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Field Guide to Predators, Parasites and Pathogens Attacking Insect and Mite Pests of Cotton

Recognizing the Good Bugs in Cotton

by
Allen Knutson
and
John Ruberson

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Cover photograph by W. Sterling of an immature (nymph) spined soldier bug, a predator of bollworms and other caterpillars in cotton.

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CONTENTS

Introduction 3
Acknowledgments 4
How to Use This Book 6
Biology of Natural Enemies 7
Use of Natural Enemies 11
Sampling for Natural Enemies 12
Further Reading 15
Table of cotton pests and their natural enemies 16
Pesticides and Natural Enemies 20
Table of chemical classes and cotton insecticides 23

Predators

Lynx Spiders 24
Celer Crab Spider 26
Jumping Spiders 28
Green Lacewings 30
Brown Lacewings 34
Ground and Tiger Beetles 36
Seven-spotted Lady Beetle or "C-7" 40
Harmonia or Asian Lady Beetle 42
Convergent Lady Beetle 44
Pink Spotted Lady Beetle 46
Collops Beetles 48
Hooded Beetle 50
Striped Earwig 52
Rove Beetles 54
Damsel Bugs 56
Spined Soldier Bug 58
Spined Assassin Bugs 62
Leafhopper Assassin Bug 64
Big-eyed Bugs 66
Hover or Syrphid Fly 68

Long-legged Fly 70
Insidious Flower Bug 72
Minute Pirate Bug 72
Scymnus Lady Beetle 74
Stethorus Lady Beetle 76
Fire Ants 78
Six-Spotted Thrips 80
Predatory Mites 82

Parasites

Archytas marmoratus 84
Tachinid Flies 86
Macrocentrus grandii 88
Microplitis croceipes 90
Cardiochiles nigriceps 92
Chelonus insularis 94
Bracon mellitor 96
Hyposoter Parasite 98
Cotesia marginiventris 100
Catolaccus grandis 102
Meteorus Parasite 104
Lysiphlebus testaceipes 106
Looper Parasite 108
Stink Bug Egg Parasites 110
Whitefly Parasites 112
Mymarid Parasites 114
Trichogramma Wasps 116

Pathogens

Cotton Aphid Fungus 120
NPV Disease 122
Beauveria and other Fungi 124

Sources of entomological supplies back cover

Introduction

The role of natural enemies in cotton pest management has often been obscured by the widespread use of broad-spectrum insecticides. Nevertheless, cotton can support a large complex of insects, spiders and mites that feed on cotton pests. For example, researchers in Arkansas recorded more than 600 different species of beneficial arthropods in cotton. In California, entomologists estimated that some 300 to 350 different species consistently breed in cotton fields. Of the many arthropod species occurring in cotton, very few are pests; the majority are beneficial.

Recently, interest in beneficial arthropods has grown tremendously. This has been encouraged by numerous changes in the cotton production system — an increase in beneficial numbers following eradication of the boll weevil in some areas of the Cotton Belt, sale of Bt-transgenic cotton, development of insecticides that are less toxic to beneficial insects, and growing public concern over pesticide use. The importance of beneficial species has become increasingly apparent. Beneficial arthropods are critical for managing the beet armyworm, they can dramatically reduce budworm and bollworm populations, and they play key roles in managing many other serious and potential pests. Given the number of insect species capable of feeding and reproducing on cotton, the

fact that so few are actual pests is a powerful testimony to the importance of natural enemies.

It is therefore timely and important that a field guide be developed for identifying key natural enemies. We must point out, however, that this guide is not comprehensive; the number of beneficial species is simply too great (and the biology of many is too poorly known) to permit the development of such a guide at the moment. Hopefully, such a task can be undertaken soon.

Acknowledgments

The authors are indebted to the many colleagues who assisted in providing publications and reviewing all or parts of the manuscript, including John Benedict, Steve Naranjo and James Hagler. Two publications, in particular, formed the foundation of this guide. They are "Predaceous and Parasitic Arthropods in California Cotton Fields" authored by R. Van den bosch and K. Hagen in 1966 (published as Bulletin 820 of the California Agricultural Experiment Station), and "Predaceous Insects, Spiders and Mites in Arkansas Cotton Fields" authored by W. H. Whitcomb and K. Bell (published as Bulletin 690 of the Arkansas Agricultural Experiment Station in 1964). These pioneering bulletins were the first to help cotton growers, extension agents, and ento-

mologists identify and appreciate the many predators and parasites attacking cotton pests.

Appreciation is also extended to the many who generously offered slides for use in the field guide. Special recognition is extended to Winfield Sterling, Professor of Entomology (retired) and Allen Dean, Research Associate at Texas A&M University, for use of their slide set. Others who provided slides included W. Jones, USDA-ARS; D. Steinkraus, University of Arkansas; Steve Naranjo, USDA-ARS; M. Merchant, Texas A&M; B. Ree, Texas A&M; D. Waters, University of Georgia; M. Badgley, Biological Photography, Moreno Valley, CA; M. Scott, Illinois Natural History Survey; J. Morales-Ramos, USDA-ARS; H. Gross, Jr. USDA-ARS; M. Rose, Texas A&M; Jack Kelly Clark, the University of California Statewide IPM Project; Ed Thomas; Andrea Southworth, Univ. Georgia; and the University of Florida Department of Entomology. We also thank Russ Ottens for the figure of stinkbug mouthparts and W. A. Frank and J. E. Slosser for use of the figures from their publication "An Illustrated Guide to the Predaceous Insects of the Northern Texas Rolling Plains," Texas Agricultural Experiment Station Bulletin MP-1718.

