# Collegiate Turf Bowl Competition Study Guide

*GCSAA would like to thank Leah Brilman, Ph.D., turfgrass product manager DLF USA; Gwen Stahnke, Ph.D.; Chrissie Segars, Ph.D., research scientist at PBI-Gordon Corporation; and Emily Braithwaite, doctoral student at Oregon State University, facilitators of the Turf Bowl, for their work updating and modifying the exam each year.*

The 2027 Turf Bowl Competition will consist of a single exam that will be administered electronically. It will include multiple choice questions covering the areas of study listed in this study guide and the physical and visual identification of samples. The top 10 teams will earn prizes.

## Eligibility

To participate in the GCSAA Collegiate Turf Bowl Competition, students must meet all the following eligibility criteria:

- Must be currently enrolled in a turf program or have graduated at the end of the most recent fall semester but have not
- yet entered a graduate program
- Be an active Student member with GCSAA
- Be a registered attendee at the GCSAA Education Conference and Golf Industry Show

## Important Dates

- December 23, 2026
    - Team rosters with captains identified and submitted via the registration form or emailed to Erin Wolfram, ewolfram@gcsaa.org.
- January 20, 2027
    - Turf Bowl Breakfast – 7:30 – 8:15 a.m. The Great Hall B & C
    - Turf Bowl Exam – 9:00 a.m. – 12:00 p.m. The Great Hall A & D
    - John Deere Booth Meet and Greet - 3:00 - 4:00 p.m., Trade Show Floor (booth #2719)
- January 21, 2027
    - Results announced at GCSAA Closing Session 1:15 – 2:30 pm LaNouevelle Ballroom (2nd level)

## Areas of Study

### Turfgrass Identification

- Identify turf specimens by their common names or traits.
- Know common name vs. scientific name.
- Identify seed of turfgrass species
- For specific turfgrass species, please see Addendum 1.

### Turfgrass Growth and Development

- Identify parts of the grass plant.
- Know management and environmental factors that influence growth.
- Understand turfgrass physiology and how it is influenced by management practices.
- Understand plant growth regulators – Use and influence on biology
- Clipping Volume on putting greens – measurement and use

### Turfgrass Soils and Soil Fertility

- Know greens construction, particle sizes, soils and fertility.
- Know of macronutrients and micronutrients, and their influence on growth.
- Soil types and classification
- Read and interpret a soil report
- Organic matter measurements – types and use

### Weed Identification and Control

- Identify common weeds. Note: Any turfgrasses on list can also be weeds.
- Know herbicides, what weeds they control and mode of action.
- Know the life cycle of
- weeds and how management influences weed growth.
- Know seed labeling for crops and weeds.
- For specific weeds, please see Addendum 2.

### Turfgrass Diseases

- Identify common diseases.
- Know environmental and management conditions, and the types of diseases that the conditions favor.
- Know common fungicides.
- Know grass species corresponding to various diseases.
- Nematodes and various Abiotic stresses may be under Diseases
- For specific diseases and nematodes, please see Addendum 3.

## Turfgrass Mathematics

- Calculate application rates of chemicals and fertilizers.
- Know quantities of sand and seed to use.
- Know how to correctly calibrate application equipment.
- Know how to use both the Metric and English units in calculations.

## Turfgrass Insects

- Identify photos of larval and adult forms of insects that attack turf.
- Know life cycles, preferred foods, feeding methods and other characteristics important in controlling insects.
- For specific insects, please see Addendum 4.

## Irrigation

- Know how to evaluate turfgrass water needs and adjust various irrigation methods and rates accordingly to ensure the efficiency and effectiveness of the irrigation system.
- Calculate water usage.
- Know the basics of using reclaimed water for irrigation.

## Water Management

- Understand how turfgrasses process water, including transpiration.
- Understand water terminology
- Know the symptoms of water stress in various turfgrasses and how to remedy.
- Know the causes of pesticide and nutrient runoff and how to prevent.
- Understand wetting agents – causes of Localized Dry Spot (LDS)

## New technology

- Robot mowers – types and uses, benefits and problems
- Sprayers with GPS, Computers
- Use of GS3 ball to improve greens – what do the numbers mean
- Moisture measurement- inground and portable measurement devices
- Irrigation Controllers
- Use of drones on golf course – potential to improve management

## Resources

The following resources, along with GCSAA's monthly publication *Golf Course Management* magazine, are recommended as study resources. The textbooks may be available through your school library, local bookstore or through the **GCSAA Store online at** https://www.gcsaastore.com/ **.**

1. **The Mathematics of Turfgrass Maintenance** (*3rd Edition*) – Michael Agnew and Nick Christians
2. **Mathematics for the Green Industry: Essential Calculations for Horticulture and Landscaping Professionals -** Michael Agnew, Nancy Agnew, Ann Marie VanDerZanden and Nick Christians
3. **Turfgrass Management** (*Edition 1.0*) – A.J. Turgeon and J.E. Kaminski, https://turfpath.com/book/
4. **Fundamentals of Turfgrass Management** *(5th Edition)* – Nick Christians
5. **Turf Management for Golf Courses** (*2nd Edition*) – James B. Beard
6. **Salt-Affected Turfgrass Sites: Assessment and Management** – R.N. Carrow and R.R. Duncan
7. **Managing Turfgrass Pests** *(2nd Edition)* **–** Thomas L. Watschke, Peter H. Dernoden and David J. Shetlar
8. **Controlling Turfgrass Pests** (*3rd Edition*) – Thomas W. Fermanian, Malcom C. Shurtleff, Roscoe Randell, Henry T. Wilkinson and Philip L. Nixon
9. **Creeping Bentgrass Management: Summer Stresses, Weeds and Selected Maladies** *(2nd Edition)* – Peter H. Dernoden
10. **Human Resource Management for Golf Course Superintendents, ch. 6** – Bob Milligan and Tom Maloney
11. **Superintendents Handbook of Financial Management** *(Revised Edition)***, ch. 2, 3, 5, and 9** – Ray Schmidgall
12. **The Turf Problem Solver: Case Studies and Solutions for Environmental, Cultural and Pest Problems** – A.J. Turgeon and J.M. Jr. Vargas (Dec. 2, 2005)
13. **Identifying Turf and Weedy Grasses of the Northern United States** – D. Pedersen and T. Voight Illinois Pocket ID series University of Illinois Extension https://pubsplus.illinois.edu/collections/gardening/products/identifying-turf-weedy-grasses-of-northern-us
14. **Turfgrass Insects of the United States and Canada** *(3rd Edition)* **–** Patricia J. Vittum

