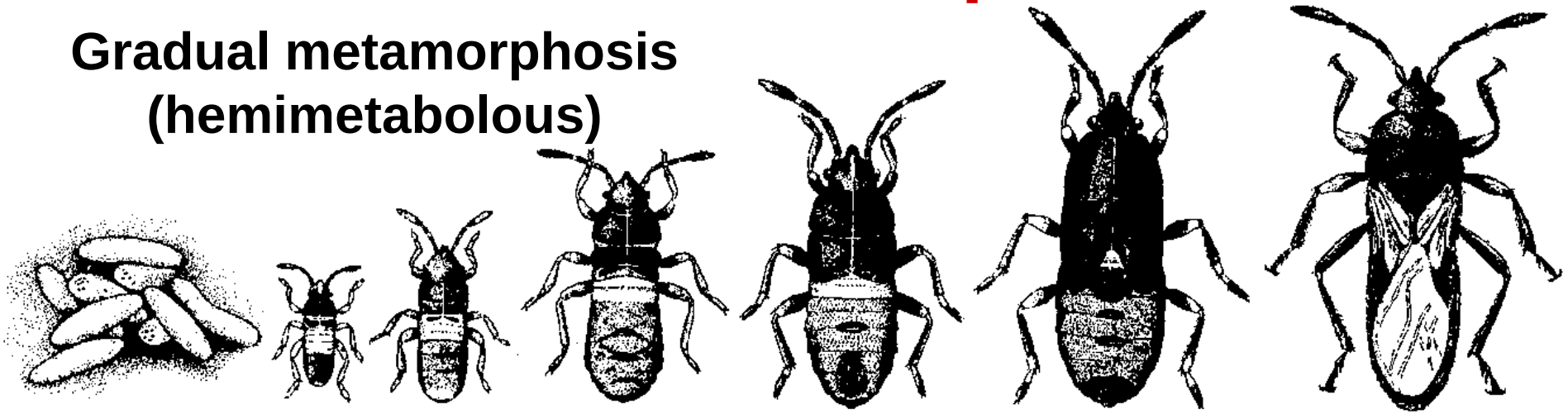


from Vittum et al.1999

Insect Development

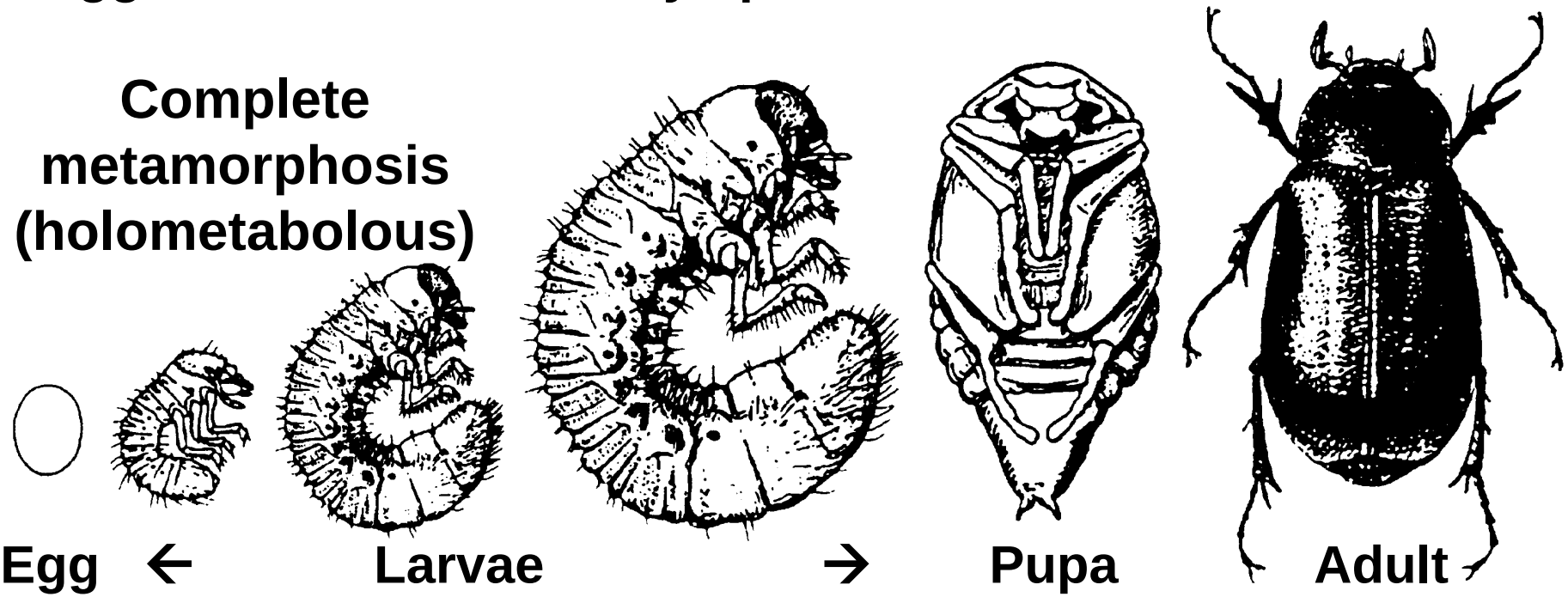
from USDA

Gradual metamorphosis (hemimetabolous)



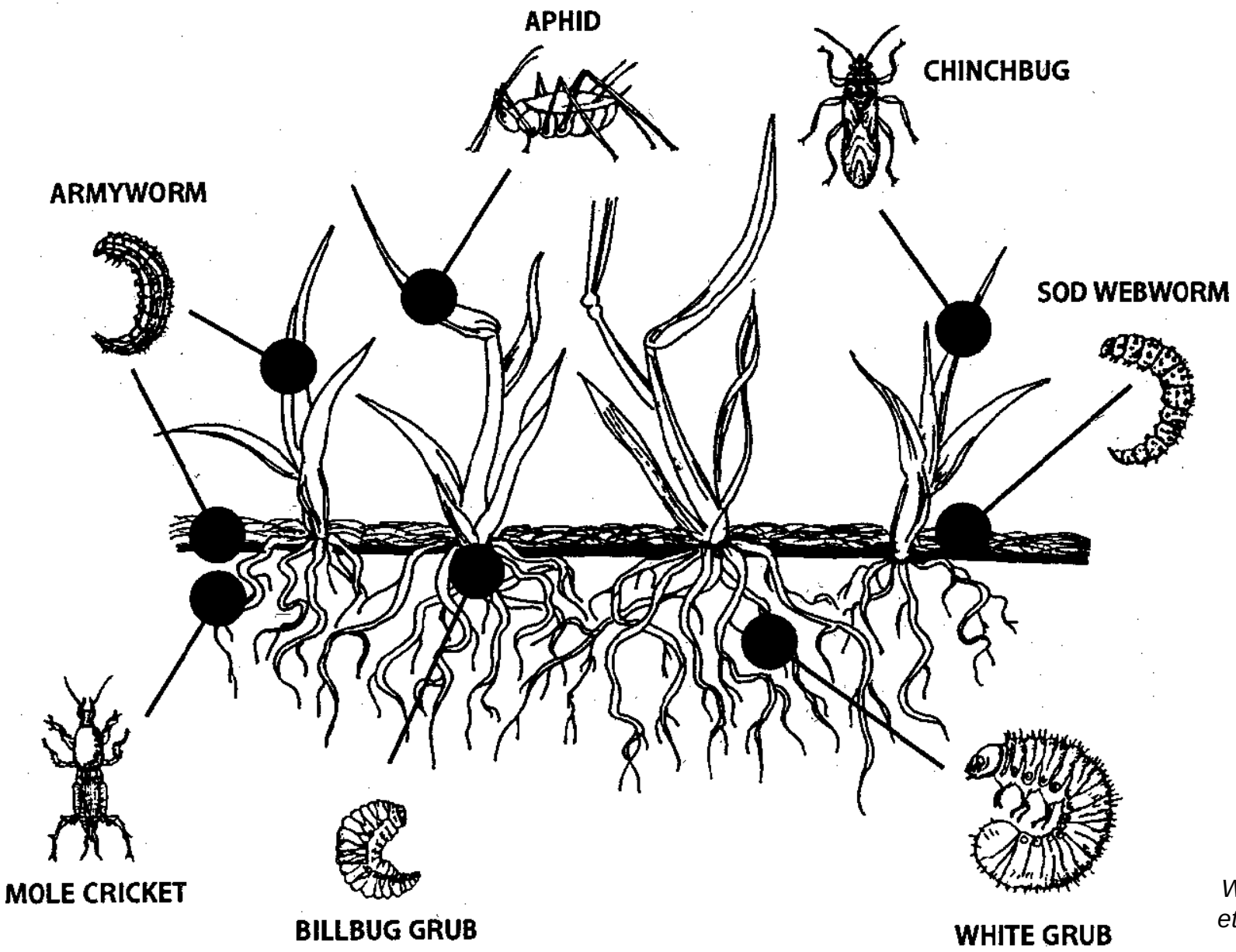
Egg ← Nymphs → Adult

Complete metamorphosis (holometabolous)



Egg ← Larvae → Pupa Adult

TURF INSECT PEST MANAGEMENT



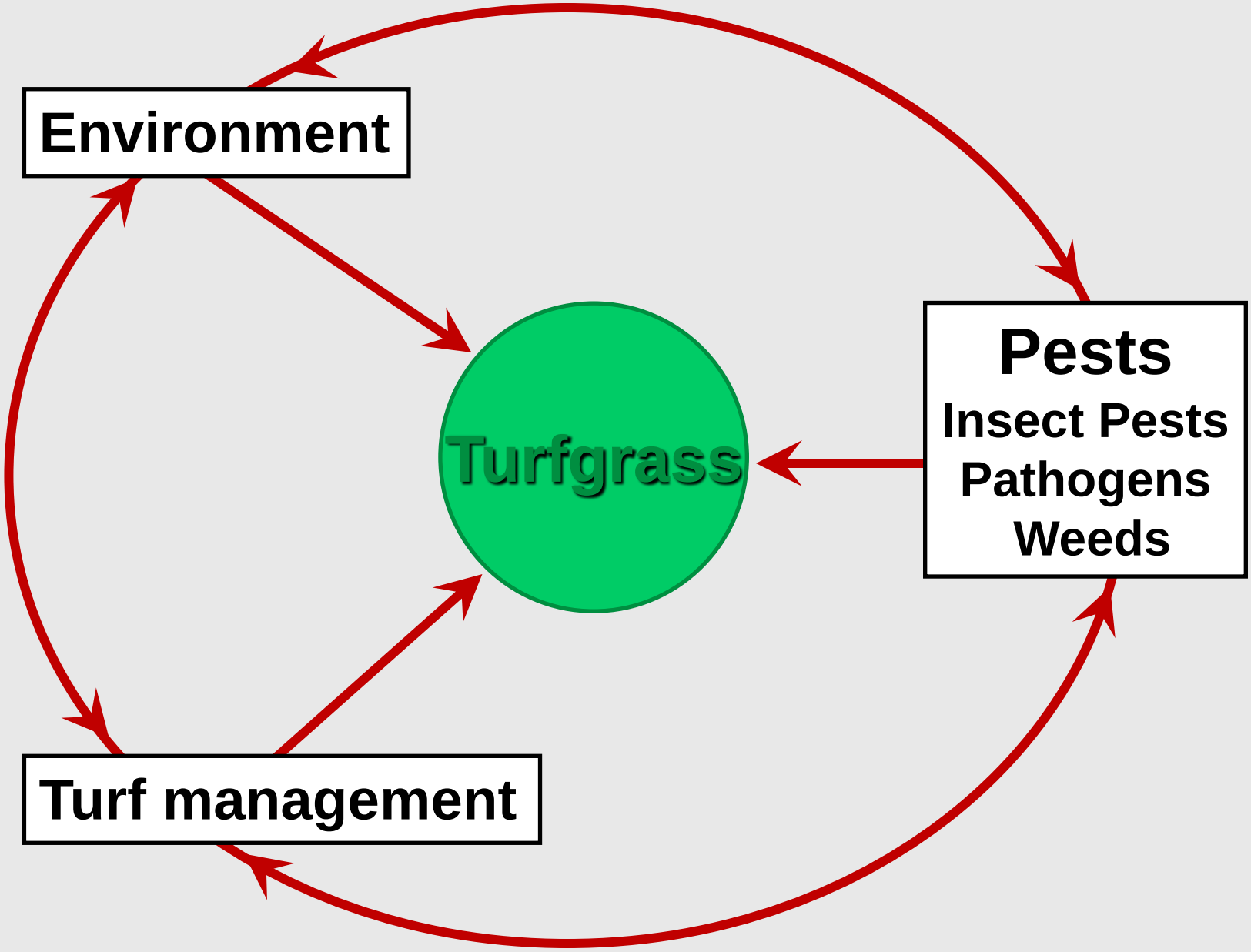
from Watschke et al. 1994

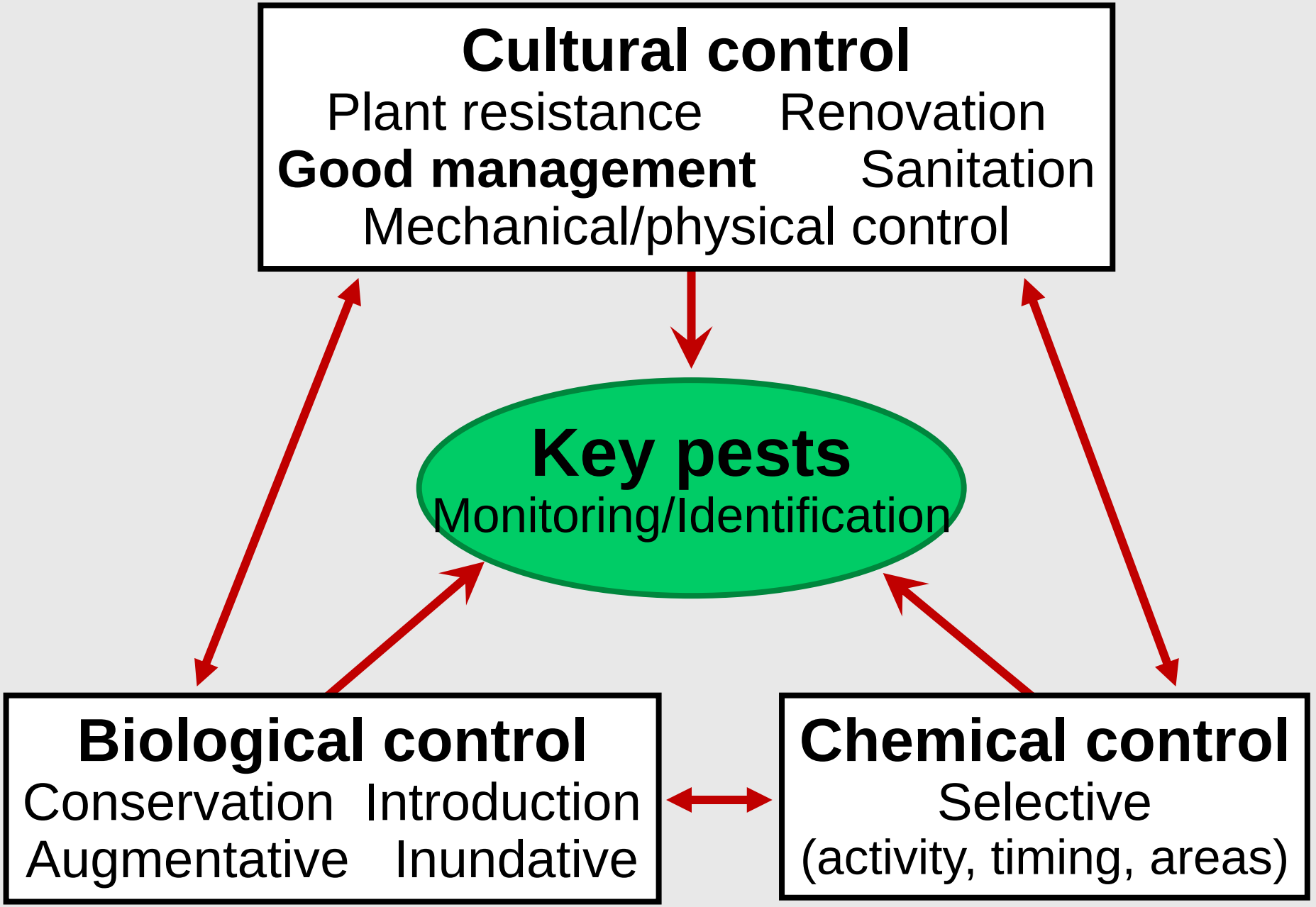
INTEGRATED PEST MANAGEMENT

IPM is the considered and coordinated use of pest control tactics in turf management.