The authors also thank Pat O'Leary, Cotton Incorporated, for her support and assistance.

How to Use This Book

We have attempted to design this handbook in such a manner that the necessary information can be quickly and easily accessed by the user. For each natural enemy, on the left-hand page we present the name of the natural enemy, the scientific name for the species or family, some general information on its identification, the pests it attacks and its biology. In addition, in the upper left corner is a silhouette showing the actual size of the adult natural enemy; or, if it is too small to show, a magnifying glass is displayed. On the right-hand page are color photographs and line drawings to help in identifying the natural enemy, as well as a color-coded band signifying whether the natural enemy is a predator, a parasite, or a pathogen. The book is arranged so that the predators are presented first, the parasites (all flies and wasps) second, and the pathogens last. Each of these sections is color coded with a strip on the figure page. Within the predator and parasite sections, the insects and spiders are arranged in order of size — from largest to smallest. The relative sizes can be seen by using the silhouette and comparing them with the insect in hand. We need to emphasize that the size refers only to the adult stages. If immatures are found, the user will have to rely on the pictures for locating the organism. Finally, remember that this handbook is not exhaustive. You will certainly see natural enemies in cotton that are not includ-

ed in this book. We have only focused on those that we felt were most important across the Cotton Belt.

Biology of Natural Enemies

The biologies of natural enemies in cotton are extremely diverse and interesting, and are difficult to generalize. Nevertheless, there are some generalizations that can be useful in considering natural enemies. Broadly speaking, beneficial organisms can be categorized into three groups: predators, parasitoids (hereafter referred to as parasites), and pathogens. Each of these groups is briefly discussed below.

PREDATORS:

Predators are those organisms that must kill and consume more than one prey to complete their development, and are free living as immatures and as adults. For example, lady beetles may eat 400-500 aphids during the course of their larval development. Predators include numerous beetles (lady beetles, ground beetles, rove beetles, collops beetles, etc.), spiders, various true bugs (pirate bugs, damsel bugs, assassin bugs, some stink bugs, etc.), lacewings, and others. The action of predators often goes unnoticed because many species are small and hidden on the plant, and spend little time actually consuming prey. However, it is not unusual to see predators actively feeding in the field if

one looks carefully. Predators fall into two groups, based on their feeding style: sucking and chewing predators. Sucking predators typically have hollow mouthparts that allow them to inject enzymes into their prey and then suck the fluids and homogenized tissues out of the prey. Examples of this feeding type can be found in the predaceous bugs and lacewings, among others. Chewing predators, such as most lady beetles, use mandibles to chew and consume their prey.

PARASITES:

Parasites destroy a single host to complete development, live in or on their hosts during immature development, and are free-living only as adults. Many of the flies and wasps present in cotton are parasites of other arthropods in cotton. Most species of arthropods (pests and beneficials) have parasites that can attack them at some life stage. Parasites generally lay their eggs in or on their hosts. The eggs hatch, and the parasite larvae feed on the host's body fluids and/or tissues. After completing their larval development, the parasites pupate. They may pupate within or on the host, or they may leave the host and pupate elsewhere. The adult parasite emerges from the pupa some time later.

Because many parasites feed internally, it is often not possible to look at an insect and determine if it is parasitized. Although

a messy task, caterpillars can be pulled apart to determine if a parasite grub large enough to see is inside. Also, insect eggs parasitized by tiny wasps turn black a few days after being parasitized. Of course the best way is to collect the insect and keep it alive to see if a parasite emerges. This is not too difficult for insect eggs but often is not practical for caterpillars which must be fed and held for many days. Other evidence of parasite activity visible in the field includes parasite cocoons, such as *Cotesia* (p. 100) on cotton leaves, aphid mummies in aphid colonies (p. 107) and adult parasitic wasps or flies searching cotton plants for hosts.

Parasites may be solitary (one develops per host) or gregarious (more than one develops per host). They also tend to be specific to the stages of the host that they attack. For example, the tiny parasitic wasps of the genus *Trichogramma* attack only eggs of their hosts. Also, some parasite species attack only one or a few related host species, while other parasite species attack many host species.

PATHOGENS:

Pathogens are those organisms that cause disease. In cotton, insects primarily fall prey to pathogens that are fungi and viruses. Fungi typically attack the host insect directly by entering through the insect's cuticle. They reproduce within the

host, ultimately killing it. They then grow out of the host and produce spores that spread to infect new hosts. Most viruses enter their hosts by being eaten. They then pass into the host's body and take over, converting the host into a virus factory. In the case of the nuclear polyhedrosis viruses often found in cotton pests, the virus somehow induces the host to climb up the plant before it dies. The host then darkens and dies, dangling from a leaf or stem. The host's body is filled with virus, and the body wall becomes fragile, so that any disturbance of the body causes the dead host to burst or rupture. The virus-filled fluid then drips out of the dead host onto the leaves and stems below where potential hosts can feed and pick up the virus.

Naturally-occurring pathogens can be highly effective in reducing or eliminating pest populations. This is particularly well demonstrated by the cotton aphid fungus, *Neozygites fresenii*, which can decimate high aphid populations in 7-10 days in some areas of the Cotton Belt.