15. **Turfgrass Identification** (vernation)- David Gardner, The Ohio State University buckeyeturf.osu.edu/pdf/01_turfgrass_identification.pdf
16. **Handbook of Turfgrass Insects** (2nd Edition) – Edited by Rick L. Brandenburg and Callie P. Freeman, 2012
17. **A Practical Guide to Turfgrass Fungicides** (2nd Edition) by Richard Latin, 2021
18. **Compendium of Turfgrass Diseases** (4th Edition) – Edited by Lane P. Tredway, Maria Tomaso-Peterson, James P. Kerns, and Bruce B. Clarke, 2023
19. Best Management Practices for Turfgrass Water Conservation https://extension.uga.edu/about/our-impact/impact-stories/impact-brief/2253/bmps-for-turfgrass-water-conservation.html
20. Best Management Practices: Planning Guide & Template – GCSAA https://www.gcsaa.org/docs/default-source/environment/bmp-planning-guide_2023_print_final.pdf?sfvrsn=f174c03e_1
21. Golf Course Environmental Profile https://www.gcsaa.org/what-we-do/environmental-stewardship/golf-course-environmental-profile
22. **Golf Turf Management** – L.B. (Bert) McCarty, 2018
23. **Practical Golf Course Maintenance**: **The Art of Greenkeeping** *(4th Edition)* – Michael Bavier, CGCS Retired, and Luke Cella, CGCS
24. Nematode Management For Golf Courses In Florida – William T. Crow https://edis.ifas.ufl.edu/publication/IN124
25. Guide for Interpreting Nematode Assay Results – University of Georgia Extension https://extension.uga.edu/publications/detail.html?number=C834&title=guide-for-interpreting-nematode-assay-results
26. Key to the Most Common Genera of Plant-Parasitic Nematode (located at the end of the Turf Bowl Study Guide)
27. Pacific Shoot-Gall Nematode *Anguina pacificae* – University of Florida Extension (located at the end of the Turf Bowl Study Guide)
28. Robotic Mowers - https://doi.org/10.1002/csc2.70081
29. GS3 – Understanding the numbers https://www.usga.org/content/usga/home-page/course-care/green-section-record/62/issue-22/gs3--understanding-the-numbers.html

30. Moisture Meters – How they work and How to get best out of them
    https://www.usga.org/content/usga/home-page/course-care/green-section-record/63/issue-15/moisture-meters--how-they-work-and-how-to-get-the-best-data-from.html
31. Are you managing Organic Matter or is it managing you.
    https://www.usga.org/content/usga/home-page/course-care/green-section-record/62/issue-22/are-you-managing-putting-green-organic-matter-or-is-it-managing-.html

## Addendum 1

### Cool Season Grasses

| Common name | Scientific name |
|---|---|
| 1. Kentucky bluegrass | *Poa pratensis* |
| 2. Perennial ryegrass | *Lolium perenne* |
| 3. Tall fescue | *Festuca arundinacea = Schedonorus arundinaceus = Lolium arundinaceum* |
| 4. Hard fescue | *Festuca brevipila (F. trachyphylla)* |
| 5. Chewings fescue | *Festuca rubra* ssp. *commutata (*ssp*. fallax)* |
| 6. Creeping bentgrass | *Agrostis stolonifera* |
| 7. Colonial bentgrass | *Agrostis capillaris* |
| 8. Strong creeping red fescue | *Festuca rubra* ssp. *rubra* |
| 9. Slender creeping red fescue | *Festuca rubra ssp. littoralis* |
| 10. Velvet bentgrass | *Agrostis canina* |
| 11. Rough bluegrass | *Poa trivialis* |
| 12. Annual bluegrass | *Poa annua* |
| 13. Annual ryegrass | *Lolium multiflorum* |

### Warm Season grasses

| | |
|---|---|
| 14. Japanese / Korean lawngrass | *Zoysia japonica* |
| 15. Manilla grass | *Zoysia matrella* |
| 16. Hybrid bermudagrass | *Cynodon dactylon* X *C. transvaalensis* |

| | |
|---|---|
| 17. Common bermudagrass | *Cynodon dactylon var. dactylon* |
| 18. Centipedegrass | *Eremechloa ophiuroides* |
| 19. Seashore paspalum | *Paspalum vaginatum* |
| 20. Buffalograss | *Bouteloua dactyloides* |
| 21. St. Augustinegrass | *Stenotaphrum secundatum* |
| 22. Kikuyugrass | *Pennisetum clandestinum* |

| | |
|---|---|
| 23. Bahiagrass | *Paspalum notatum* |
| 24. Carpetgrass | *Axonopus affinis* |
| 24. Blue grama | *Bouteloua gracilis* |
| 25. Sideoats grama | *Bouteloua curtipendula* |

