

STUDY GUIDE
ENTOMOLOGY & NEMATOLOGY DEPARTMENT
DPM COMPREHENSIVE EXAMINATIONS

The Entomology & Nematology Comprehensive Examinations consist of 3 sections: pest identification (30%), pest biology and management (40%), and core concepts and synthesis (30%). These examinations are limited to information about invertebrate animal pests, principally insects and nematodes, but also plant feeding mites and terrestrial molluscs.

A. Pest identification

Students will be presented with insects, mites, molluscs, and nematodes that they must identify. Some may be recognizable by sight, but others may require keys for identification. Students will be provided with identification aids (keys), where necessary, and be expected to use them to identify the subjects accurately. The unknowns will be selected from the list of important insect, mite, mollusc, and nematode pests (Table 1) though we will emphasize those with a single or double asterisk [* or **]), as these normally are the more important pests. Included in this list are some that pose a threat but are not currently found in Florida.

B. Pest biology and management

Students will answer 8-10 questions on insect, mite, mollusc, and nematode pest biology (sampling, distribution, life cycle, damage) and management. The animals for which students are responsible to know biology and management are listed in Table 1 (preceded by double asterisk [**]).

C. Core Concepts and Synthesis Section:

Students will answer 3 or 4 questions that cover core areas of Entomology/Nematology and demonstrate knowledge of core areas, but also analysis and problem solving. Suggested reference/reading material is listed in Table 2. You might want to read through these in preparation for the Comprehensive Examinations.

Diagnostic material for Part A will be provided during the exam. Students will not have access to the internet or cell phones during the exam. Written answers will be entered onto a laptop computer, provided at the testing site. The nematology examination is separate from the entomology/acarology/malacology test; each test is limited to an 8-hour period. All testing must be completed by the end of the test period.

CORE COMPETENCY AREAS FOR THE DOCTOR OF PLANT MEDICINE PROGRAM

1. Pest identification
 - a. Processes and procedures for identification
 - b. Ability to use diagnostic keys

- c. Sources of information that serve as an aids in identification
- d. Important morphology and anatomy used in identification
- e. Characteristics of orders and important families
- 2. Pest biology
 - a. How these animal pests are organized structurally
 - b. How these animal pests function physiologically
 - c. Signaling among animals
 - d. How these animal pests interact with the biotic and physical environment
 - e. The life cycles of these animals
 - f. Temperature effects on insect development (including degree days)
- 3. Pest population biology
 - a. Environmental factors affecting animal abundance
 - b. Natural enemies affecting animal abundance
 - c. Host plant effects on animal abundance
 - d. Life tables and key factor analysis
 - e. Factors affecting spatial distribution
 - f. Pesticide effects on animal abundance
 - g. Invasiveness of animals (including eradication, quarantine, interception, and history of invasion)
- 4. Animal-plant interactions and problem identification
 - a. How plants are affected by animals
 - i. Types of damage
 - ii. Disease transmission
 - iii. Damage thresholds & economic injury levels
 - iv. Pollination
 - b. Plant defenses against herbivory
 - i. Host range & feeding behavior
 - ii. Chemical
 - iii. Structural
 - iv. Compensatory growth
 - v. Biotechnology
- 5. Beneficial organisms
 - a. Predators
 - b. Parasitoids
 - c. Disease-causing organisms
- 6. Principles and tactics of pest management
 - a. Sampling, monitoring, and forecasting
 - b. Site-specific and area-wide management (including SIT)
 - c. Cultural & interference methods of management
 - i. Modifying the physical environment
 - ii. Cropping practices
 - iii. Host plant resistance
 - iv. Semiochemicals
 - v. Sterility
 - d. Biological methods of management
 - i. Conservation