"BENEPESTS":

Some insect species can be both pest and natural enemy. For example, lygus bugs, the cotton fleahopper and the black fleahopper can inflict considerable damage on cotton plants, but can also be very effective predators of moth eggs, small larvae and in the case of lygus, whiteflies. Another example is the western flower

thrips. It is a serious pest of seedling cotton throughout much of the Cotton Belt but is also an important predator of spider mite eggs early in the season in California. At times these species may be more important as natural enemies than as pests, whereas at many other times the reverse is true. We have not included these two-way players in the handbook.

Use of Natural Enemies

There are several approaches to using natural enemies in crop production. The first, and most useful, is to conserve the natural enemies already present in the field. This may be done by minimizing use of insecticides, using selective insecticides or rates, by providing refuge habitats in or around fields, or through use of food sprays. The second method is augmentation, or releasing natural enemies into a field. In most cases, these natural enemies are purchased from a commercial supplier. Augmentation is an effective tool for managing pests in some crops, but additional research on release rates, timing and economic return is needed to better use augmentation for cotton pests. The third method is importation, which involves the introduction of natural enemies from other areas of the world for pests that do not already have effective natural enemies. This method requires some time to complete (usually a number of years), as appropriate

organisms must be located, tested for safety, and released. Although this method has been quite successful in some instances, it has also failed in a number of others. Where successful, it usually provides permanent full or partial control of the pest.

Sampling for Natural Enemies

There are various methods in use for sampling natural enemies in cotton. It is beyond the scope of this text to present a full discussion of those methods, with their pros and cons. We will present a few of the more widely used methods here for consideration.

Direct Observation:
This method involves simply looking for natural enemies during the process of scouting. It does not require any additional effort. But it also tends to miss many of the natural enemies. More mobile species will move away or drop from the plant quite rapidly as you approach.

Drop Cloth or Shake Cloth:
This method uses a 3x3 foot square durable cloth, and 2 dowels (usually about 1/2 inch in diameter, 36-48 inches long). The dowels are anchored parallel to one another along each of two sides of the cloth (usually through a loop stitched in the cloth), forming something resembling a square stretcher. To sample with the

cloth, spread the cloth between two rows of cotton, then vigorously shake about 3 feet of row, on one or both sides of the cloth, onto the cloth. The insects on the cloth can then be counted. This method is reasonably effective at sampling various natural enemies, although some natural enemies (such as green lacewing larvae and big-eyed bug adults) are not well sampled using this approach. In addition, the disturbance of the plants prior to shaking can cause mobile species to take off. Counts should be done quickly after shaking as some insects will rapidly leave the cloth. This problem is particularly apparent when sampling on warm afternoons. This method can also be quite unpleasant in fields infested with fire ants, as the sampler must get down on the ground to sample, and can become quickly involved with angry fire ants.

Beat Bucket:

This method requires a large bucket, such as a 5-gallon bucket; preferably one that is white or light colored. The approach is similar to that of the shake cloth: a single plant is gently bent into the bucket and shaken vigorously. The plant is then quickly removed and the insects and spiders counted. The beat bucket is somewhat more effective than is the shake cloth at dislodging natural enemies, but requires more time to sample the same area as can be done with the shake cloth. Like the shake

cloth, some of the mobile species will take off before the shaking can get started. The bucket is, however, easy to carry and use.

Sweep Sampling:
A heavy-duty sweep net (usually made of muslin or canvas) can be used to collect natural enemies. The net is swung rapidly back and forth in a sweep through the cotton, and the contents of the net bag are then examined for insects. This method is good for collecting some of the more mobile species, but overall is one of the least accurate sampling methods because of variability in sampling efficiency due to plant height and density, differences in speed of the sweeps, and tendency of natural enemies to change their locations in the plant throughout the day.

Vacuum Sampling:
Vacuum samplers are available that suck into bags most everything from on and around a single plant or plant part. Most of these samplers are impractical for regular use in sampling, and the samples are terribly messy to process (they usually contain quite a bit of dirt and debris). In addition, the efficiency of vacuum sampling drops considerably as the cotton plant grows. The act of placing the vacuum funnel over the plant can also disturb and scatter mobile species.

FURTHER READING

The following publications provide additional information on natural enemies of cotton insect pests:

Integrated Pest Management for Cotton. University of California Division of Agriculture and Natural Resources Publication 3305. To order, 510-642-2431.

Biology, Predation Ecology and Significance of Spiders in Texas Cotton Ecosystems with a Key to Species. 1993. Texas Ag. Exp. Sta. Bull. B-1711. 115 pp.

Identification, Biology and Sampling of Cotton Insects. B-933. Texas Ag. Ext. Service. College Station, TX. To order, contact Publication and Supply Distribution, P.O. Box 1209, Bryan, TX 77806-1209