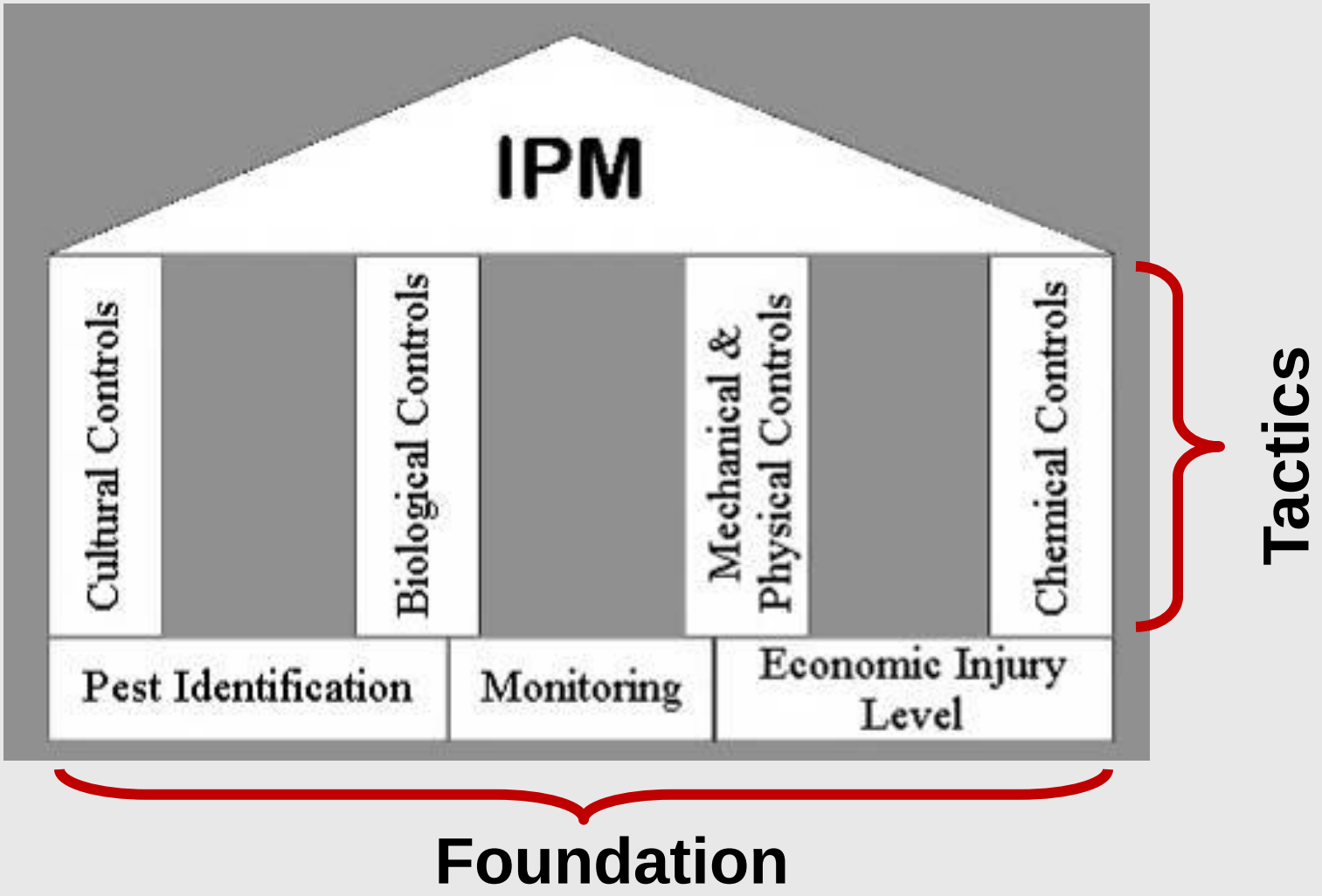
The goal of IPM is to maintain healthy, functional turf in an economically viable and environmentally sound manner.

IPM is a decision making and management system.


Environment
Turfgrass
Pests
Insect Pests
Pathogens
Weeds
Turf management


Cultural control
Plant resistance
Renovation
Good management
Sanitation
Mechanical/physical control
Key pests
Monitoring/Identification
Biological control
Conservation
Introduction
Augmentative
Inundative
Chemical control
Selective
(activity, timing, areas)

Structure of an IPM Program



Record Keeping

- Records are the memory of the IPM program.
- Record should show “What, Where, When, and Who.”

Identifying the Target Pest

- Correct ID *extremely* important.
- You cannot manage a pest without knowing it.
- Gather information about pest(s) including life cycle, habits, natural enemies.

Setting Injury Levels

- Develop tolerance levels involving representatives of interest groups.
- Determine injury levels.
- Determine action levels.
- Evaluate levels.

Injury level – pest density or amount of pest- related damage that can be tolerated without suffering an unacceptable medical, economic, or aesthetic loss.

Action level - pests density or amount of pest-related damage that triggers a treatment to prevent pest numbers from reaching the injury level.

Determine Injury Levels

- Injury levels vary with pest and location.
- Adapt available injury levels to system.

→ Correlate injury and pest density through monitoring.

→ Evaluate levels periodically.

Evaluation

- Consider the whole system
- Was pest adequately suppressed?
- … suppressed in timely manner?
- Was planned procedure used?
- What damage was produced?
- Natural enemies affected?
- Any treatment side effects?
- Treatment cost effective?

DETECTION & MONITORING

Monitoring is the regular and ongoing inspection of areas where pest problems do or might occur.

Before starting a monitoring program…

- Develop background on local pests.
- Map turf areas noting grass species, maintenance history, current practices, soil type.
- Divide site into pest management units (PMU).
- Prepare monitoring forms for each PMU.

Why Monitor?

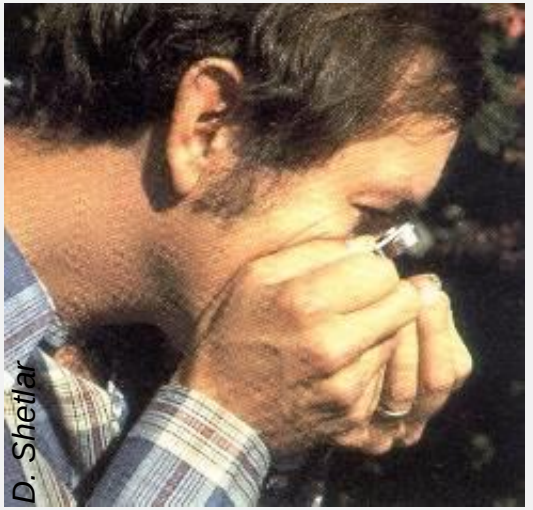
- Anticipate conditions that can trigger pest problems
- Determine if treatment needed
- Determine where, when, and what kind of treatments needed
- Evaluate and fine-tune treatments

What to Monitor

- Condition of plants
- Kind and abundance of pests and natural enemies
- Amount of plant damage
- Weather conditions
- Human behaviors affecting plants and pests
- Management activities

Visual Inspection

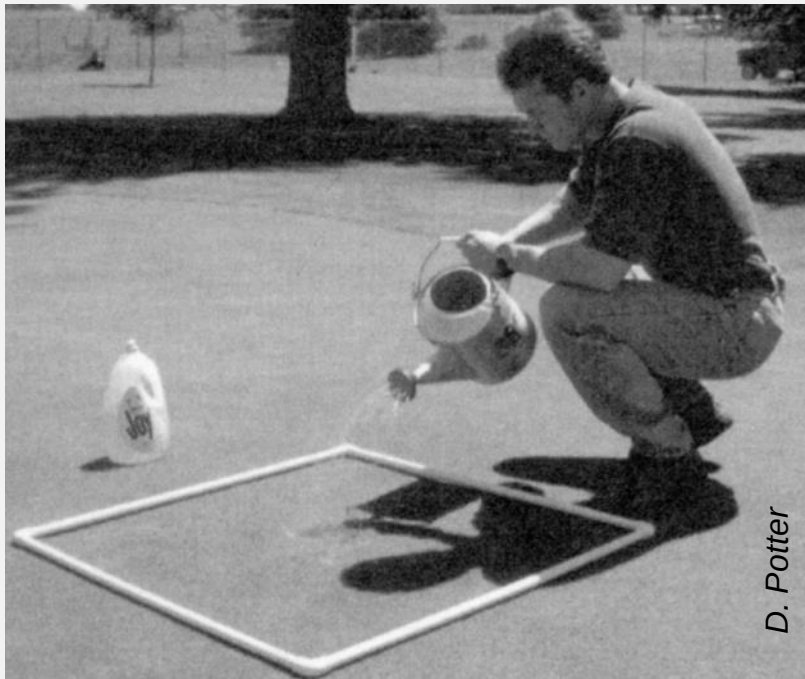
- Scan for signs of infection.
- “hands-and-knees method”).
- Use hand lens.
- Check boundary between healthy and damaged areas.
- Check for signs of insect activity.
- Observe adult pest activity.
- Observe vertebrate predator activity.



Disclosing (Irritant) Solution

Sod web/cut/armyworms, billbug adults, mole crickets (best on short grass and warm, moist soil)

- 2 gal water + 1 oz liquid dish-washing detergent (preferably lemon-scented) or 2 drops of pyrethroid
- Apply over 1 yd^2 → insect emerge in 5-10 min (small sod webworms up to 20 min)
- Count / ID emerging pests
- Irrigate
- Sample every 14-21 days
- Evaluate treatments 3-4 days after application

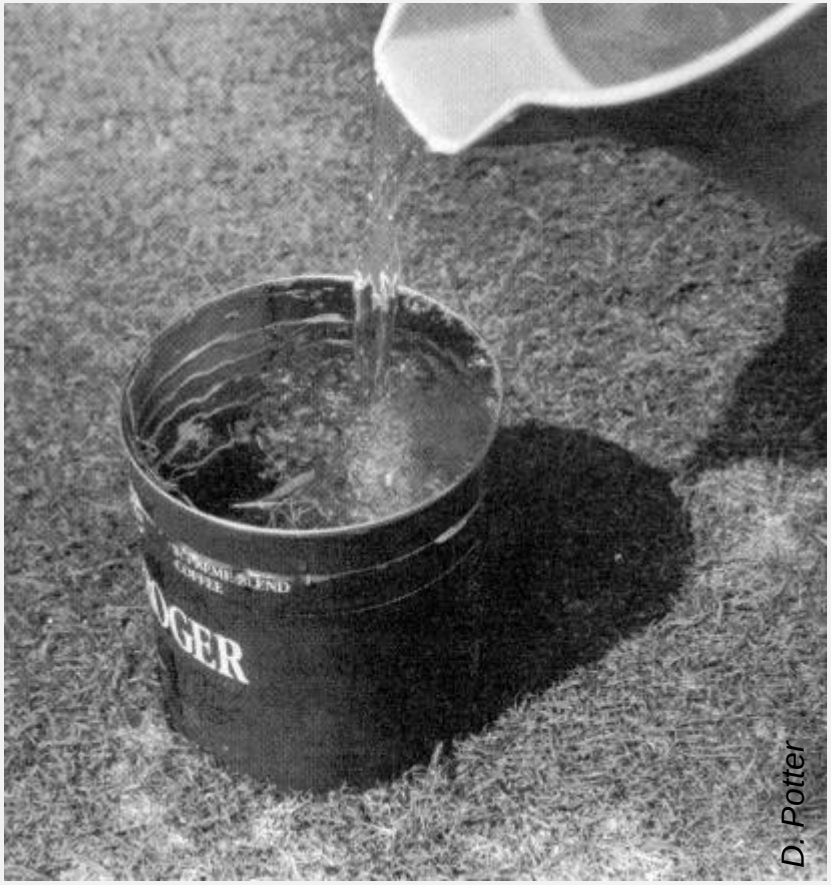


D. Potter

Floatation Sampling

Chinch bugs and their natural enemies

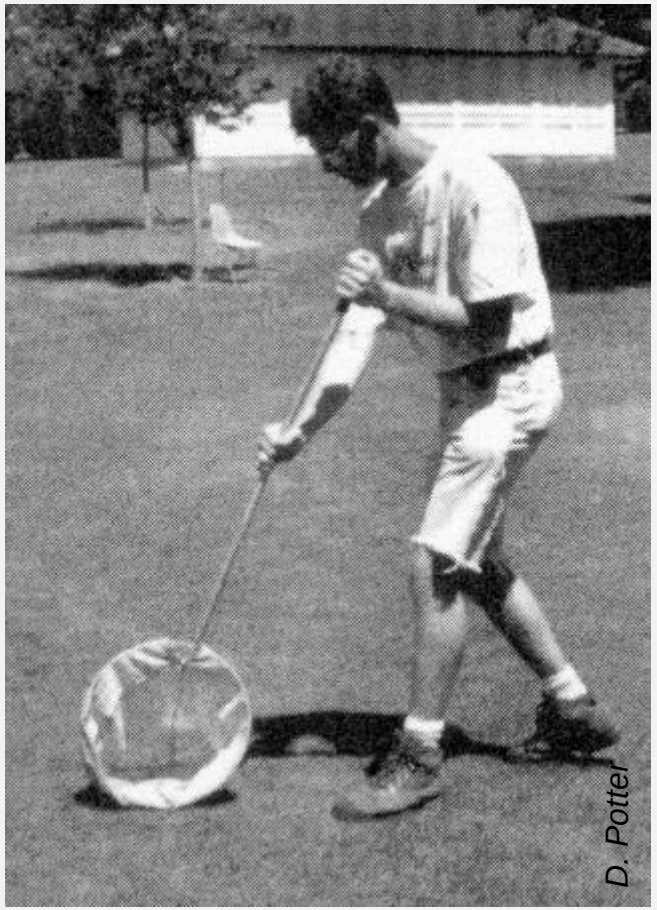
- Push cylinder 1” into turf
- Fill with water
- Insects float up in 5-10 min
- Count and ID
- Treatment threshold
  ~ 20-25 chinch bugs / ft^2



Sweep Net Sampling

Greenbugs, chinch bugs, flying insects

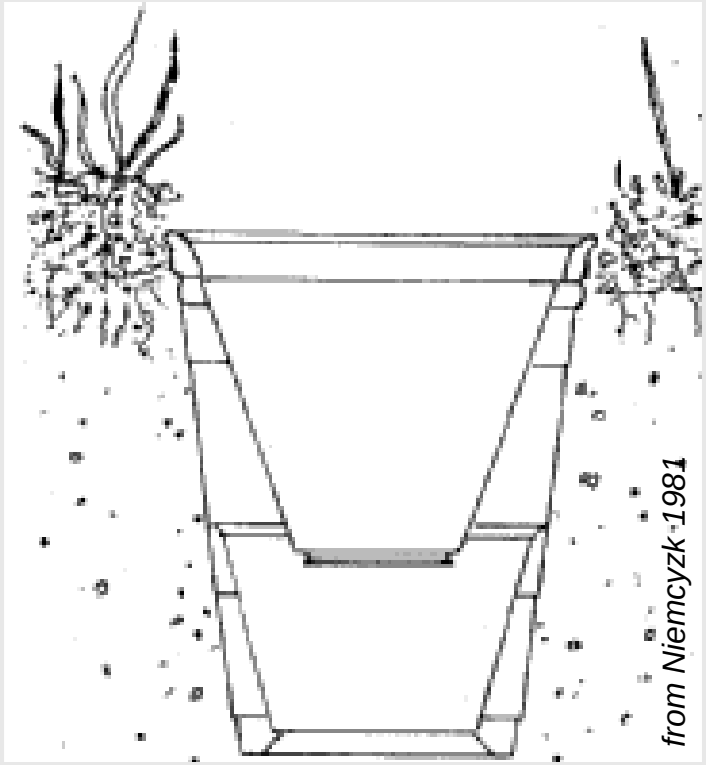
- Sturdy frame + bag
- Walk slowly sweeping net back and forth over turf.
- Examine contents every 10-20 sweeps (use consistent number of sweeps).