- ii. Augmentative
- iii. Introduction/classical
- e. Chemical methods of management
 - i. Classification
 - ii. Mode of action & metabolism
 - iii. Safety & regulations
 - iv. Environmental/nontarget effects
 - v. Methods of formulation & application
 - vi. Methods of evaluation
 - vii. Resistance management
- 7. Management based on regulations
- 8. Experimental design and analysis
 - i. Observations (e.g., categorical, discrete)
 - ii. Hypothesis testing
 - iii. P-values & significance levels
 - iv. Controls, sample size & replication
 - v. Descriptive statistics (e.g., mean, median, mode, range)
 - vi. Displaying data (e.g., SD, SE, CI, box plots, scatter plots, trend lines, columns, plotted lines)
 - viii. Tests of difference (e.g., unpaired t-test, paired t-test, Mann-Whitney test, Wilcoxon signed ranks test, one-way ANOVA, two-way ANOVA, Kruskal-Wallis test, Friedman's test, interactions, repeated measures)
 - ix. Tests of relationship & frequency (e.g., correlation, regression, Chi-square & Fishers test}
 - x. Other (e.g., data transformation, outliers, parametric versus non-parametric tests, homogeneity of variance, normality tests, post-hoc/multiple comparison tests)
 - xi. Standard experimental designs (e.g., random, randomized complete block, Latin square)
 - xii. Sampling (e.g., absolute & relative methods, sequential sampling, dispersion, diversity, habitat description)

Table 1. Invertebrate animal pests of importance to Florida, and their hosts

(* = important plant pests)

**= consistently important plant pests)

(# not presently occurring in Florida)

(host relationship/importance is:

A = animals and humans;

B = beneficial;
FR = fruit or berry crop;
FC = field crops;
G = turf or forage grass;
N = nuisance or contaminant;
T = tree;
O = ornamental plant;
S = stored products;
V = vegetable crops;
W = wood.)

BEETLES

*Banded cucumber beetle, *Diabrotica balteata* LeConte; **V**
Yellow-margined leaf beetle, *Microtheca ochroloma* Stal; **V
Pepper weevil, *Anthonomus eugenii* Cano; **V
*White-fringed beetle, *Naupactus* (= *Graphognathus*) spp.; **V, FC**
White grubs, *Phyllophaga* spp.; **V, FC, FR, G, T, O
Southern pine bark beetle, *Dendroctonus frontalis* Zimmermann **T
Diaprepes root weevil, *Diaprepes abbreviatus* (Linnaeus); **FR, O, FC, V
*Citrus root weevils (southern citrus root weevil, *Pachnaeus litus*; northern citrus root weevil, *Pachnaeus opalus*; little leaf notcher, *Artipus floridanus*); **FR**
*Mexican bromeliad weevil, *Metamasius callizona* (Chevrolat); **O**
Asian grey weevil, *Myllocerus undatus* (Marshall); **O
*Hunting billbug, *Sphenophorus venatus* Chittenden; **G**
Palmetto weevil, *Rhynchophorus cruentus* Fabricius; **O, T
*Twig girdler, *Oncideres cingulata* (Say); **T**
*Black twig borer, *Xylosandrus compactus* (Eichoff); **T**
Mexican bean beetle, *Epilachna varivestris* Mulsant; **V, FC**
Colorado potato beetle, *Leptinotarsa decemlineata* (Say); **V
Striped cucumber beetle, *Acalymma vittatum* (Fabricius); **V**
Southern corn rootworm, *Diabrotica undecimpunctata* (Barber); **V, FC**
Banded cucumber beetle, *Diabrotica balteata* LeConte; **V**
Western corn rootworm, *Diabrotica virgifera* LeConte; **FC, V**
Green June beetle, *Cotinus nitida* (Linnaeus); **V, FR**
Sawtoothed grain beetle, *Oryzaephilus surinamensis* (Fitch); **S**
Drugstore beetle, *Stegobium paniceum* (Linnaeus); **S**
Cigarette beetle, *Lasioderma serricorne* (Fabricius); **S**
Pales weevil, *Hylobius pales* (Herbst); **T**
*Redbay ambrosia beetle, *Xyleborus glabratus* Eichoff; **T, FR**
Asian longhorned beetle, *Anoplophora glabripennis* (Motschulsky); **T**
Emerald ash borer, *Agrilus planipennis* Fairmaire; **T**
Japanese beetle, *Popillia japonica* Newman; **T, FR, O, V, FC, G**
Asian ladybird beetle, *Harmonia axyridis* (Pallas); **N, B**