## Addendum 2

**Weeds**

| | |
|---|---|
| Alkaligrass | *Puccinella distans* |
| Barnyardgrass / Watergrass | *Echinochloa crus-galli* |
| Bedstraw / Catchweed | *Galium aparine* |
| Bindweed, Field | *Convolvulus arvensis* |
| Brassbuttons, Souther | *Cotula australis* |
| Buttonweed, Virginia | *Diodia virginia* |
| Carpetweed | *Mollugo verticillata* |
| Carrot, Wild | *Daucus carota* |
| Chess, Soft | *Bromus hordeaceus* |
| Chickweed, Common | *Stellaria media* |
| Chickweed, Mouseear | *Cerastium vulgatum* |
| Chicory | *Cichorium intybus* |
| Clover, White | *Trifolium repens* |
| Crabgrass, Hairy (Large) | *Digitaria sanguinalis* |
| Crabgrass, Smooth | *Digitaria ischaemum* |
| Cudweed, purple | *Gnaphalium purpureum* |
| Dallisgrass (smooth paspalum) | *Paspalum dilatatum* |
| Dandelion, False /spotted catsear | *Hypochoeris radicata* |
| Dandelion | *Taraxacum officinale* |
| Dichondra | *Dichondra repens* |
| Dock, Curly | *Rumex crispus* |
| Downy Brome / cheatgrass | *Bromus tectorum* |
| English Daisy | *Bellis perennis* |
| Foxtail, Yellow (pigeon / bristle grass) | *Setaria glauca (pumilla ssp pumilla)* |
| Foxtail , Green | *Setaria viridis* |
| Garlic , Wild | *Allium vineale* |
| Geranium, Carolina / dovefoot | *Geranium ssp.* |
| Goosegrass/Silver Crab/ Crowfoot | *Elusine indica* |
| Ground Ivy (Creeping Charlie/Jenny) | *Glechoma hederacea* |
| Hawkweed | *Hieracium pratense* |
| Henbit | *Lamium amplexicaule* |
| Johnsongrass | *Sorghum halapense* |
| Khaki weed | *Alternanthera pungens* |

| | |
|---|---|
| Kikuyugrass | *Pennisetum clandestinum* |
| Knotweed, Prostrate / Common | *Polygonum aviculare* |
| Kochia | *Kochia scoparia* |
| Kyllinga, Annual / Fragrant | *Kyllinga odorata* |
| Kyllinga, Green / Perennial | *Kyllinga brevifolia* |
| Lambsquarter | *Chenopodium album* |
| Lettuce, Prickly | *Lactuca serriola* |
| Mallow, Common | *Malva neglecta* |
| Medic, Black | *Medicago lupulina* |
| Medic, Burr/Burr Clover | *Medicago polynorpha* |
| Moss, silvery thread | *Bryum argenteum* |
| Mullein, Common | *Verbascum thapsus* |
| Nimblewill | *Muhlenbergia schreberi* |
| Nutsedge, Purple | *Cyperus rotundus* |
| Nutsedge, Yellow | *Cyperus esculentus* |
| Oats, Wild | *Avena fatua* |
| Orchardgrass | *Dactylis glomerata* |
| Pearlwort | *Sagina apetala (procumbens)* |
| Pennywort / dollarweed | *Hydrocotyle umbellate* |
| Peppergrass / pepperweed | *Lepidium virginicum* |
| Pigweed, Prostrate | *Amaranthus blitoides* |
| Pineapple Weed / wild chamomile | *Matricaria discoidea* |
| Plaintain, Broadleaf | *Plantago major* |
| Plantain, Buckhorn / Narrowleaf | *Plantago lanceolata* |
| Puncture Vine / goatshead | *Tribulus terrestris* |
| Purslane, common | *Portulaca oleracea* |
| Quackgrass | *Elytrigia repens* |
| Rattail fescue | *Vulpia myuros* |
| Redtop | *Agrostis gigantean (alba)* |
| Salsify, Western | *Tragopogon dubius* |
| Sandbur/ grassbur | *Cenchrus incertus* |
| Sedge, Annual | *Cyperus compressus* |
| Shepherd's Purse | *Capsella bursa-pastoris* |
| Signalgrass | *Urochloa subquadripara* |
| Smartweed, Spotted (Ladysthumb) | *Polygonum persicaria* |
| Smutgrass | *Sporobolus indicus* |
| Sorrell, Red / Sheeps | *Rumex acetosella* |
| Speedwell, creeping | *Veronica filiformis* |
| Spurge, Prostrate / Spotted | *Chamaesyce maculata (Euphorbia)* |
| Star of Bethlehem | *Ornithogalum umbellatum* |
| Strawberry, Wild | *Fragaria virginiana* |

| | |
|---|---|
| Swinecress | *Coronopus didymus* |
| Timothy | *Phleum pratense* |
| Thistle, Bull | *Cirsium vulgare* |
| Thistle, Canada | *Cirsium arvense* |
| Thistle, Musk | *Carduus nutans* |
| Torpedograss | *Panicum repens* |
| Velvetgrass, German | *Holcus mollis* |
| Violet | *Viola ssp.* |
| Woodsorrel, Creeping | *Oxalis corniculata* |
| Woodsorrel, Yellow (Oxalis) | *Oxalis stricta* |
| Yarrow | *Achillea millefolium* |
| Yellowcress | *Rorippa palustris* |

## Addendum 3

**Bacterial Diseases**

| | |
|---|---|
| Bacterial wilt | *Xanthomonas translucens* |
| Bacterial etiolation and decline | *Acidovorax avenae* |