Pitfall Traps

Billbug adults and other crawling insects

- Place out-of-the way
- Remove soil core
- 16 oz cup in hole
- 4 oz cup as receptacle
- Coffee cup liner as funnel
- Billbug threshold during spring migration: > 7-10 adults/trap/day



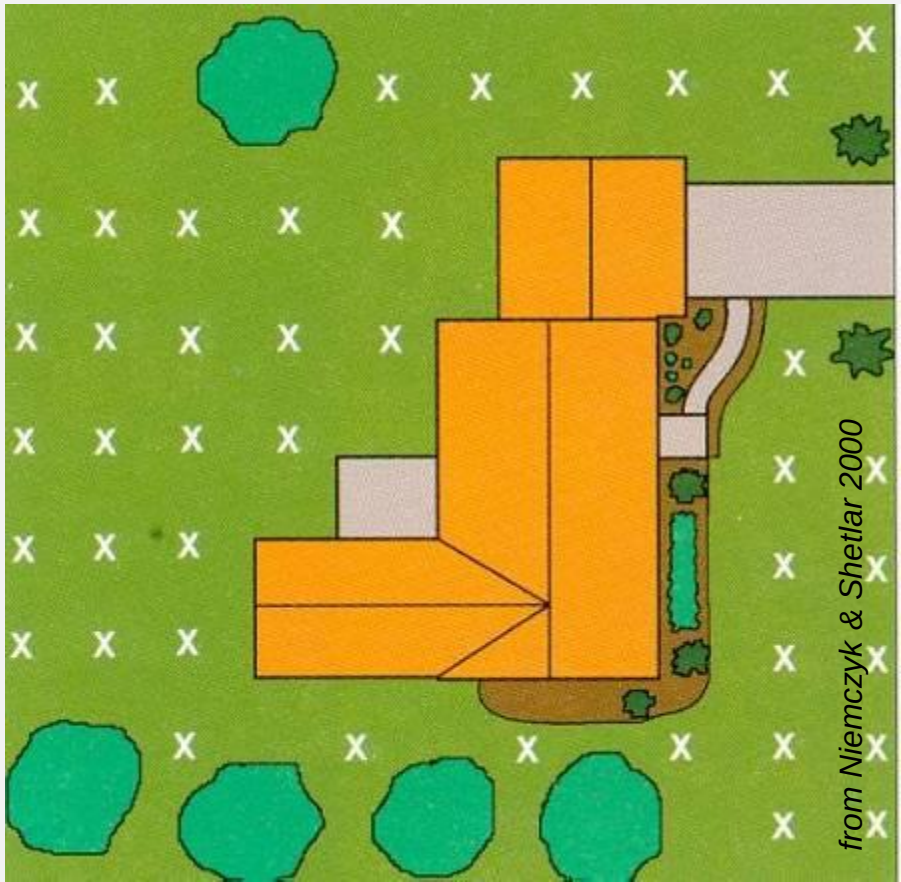
Soil Pest Sampling

White grubs, billbug larvae, root-feeding insects

- Take soil core (~3” deep), brake up, count, ID insects.
- Split core in ½s, ¼s, etc., to expose grubs.
- Replace soil/sod cap
- Sample in grid pattern
- Irrigate if dry

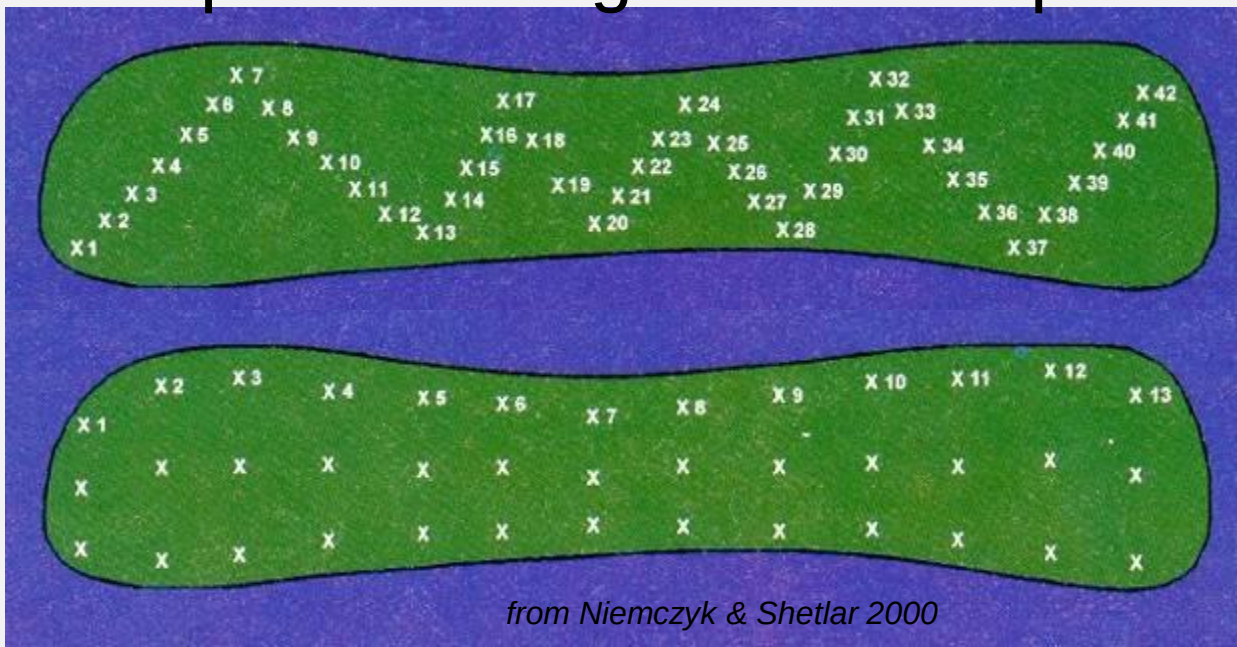
White grub – mapping & surveying
Home lawns / sport fields

- Best when grubs 2nd instars (~mid August)
- Prepare map of area
- Sample in grid pattern: 6-10’ (home lawn), 10-20’ (sports field)
- Record number and species (hand lens!) per sample (also 0’s!).
- Standard cup cutter → 1 grub = 10/ft^2.
- Several adjacent sample with 1+ grub → hot spot → consider treatment



White grub – mapping & surveying

- Best when grubs 2nd instars (~mid August)
- Prepare map of area.
- Sample in zigzag pattern 10-15’ or transect pattern 10-20’ apart.
- Record number and species per sample.
- Standard cup cutter → 1 grub = 10/ft^2
- Several adjacent samples w\ ≥ 1 grub → hot spot →consider treating affected area.
- 1-2 man days per 9 holes

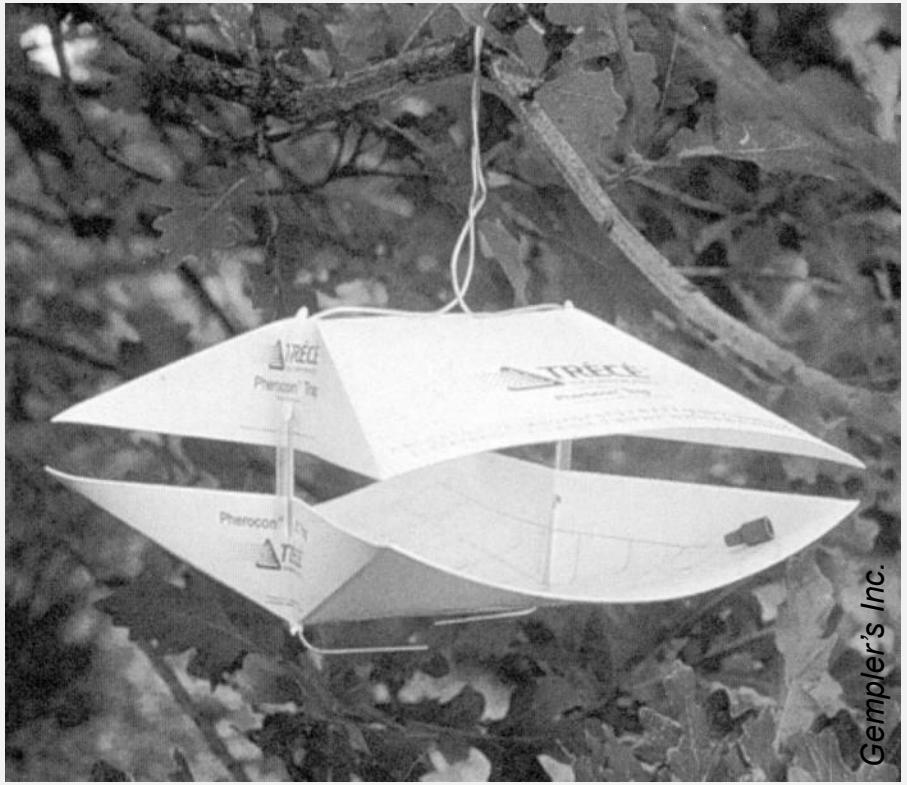


from Niemczyk & Shetlar 2000

Pheromone Traps

Japanese (!)/oriental beetle, black/variegated cutworm, armyworm, fall armyworm, bluegrass webworm, cranberry girdler

- Attract only males (except Japn. beetle)
- Species specific.
- Used to fine-tune treatment timing
- Clean/replace traps regularly



Indicator or Signal Plants

- Predict insect activity, fine-tune treatment timing.
- Relate seasonal occurrence of pest stages to developmental stages of certain plants.
- Flowering trees / shrubs good indicators
- Set up ‘phenology calendar’ for your region.
- Available for: annual bluegrass weevil, black turfgrass ataenius, European chafer, hairy chinch bug

Degree-Day Models

- Predict insect activities and fine-tune treatment timing.
- Baseline developmental temperature for most insects 50°F.
- Calculate degree-day (DD) units for each day:

$$\frac{(\text{min.temp.} + \text{max.temp.})}{2} - \text{baseline temp}$$

- Add up average DD units for each day
  → DD accumulation

Degree-Day Models

- E.g.: low/high 45/65 → (45 + 65)/2 - 50 = 5
- No negative values. Insects do not develop backwards!
- DD accumulation available from companies or extension services, e.g. → https://plant-pest-advisory.rutgers.edu/
- For best regular updates:
  -Use own weather station data to calculate GDDs.
  -Use weather/GDD trackers, ideally more than 1 per GC.

Degree-Day Accumulation

Date	Max Temp	Min Temp	Total	Ave	Minus 50 for baseline	DD Accumu-lation
4/13	58	40	98	49	0	0
4/14	66	42	108	54	4	4
4/15	70	46	116	58	8	12
4/16	75	49	124	62	12	24
4/17	71	47	118	59	9	33

Target Pest	Stage	Degree-Days*
north. masked chafer	1st adults	898-905
" "	90% adults	1377-1579
Bluegrass billbug	1st adult activity	280-352
" "	30% adult activity	560-624
" "	70% egg hatch	925-1035
Hairy chinch bug	1st egg laying	198-252
" "	1st egg hatch	522-702
Bluegrass webworm	1st gen. adults	864-900
" "	2nd gen. Adults	1900-2000
Larger sod webworm	1st gen. adults	846-882
" "	2nd gen. adults	1980-2100
Cranberry girdler	peak adult flight	1080-1170

*Baseline 50°F, starting Feb. 1

MANAGEMENT OPTIONS

- **Cultural control**
- **Physical control**
- **Biological control**
- **Chemical control**

Criteria for Selection

- Least hazardous to human health
- Least disruptive of natural control
- Least toxic to non-target organisms
- Most likely to be permanent
- Most cost-effective in the long term
- Easiest to carry out safely and effectively

Good turf management

- Sound management (irrigation, mowing, fertilization, etc.) increases turf vigor, pest tolerance, and recuperative potential.

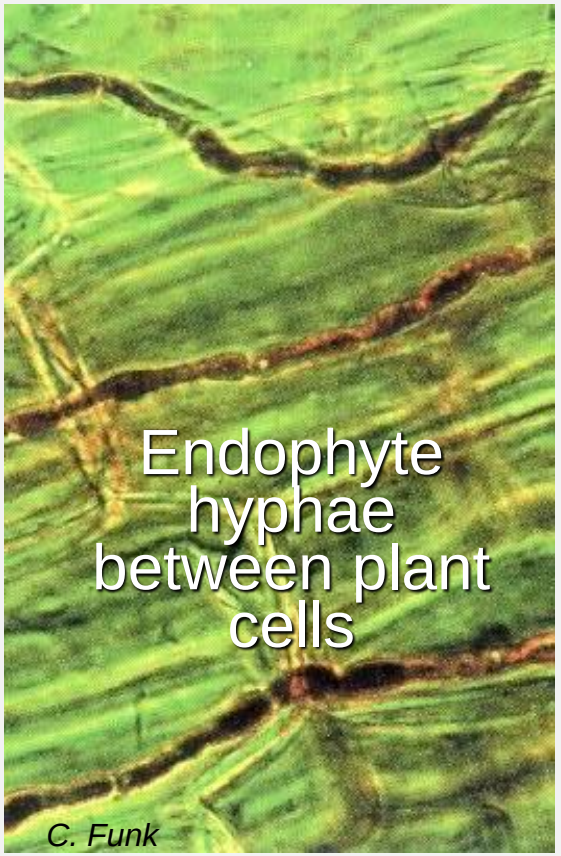
- Light irrigation and/or fertilization can improve turf recovery after light insect damage

Insect Tolerance

- Use grasses adapted to local conditions → less stressed, more tolerant.
- Use blends of improved, adapted turfgrasses.
- Thin-leafed, aggressive creeping, heat tolerant Kentucky bluegrasses generally more billbug tolerant
- Deep-rooting, heat/drought tolerant warm season grasses and tall fescue more white grub tolerant
- Creeping bentgrasses more ABW tolerant

Insect Resistance - Endophytes

- Endophytic fungi in many cvs. of tall fescue, fine fescue, perennial ryegrass
- In above-ground part of plants
- Produce alkaloids → feeding-deterrents or toxic to many insects.
- Little transfer into roots
- Endophytic grasses resistant to billbugs, chinch bugs, greenbugs, sod webworms, fall armyworm



Thatch management


D. Shetlar

- Thatch prime habitat for many insect pest
- Barrier to penetration of control agents
- Best preventative control → healthy earthworm populations
- Soil pH 6-7, coring, slicing, vertical cutting, and light topdressing can reduce thatch.

Biological control

Conserve natural enemies !!!

- Many predators and parasites in healthy turf → buffer pest populations
- 80% of insecticide applications in turf unnecessary (NY study) !!!
- Use pesticides only when/where necessary.
- Use control agents with reduced impact on natural enemies.