FLIES

- **American serpentine leafminer, *Liriomyza trifolii* (Burgess); **V, O, FC**
- **Cornsilk fly, *Euxesta stigmatias* Loew; **V**
- **Caribbean fruit fly, *Anastrepha suspensa* (Loew); **FR**
- # Medfly, *Ceratitis capitata* (Weidemann); **FR**
- # Oriental Fruit fly, *Bactrocera dorsalis* Hendel; **FR, V**
- *Spotted wing drosophila, *Drosophila suzukii* (Matsumura); **FR**
- *Darkwinged fungus gnats, *Bradysia* spp.; **O, V**
- Asian tiger mosquito, *Aedes albopictus* (Skuse); **A**
- Florida SLE mosquito, *Culex nigripalpus* Theobald; **A**
- Black salt-marsh mosquito, *Ochlerotatus taeniorynchus*; **A**
- Eastern salt-marsh mosquito, *O. sollicitans* (Walker); **A**
- Common malaria mosquito, *Anopheles quadrimaculatus* Say; **A**
- Dark ricefield mosquito, *Psorophora columbiae* (Dyar & Knab); **A**
- Floodwater mosquito, *Coquilletidia perturbans* (Walker); **A**
- Stable fly, *Stomoxys calcitrans* (Linnaeus); **A**
- Deer flies, *Chrysops* spp. and others; **A**
- Horse flies, *Tabanus* spp. and others; **A**
- Moth flies, *Psychoda* spp.; **N**
- House fly, *Musca domestica* Linnaeus; **N**
- Humpbacked or Phorid flies; **N**
- Soldier flies; **B, N**
- Lovebug, *Plecia nearctica* Hardy; **N**

BUGS, ETC.

- **Leaf-footed bug, *Leptoglossus phyllopus* (Linnaeus); **V, O, FC, FR**
- **Squash bug, *Anasa tristis* (DeGeer); **V**
- **Lantana lace bug, *Teleonemia scrupulosa* Stal; **O**
- **Garden fleahopper, *Halticus bractatus* (Say); **V**
- **Glassywinged sharpshooter, *Homalodisca coagulata* (Say); **FR, O**
- **Jadera bug, *Jadera haemataloma* (Herrich-Schaeffer); **T**
- *Twolined spittlebug, *Prosapia bicincta* (Linnaeus); **G**
- **Southern chinch bug, *Blissus insularis* Barber; **G**
- *Brown stink bug, *Euschistus servus* (Say); **FC, FR, V**
- **Southern green stink bug, *Nezara viridula* (Linnaeus); **V, O, FC, FR**
- *Harlequin bug, *Murgantia histrionica* (Hahn); **V**
- **Silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring; **FC, O, V**
- *Citrus whitefly, *Dialeurodes citri* (Ashmead); **FR**
- *Cloudywinged whitefly, *Dialeurodes citrifolii* (Morgan); **FR**
- **Rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin; **O, FR, T**
- *Citrus blackfly, *Aleurocanthus woglumi* Ashby; **FR**
- **Cabbage aphid, *Brevicoryne brassicae* (Linnaeus); **V**
- **Green peach aphid, *Myzus persicae* (Sulzer); **O, FC, V, FR**
- **Melon aphid, *Aphis gossypii* Glover; **FC, FR, V, O**
- *Potato aphid, *Macrosiphum euphorbiae* (Thomas); **V, O**