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Pest Species	Natural Enemies Listed in Handbook
Thrips	Minute pirate bug (N,A), Insidious flower bug (N,A)
Lygus Bugs/ Fleahoppers	Big-eyed bug (N,A), Leafhopper assassin bug (N,A), Spined assassin bug (N,A), Jumping spiders (N,A), Lynx spiders (N,A), Celer crab spider (N,A), Minute pirate bug (N,A), Insidious flower bug (N,A), Damsel bugs (N,A), Spined soldier bug (N,A), Fire ants (N,A), *Anaphes iole* (E)
Cotton Aphid	Seven-spotted lady beetle (N,A), Harmonia or Asian lady beetle (N,A), Convergent lady beetle (N,A), Pink spotted lady beetle (N,A), Scymnus lady beetle (N,A), Green lacewings (N,A), Brown lacewings (N,A), Hover flies (N,A), *Lysiphlebus testaceipes* (N,A), Cotton aphid fungus
Boll Weevil	Fire ants (L), Leafhopper assassin bug (A), Spined assassin bug (A), Jumping spiders (A), *Bracon mellitor* (L), *Catolaccus grandis* (L)
Tobacco Budworm	Seven-spotted lady beetle (E,L), Harmonia lady beetle (E,L), Convergent lady beetle (E,L), Pink spotted lady beetle (E,L), Scymnus lady beetle (E), Green lacewings (E,L), Brown lacewings (E,L), Big-eyed

	bugs (E,L), Leafhopper assassin bug (L), Spined assassin bug (L), Jumping spiders (E,L), Lynx spiders (L), Celer crab spider (L), Minute pirate bug (E,L), Insidious flower bug (E,L), Damsel bugs (E,L), Spined soldier bug (E,L), Fire ants (E,L), Collops beetle (E,L), Earwigs (E,L), Ground beetles (E,L), *Trichogramma* (E), *Archytas* (L), Other tachinid flies (L), *Cotesia marginiventris* (L), *Cardiochiles nigriceps* (L), *Chelonus insularis* (E), *Microplitis croceipes* (L)
Cotton Bollworm	Seven-spotted lady beetle (E,L), Harmonia lady beetle (E,L), Convergent lady beetle (E,L), Pink spotted lady beetle (E,L), Scymnus lady beetle (E), Green lacewings (E,L), Brown lacewings (E,L), Big-eyed bugs (E,L), Leafhopper assassin bug (L), Spined assassin bug (L), Jumping spiders (E,L), Lynx spiders (L), Celer crab spider (L), Minute pirate bug (E,L), Insidious flower bug (E,L), Damsel bugs (E,L), Spined soldier bug (E,L), Fire ants (E,L), Collops beetle (E,L), Earwigs (E,L), Ground beetles (E,L), *Trichogramma* (E), *Archytas* (L), Other tachinid flies (L), *Cotesia marginiventris* (L), *Chelonus insularis* (E), *Microplitis croceipes* (L)

Pink Bollworm	*Trichogrammatoidea bactrae* (E)
Beet Armyworm/ Fall Armyworm	Seven-spotted lady beetle (E,L), Harmonia lady beetle (E,L), Convergent lady beetle (E,L), Pink spotted lady beetle (E,L), Scymnus lady beetle (E,) Green lacewings (E,L), Brown lacewings (E,L), Big-eyed bugs (E,L), Leafhopper assassin bug (L), Spined assassin bug (L), Jumping spiders (L), Lynx spiders (L), Celer crab spider (L), Minute pirate bug (E,L), Insidious flower bug (E,L), Damsel bugs (E,L), Spined soldier bug (L), Fire ants (E,L), Collops beetle (E), Earwigs (E), Ground beetles (E,L), *Archytas* (L), Other tachinid flies (L), *Cotesia marginiventris* (L), *Meteorus* (L), *Chelonus insularis* (E), Nuclear polyhedrosis virus (L).
Soybean Looper/ Cabbage Looper (*Copidosoma* is specific to soybean looper)	Seven-spotted lady beetle (E,L), Harmonia lady beetle (E,L), Convergent lady beetle (E,L), Pink spotted lady beetle (E,L), Scymnus lady beetle (E), Green lacewings (E,L), Brown lacewings (E,L), Big-eyed bugs (E,L), Leafhopper assassin bug (L), Spined assassin bug (L), Jumping spiders (L), Lynx spiders (L), Celer crab spider (L), Minute

	pirate bug (E,L), Insidious flower bug (E,L), Damsel bugs (E,L), Spined soldier bug (L), Fire ants (E,L), Collops beetle (E), Earwigs (E), Ground beetles (E,L), *Trichogramma* (E), *Cotesia marginiventris* (L), *Meteorus* (L), *Copidosoma* (E), Nuclear polyhedrosis virus (L)
European Corn Borer	*Macrocentrus grandii* (L)
Stink Bugs	*Telenomus wasps* (E), *Trissolcus* wasps (E)
Spider Mites	Six-spotted thrips (E), Western predatory mite (E,N,A), Stethorus (E,N,A), Minute pirate bug (E,N,A), Insidious flower bug (E,N,A), Green lacewings (E,N,A)
Whiteflies	Minute pirate bug (N,A), Green lacewings (N,A), Collops beetles (N,A), Big-eyed bugs (N,A), Whitefly parasites (N), Convergent lady beetles (N,A).

Parenthetical letters designate life stages of the pest attacked by the natural enemy: (E) = eggs, (N) = nymphs, (L) = larvae, (A) = adults

Pesticides and Natural Enemies

In this book, we have attempted to provide some general information on the toxicity of insecticides to the various natural enemies. However, for most of the natural enemies presented there is little information available on pesticide effects. These effects also vary with the pesticide used, the rate and volume applied, the timing of the application, the equipment used, the size of the plants, and the environmental conditions. Further, toxicity tests are often conducted with only one or a few representative pesticides within a particular pesticide class. It is not possible at present to state for each natural enemy how every available pesticide will affect it. Also, several new insecticide classes (imidacloprid, spinosads, pyrroles, and insect growth regulators) have recently been introduced and have not been fully evaluated for their impact on beneficial insects and spiders.