Chemical Control

- Only when and where necessary
- Spot rather than blanket treatments
- Use biorationals when possible.
- Use least toxic chemicals.
- Use chemicals that are compatible with other IPM components.

Control Approaches

- Preventative vs. curative
- Multi Target Principle (but: key pest!!)

Factors influencing decision to treat

- Perspectives of person making decision
- Financial considerations
- Turf quality standards
- Present and past pest spectrum

Turfgrass Insecticides: Activity, Use, and Safety

Sevin

- AI: carbaryl
- Class: carbamate (IRAC Grp. 1A)
- Moa: Acetylcholine esterase inhibitor
- Toxicology: sligthly toxic to mammals and birds; mod. toxic to fish; toxic to honeybees and aquatic invertebrates
- Toxic to arthropod natural enemies (predators/parasitoids)
- Use rate (lb ai/ac): 2-8; max. ? /y broadcast

Sevin

- Activity spectrum: white grubs, caterpillars, chinch bugs, crane flies
- Armyworms/cutworm: 2-4 lb ai/ac curatively
- Sod webworms or chinch bugs: 6-8 lb ai/ac curatively
- White grubs: 8 lb ai/ac curatively (Aug/Sept)
- Crane flies: 8 lb ai/ac preventively vs. small larvae (Sept/Oct)

Dylox

- AI: trichlorfon
- Class: organophosphate (IRAC Grp. 1B)
- Moa: Acetylcholine esterase inhibitor
- Toxicology: mod. toxic to mammals; pract. non-toxic to birds and fish; slightly toxic to honeybees; toxic to aquatic invertebrates
- Toxic to arthropod natural enemies (predators/parasitoids)
- Use rate (lb ai/ac): 5.4-8.1; max. 24.5/y broadcast

Dylox

- Activity spectrum: white grubs, caterpillars, ABW, mole crickets
- Caterpillars : 5.4 lb ai/ac curatively (max. 16.2/ y)
- White grubs: 8.1 lb ai/ac curatively [Aug/Sept (Oct)]
- ABW: 8.1 lb ai/ac curatively vs. larvae (mid-May to early June; summer as necessary)
- Crane flies: 8.1 lb ai/ac preventively vs. small larvae (~Oct)

Talstar

- AI: bifenthrin
- Class: pyrethroid (IRAC Grp. 3A)
- Moa: Na+ channel modulator
- Toxicology: mod. toxic to mammals; pract. non-toxic to birds; extr. toxic to fish and aquatic invertebrates; toxic to honeybees
- Toxic to arthropod natural enemies (predators/parasitoids)
- Use rate (lb ai/ac): 0.1-0.4; max. 0.4/y broadcast

Talstar

- Activity spectrum: everything on surface and in thatch
- Caterpillars: 0.1 lb ai/ac curatively
- Adults of ABW, billbugs, BTA: 0.1-0.2 lb ai/acre curatively
- Chinch bugs: 0.2-0.4 lb ai/ac curatively
- Crane flies : 0.2-0.4 lb ai/ac preventively vs. small larvae (~Oct)

Merit

- AI: imidacloprid
- Class: neonicotinoid (IRAC Grp. 4A)
- Moa: nicotinic ACh receptor agonist
- Toxicology: mod. toxic to mammals; pract. non-toxic to birds and fish; highly toxic to honeybees and aquatic invertebrates
- Use rate (lb ai/ac): 0.3-0.4; max. 0.4/y broadcast
- Activity spectrum: white grubs, billbugs

Merit

- White grubs: 0.3 lb ai/ac in June-July → also chinch bug and sod webworm suppression. Higher rate for early preventive (May) or early curative (mid-Aug) white grub applications
- Billbugs: 0.3 lb ai/ac late April to mid-May → also white grub control

Arena *

- AI: clothianidin
- Class: neonicotinoid (IRAC Grp. 4A)
- Moa: nicotinic ACh receptor agonist
- Toxicology: pract. non-toxic to mammals, birds, fish; mod. toxic to honeybees; toxic to aquatic invertebrates
- Use rate (lb ai/ac): 0.2-0.33; max. 0.4/y broadcast
- Activity spectrum: white grubs, billbugs, chinch bugs, sod webworms, crane flies

**Not registered in NY*

Arena

- White grubs: 0.2 lb ai/ac in June-July → also chinch bug and sod webworm control. Higher rates for early preventive (May) or early curative (>mid-Aug) white grub applications
- Billbugs: 0.2 lb ai/ac late April to mid-June → also white grub control
- Sod webworms or chinch bugs: 0.2 lb ai/ac curatively → only ~20 d residual → also white grub control

Meridian *

- AI: thiamethoxam
- Class: neonicotinoid (IRAC Grp. 4A)
- Moa: nicotinic ACh receptor agonist
- Toxicology: slightly toxic to mammals, birds; pract. non-toxic to fish; highly toxic to honeybees and aquatic invertebrates
- Use rate (lb ai/ac): 0.2-0.27; max. 0.27/y broadcast
- Activity spectrum: white grubs, billbugs

*Not registered in NY

Meridian

- White grubs: 0.2 lb ai/ac in June-July → also chinch bug and sod webworm suppression. Higher rate for early preventive (May) or early curative (mid-Aug) white grub applications
- Billbugs: 0.2-0.27 lb ai/ac late April to mid-May → also white grub control

Zylam

- AI: dinotefuran
- Class: neonicotinoid (IRAC Grp. 4A)
- Moa: nicotinic ACh receptor agonist
- Toxicology: slightly toxic to mammals, birds, fish; toxic to honeybees and aquatic invertebrates
- Use rate (lb ai/ac): 0.54; max. 0.54/y broadcast
- Activity spectrum: white grubs, billbugs, ABW, chinch bugs, cutworms, sod webworms, crane flies, mole crickets

Zylam

- White grubs: 0.54 lb ai/ac in June-July
- Billbugs: 0.54 lb ai/ac late April to mid-May
- ABW: 0.54 lb ai/ac late April to mid-May

Matchpoint

- AI: Spinosad
- Class: spinosyn (IRAC Grp. 5)
- Moa: Nicotinic Acetylcholine receptor agonist (allosteric)
- Toxicology: pract. non-toxic to mammals and birds; slightly toxic to fish; toxic to honeybees and aquatic invertebrates
- Use rate (lb ai/ac): 0.075-0.4; max. ? /y broadcast

MatchPoint

- Activity spectrum: caterpillars, ABW, BTA
- Short residual → apply curatively
- Sod webworms, small armyworms/: 0.075 lb ai/ac
- Small cutworms: 0.275 lb ai/ac
- Larger army/cutworms, ABW, BTA: 0.4 lb ai/ac

Provaunt

- AI: indoxacarb
- Class: oxadiazine (IRAC Grp. 22)
- Moa: voltage-dependant Na^+ channel blocker
- Toxicology: sligthly toxic to mammals and fish; pract. non-toxic to birds; toxic to honeybees and aquatic invertebrates
- No direct impact on arthropod natural enemies (predators/parasitoids)

Provaunt

- Use rate (lb ai/ac): 0.04-0.23; max. 0.45/y broadcast
- Activity spectrum: caterpillars, crane flies, ABW
- Caterpillars: 0.04-0.08 lb ai/ac curatively
- Crane flies: 0.11-0.23 lb ai/ac preventively (Sept/Oct) or curatively (May)
- ABW: 0.23 lb ai/ac curatively vs. larvae

Acelepryn

- AI: chlorantraniliprole
- Class: anthranilic diamide (IRAC Grp. 28)
- Moa: ryanodine receptor modulator
- Toxicology: pract. non-toxic to mammals, birds, fish; mod. toxic to honeybees; toxic to aquatic invertebrates
- No direct impact on arthropod natural enemies (predators/parasitoids)
- Use rate (lb ai/ac): 0.026-0.26; max. 0.5 per year broadcast

Acelepryn

- Activity spectrum: white grubs, billbugs, caterpillars, ABW, crane flies
- Caterpillars, use curatively: 0.03-0.05 lb ai/ac → 4-8 wk residual; 0.1 lb ai/ac → 8-12 wk; 0.2 lb ai/ac 12-16 wk residual
- White grubs: 0.1 lb ai/ac in May-July, 0.2 lb ai/ac for early curative (to mid-Aug)
- Billbugs: 0.1-0.26 lb ai/ac in late April/early May
- ABW: 0.16-0.26 lb ai/ac in late April to mid-May
- Craneflies: 0.1-0.2 lb ai/ac in late summer/early fall

Tetrino

- AI: tetraniliprole
- Class: anthranilic diamide (IRAC Grp. 28)
- Moa: ryanodine receptor modulator
- Toxicology: pract. non-toxic to mammals, birds(?), fish; highly toxic to honeybees; toxic to aquatic invertebrates
- No direct impact on arthropod natural enemies (predators/parasitoids)
- Use rate (lb ai/ac): 0.045-0.9; max. 0.178 per year broadcast

Tetrino

- Activity spectrum: white grubs, billbugs, ABW, caterpillars, chinch bugs
- Caterpillars, curatively: 0.045-0.9 lb ai/ac
- White grubs: preventively 0.045-0.09 lb ai/ac in June-July, 0.09 lb ai/ac for early curative (mid-Aug)
- Billbugs/ABW: 0.45-0.09 lb ai/ac preventively (early to mid-May)
- Chinch bugs: 0.045-0.09 lb ai/ac preventively (mid-May to mid-June)

Ference

- AI: cyantraniliprole
- Class: anthranilic diamide (IRAC Grp. 28)
- Moa: ryanodine receptor modulator
- Toxicology: pract. non-toxic to mammals, birds(?), fish(?); highly toxic to honeybees; toxic to aquatic invertebrates
- No direct impact on arthropod natural enemies (predators/parasitoids)
- Use rate (lb ai/ac): 0.026-0.26; max. 0.4 per year broadcast

Ference

- Activity spectrum: white grubs, billbugs, caterpillars, ABW, crane flies
- Caterpillars, curatively: 0.03-0.2 lb ai/ac
- White grubs: 0.1 lb ai/ac in mid-June-July, 0.1-0.2 lb ai/ac for early curative (mid-Aug)
- Billbugs: 0.1-0.2 lb ai/ac in early May
- ABW: 0.16-0.26 lb ai/ac in early to late-May
- Craneflies: 0.1-0.2 lb ai/ac September/October

Note: much shorter soil half life than Acelepryn: precisely time vs. most susceptible stages.

Suprado

- AI: novaluron
- Class: benzoylureas (IRAC Grp. 15)
- Moa: chitin synthesis inhibitor
- Toxicology: pract. non-toxic to mammals, birds, fish; low toxic. to honeybees; toxic to aquatic invertebrates
- No direct impact on arthropod natural enemies (predators/parasitoids)
- Use rate (lb ai/ac): 0.67-0.89; max. 2.03 per year broadcast

Suprado

- ABW: 0.67-0.89 lb ai/ac vs. adults, small and mid-size larvae (late April-late May; as necessary in summer).
- Billbugs: 0.67-0.89 lb ai/ac vs. mid-size larvae (mid-June to early July)*
- Caterpillars: 0.22-0.45 lb ai/ac curatively*
- White grubs: 0.67-0.89 lb ai/ac late June to late July*
- Chinch bugs: 0.67-0.89 lb ai/ac preventively (mid-May to mid-June)*

*per label! Data?

Triple Crown

- AI: imidacloprid + bifenthrin + zeta-cypermethrin (5:3:1 ratio)
- Class: neonic. + pyrethr. (IRAC Grp. 4A + 3)
- Moa: nicotinic ACh receptor agonist + Na^+ channel modulator
- Toxicology: mod. toxic to mammals, pract. non-toxic to birds; extrem. toxic to fish and aquatic invertebrates; highly toxic to honeybees
- Use rate (lb ai/ac): 0.176-0.616 (10-35 fl oz); max. 0.88/y (50 fl oz) broadcast

Triple Crown

- Activity spectrum: you name it
- White grubs: 20-35 fl oz/ac in June/July → also chinch bug and sod webworm control
- Billbugs: 20-35 fl oz/ac vs adults in late April to mid-May → also white grub suppression
- ABW: 20-35 fl oz/ac when adults active
- Caterpillars: 10-15 fl oz ai/ac curatively
- Chinch bugs, ants, crane flies, ticks: 20-35 fl oz/ac as needed
- **Max. 4 wk residual for surface insects!!!**

Allectus

- AI: imidacloprid + bifenthrin (5:4 ratio)
- Class: neonic. + pyrethr. (IRAC Grp. 4A + 3A)
- Moa: nicotinic ACh receptor agonist + Na^+ channel modulator
- Toxicology: mod. toxic to mammals, pract. non-toxic to birds; extrem. toxic to fish and aquatic invertebrates; highly toxic to honeybees
- Use rate (lb ai/ac): 0.34-0.43; max. 0.9/y broadcast

Allectus

- Activity spectrum: you name it
- White grubs: 0.34 lb ai/ac in mid-June/July → also chinch bug and sod webworm control
- Billbugs: 0.34 lb ai/ac in late April to mid-May → also white grub control
- Sod webworms or chinch bugs: 0.34 lb ai/ac curatively → also white grub control
- ABW: 0.35 lb ai/ac when adults active
- **Max. 4 wk residual for surface insects!!!**

Aloft *

- AI: clothianidin + bifenthrin (2:1 ratio)
- Class: neonic. + pyrethr. (IRAC Grp. 4A + 3A)
- Moa: nicotinic ACh receptor agonist + Na^+ channel modulator
- Toxicology: mod. toxic to mammals; pract. non-toxic to birds; extrem. toxic to fish and aquatic invertebrates; highly toxic to honeybees
- Use rate (lb ai/ac): 0.3-0.6; max. 0.6/y broadcast

**Not registered in NY*

Aloft

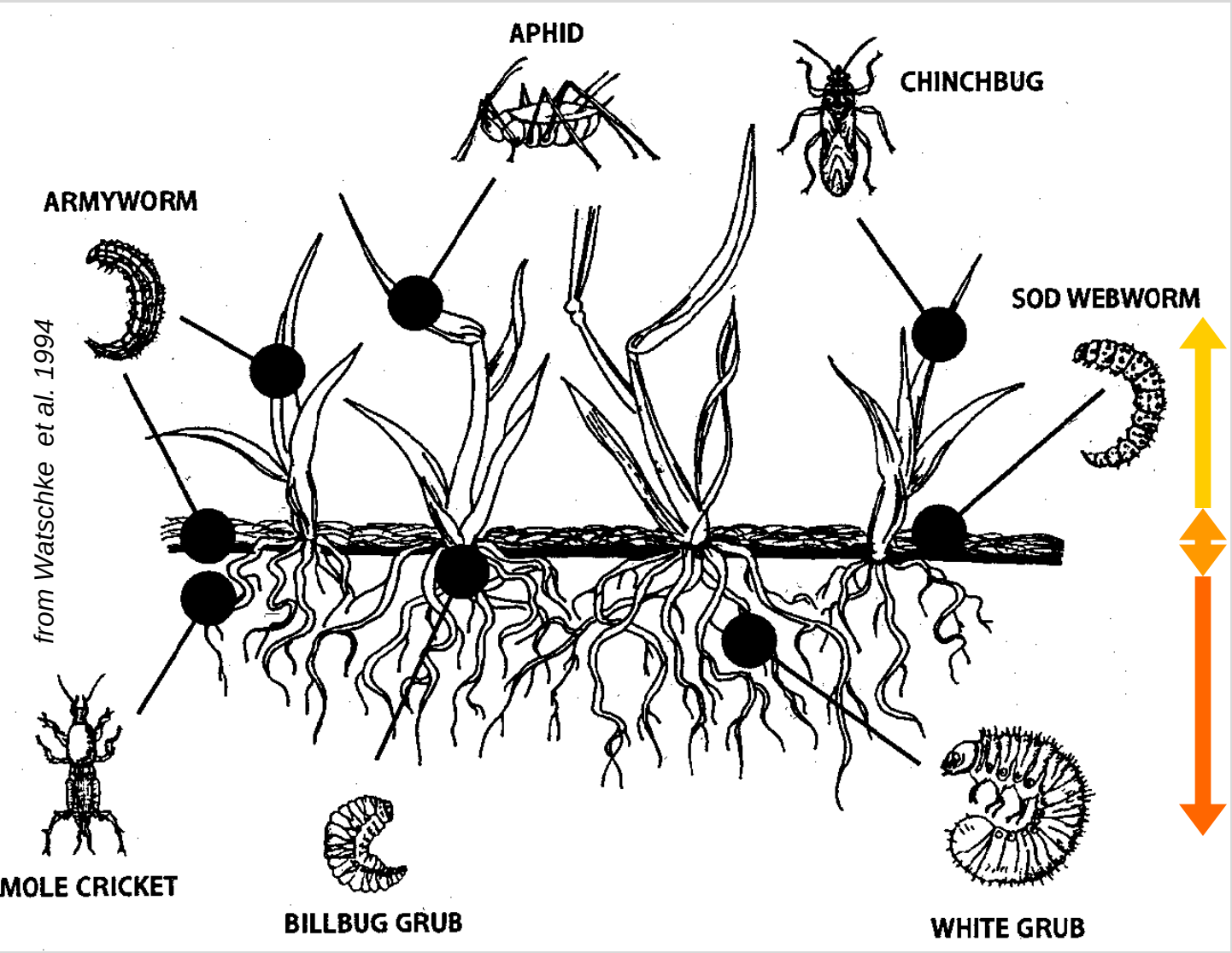
- Activity spectrum: you name it.
- White grubs: 0.3 lb ai/ac in May to August
- Billbugs: 0.3 lb ai/ac in late April to mid-June → also white grub control
- Sod webworms or chinch bugs: 0.3 lb ai/ac curatively → also white grub control
- ABW: 0.371 lb ai/ac when adults active
- **Max. 4 wk residual for surface insects!!!**