**Fungal Diseases**

| | |
|---|---|
| Anthracnose | *Colletotrichum cereale, C. eremochloae* |
| Ascochyta leaf blight | *Ascochyta avenae* |
| Bermudagrass decline | See Root decline of warm-season grasses |
| Blister smut | *Jamesdicksonia dactylidis* |
| Brown patch **(**C3) & large patch (C4) | *Rhizoctonia solani* |
| Brown ring patch | *Waitea circinata* var. *circinata* |
| Brown stripe | *Mycosphaerella recutita* |
| Cladosporium eyespot | *Cladosporium phlei* |
| Copper spot | *Gloeocercospora sorghi* |
| Coprinus snow mold | *Coprinopsis psychromorbida* |
| Crown rust | *Puccinia coronata* |
| Curvularia blight | multiple *Curvularia sp.* |
| Dead spot | *Ophiosphaerella agrostis* |
| Dollar spot | *Clarireedia* is new genus<br>*Clarireedia homeocarpa* on *Festuca rubra,* UK only<br>*Clarireedia bennettii* on mostly cool season grasses, UK, Netherlands, USA<br>*Clarireedia monteithiana* on Warm-season grasses; found worldwide<br>*Clarireedia jacksonii* on cool-season grasses; found worldwide |
| Drechslera leaf spots and melting-out | multiple *Drechslera* and *Marielliottia sp.* |

| | |
|---|---|
| Endophytic fungi | *Neotyphodium coenophialum, N. lolii, Epichloe typhina* |
| Fairy ring | Species of Agraricales and Gastromycetales, mostly in the genera *Agaricus, Calvatia, Chlorophyllum, Clitocybe, Lepiota, Lycoperdon, Marasmius, Scleroderma*, and *Tricholoma*. |
| Flag smut | *Urocystis agropyri* |
| Gray leaf spot | *Pyricularia grisea* |
| Gray snow mold | *Typhula incarnata* |
| Leaf and sheath spot (Mini-ring) | *Waitea circinata var. zeae, W. circinata var. oryzae* |
| Leaf rust | *Puccinia brachypodii* |
| Leptosphaerulina leaf blight | *Leptosphaerulina trifolii* |
| Mastigosporium leaf spot (leaf fleck) | *Mastigosporium rubricosum* |
| Microdochium patch | *Microdochium nivale* |
| Necrotic ring spot | *Ophiosphaerella korrae* |
| Phyllosticta leaf blight | Multiple species of *Phyllosticta* and *Guignardia* |
| Physoderma leaf spot and leaf streak | *Physoderma graminis* |
| Pink patch and cream leaf blight | *Limonomyces roseipellis* |
| Pink snow mold | See Microdochium patch |
| Powdery mildew | *Blumeria graminis* |
| Pythium foliar blight | *Pythium aphanidermatum*, *P. graminicola*, *P. ultimum, Several other Pythium species* |
| Pythium root and crown rot | *Pythium aristosporum*, *P. arrhenomanes*, *Pythium volutum, several other Pythium species* |
| Pythium root dysfunction: | *Pythium volutum*, *P. arrhenomanes*, *P. aristosporum, several other Pythium species* |
| Rapid blight | *Labyrinthula terrestris* |
| Red thread | *Laetisaria fuciformis* |
| Root decline of warm-season grasses | *Gaeumannomyces graminis* var. *graminis, Magnaporthiopsis incrustans, G. wongoonoo* |
| Septoria leaf spot | several *Septoria* species |
| Snow scald | *Sclerotinia borealis* |
| Southern blight | *Athelia rolfsii* |
| Speckled snow mold | *Typhula ishikariensis* |
| Spring dead spot | *Ophiosphaerella narmari, O. korrae, O.herpotricha* |
| Stem rust | *Puccinia graminis* |
| Stripe rust | *Puccinia striiformis* |
| Stripe smut | *Ustilago striiformis* |
| Summer patch | *Magnaporthiopsis poae* |
| Take-all patch | *Gaeumannomyces graminis* |
| Tar spot | *Phyllachora* spp. |

| | |
|---|---|
| Thatch collapse | *Sphaerobollus stellatus* |
| Yellow patch | *Rhizoctonia cerealis* |
| Yellow tuft | *Sclerophthora macrospora* . |
| Yellow ring | *Trechispora alnicola* |

**Nematodes, Parasitic**

Awl**:** *Dolichodorus* spp. Cobb
Cyst**:** *Heterodera* spp. Schmidt
Dagger**:** *Xiphinema* spp. Cobb
Lance**:** *Hoplolaimus* spp. Daday
Lesion**:** *Pratylenchus* spp. Filipjev
Needle**:** *Longidorus* spp. (Micoletzky) Thorne & Swanger
Pacific Shoot Gall: Anguina pacifica
Pin**:** Paratylenchus spp.
Pseudo-root knot**:** *Hypsoperine* spp. Sledge & Golden
Ring**:** Criconemella, Criconemoides, *Macroposthonia,* and *Mesocriconema* spp.
Root gall**:** *Subanguina* spp.
Root knot**:** *Meloidogyne* spp. Goeldi
Sheath**:** *Hemicycliophora* spp.
Sheathoid**:** *Hemicriconemoides* spp.
Spiral**:** *Helicotylenchus* spp. Steiner
Sting**:** *Belonolaimus* spp. Steiner
Stubby root**:** *Paratrichodorus* and *Trichodorus* spp.
Stylet or stunt**:** *Tylenchorhynchus* spp. Cobb

**Miscellaneous Diseases or Disorders**

Black Layer**:** A
Anaerobic soil plus blue-green algae and/or sulfate-reducing bacteria
Slime Molds (superficial, not pathogenic)**:**
*Mucilago crustacea*
**:** *Didymium squamulosum*
**:** *Physarum cinereum*.
**:** Species of *Physarum* and *Fuligo*

## Addendum 4:

**Insects**

Annual Bluegrass Weevil

Billbugs

- bluegrass billbug

- hunting billbug
- Denver/Rocky Mountain billbug
- Phoenix billbug

Black Turfgrass Ataenius

Flea Beetle

Chinchbugs

- hairy chinchbug
- southern chinchbug

Craneflies

- European cranefly *(Tipula paludosa)*
- "common" cranefly *(Tipula oleraceae)*

Caterpillars and adults

- armyworm
- black cutworm
- fall armyworm
- winter cutworm
- sod webworm

Mole Crickets

- southern mole cricket
- northern mole cricket
- tawny mole cricket

Ant

- red imported fire ant
- turfgrass ant
- formica ant

White Grubs and Adult Beetles

- Asiatic garden beetle
- European chafer
- Japanese beetle
- masked chafer (southern)
- masked chafer (northern)
- masked chafer (western)