The various classes of insecticides (see the Table) differ in their toxicity to natural enemies. Generally, the most toxic compounds are the organophosphates. These materials have a broad range of toxicity and are typically quite toxic to natural enemies. There is some evidence that rate reductions can reduce the toxicity of these compounds to some degree but even then they remain highly toxic relative to other insecticide classes. Some organophosphates (e.g., methyl parathion) have short residual toxicity that renders a field safe for

recolonization by natural enemies only a short time after treatment. Pyrethroids tend to be more selective than organophosphates to natural enemies. They are, however, still quite toxic to many natural enemies. Some of the more recently developed pyrethroids are particularly toxic, approaching the activity of the more toxic organophosphates. Repeated applications of pyrethroids can have a devastating cumulative effect on natural enemy populations. Carbamates are quite variable in their selectivity, but tend to be less toxic to natural enemies than are the organophosphates or pyrethroids. Their toxicity varies with rate and material — some compounds are quite toxic to a wide range of natural enemies. Cyclodienes exhibit moderate to high selectivity, and can be quite useful for conserving some natural enemies while killing the targeted pest(s). Insect growth regulators are quite generally selective in their toxicity, and tend to have limited negative effects on natural enemy populations. Bt's are highly specific to target pests, and as such are quite safe for natural enemies. Information is still being gathered on imidacloprids, pyrroles, spinosads, and pyrazoles. The latter two classes appear to be less toxic to a number of natural enemies than are organophosphates, pyrethroids, and carbamates. Formamidines vary in toxicity to natural enemies, but are moderately to highly toxic at larvicidal rates. At ovicidal rates, toxicity to some natural enemies can be reduced.

Using in-furrow or soil-applied systemic pesticides may have advantages for natural ene-

mies by reducing direct exposure of the pesticide to the natural enemies. There is some evidence, however, that systemic pesticides can still cause problems. Reduced natural enemy populations are often observed where systemic insecticides are used, particularly when high rates are applied. Cotton produces nectar, and if the pesticide concentrates in the nectar it could be deadly for those insects that feed on it. In addition, many natural enemies occasionally suck on plant juices (such as the pirate bugs, big-eyed bugs, damsel bugs, and assassin bugs). They may pick up deadly amounts of insecticide while feeding.

All chemicals used in cotton production have the potential to influence natural enemies, from herbicides and fungicides to plant growth regulators and defoliants. Effects of these other chemicals on natural enemies are poorly known, although in some cases, such as with the arsenical herbicide MSMA, dramatic reductions in natural enemies frequently follow application.

Besides toxic effects, pesticides can also exert what are termed "sublethal effects." These effects are not expressed as mortality, but rather as changes in the insect's behavior and/or physiology. The changes, which by the way are not always bad, may occur in such things as the insect's movement, reproduction, development, feeding, egg laying ability, and rates at which eggs hatch. Such effects are more difficult to study than mortality, so they have not received much attention. Nevertheless, they can be very

important.	
Chemical Class	**Cotton Insecticides in the Class**
Organophosphates	Bidrin®, Bolstar®, Curacron®, Cygon®, Cythion®, Danitol®, Dimate®, Dimethoate®, Di-Syston®, Guthion®, Lorsban®, Malathion, Metasystox®, Methyl parathion, Orthene®, Parathion®, Payload®, Penncap-M®, Thimet® Monitor®, Supracide®
Pyrethroids	Ambush®, Ammo®, Asana®, Baythroid®, Capture®, Decis®, Fury®, Karate®, Pounce®, Scout X-tra®, Danitol®
Carbamates	Lannate®, Larvin®, Sevin®, Temik®, Vydate®
Cyclodienes	Comite®, Kelthane®, Phaser®, Thiodan®
Insect Growth Regulators	Confirm®, Dimilin®
Bt's	Agree®, Condor®, Design®, Dipel®, Javelin®, MVP®, Xentari®
Imidacloprids	Gaucho®, Provado®
Other Classes	Formamidines: Ovasyn®, Pyrroles: Pirate®, Spinosads: Tracer®,

Lynx Spiders

Oxyopes salticus
Peucetia viridans

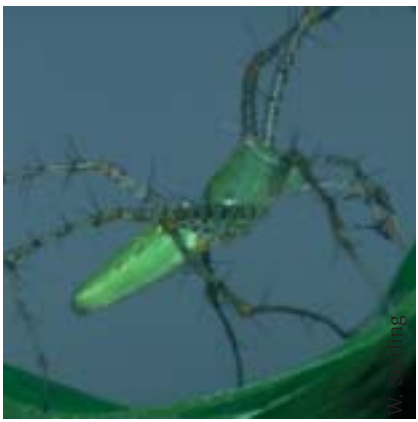
Characteristics: The striped lynx, *Oxyopes salticus*, and the green lynx, *Peucetia viridans*, are common spiders in cotton and are found throughout the Cotton Belt. The striped lynx is brown, about 1/4 inch long with 4 long, gray stripes behind the head on the front half of the body. The green lynx is a bright green spider about 1/2-3/4 inch long with small red spots on the legs and abdomen. Both species have eight eyes and two black lines running down the face and jaws, and the end of the abdomen is pointed. The legs are long and thin and armed with many long spines. They often run and jump erratically when disturbed.