EcoTox Profiles - Turfgrass Insecticides (Technical Grade)

Class	Trade name	Use rate (lb ai/a.)	Mammal. LD50 (mg/kg)	Avian, LD50 (mg/kg)	Fish, LC50 (ppm)	Bee, LC50 (µg/bee)	Water solub. (mg/L)
Carbamate	Sevin	2.0 - 8.0	550	>2,179	2		40
OP	Orthene	1.0 - 3.0	906	350	>1,000	1.2	790,000
	Dursban	1.0	97	170	8	0.6	0.4–4.8
	Dylox	5.5 - 8.2	400	>5,000	430	59.8	136,000
Pyrethroid	Talstar	0.04 - 0.11	63	2,150	<0.01	<0.1	0.1
	Tempo	0.05 - 0.1	1,070	>5,000	<0.01		2
	DeltaGard	0.03 - 0.13	96	>4,640	<0.01		2
	Scimitar	0.03 - 0.12	100	>3,950	<0.01	<0.1	0.005
Neo-nico-tinoid	Arena	0.2 - 0.33	>5,200	>2,000	105	4	327
	Merit	0.3 - 0.4	424	>4,797	>8,300	0.4	514
	Meridian	0.2 - 0.27	1,563	576	>100	<0.1	4,000
Spinosyn	Conserve	0.08 - 0.4	>5,000	>2,000	30	<0.1	235
Diacylhydraz.	Mach2	1.0 - 2.0	>5,000	>5,000	9	>100	12.3
Oxadiazine	Provaunt	0.04 - 0.24	1,000	>5,620	650	1.3	0.2
Anthr.diamide	Acelepryn	0.03 - 0.26	>5,000	2,200	>15,000	> 4	1

Class	Trade name	Use rate (lb ai/a.)	Mammal LD50 (mg/kg)	Avian LD50 (mg/kg)	Fish LC50 (ppm)	Bee LC50 (µg/bee)
Carb	Sevin	2.0–8.0	550	>2,179	2	
OP	Dylox	5.5–8.2	400	>5,000	430	60
Pyr	Talstar	0.04–0.11	63	2,150	<0.01	<0.1
Neo-nic	Merit	0.3–0.4	424	>4,797	>8,300	0.4
	Meridian	0.2–0.27	1,563	576	>100	<0.1
	Arena	0.2–0.33	>5,200	>2,000	105	4
Spin	Conserve	0.08–0.4	>5000	>2,000	30	<0.1
Diac	Mach2	1.0–2.0	>5,000	>5,000	9	>100
Oxa	Provaunt	0.04–0.24	1,000	>5,620	650	1.3
Anth	Acelepryn	0.03–0.26	>5,000	2,200	>15 k	> 4

Target principle – turf zones



Turf zones:

Foliar/stem

Stem/thatch

Thatch/soil

Target principle

- Control agent has to be delivered to the target zone in which the pest feeds or hides.
- The target zone determines:

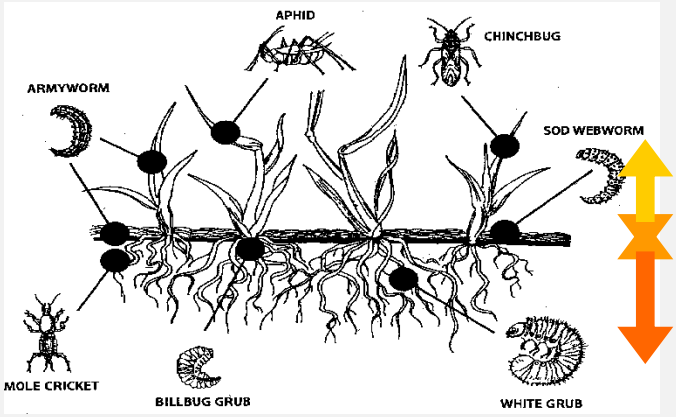
  a. insecticide formulation

  b. timing of application

  c. application technique

  d. watering in of treatment

Target principle – soil/thatch zone



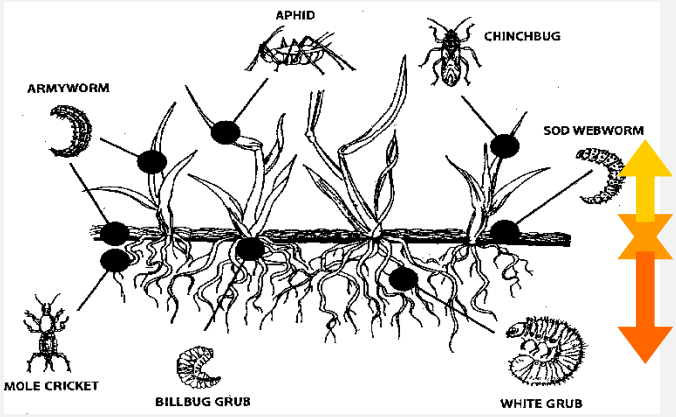
- Pre-irrigate dry soil 1 d before treatment (espec. when thatchy)

→ draws insects closer to surface

→ improves infiltration

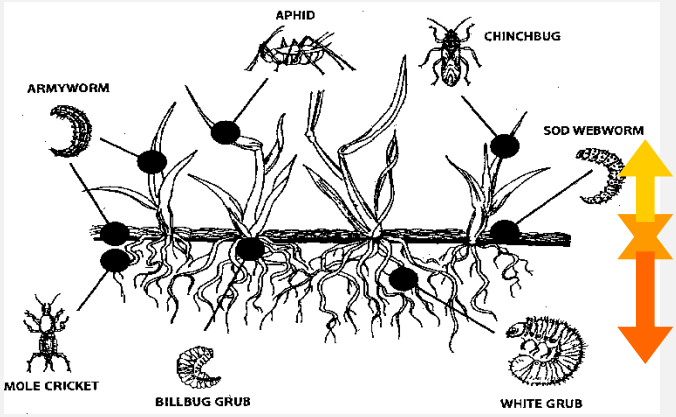
- Granular and liquid formulations
- Liquid: coarse spray (2 gal/1,000 ft^2)
- Water in (or timely rainfall) (~0.25”)

Target principle – thatch/stem zone



- Granular and liquid formulations
- Liquid: coarse spray (2 gal/1,000 ft^2)
- Light post-treatment irrigation (~0.1”)
- Systemics for pests inside stems
- Delay irrigation and mowing for 1-2 d

Target principle – stem/foliar zone



- Liquid: coarse spray (2 gal/1,000 ft^2)
- Coincide treatments with feeding activity of pest
- Delay irrigation and mowing for 1-2 d
- Granular formulation only if compound systemic (→ post-application irrigation)

Reasons for control failures

- Insecticide selection
- Incorrect pest ID
- Wrong formulation
- Poor calibration
- Deactivation in spray tank
- Bad timing

Reasons for control failures (cont'd)

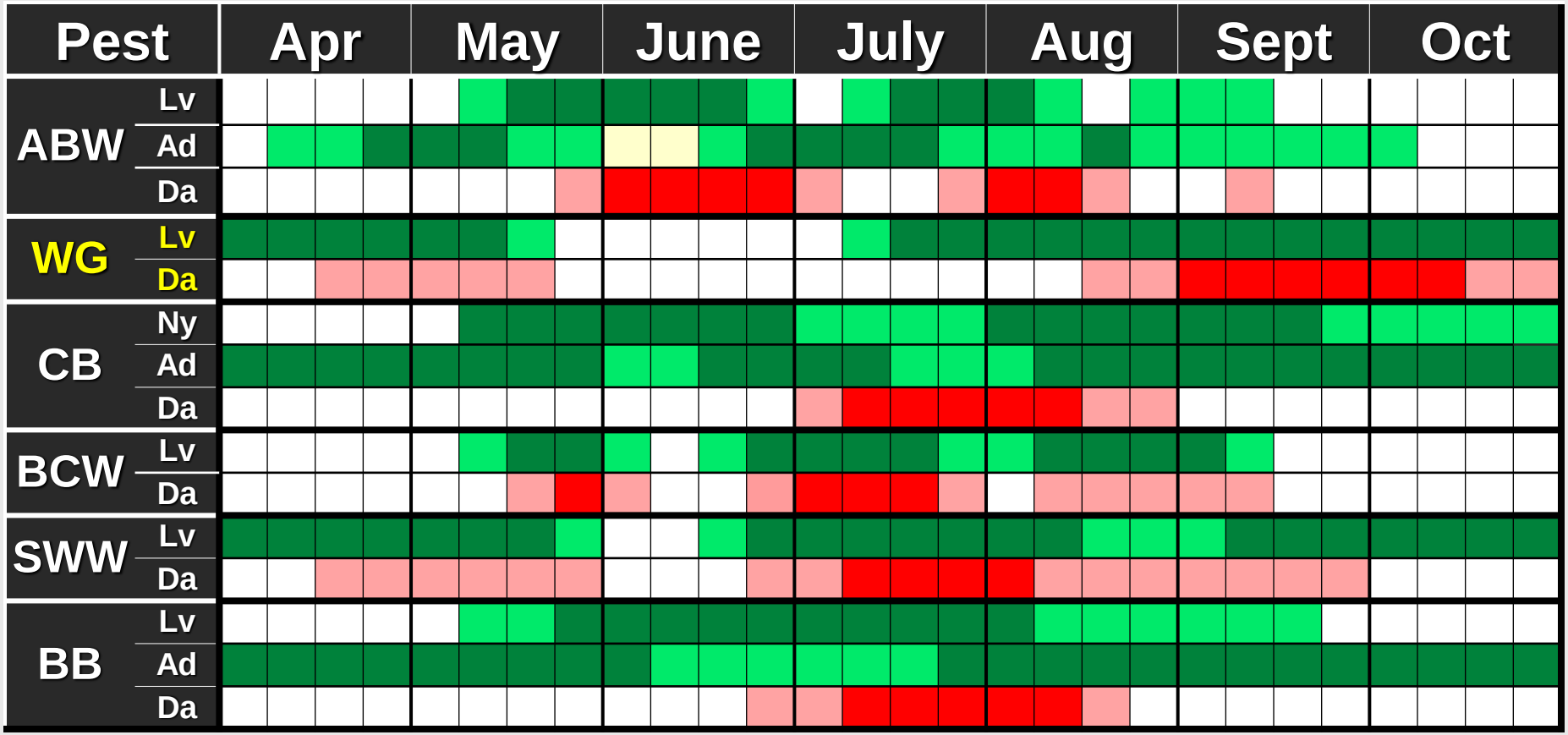
- Volatilization (windy! warm!)
- Insufficient irrigation
- Temperature
- Failure to penetrate thatch
  (chlorpyrifos !!)
- Deactivation in soil (chemical, microbial)
- Pest resistance

Multi Target Principle

- Correct AI at right time and rate can control more than 1 (potential) pest
- But prioritize key pest !!!
- Use to reduce labor AND ‘toxicity load’ for environment AND negative impacts on beneficials.

*See specific examples for each insect group presented

Key pests: *Timing of critical stages and damage**



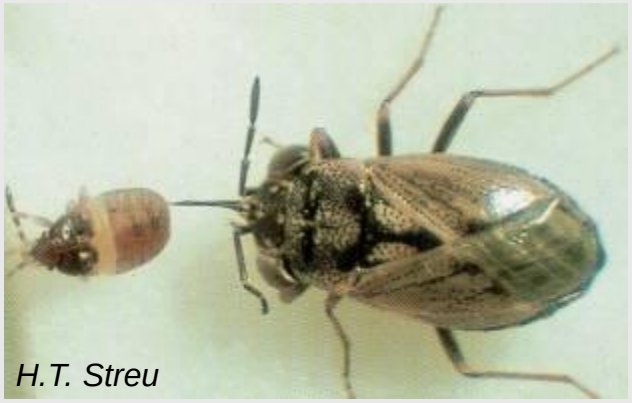
***Average timing for NJ**

ABW = annual bluegrass weevil; WG = white grubs;
CB = chinch bug; BCW = black cutworm; BB = billbugs;
SWW = sod webworms;
Ad = adults; Lv = larvae; Ny = nymphs; Da = turf damage

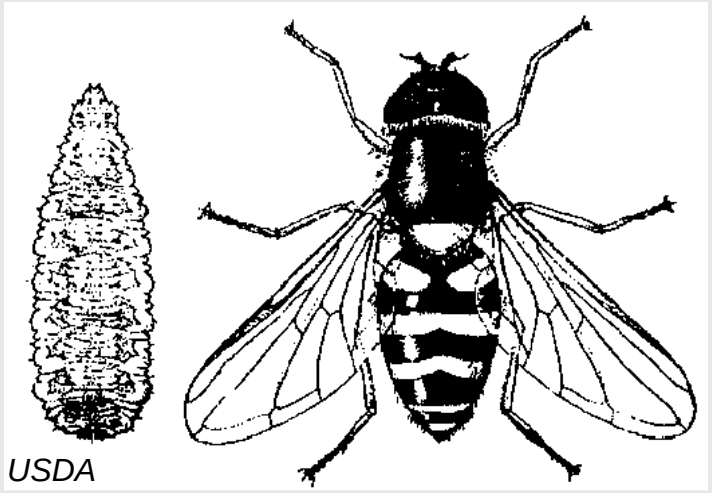
Beneficial insects & insect pathogens

- **Predators**
- **Parasites**
- **Pathogens**

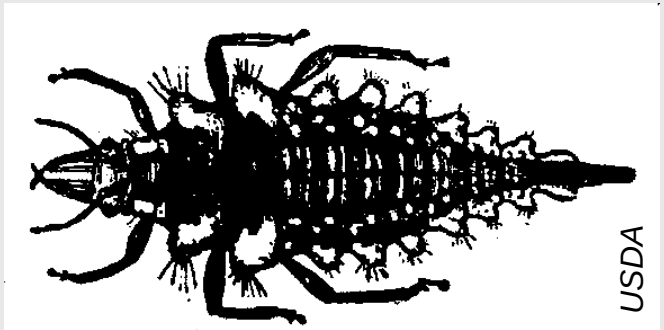
Beneficial turfgrass insects - Predators