- masked chafer (southwestern)
- sugarcane beetle
- Green June beetle
- May/June beetle
- Oriental beetle

Mites

- Stunt (Bermuda)
- Banks grass

Wasps

- Scoliid
- Cicada Killers
- yellow jacket
- Paper wasp

Two-lined spittlebug

Rhodesgrass Mealybug

Groundpearl (pearl scales)

Wireworm

**Beneficials**

Honey bees

Assassin bugs

Ground beetle

Lacewing

Praying Mantis

Rove beetles

Big Eyed bug

## J(ey to the most common genera of plant-parasiticnematodes

J Styleatbsent..... nonparasiticnematodes
1:. Stylet present: Mainlyplant-parasitic ne□□□□□d□□:·.:·.:::·.:::·.:::::.....□ .....2.
*r''' r,t.Aouvp,>* .

2. fwo-part esophagus, me□1□nbulb absetID odontostyle;.....Dorylaimida .....3
2•]"hree-partesophagus,d1stmtme□acorpuil stomatostyle;.....Tylenchid..a 5.

3. Styletlongs,h·aight; bodylong, slender; very large nematodes;.....Longidorid.a.e.....4
3'. Stylet shortç urved, weak; body short, *thick;.....Trichodorida..e.....Trichodorus Paratrichodorus*

4. Stylet with flangesguiding ring near *base*.....*Xiphinema*
4'.Styletw ithout flanges, guiding ring near *apex* ..... *L.ongidorus*
*,.--•fl..,'l-llt or □ rP?,.., -4&> w□/1*

5. Metacorpus morethan3/4 body width; DGO in metacorpus;.....Aphelenchina.....6.
5'. Metacorpusless than3/4 body width; DGO in procorpus; ..... .....Tylenchina ..... 7.
*-.... fl_»,... '-+vofvt. \J□r,, '?--'□1,.,□.,, b,,111*

6. Female tailblunt, male without bursa; *Aphe!enchidae.:-:r.P□□.□?.□□'!.....Aphelenchus*
6'.Femaletail conoid with mucro, male witho□rsa; .....
*....•••••••••••••••.••.••.....•.....□.□□.: ..□□'.":.....Aphe!enchoida..e .... Aphelenchoides*

7. Procorpuseparated from metacorpus.....8
7'. Procorpus fused with metacorpus; Criconematidae.....21
*(l i..:•'''' I□tt..* .

8. Female vermiform; Tylencho1dea .....9
8'.Female swollen; Heteroderoidea .....9

9. Stylet v□ry l-lo□n>g+; head re•gion d1·st1·11ctly rounded·, .....Belonolaimidae..... 10
9'.Sty1etmoderately Iong to Short..... 11

IO. Tail rounded..... □□f;,□□□;,,....
IO'. Tail pointed.....

I I. Stylet weak; .....Tylenchidae .. !;
11'. Stylet strong;.....

12. Tail subdcu□t□h□e□o□r□,□r□+□-□p□ointed; vulva 1·11 pos□en·or l/J ..... *Dit l Tylenchus*
12'. Tail filiform, more than 6x body width at anus.....

13 Vulvainmu'd'dleof bodY·,..... *Tylenchorhynchidae. Tylenchorhynch1u4s*

13;. Vulva in posterior of body.....
14. Stylet strong;2 ovari•es; female tai•11ess t h n BWA-,.... .Hop lo la i m i n a e 5
14' Stylet relatively strong; head flattened;..... *P r a ty le n c h i n a e..* 18
16
II..... 17
15. Scuteae..... .....
15' Phasmids.....••••••.....••••.....
*Hoplolaimus*
16•. Anterior and posterior to vulva..... ..... *Scutellonema*
16'. Both in anal region..... .

17. entralo erlap;D O > 1/4 stylet *lcngth*..... *1/e/icotylenchus*
*IT*.Dorsabverlap;D O < 1/4 slylet *length*..... *Roty/enchus*

I • Oneo ary; ula po *tcrior*..... *Pratylenchus*
I ••Two ovarie; vuh·a *medial*..... *Radopholus*

19. Body" hite, no cy t, eggs deposited in a *matrix;*.....*Meloidogynidae* .. *Meloidogyne*
19'. Body brown hardcyst, most eggs retained;.....Heteroderidae.....20

20. Round *eys..t*..... *Globodera*
20'. Lemon haped*cyst*.....*!1eterodera*

21. \ itha heath; *Hemicyeliophoridae*.....*Hemicycliophora*
21'. Withouta sheath.....22

22. Female posterior swollen, ex. pore posterior; on *roots; .... Tylenchulidae .Tylenchu/us*
22'.Femaleposterior not swollen..... 23

23. Body short, thick; apparent segmentation; .....Criconematidae ..... 24
23••Female small, slender, vulva posterior, no stylet *in* other stages.....*Paraty/enchus*

24. Cuticular annulations *rounded*..... *Mesocriconema*
24'.Cuticular annulations *serrated* .....*Criconema*

*Source:* ***J.D.*** *Eisenback, ematology Laboral01J1luvestigatio11s (2003)*

| *ObjelA Vl;* | D: o-ler V |
|---|---|
| £-1i<.. | I-1.S |
| 10 | ?-. I .m"' |
| ')o | \ 0 ,,.,., |
| "10 | 0. S,,,,.,, |
| 00 | o•2 .m |

f/M absent

**STYIET**

present

nonparasitic nematodes

parasitic nematodes
(often plant-parasitic)

**MEDIAN BULB**

prominent

absent

**BODY SHAPE**

**BODY SIZE**

small (<I mm)

large(> I mm)