Prey: Lynx spiders are probably the most important spiders in cotton because of their wide distribution and abundance. They are active and aggressive hunters that chase their prey or hide in wait and leap out. They do not build webs. Lynx spiders feed on a wide variety of insects, both pests (fleahoppers, bollworm/tobacco budworm larvae and eggs) and occasionally, beneficials. The striped lynx is a key predator of the cotton fleahopper.

General Biology: Spiders "balloon" into cotton fields by floating on wind-blown strands of silk. The egg-sac of the striped lynx is disc-shaped and attached to a leaf. The female guards the egg-sac until the spiderlings emerge. Reproduction occurs throughout the growing season and there are one or two gen-

erations per year. The green lynx produces a straw-colored egg-sac in the fall and guards it until the spiderlings emerge about 4 weeks later. Immature spiders overwinter and mature in July and August. The life cycle from egg hatch to mature adult is about 300 days. There is one generation a year.

Striped lynx spider



Green lynx spider

Celer Crab Spider

Misumenops celer

Characteristics: Crab spiders can be identified by their front legs which are much longer and more robust than the other legs, giving it a crab-like appearance. Crab spiders also move quickly backwards or sideways like a crab, facing their antagonist or prey. The celer crab spider is a common species in cotton and in some cases is the most abundant spider species present. The color of the female ranges from dull to bright yellow to white. There is an X-shaped mark on the back. The male has red along the edges of its body. In some individuals, two black or red bands are present on the abdomen. Several other species of crab spiders are found in cotton, including *M. formosipes*, a large species which changes color to match its surroundings.

Prey: Crab spiders feed on many cotton pests and occasionally on beneficial insects. Crab spiders do not build webs but wait to ambush passing insects using their strong legs and venom.

General Biology: Celer crab spiders are found in other crops and uncultivated areas and are carried into cotton fields on strands of silk by breezes early in the season. There are 1 or 2 generations per year.

Celer
crab
spider

Jumping Spiders

Family: Salticidae

Characteristics: Jumping spiders have compact, rectangular bodies with short, powerful legs. Their eyes are organized into three rows. The front portion of their body is as large or larger than the rear portion (abdomen). They range in size from 1/8 to 1/2 inch. Color is highly variable depending upon species. Some species have bright iridescent scales that give them a metallic green or purplish appearance. A commonly seen species, *Phidippus audax*, is a large, black and hairy spider with a large white spot on its back. All jumping spiders have large eyes that provide excellent eyesight for visually locating and pursuing prey. True to their name, they quickly jump when disturbed or when attacking prey. Jumping spiders are found throughout the Cotton Belt.

Prey: Jumping spiders feed on a wide variety of pest insects and occasionally beneficial insects. Adults can capture large caterpillars and boll weevil adults and are important predators of fleahoppers. Jumping spiders will also feed on moth eggs.

General Biology: Jumping spiders have excellent eyesight which they use to stalk and capture their prey with a sudden pounce. Females place their egg sacks inside nests of silk and remain with them until the spiderlings hatch and disperse. One generation is completed each year.

Black and white jumping spider

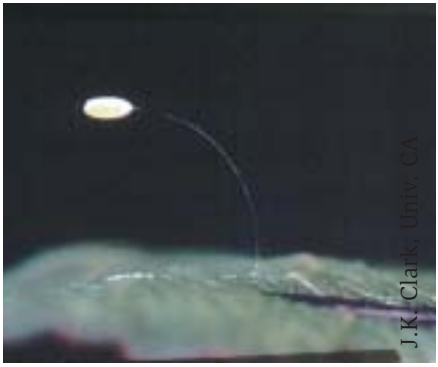
Another species of jumping spider

Green Lacewings

Chrysoperla carnea
Chrysoperla rufilabris
Chrysopa nigricornis
Chrysopa oculata

Characteristics: Adults are delicate, slender insects 1/2 to 3/4 inch long, green with golden eyes and long antennae. The large, delicate wings are laced with a network of veins and are held roof-like over the back. Larvae are alligator-shaped, grayish-brown with long sickle-shaped mandibles projecting from the head. Full grown larvae are 1/2 to 3/8 inch long. Eggs are laid singly on top of a fine thread attached to leaves or stems except those of *C. nigricornis* which are also attached to stalks, but are deposited in a large, tight cluster. Adult *Chrysopa* species release a pungent odor when handled. *C. carnea* is found throughout the Cotton Belt while *C. rufilabris* is found from Texas eastward. Various other species of *Chrysoperla* and *Chrysopa* can be found in cotton.

Prey: Larvae are important predators of aphids, mites, whiteflies, and eggs and small larvae of bollworms, budworms, armyworms, and loopers. They also feed on other lacewing larvae. Lacewings become very abundant when aphids are present. Like their larvae, adult *Chrysopa*



Green lacewing egg

Larva of the green lacewing

Green Lacewings

(Continued)

species also feed on insects, while adults of the *Chrysoperla* species feed only on honeydew, nectar and pollen.

General Biology: Eggs hatch in 3-6 days. Larvae feed for 2 weeks and then spin spherical, white cocoons of tough silk which are found behind bracts and in plant terminals. Larvae pupate inside the cocoons and the adults emerge in about 2 weeks. Adults fly at night and may travel several miles during the first 2-3 nights after emergence. Females lay their first eggs 4-6 days after emergence, produce a total of 200-800 eggs, and live for several weeks. *C. carnea* and *C. rufilabris* overwinter as adults while *Chrysopa nigricornis* and *oculata* overwinter as pupae in cocoons.