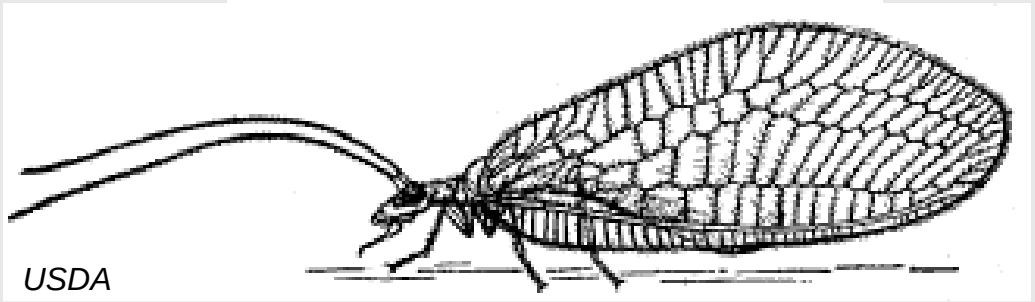


Big-eyed bugs
(Chinch bugs & small insects, eggs)



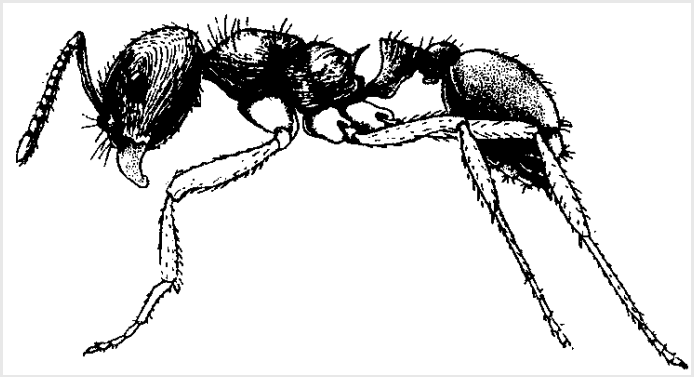
Sirphid flies
(aphids, mealybugs)



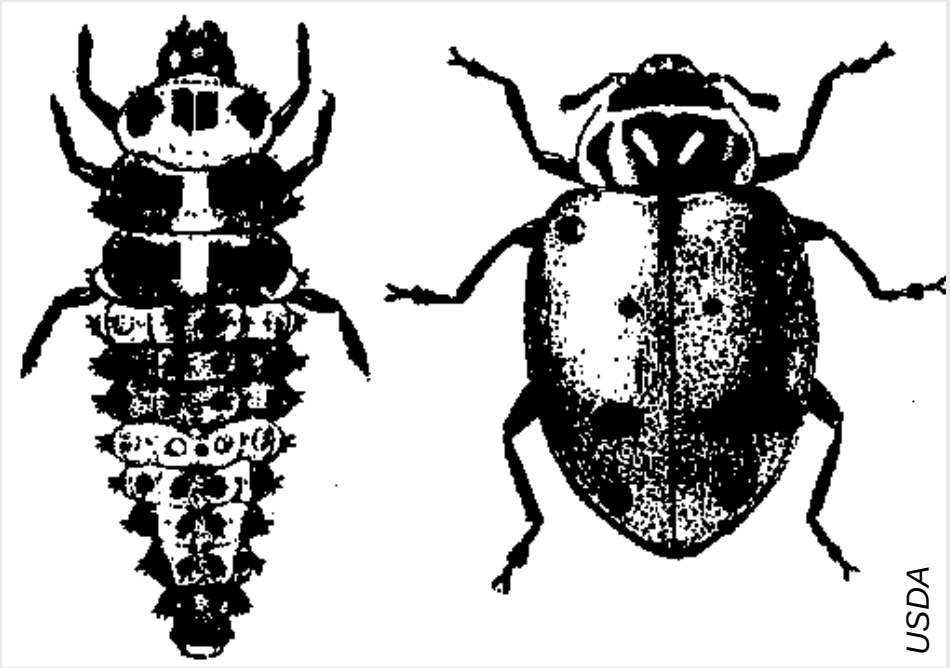


Lacewings
(aphids, mealybugs)

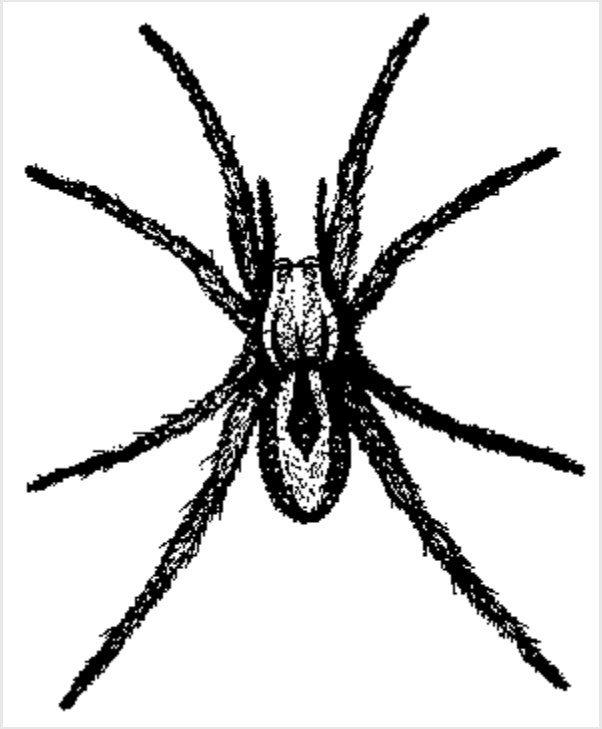
Beneficial turfgrass insects - Predators



Ants (generalists)

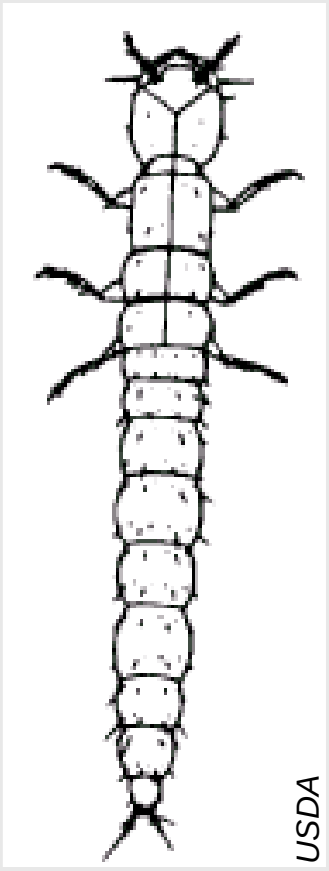


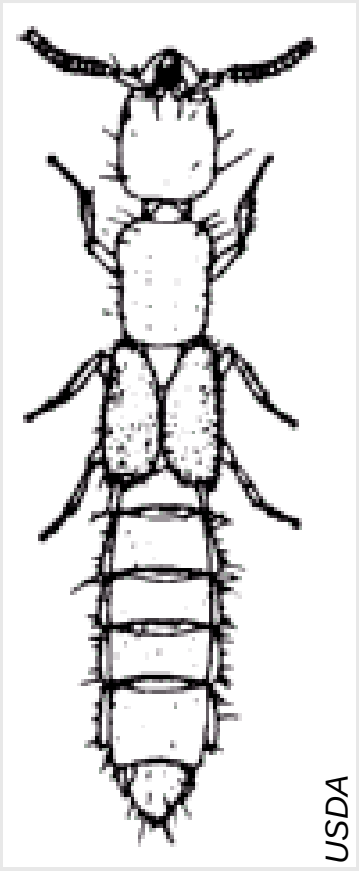
Lady beetles (aphids, mealybugs)



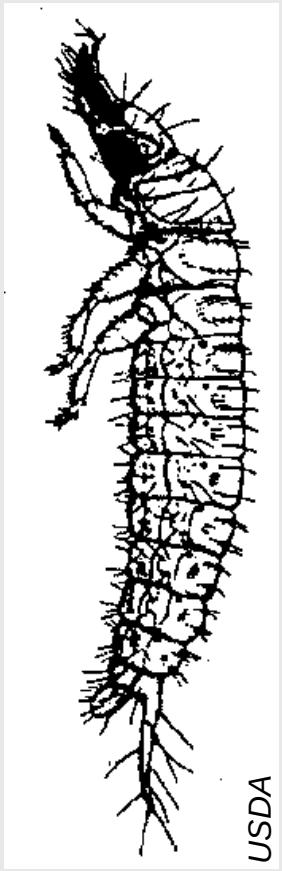
Ground spiders
(generalists)

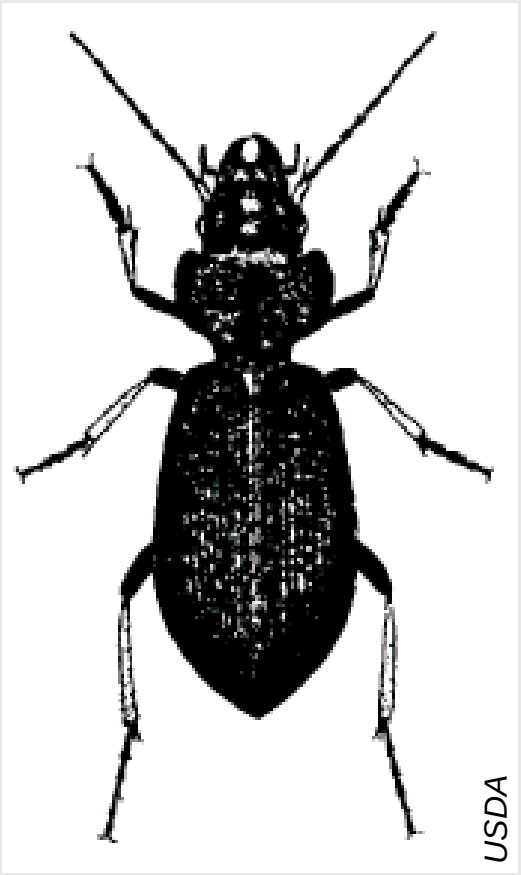
Beneficial turfgrass insects - Predators





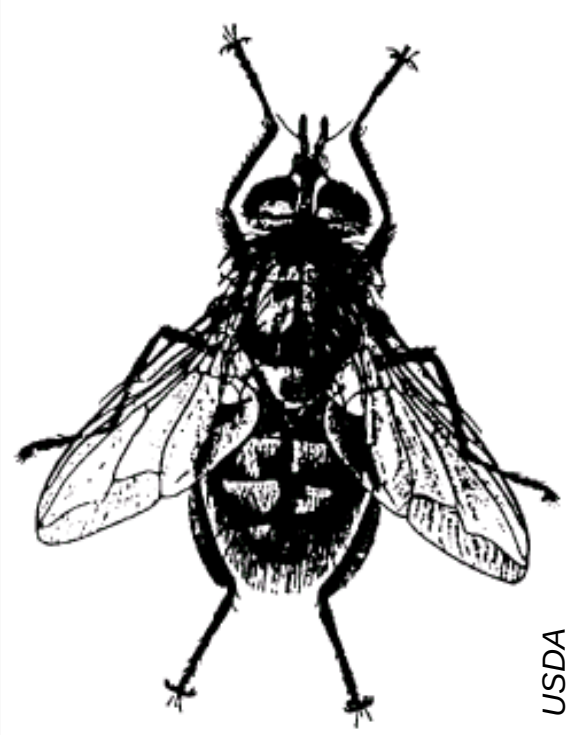
Rove beetle
(generalists)



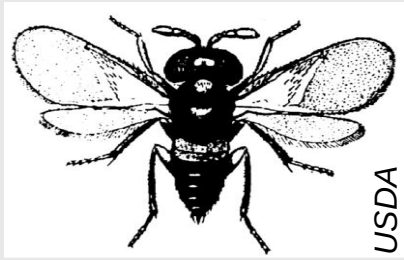


Ground beetle
(generalists)

Beneficial turfgrass insects - Parasites

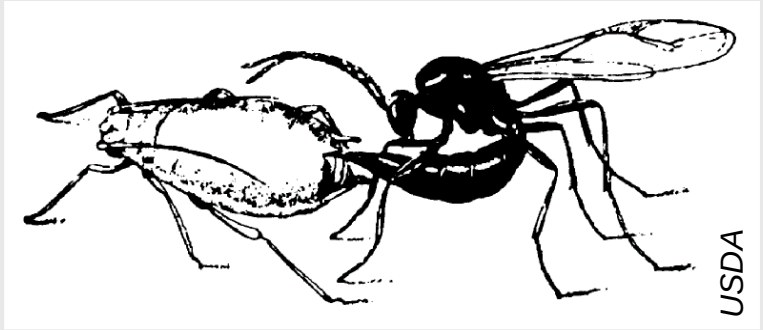


Tachinid flies
(larvae, adults
of various pests)



Chalcid wasps
(eggs, larvae, pupae
of various pests)

Tachinid larva
on white grub



Aphelinid wasps (aphids)

Beneficial turfgrass insects - Parasites

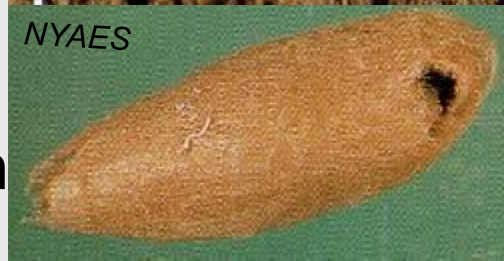
Tiphiid wasps
(white grub spp.)

Scoliid wasps
(white grub spp.)