Brown citrus aphid, *Toxoptera citricida* (Kirkaldy); **FR, O
 Pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green); **O
 *Papaya mealybug, *Paracoccus marginatus* Williams; **FR, O**
 Longtailed mealybug, *Pseudococcus longispinus* (Targioni-Tozzetti); **FR, O, T
 Madiera mealybug, *Phenacoccus madeirensis* Green; **O, V
 Citrus mealybug, *Planococcus citri* (Risso); **O, FR, V
 Cycad aulacaspis scale, *Aulacaspis yasumatsui* Takagi; **O, T
 Citrus psyllid, *Diaphorina citri* Kuwayama; **FR
 Tea scale, *Fiorinia theae* Green; **O, T
 *Citrus snow scale, *Unaspis citri* (Comstock); **FR**
 *False oleander scale, *Pseudaulacaspis cockerelli* (Cooley); **O, T**
 White peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti); **O, T
 Green scale, *Coccus viridis* (Green); **O, T
 Florida wax scale, *Ceroplastes floridensis* (Comstock); **O, T, FR
 Florida red scale, *Chrysomphalus aonidum*; **T, FR, O
 Hemispherical scale, *Saissetia coffeae* (Walker); **O, FR
 Pyriform scale, *Protopulvinaria pyriformis* (Cockerell); **FR, O
 Cottony cushion scale, *Icerya purchasi* Maskell; **FR
 Lobate lac scale, *Paratachardina lobata* (Chamberlin); **O, T
 # Brown marmorated stink bug, *Halyomorpha halys* Stal; **FR, FC**
 # Bagrada bug, *Bagrada hilaris* (Burmeister); **V, FC, F**
 Bed bug, *Cimex lectularius* Latreille; **A**

ANTS, BEES, ETC.

Red imported fire ant, *Solenopsis invicta* Buren; **A, N, V, FC
 Tawny crazy ant, *Nylanderia fulva* (Mayr); **N
 Florida carpenter ant, *Camponotus floridanus* (Buckley); **N**
 Pharaoh ant, *Monomorium pharaonis* (Linnaeus); **N**
 Acrobat ant, *Crematogaster ashmeadi* (Emery); **N**
 Whitefooted ant, *Technomyrmex albipes* (Fr. Smith); **N**
 *Elongate twig ant, *Pseudomyrmex gracilis* (Fabricius); **A, N**
 Carpenter bee, *Xylocopa virginica* (Linnaeus); **W**
 Honey bee, *Apis mellifera* Linnaeus; **B, N**
 Cicada killer, *Sphecius speciosus* (Drury); **B, N**
 Bumble bees, *Bombus* spp.; **B**
 Honey bee; *Apis mellifera*; **B**
 Paper wasps, *Polistes* spp.; **B, N**

MOTHS AND BUTTERFLIES

Citrus leafminer, *Phyllocnistis citrella* Stainton; **FR
 Corn earworm, *Helicoverpa zea* Boddie; **FC, FR, O
 *Velvetbean caterpillar, *Anticarsia gemmatalis* Hübner; **FC**
 *Azalea caterpillar, *Datana major* Grote & Robinson; **O**
 Oleander caterpillar, *Syntomeida epilais* Walker; **O
 *Eastern tent caterpillar, *Malacosoma americanum* (Fabricius); **T, N**
 *Forest tent caterpillar, *Malacosoma disstria* Hübner; **T**