Pupa of the green lacewing

Adult green lacewing

Brown Lacewings

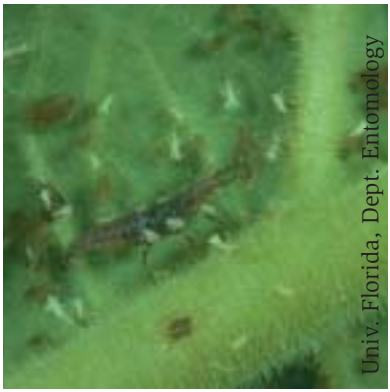
Hemerobius species
Micromus species

Characteristics: Adults are similar in appearance to the adult green lacewing but are smaller, brown and appear to be hairy. Larvae are reddish-brown with two to four white spots in the middle of the body. Like green lacewing larvae, they are alligator shaped with long, sickle like mouthparts used to suck juices from their prey. Brown lacewing larvae have a characteristic side-to-side "head-wagging" behavior which also distinguishes them from green lacewing larvae. Brown lacewings can be found throughout the Cotton Belt.

Prey: Adults and larvae feed on aphids and whiteflies. Larvae have been observed feeding on a variety of pest eggs, including bollworms, budworms, loopers and armyworms.

General Biology: Unlike the green lacewing, brown lacewing eggs are not placed on a stalk. Eggs are laid on the underside of leaves and turn from a cream color to pink or purple before hatching. Full grown larvae pupate inside an elliptical cocoon (in concealed locations, such as within bracts) made of loosely woven silk through which the pupa is visible. Adults fly during the evening and at night. Brown lacewings tend to be more abundant when weather conditions are cool, when rain is frequent, and when the plant canopy closes. Most species have 2 or 3 generations per year.

Brown lacewing adult



Larva of a brown lacewing

Pupa of a brown lacewing

Ground and Tiger Beetles

Carabidae: *Calasoma* species
Lebia species
Pterostichus species
Cicindelidae: *Cicindela* species
Megacephala species

Characteristics: Ground beetles are dark and shiny with long, slender legs and antennae, and prominent eyes. These beetles run quickly but many species are not commonly seen because they are most active at night. Immatures are worm-like predators with well developed legs and jaws. Both stages are active on the soil surface or may climb into the plant canopy in search of prey.

Tiger beetle adults are active during the day, and run and fly very quickly. They can often be seen running on sandy soils and open areas between rows of cotton or along field margins. They have long legs and hold their bodies well off the ground when standing or running. Tiger beetles quickly fly if approached too closely but often land a short distance away. Unlike most ground beetles, tiger beetles have heads that are wider than their thoraxes.

Prey: Adults and larval ground beetles hunt caterpillars, including cutworms and bollworms that drop to the soil to pupate, and other insects in the soil. Some species such as *Lebia* climb the cotton plant in search of caterpillars. Tiger beetle adults feed on the same types of prey as ground beetles. Larval tiger beetles feed on insects active on the ground.

Adult
ground
beetle

Adult
Calasoma
ground beetle

Ground and Tiger Beetles

(Continued)

General Biology: A large number of species fall into this group and their biologies vary widely. Ground beetles hide in soil cracks and under loose soil during the day and hunt for prey at night. Field margins and borders can be very important refuge habitats for ground beetles which move into cotton fields in search of food. Eggs are laid in or on soil. Larvae are also active on the soil surface, but some will climb plants in search of prey. Larval tiger beetles construct small tunnels and turrets in the soil, from which they capture passing insects.

Larva of a ground beetle

Adult tiger beetle

Seven-spotted Lady Beetle or "C-7"

Coccinella septempunctata

Characteristics: The seven-spotted lady beetle is a large (1/3 inch long), orange-red lady beetle with seven, distinct dark spots on the forewings (back). The shield behind the head (pronotum) is black with a white mark on each side. Larvae are alligator-shaped and black with an orange-white strip down the middle of the thorax (central body region where legs are attached). Full grown larvae are about 1/2 inch long. This species is found throughout the eastern U.S. west to Oklahoma and Texas.

Prey: Both adults and larvae feed primarily on aphids but will also prey on eggs and caterpillars of various moth pests. Like the convergent lady beetle, the seven-spotted is most abundant in cotton when aphids are present. Adults can survive on pollen and nectar when aphids are absent.

General Biology: This species was introduced into the U.S. from Europe. Eggs are yellow-orange, football-shaped and laid on end in groups of 10-30. Each female can deposit up to 1,000 eggs during a 6-8 week period. Eggs hatch in 7-10 days. Larvae are full grown in 10-50 days, depending on temperature and availability of food. Pupae are black with spots of yellow. Adults emerge in 3-10 days. The life cycle is completed in about 2-3 weeks, and there are several generations each

year. Small groups of adult beetles gather in protected areas to overwinter.

Adult seven-spotted lady beetle

Seven-spotted lady beetle larva

Harmonia or Asian Lady Beetle

Harmonia axyridis

Characteristics: Adults are a bright yellow-orange to reddish orange to red. The number of spots varies from 0 to 20. A black "M" shaped mark or solid mark in the center of the white pronotum (shield-like area just behind the head) identifies the harmonia or Asian lady beetle. The two large white areas on each side of the pronotum create the appearance of two large "eyes." Larvae are alligator-shaped, black, with an orange jagged streak or blaze on each side of the abdomen. Eggs are yellow, football-shaped and laid in masses of 10-30 on leaves. *H. axyridis* is found throughout the southeastern U.S. to central Texas.