**wollea, saccate**

vennifonn./

- short, c'urved stylet

long, straight stylet

*Me/oidogyne*
*Heterodera*
*Globodera*

*Paratrichodorus*
*Trichodorus*

**ANNULATIONS**

**STYLET FLANGES**

disinct

(apparent segmentations)

nondistinot

*Xiphinema*

*Longidorus*

*Mesocriconema*

**TAIL SHAPE**

pointed

blunt

**STYLET KNOBS**

present

absent

**BODY SIZE**

large(>I mm)

small (<Imm)

*Belonolaius*
*Hoplolaimus*
*Scutel/onema*

*Aphelenchus*

*Ditylenchus*
*Hemicyc/iophora*

*Paratylenchus*
*Pratylenchus*
*Radopholus*

UF IFAS Extension UNIVERSITY of FLORIDA

EENY-785

https://doi.org/10.32473/edis-IN1361-2022

# Pacific Shoot-Gall Nematode *Anguina pacificae* (Cid Del Prado Vera and Maggenti, 1984) (Nematoda: Rhabditida: Anguinidae)[1]

Christian Kammerer and William T. Crow[2]

*The Featured Creatures collection provides in-depth profiles of insects, nematodes, arachnids and other organisms relevant to Florida. These profiles are intended for the use of interested laypersons with some knowledge of biology as well as academic audiences.*

## Introduction

The nematode *Anguina pacificae*, commonly known as the Pacific shoot-gall nematode (Figure 1), is a major pathogen on annual bluegrass (*Poa annua)* in the Pacific region of the United States (McClure et al., 2008; Westerdahl et al., 2004). The family Anguinidae is made up of both fungal feeding nematodes and plant parasitic nematodes. Plant-parasitic genera in the Anguinidae include certain species of *Anguina, Subanguina,* and *Ditylenchus*. Unlike most other plant-parasitic nematodes, many species in this family feed on, and cause malformation of, aboveground plant parts (seeds, stems, etc.). Notable turfgrass pests in this group are the root gall nematode (*Subanguina radicicola*), the bentgrass nematode (*Anguina agrostis*) and the Pacific shoot-gall nematode *Anguina pacificae*. *Anguina pacificae* feeds on the stem of *Poa annua,* causing stem galls. *Anguina pacificae* is primarily an issue on golf courses where *Poa* is used as a turfgrass for putting greens, primarily in northern coastal California and Ireland. They cause chlorotic and necrotic spots that coalesce and enlarge over time, creating an inconsistent and unsightly putting surface (Figures 5 and 6).



Figure 1. A second-stage juvenile Pacific Shoot-gall nematode *Anguina pacificae*.
Credits: C. L. Kammerer, University of Florida

1. This document is EENY-785, one of a series of the Entomology and Nematology Department, UF/IFAS Extension. Original publication date April 2022. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication. This document is also available on the Featured Creatures website at http://entnemdept.ufl.edu/creatures/.

2. Christian Kammerer, graduate student; and William T. Crow, professor; Entomology and Nematology Department, UF/IFAS Extension, Gainesville, FL 32611.

The Institute of Food and Agricultural Sciences (IFAS) is an Equal Opportunity Institution authorized to provide research, educational information and other services only to individuals and institutions that function with non-discrimination with respect to race, creed, color, religion, age, disability, sex, sexual orientation, marital status, national origin, political opinions or affiliations. For more information on obtaining other UF/IFAS Extension publications, contact your county's UF/IFAS Extension office. U.S. Department of Agriculture, UF/IFAS Extension Service, University of Florida, IFAS, Florida A & M University Cooperative Extension Program, and Boards of County Commissioners Cooperating. Andra Johnson, dean for UF/IFAS Extension.

## Distribution

*Anguina pacificae* has a limited distribution, favoring damp, cooler climates with temperatures around 12°C to 14°C (53°F to 57°F). *Anguina pacificae* was first reported in northern California in close proximity to the Pacific coast (Cid Del Prado Vera and Maggenti, 1984). Subsequent surveys have found them only in golf courses in a narrow band along California's northern Pacific coast. The first, and so far only, confirmed report of *Anguina pacificae* outside of North America is in Ireland (Fleming et al., 2015). It is believed that *Anguina pacificae* was introduced to Ireland from California on contaminated golf course equipment.

## Life Cycle and Biology

The life cycle of *Anguina pacificae* was thoroughly documented by McClure et al. (2008), which is the source for most of the information below. The second-stage juvenile (J2) of *Anguina pacificae* (Figure 1) is the life stage that hatches from the egg and is the infective stage. The J2 crawl up the stem of the bluegrass plant in a film of water; this is thought to be one of the reasons this nematode is prevalent in damp regions. The J2 then enter the leaf sheath, and crawl downward within the sheath to the stem base or crown. Generally multiple nematodes enter a single crown. They enter the crown tissue and manipulate the plant cells in a way that a gall starts to form around them as they feed. Within the gall the nematodes molt into third-stage juveniles, then fourth-stage juveniles, and finally into adults. Because *Anguina pacificae* reproduces sexually by amphimixes, adults are either male or female and both sexes are required for reproduction to occur. While only one male and one female adult would be needed for reproduction, it has been noted that multiple adults of both sexes have been found in a single gall. After mating, the female *Anguina pacificae* (Figure 2) begins laying eggs, usually 1000 or more, within the gall. As the eggs hatch, the gall will contain eggs, juveniles, and adults at the same time (Figure 3). After 36 days or so post infection the females die, leaving eggs and juveniles behind. Around 80 days after infection the gall begins to rot and the J2 leave the gall to search for a new host. As the gall rots, the aboveground portion of the plant dies, causing chlorotic and later necrotic patches on the turf surface (Figure 6). When there is a lack of water, J2 are able to enter an anhydrobiotic state until sufficient moisture is present to resume nematode activity. In anhydrobiosis the nematodes can remain in a state of dormancy for up to 17 months and be readily moved on contaminated equipment.