Young *Tiphia* larva

Mature *Tiphia* larva

***Tiphia* cocoon**

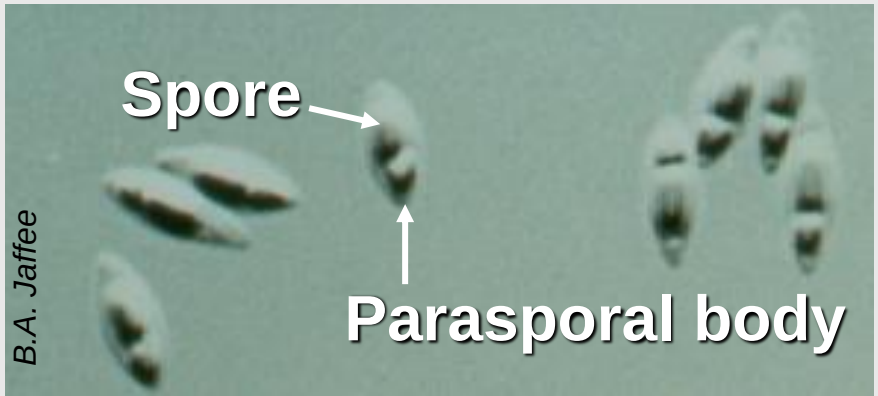


Naturally Occurring Pathogens of Turfgrass Insect Pests

- Entomopathogenic nematodes
  (*Steinernema* spp., *Heterorhabditis* spp.)
- Entomopathogenic fungi
  (*Beauveria* spp., *Metarhizium anisopliae*)
- Bacteria
  (*Paenibacillus popilliae*, *Serratia* spp.)
- Rickettsia, Microsporidia, Protozoa

Milky disease, *Paenibacillus popilliae*

- bacterial pathogen
- grubs ingest spores with soil during feeding
- colonizes grub's body fluid
- grub starves; death in ~4 wk
- forms spores → white color
- spores released from dead grub survive for years in soil



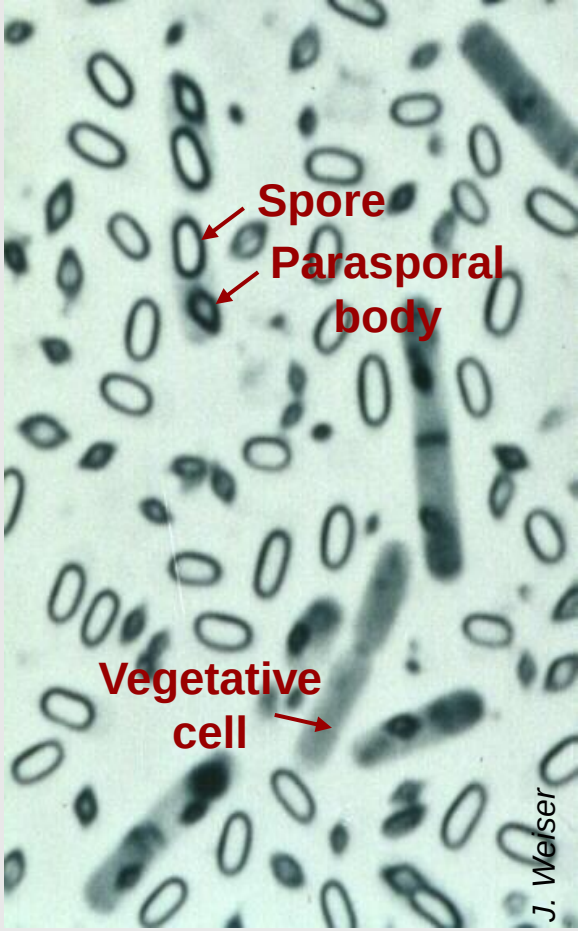
Milky Disease

- Most grub species have their own strain
- Commercials strain effective (?) only vs. Japanese beetle
- Inoculative applications in a 3'x 3' grid pattern

- Recycling in hosts → 1-3 year to spread throughout treated area
- Best establishment at high Japn. btl. densities and where soil temperatures stay > 70°F for longer periods

Bt - Bacillus thuringiensis

- Endospore-forming facultative insect pathogen
- Common in soil and sediment
- Produces parasporal body: contains insecticidal crystal protein (delta endotoxin)



- When ingested, endotoxin disrupts midgut epithelium → gut paralysis → septicemia, starvation → death.
- Strains specific to different insect groups

Bt - Bacillus thuringiensis

- rapidly inactivated by UV light → foliar applications use UV protectants, apply late in day.
- Most strains more effective vs. young pest stages
- *Bt kurstaki* (DiPel, Javelin), *Bt aizawai* (XenTari) active vs. armyworms and sod webworms (not black cutworm)
- *Bt israelensis* vs. crane flies
- *Bt galleriae*, *Bt japonensis* (shelved) vs. white grubs

Bt galleriae SDS-502

- grubGONE!® - 9% ai granular formulation
- Applied at 100-150 lbs/ac (9 – 13.5 lbs ai/ac)
- **> 2 years shelf life**
- OMRI approved
- **Apply vs. young grubs (L1, L2)**
- Most effective vs. Japanese beetle
- **More variable with masked chafers and oriental beetle**

Chromobacterium subtsugae

- GRANDEVO® PTO ! - 30% ai
- ***Chromobacterium subtsugae* strain PRAA4-1 and spent fermentation media**
- 2-4 lbs/ac f. surface feeders
- 10-20 lbs/ac f. white grubs
- **> 2 years shelf life**
- OMRI approved

- **Performance vs. white grubs can be excellent (80+%) but variable. Might vary with species.**

Entomopathogenic Fungi

- facultative lethal parasites of insects
- *Beauveria & Metarhizium* species
- host range +/- broad; many different strains

before spore germination after

***Metarhizium* sp. (white grub)**

***Beauveria* sp. (chinch bug)**

Entomopathogenic Fungi

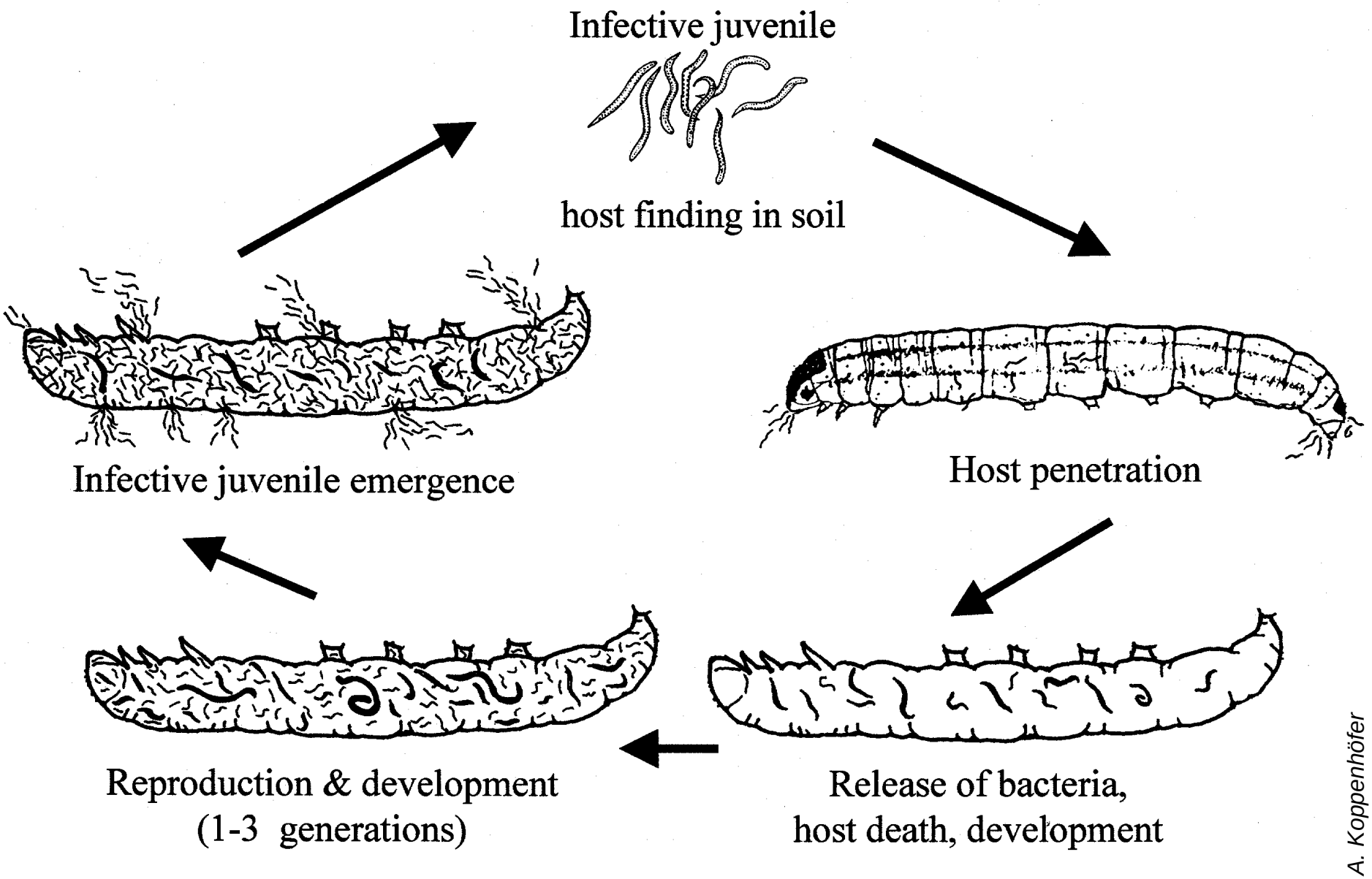
- Fungal spores generally most infective under warm, moist conditions
- Spores sensitive to UV radiation
- *B. bassiana* (Botanigard, Mycotrol) labeled for turf and billbugs and white grubs
- *M. anisopliae* (Met52) labeled for turf and ticks
- Not much efficacy data.
- Use vs. soil insects in turf questionable because difficult to get spores in soil. (Subsurface applications!!!)

Entomopathogenic nematodes (EPN)

- obligate lethal parasites of insects
- mutualistic association with bacteria
- > 26 *Heterorhabditis* & 100 *Steinernema* spp.
- host searching capacity
- host range +/- broad
- ease of production
- recycling capacity

Infective juvenile nematodes

Entomopathogenic nematode life cycle



A. Koppenhöfer

EPN Infections

Nematode products for US turf market

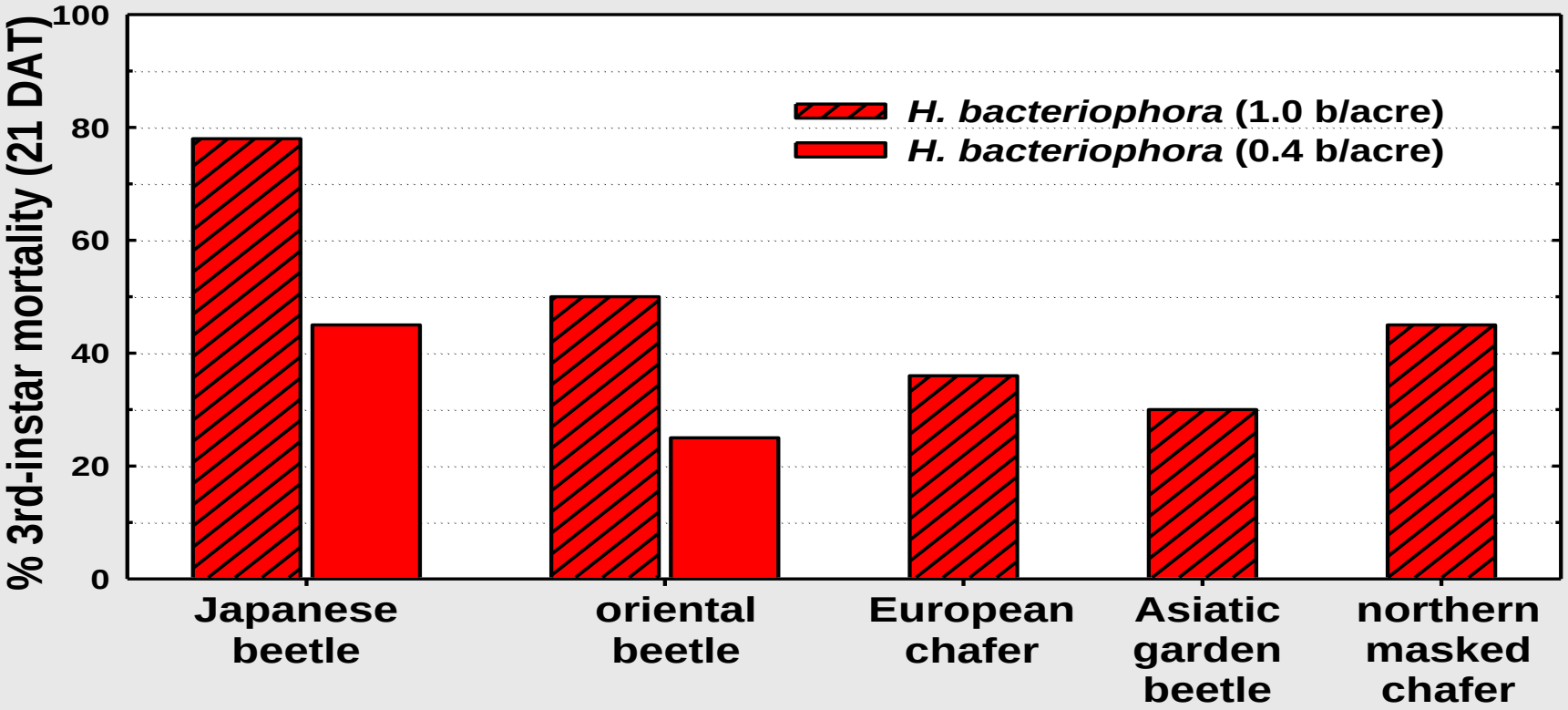
Nematode	Targets[1]	Product (Producer)
Steinernema carpocapsae	BCW, SWW, AW, BB, Fleas	Millenium (BASF), Capsanem (Koppert), Ecomask (BioLogic)
Heterorhabditis bacteriophora	WG, BB	Nemasys G (BASF), Terranem NAm (Koppert), Heteromask (BioLogic)
Steinernema scarabaei	WG	Nemagard (Lawn Life)

[1]BCW = black cutworm; SWW = sod webworm; AW = armyworm
BB = billbugs; WG = white grubs; MC = mole crickets

White grub species and EPN efficacy

Summary of multiple field experiments

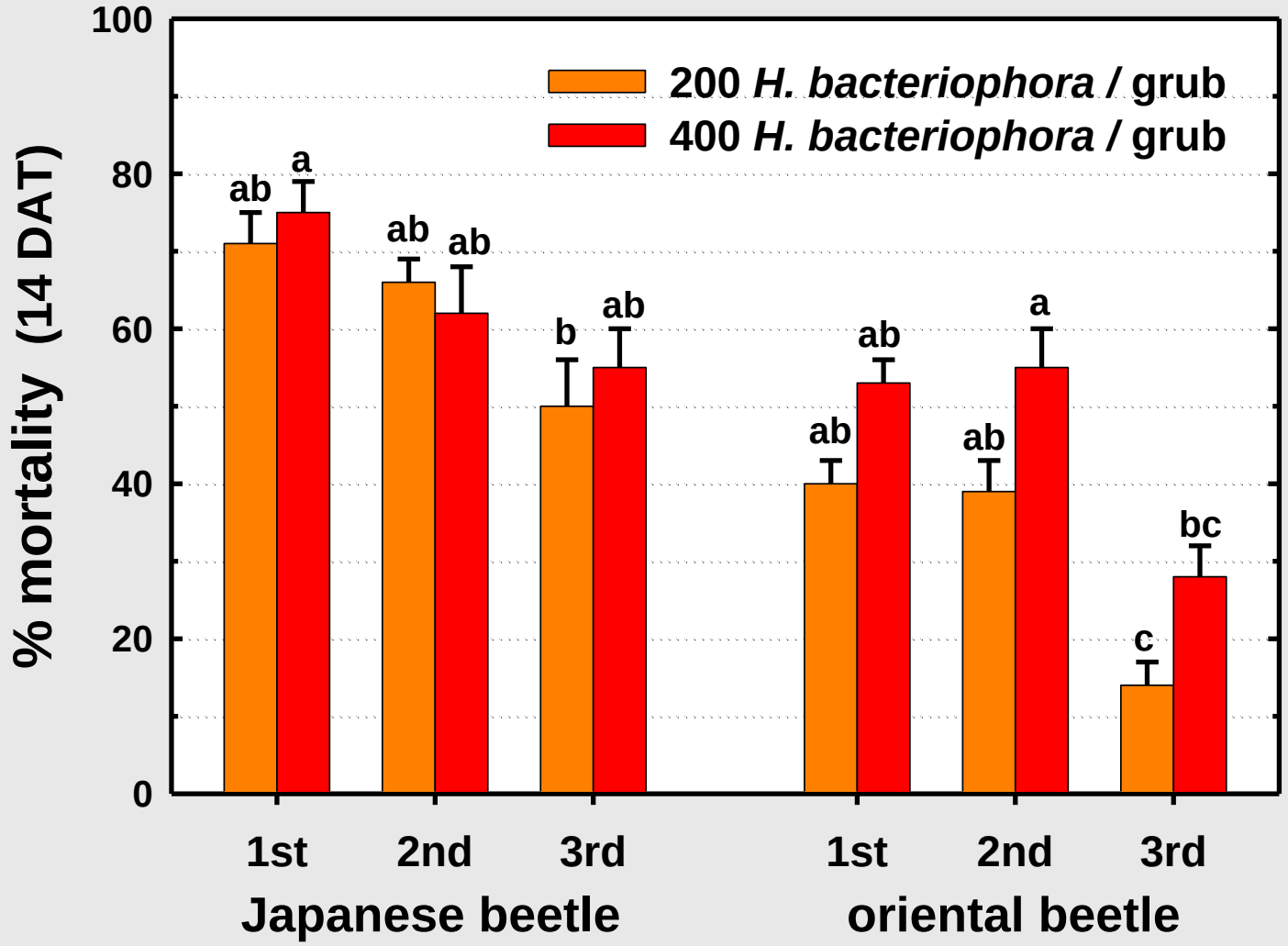
Applications around mid-September



- *JB control feasible.*
- *Other species less susceptible. 2 b/acre necessary?*
- *Earlier applications vs. younger stages?*