*Fall webworm, *Hyphantria cunea* (Drury); **T**
 *Tussock moths, *Orgyia detrita*, *Orgyia leucostigma*, and *Orgyia definate*; **T**
 *Cabbage palm caterpillar, *Litoprosopus futilis* (G. & R.); **T**
 *Palm leafskeletonizer, *Homaledra sabalella* (Chambers); **T**
 Bean leafroller, *Urbanus proteus* (Linnaeus); **V
 Beet armyworm, *Spodoptera exigua* (Hübner); **FC, V
 Fall armyworm, *Spodoptera frugiperda* (J. E. Smith); **G, FC, V
 *Cabbage looper, *Trichoplusia ni* (Hubner); **V, FC, O**
 *Granulate cutworm, *Agrotis subterranean* (Fabricius); **FC, V, O**
 Armyworm, *Pseudaletia unipuncta* (Haworth); **FC, V
 Southern armyworm, *Spodoptera eridania* (Cramer); **FC, O, V
 *Yellowstriped armyworm, *Spodoptera ornithogalli* (Guenée); **FC, V**
 Imported cabbageworm, *Pieris rapae* (Linnaeus); **V
 Diamondback moth, *Plutella xylostella* (Linnaeus); **V
 Tropical sod webworm, *Herpetogramma phaeopteralis* Guenée; **G
 Lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller); **FC, V
 Melonworm, *Diaphania hyalinata* (Linnaeus); **V
 Pickleworm, *Diaphania nitidulis* (Stoll); **V
 *Tobacco hornworm, *Manduca sexta* Linnaeus; **V, FC**
 Grape root borer, *Vitacea polistiformis* (Harris); **FR
 *Florida fern caterpillar, *Callopistria floridensis* Guenée; **O**
 Oakworms, *Anisota* spp; **T**
 Oak leafrollers, *Archips semiferrana* (Walker); **T**
 Carpenterworm, *Prionoxystus robiniae* (Peck); **T**
 Saddleback caterpillar, *Sibine stimulae* (Clemens); **T, A**
 Puss caterpillar, *Megalopyge opercularis* (J.E. Smith), **A**
 White flannel moth caterpillar, *Orape ovina* (Sepp); **T, A**
 Io moth, *Automeris io* (Fabricius); **O, A**
 Orangedog, *Papilio cresphontes* Cramer; **F**
 Indian meal moth, *Plodia interpunctella* (Hübner); **S**
 Household casebearer (Plaster bagworm), *Phereoeca uterella* Walsingham; **N**

GRASSHOPPERS AND CRICKETS

American grasshopper, *Schistocerca americana* (Drury); **FR, T, O, G
 Eastern lubber grasshopper, *Romalea guttata* (Houttuyn); **FR, T, O, G
 Southern mole cricket, *Scapteriscus borellii* Giglio-Tos; **G
 Tawny mole cricket, *Scapteriscus vicinus* Scudder; **G

WALKINGSTICKS

Two-striped walkingstick, *Anisomorpha buprestoides* (Stoll); **N**

PSOCIDS

Bark lice; **N**
 Book lice; **N**
 Grain psocid, *Lachesilla pedicularia* (Linnaeus); **S**

COCKROACHES

American cockroach, *Periplaneta americana* (Linnaeus); **N**

Asian cockroach, *Blattella asahinai* Mizukobo; **N**

German cockroach, *Blattella germanica* (Linnaeus); **N**

Florida woods cockroach, *Eurycotis floridana* (Walker); **N**

FLEAS

Cat flea, *Ctenocephalides felis* Bouché; **A**

TERMITES

Eastern subterranean termite, *Reticulitermes flavipes* (Kollar); **W**

Formosan termite, *Coptotermes formosanus* Shiraki; **W**

Drywood termites; **W**

THRIPS

Western flower thrips, *Frankliniella occidentalis* (Pergande); **O, V, FC

Melon thrips, *Thrips palmi* Karny; **V

Florida flower thrips, *Frankliniella bispinosa* (Morgan); **FR, FC, V

*Cuban laurel thrips, *Gynaikothrips ficorum* (Marchal); **O**

Chilli thrips, *Scirtothrips dorsalis* Hood; **O, V

MITES

Broad mite, *Polyphagotarsonemus latus* (Banks); **V

Twospotted spider mite, *Tetranychus urticae* Koch; **O, V, FC, FR

*Tomato russet mite, *Aculops lycopersici* (Masse); **V**

Citrus rust mite, *Phyllocoptruta oleivora* (Ashmead); **FR

*Red palm mite, *Raoiella indica* Hirst; **2:55 PM, O, FR**

TICKS

Lone star tick, *Amblyomma americanum* (Linnaeus); **A**

Brown dog tick, *Rhipicephalus sanguineus* (Latreille); **A**

Blacklegged tick, *Ixodes scapularis* Say; **A**

NEMATODES

Root-knot nematodes, *Meloidogyne incognita*, *M. javanica*, *M. arenaria*, *M. hapla*; **V