Figure 2. An adult female *Anguina pacificae* with eggs.
Credits: A. Habteweld, University of Florida

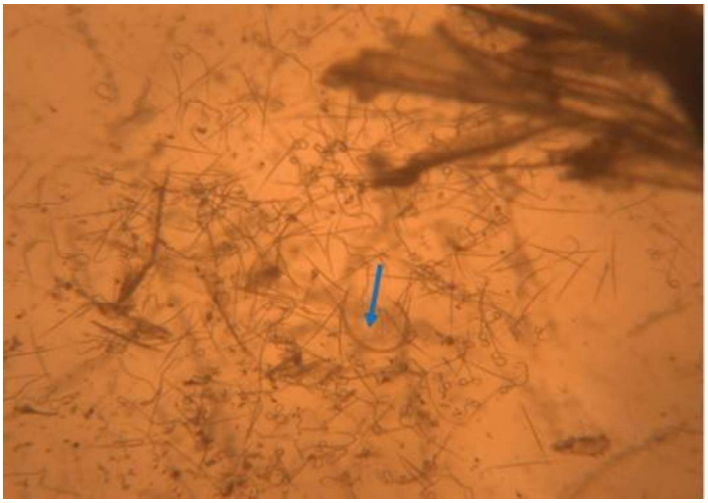

Figure 3. Contents from ruptured *Anguina pacificae* gall including juveniles and adults. The blue arrow points to an adult. All the smaller nematodes present are juveniles.
Credits: C. L. Kammerer, University of Florida

## Symptoms and Diagnosis

The major indicator of *Anguina pacificae* on an individual plant is an enlarged crown or gall (Figures 4 and 5). The most characteristic turf symptom of *Anguina pacificae* are yellow patches that vary in size and shape (Figure 6). These patches will eventually become brown in color (Figure 7). Over time these patches coalesce and become larger. These larger patches can culminate in an uneven putting surface caused by a loss of turf (Fleming et al., 2015).

The easiest and most accurate way to diagnose *Anguina pacificae* is to look for stem galls on symptomatic plant tissue, and then mechanically rupture the galls and look for the nematodes within (Figures 3 and 4). For general *Anguina pacificae* assessment, pre-infective J2 can be found in soil and be detected in a typical soil nematode assay. However, for more accurate population density assessment, the UF Nematode Assay Lab recommends incubating turf plugs using a modified Baermann bowl extraction method.



Figure 4. Visible swelling in the crown of *Poa annua* indicating a gall caused by *Anguina pacificae*.
Credits: C. L. Kammerer, University of Florida



Figure 5. Galls present on cores from *Poa annua* putting greens. Red arrow points to gall on crown.
Credits: C. L. Kammerer, University of Florida



Figure 6. Yellow patches characteristic of *Anguina pacificae* on *Poa annua*.
Credits: M. M. Mahady, Mark M. Mahady and Associates, Inc.



Figure 7. With advanced-stage damage caused by *Anguina pacificae* patches become necrotic.
Credits: M. M. Mahady, Mark M. Mahady and Associates, Inc.

## Hosts

The primary host to *Anguina pacificae* is *Poa annua*, although it can also infect *Agrostus stolonifera* to a lesser extent (McClure et al., 2008; Fleming et al., 2015).

## Importance

In coastal California and parts of Ireland, this nematode is the primary nematode concern for turfgrass managers. While *Anguina pacificae* has a very narrow host range made up almost exclusively of *Poa annua*, its effect on annual bluegrass putting greens can be devastating. Where available, nematicides used to manage *Anguina pacificae* are expensive, but revenue losses as golfers choose to play on other courses with better greens are even more costly. Severe infestation can cause golf greens to become unplayable, leading golf courses to renovate and regrass the greens, costing millions of dollars in renovation costs and revenue losses during the renovation process. While *Anguina pacificae* is not known to occur in Florida, its primary host, annual bluegrass, is commonly used as a winter overseed on golf greens in this state. If *Anguina pacificae* became established in Florida it could potentially cause damage to overseeded golf greens under certain conditions, but not likely to the severity as in locations where annual bluegrass is the primary grass year-round.

## Morphology

Adult *Anguina pacificae* are roughly 1.4–2.5 mm in length for females and 1.2–1.8 mm in length for males. The body of adults (Figure 8) is much thicker than that of the slender juveniles. A small median bulb is present behind the esophageal lumen which is connected to the feeding part of this nematode, the stylet, but is often difficult to see. *Anguina pacificae* is armed with a slender stylet with knobs and weakly defined cephalic framework (Figure 9). At the rear caudal end of the female, the vulva is situated close

to the tail (Figure 10) (Cid Del Prado Vera and Maggenti, 1984). Annulations are present on the end of the tail (Fleming et al., 2015). These annulations are especially prominent on second stage juveniles. Second-stage juveniles recovered from soil samples are thin, have a small, weak stylet more typical of fungal-feeding than plant-parasitic nematodes, and poorly developed esophageal region (Figure 11).