White grub larval stage and EPN efficacy

Lab test: 1 grub / 1-oz cup



Koppenhöfer & Fuzy 2004

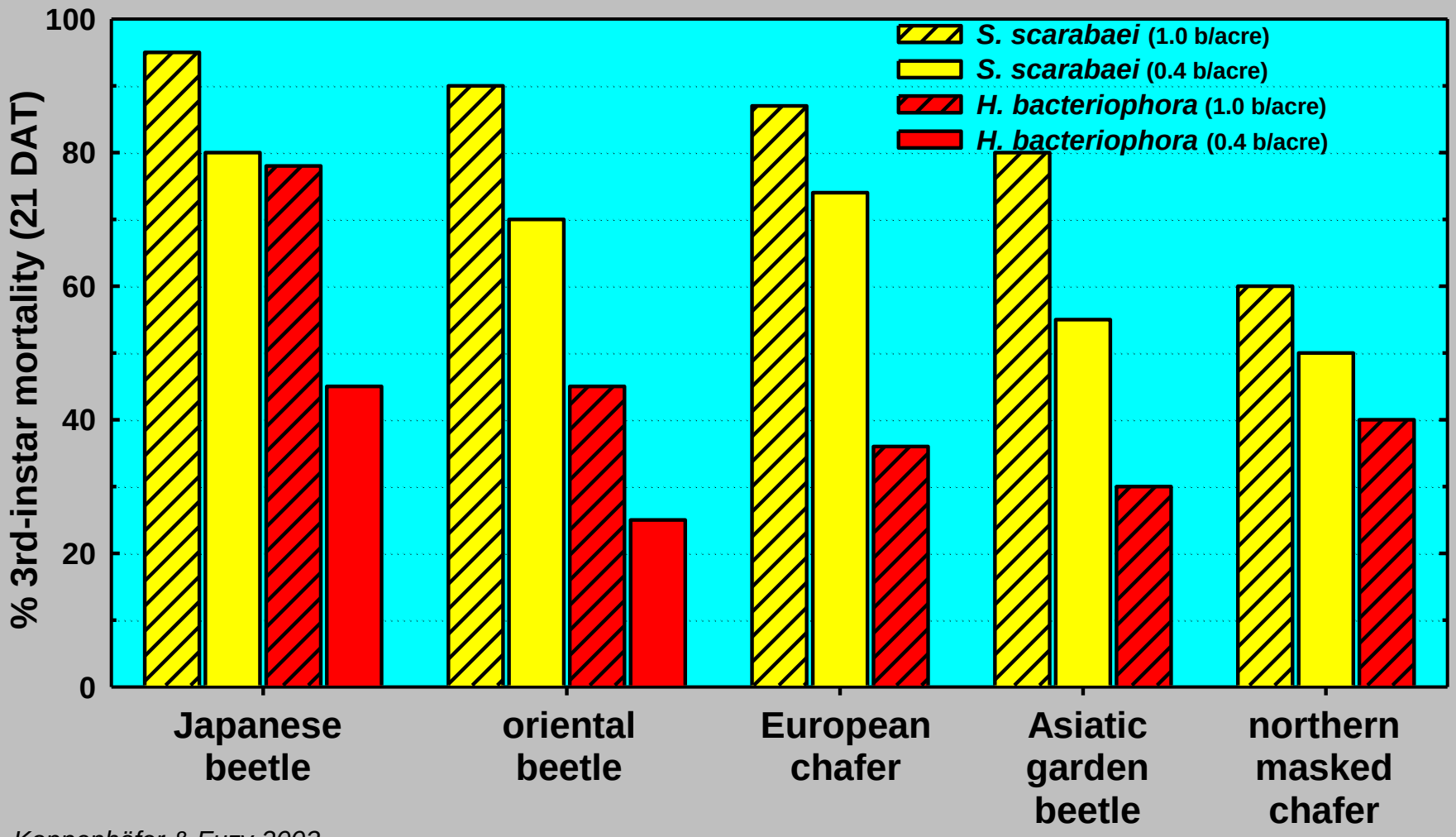
New EPN species for better white grub control

- Presently available nematodes like *Heterorhabditis bacteriophora* are effective against Japanese beetle but less or not against other white grub species.
- *Steinernema scarabaei*, isolated from Japanese and oriental beetle larvae in central NJ, is highly virulent and specific to many white grub species.

White grub species and EPN efficacy

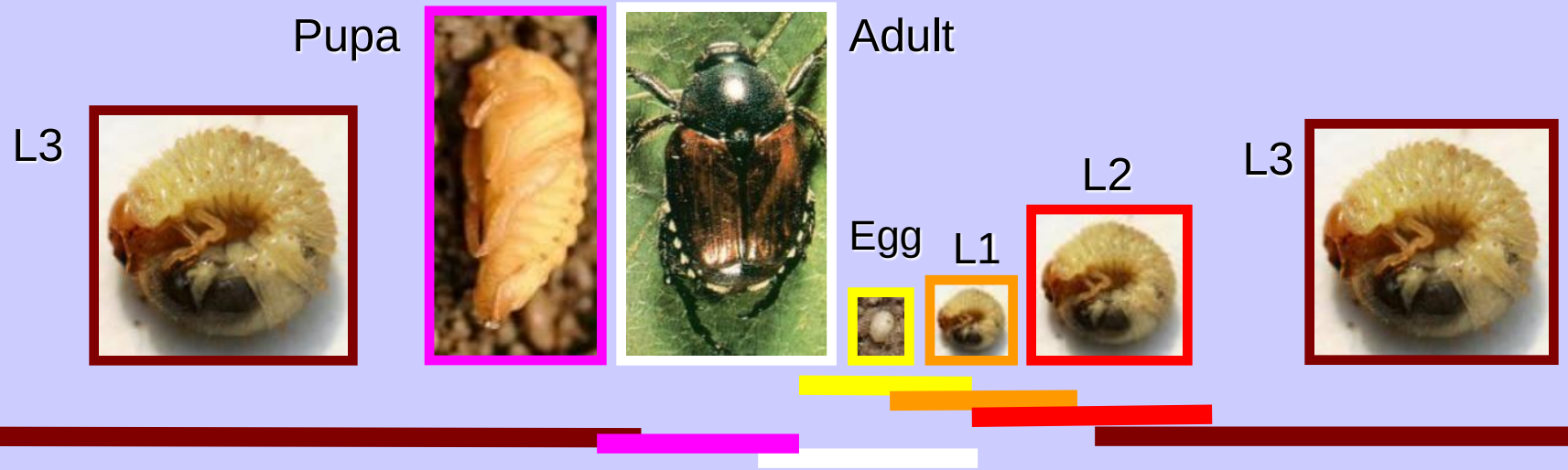
Summary of multiple field experiments

Applications around mid-September



Koppenhöfer & Fuzy 2003
Cappaert & Koppenhöfer 2003

Japanese Beetle Life Cycle (NJ latitude)



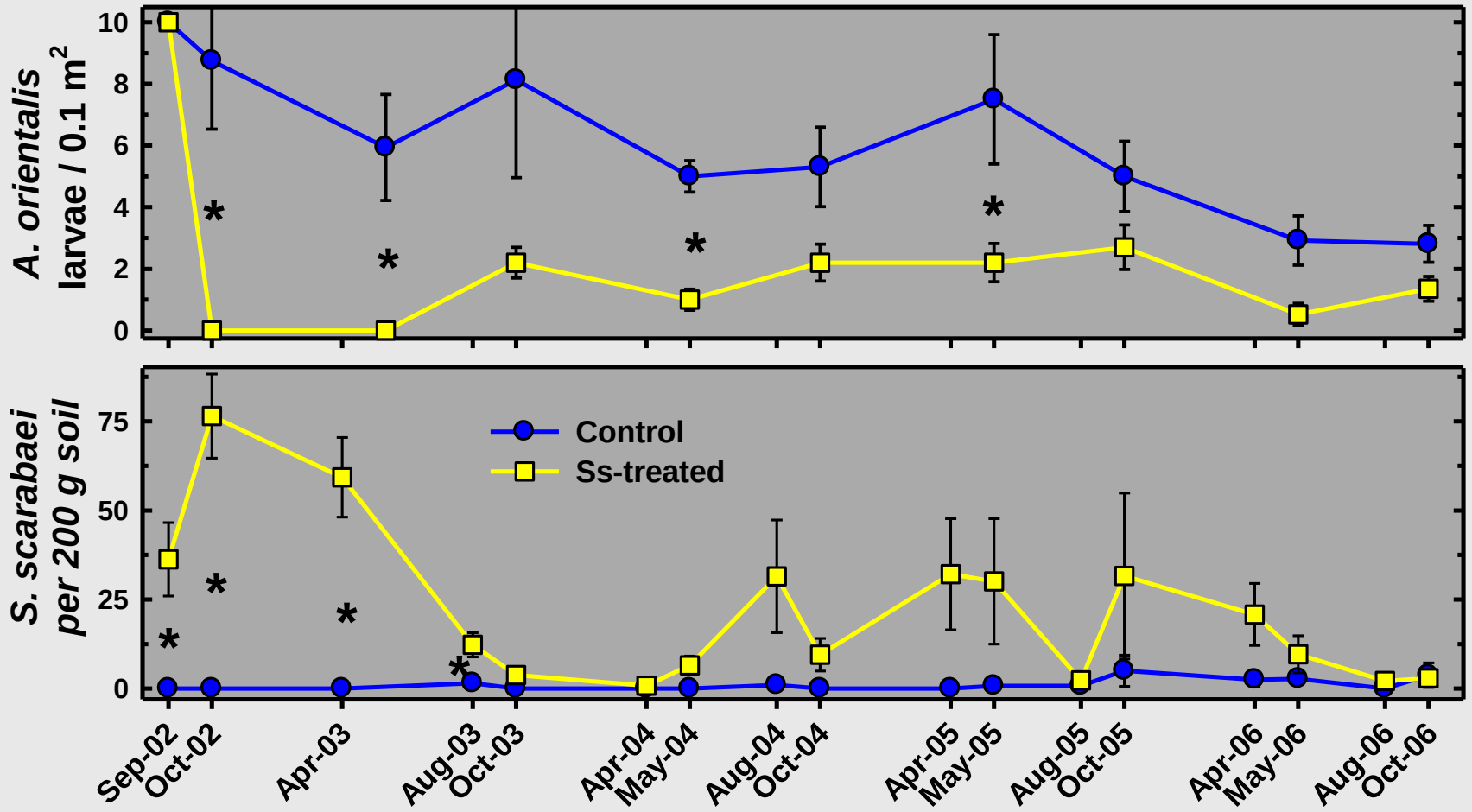
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Nematode: *H. bacteriophora*
Application time: early August to late September
Optimal time: mid-August to early September (target L1+L2)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Nematode: *S. scarabaei*
Application time: mid-August to mid-October / May
Optimal time: late-August to mid-September (target L2+L3)

S. scarabaei long-term Effects



- **Ss: 0.16, 0.4, 1.0 b/ha → nsd → Ss rates combined**
- **Ss suppresses *Ao*; effect becomes variable over time**
- **Ss persists in plots for up to 4 years.**

Koppenhöfer & Fuzy 2009

Long-term suppression of oriental beetle in turfgrass by *S. scarabaei*

Field experiments (16 ft^2 microplots, 10 L3/ft^2)

Ss rate* (× b/acre)	Months after *S. scarabaei*-Application						
	1 (Oct)	8 (May)	13 (Oct)	20 (May)	25 (Oct)	32 (May)	37 (Oct)
0.16 – 1.0	86-100	96-100	62-92	69-94	0-94	63-100	0-64
0.04 – 0.1	50-77	86-100	76-77	93-95	33-50	67-83	55-88

*Standard application rate for EPN: 1 billion per acre

Koppenhöfer & Fuzy 2009

Biorational Controls

Organic Options

Minimum Risk Insecticides

“Minimum-risk” pesticides (EPA)

- http://www.epa.gov/oppbppd1/biopesticides/regtools/25b_list.htm
- Special class of pesticides not subject of federal registration requirements because ingredients are safe for intended use → FIFRA 25(b) Exemption
- Active ingredients must be on list.
- Inert ingredients on List 4A “Inert Ingredients of Minimal Concern”

Actives exempt under 25(b) FIRFA

Castor oil	Dried blood	Peppermint (oil)
Cedar oil	Eugenol	Potassium sorbate
Cinnamon (oil)	Garlic (oil)	Rosemary (oil)
Citric acid	Geraniol	Sesame (oil)
Citronella (oil)	Geranium oil	Sodium chloride
Cloves (oil)	Lemongrass oil	Soybean (oil)
Corn gluten meal	Linseed oil	Thyme (oil)
Corn (oil)	Malic acid	White pepper
Cotton seed (oil)	Mint (oil)	Zinc metal strips
(Sodium) Lauryl sulfate	2-Phenethyl propionate	Putrescent whole egg solids

“Minimum-risk” pesticides (EPA)

→ **No efficacy data required !!!** (except for public health pests)

- May result in products that make wide-reaching control claims with little to no reliable efficacy data behind them.

→Check with University / Extension personnel if control claims are well-founded and reliable.

→Check with experienced well-respected peers

"Low Impact" Pesticides

(NJ School IPM Law)

- http://www.nj.gov/dep/enforcement/pcp/ipm-lowimpact.htm
- Gel, paste, bait formulations
- Botanical insecticides (not synthetic) (e.g., pyrethrins, neem oil)
- Microbe-based insecticides (e.g., *Bt*, *Pp*)
- Biological (i.e., living organisms) (e.g., insect-pathogenic nematodes / fungi / bacteria / viruses)

“Least Toxic” Pest Control Products

- http://www.birc.org/Directory.htm
- The IPM Practitioner’s 2015 Directory of Least-Toxic Pest Control Products
- > 2000 products by > 600 suppliers.
- compiled by IPM technical experts
- includes specific product descriptions

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Turf Insect Fact Sheets

http://njaes.rutgers.edu/pubs/

→ Gardening and landscaping → 'Lawns' or 'All gardening and landscaping fact sheets.'

FS1007 - sod webworms

FS1008 - hairy chinch bug

FS1009 - white grubs

FS1013 - black cutworm

FS1014 – nematodes (plant-parasitic)

FS1015 - billbugs

FS1016 - annual bluegrass weevil (Hyperodes)

FS013 - ants

FS0025 - moles

My Rutgers Entomology Webpage:

http://entomology.rutgers.edu/personnel/albrecht-koppenhofer/

→ Extension presentations

→ Extension publications

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Turf Insect Literature

Niemczyk H.D., Shetlar D.J. 2000. Destructive turf insects, 2nd edition. H.D.N. Books. 148pp.

Vittum P.J., Villani M.G., Tashiro H. 1999. Turfgrass insects of the United States and Canada. Cornell University Press. 496pp.

Potter D.A. 1998. Destructive turfgrass insects. Ann Arbor Press. 344pp.

Brandenburg R.L., Freeman C.P. 2012. Handbook of turfgrass insect pests, 2nd edn. Entomological Society of America. 136pp.

Watschke T.L., Dernoeden P.H., Shetlar D.J. 1994. Managing turfgrass pest. Lewis Publishers. 361pp.