Soybean cyst nematode, *Heterodera glycines*; **FC

Citrus nematode, *Tylenchulus semipenetrans*; **FR

Reniform nematode, *Rotylenchulus reniformis*; **FC, V

Lesion nematode, *Pratylenchus*; **FC, O, F

Burrowing nematode, *Radopholus*; **FR

Sting nematode, *Belonolaimus*; **G, FR, V

Lance nematode, *Hoplolaimus*; **G, O

Spiral nematode, *Helicotylenchus*; **G

Ring nematode, *Mesocriconema*; **G

Dagger nematode, *Xiphinema*; **G, FR, O

Awl nematode, *Dolichodorus*; **G, FR, O, V

Stubby nematode, *Trichodorus/Paratrichodorus*; **G, O, V

Stunt nematode, *Tylenchorhynchus*; **G, FC, V

MOLLUSCS

Cuban brown snail, *Zachrysia provisoria* (L. Pfeiffer); **O, V

*Perforate dome snail, *Ventridens demissus* (A. Binney); **O, V**

Giant African Snail, *Lissachatina (Achatina) fulica* (Férussac); **O, T, N**

*Asian tramp snail, *Bradybaena similaris* (Férussac); **O, V, FR**

*Florida leatherleaf slug, *Leiydula floridana* (Leidy); **O**

Marsh slug, *Deroceras laeve* (Müller); **O, V

Table 2. Suggested readings and references

Pest identification

Borror, Triplehorn and Johnson, An Introduction to the Study of Insects

Cranshaw, Garden Insects of North America

Potter, Destructive Turfgrass Insects

Evans, Beetles of Eastern North America

Miller and Johnson, Armored Scale Insect Pests of Trees and Shrubs

Johnson and Lyon, Insects that Feed on Trees and Shrubs

Capinera, Handbook of Vegetable Pests

Stehr, Immature Insects

Wagner, Caterpillars of Eastern North America

Wagner et al., Owllet Caterpillars of Eastern North America

Pest biology

Whitfield and Purcell, Introduction to Insect Biology and Diversity

Pedigo and Rice, Entomology and Pest Management

Cranshaw and Redak, Bugs Rule!

Speight, Hunter, and Watt, Ecology of Insects

Schowalter, Insect Ecology, An Ecosystem Approach

Agrios, Transmission of plant disease by insects. in Capinera, ed. Encyclopedia of Entomology, 2nd edition.

Hull, Matthews' Plant Virology, 4th edition

Hunter, Plant Viruses and Insects. in Capinera, ed. Encyclopedia of Entomology, 2nd edition.

Pest management

Pedigo and Rice, Entomology and Pest Management

Van Emden and Service, Pest and Vector Control

Thacker, An Introduction to Arthropod Pest Control
Dent, Insect Pest Management
Hoy, Agricultural Acarology: Introduction to integrated mite management
Halbert, Management of Insect-Vectored Pathogens of Plants. in J. L. Capinera, ed.
Encyclopedia of Entomology, 2nd edition.
Hoy, M.A. 1998. Myths, models and mitigation of resistance to pesticides. Proc. R. Soc.
London B 353: 1787- 1795. Available at:
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1692395/pdf/10021775.pdf>

Experimental design and analysis

Southwood, Ecological Methods
Krebs, Ecological Methodology
Gotelli and Ellison, A Primer of Ecological Statistics
Dytham, Choosing and Using Statistics, A Biologist's Guide
Motulsky, Intuitive Biostatistics, A Nonmathematical Guide to Statistical Thinking