Figure 8. An adult (male) *Anguina pacificae*. The body of the adult is much thicker than that of the juvenile.
Credits: undefined

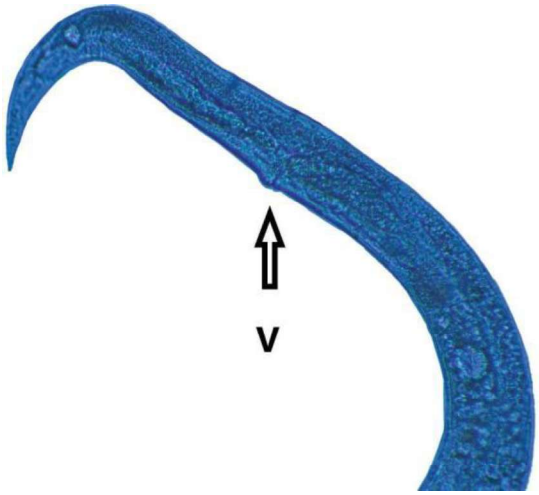


Figure 9. The vulva (V) of the female *Anguina pacificae* is located anteriorly, near the tail (T) of the nematode.
Credits: A. Habteweld, University of Florida

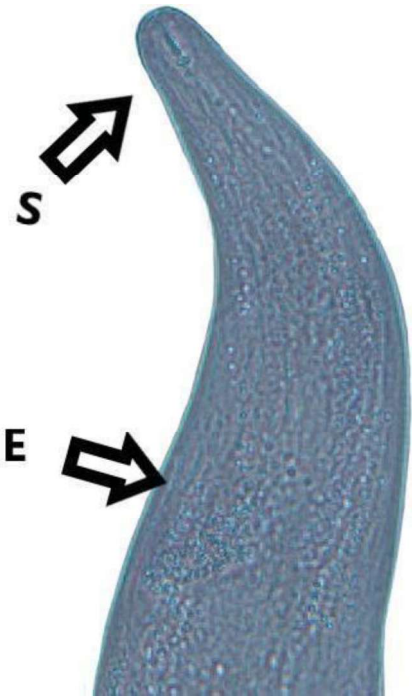


Figure 10. The stylet (S) of *Anguina pacificae* is small and has knobs at the base. Esophageal (E) features lack definition on *Anguina pacificae*.
Credits: C. L. Kammerer, University of Florida

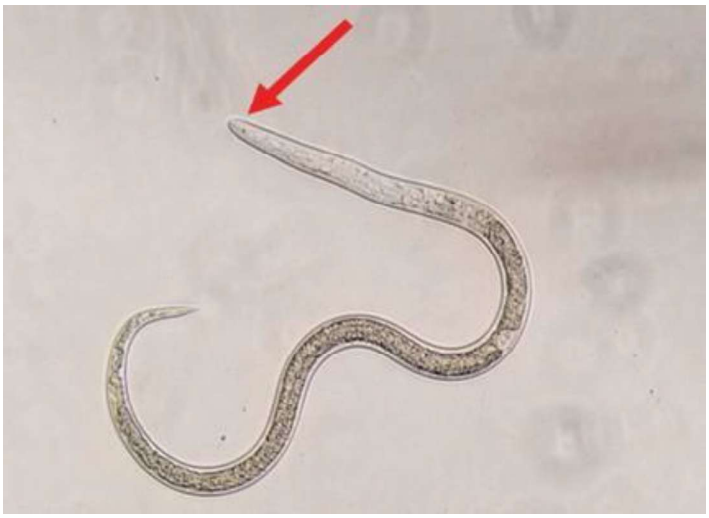

Figure 11. Red arrow pointing to anterior of *Anguina pacificae* juvenile. Note the small stylet with knobs (arrow), and poorly lack of esophageal definition. The juveniles are much slimmer than the adults.
Credits: C. L. Kammerer, University of Florida

## Management

As with many other pathogens, the management of this pest includes both cultural practices as well as chemical controls. Due to this nematode's ability to survive without moisture via anhydrobiosis, contaminated equipment poses a serious risk of spreading *Anguina pacificae*. Ensuring that all equipment is properly cleaned prior to use and after use is crucial. Chemical control is an effective method to reduce the low population density of *Anguina pacificae* and to reduce plant damage. Fluopyram (Petelewicz et al., 2020)

and abamectin (Orlinski et al., 2021) have been shown to be effective for managing *Anguina pacificae* and reducing its damage on Poa golf greens (Figure 12). The botanical pesticide azadirachtin has shown some activity against *Anguina pacificae* in some trials (McClure and Schmitt, 2012), but not others (Petelewicz et al., 2020). Novel methods of controlling nematodes may also be implemented in the future. White creamy bacteria inside *Anguina pacificae* galls has been inhibiting the developmental cycle of the nematode (McClure et al., 2008).



Figure 12. *Poa annua* green affected by *Anguina pacificae* with fluopyram treated plot showing visible green-up compared to control. Credits: M. M. Mahady, Mark M. Mahady and Associates, Inc.

## Resources


Cid Del Prado Vera I, Maggenti AR. 1984. A new gall-forming species of *Anguina* Scopoli, 1777 (Nemata: Anguinidae) on bluegrass, *Poa annua* L., from the coast of California. Journal of Nematology 16(4): 386–392.

Fleming TR, Maule AG, Martin T, Hainon-McDowell M, Entwistle K, McClure MA, Fleming CC. 2015. A first report of *Anguina pacificae* in Ireland. Journal of Nematology 47(2): 97–104.

McClure MA, Schmitt ME, Mccullough MD. 2008. Distribution, biology and pathology of *Anguina pacificae.* Journal of Nematology 40(3): 226–239.

Orlinski PM, Petelewicz P, Schiavon M, Mundo-Ocampo M, Becker JO, Baird JH. 2021. Pacific shoot-gall disease control in annual bluegrass putting greens using a new formulation of abamectin. International Turfgrass Society Research Journal 2021: 1-10. https://doi.org/10.1002/its2.53

Petelewicz P, Orliński PM, Schiavon M, Mundo-Ocampo M, Becker JO, Baird JH. 2020. Fluopyram controls shoot-galling caused by pacific shoot-gall nematode and improves turf quality in annual bluegrass putting greens. HortTechnology 30(6): 709–718. https://doi.org/10.21273/HORTTECH04680-20

Westerdahl BB, Harivandi MA, Costello L, McCullough M, Gross P. 2004. Management of plant-parasitic nematodes on turfgrass in Northern California. Acta Horticulturae 661: 531–533. https://doi.org/10.17660/ActaHortic.2004.661.72