Prey: Both adults and larvae feed primarily on aphids but also feed on armyworm eggs and small caterpillars.

General Biology: The harmonia lady beetle was introduced into the U.S. to control aphids on pecan trees. It commonly moves into cotton when cotton aphids are abundant. Eggs hatch in 4 days and larvae feed for about 2 weeks and then enter the pupal stage. After about 6 days, the adult emerges. Females begin laying eggs 7-12 days later and each can produce 500-700 eggs. Adults live 30-80 days under laboratory conditions. Adults overwinter in masses in protected areas, sometimes becoming a nuisance in homes.

Adult harmonia or Asian lady beetle

Adults of the harmonia or Asian lady beetles showing variation in color pattern

Larva of the harmonia or Asian lady beetle

Convergent Lady Beetle

Hippodamia convergens

Characteristics: The convergent lady beetle is named for the two white lines on the pronotum (plate behind the head) that, if extended, would converge. The margin of the pronotum is also lined with white. The number of black dots on the adults ranges from only a few up to 13. Larvae are alligator-shaped and black with rows of orange spots. Eggs are bright yellow, football-shaped and laid in clusters of 10 or more on plants or on debris on the soil. Pupae are immobile, attached to the plant, and resemble spotted bike helmets. The convergent lady beetle is found throughout the U.S. and is one of the most common lady beetles in cotton.

Prey: Adults and larvae feed primarily on aphids. When aphids are not available, adults feed on bollworm and budworm eggs and small larvae. Convergent lady beetles and larvae can become very abundant when aphids are present. Adults also feed on nectar and pollen.

General Biology: Females lay 200-1,000 eggs during a 1- to 3-month life span. Eggs hatch in 3-4 days and larvae feed for 2-3 weeks and then enter the pupal stage. Pupae are immobile and attached to stems and leaves. Adults emerge from the pupae in about a week. There are several generations per year. Adults congregate in sheltered sites to overwinter.

Adult convergent lady beetle

Convergent lady beetle larva

Pupa and adult of the convergent lady beetle

Pink Spotted Lady Beetle

Coleomegilla maculata

Characteristics: The pink spotted lady beetle is a slender, pink beetle with six very large black spots on each forewing. The spots sometimes join. There are two large triangular black marks on the area just behind the head. Larvae are alligator-shaped and black with cream or yellow spots. Eggs are yellow and football-shaped and laid on end in masses of 10-30. The pink spotted lady beetle is found throughout the eastern half of the U.S. to east Texas and only along the southern border of west Texas, New Mexico, Arizona and California.

Prey: Adults and larvae feed primarily on aphids but may also feed on eggs and small caterpillars. Adults feed heavily on pollen and may become abundant when cotton is blooming.

General Biology: Adults emerge from overwintering sites in the spring and lay egg masses on leaves often near aphid colonies. Females lay several hundred eggs during a 2-3 month period. Larvae feed for several weeks and then molt to the pupal stage. The pupa is attached to a leaf or stem and does not move. The adult beetle emerges from the pupa in about a week. There are several generations each year, and adults overwinter in protected sites.

Lady beetle eggs

Pink spotted lady beetle

Collops Beetles

Collops quadrimaculatus
Collops vittatus
Collops balteatus
Collops marginellus

Characteristics: These are active, soft-bodied beetles. They are dark blue with orange spots or stripes. *C. quadrimaculatus* is often called the 'red-cross' beetle because of the orange-red cross on its back. *C. vittatus* is dark blue with an orange stripe on each side. The front section of the thorax of these beetles is often orange and may or may not have a central dark spot. Larvae have a pincher-like structure at the tip of the abdomen and are rarely seen. In California and Arizona, *C. marginellus* and *C. vittatus* are important species in cotton.

Prey: Adults feed on moth eggs and small caterpillars, aphids, whiteflies, spider mites, aphids and stink bug eggs. *C. quadrimaculatus* commonly feeds on bollworm eggs and larvae. In Arizona, *C. vittatus* feeds on whiteflies in cotton.

General Biology: Eggs are yellow to pinkish-orange and spindle-shaped. Most eggs are laid in clusters on soil debris but sometimes are found in the plant terminal. Larvae are pink to brownish-red and feed on insects in the soil. These beetles overwinter as adults.

Collops balteatus

Hooded Beetle

Notoxus monodon
Notoxus species

Characteristics: When viewed from the side with a hand lens, the hooded beetle is easily recognized by the horn-like projection which extends over its head, creating a "hood." These small, ant-like beetles are tan or reddish with black patches, often forming zigzag patterns on the back (elytra).

Prey: Feeding habits of this insect in cotton are not well known. Adults feed on nectar, and under laboratory conditions, readily feed on budworm and bollworm eggs and small larvae.

General Biology: Adults are often found hidden behind bracts on squares or nestled in terminals. Larvae live in sandy soil. They are believed to complete several generations a year and overwinter as adults.

Adult hooded beetle

Striped Earwig

Labidura riparia

Characteristics: The striped earwig is a slender, flattened insect 3/4-1 inch long with large pinchers at the tip of the abdomen. The two lengthwise stripes on the front of the thorax (pronotum) help identify *L. riparia*. Immature earwigs resemble adults but are smaller. Earwigs are active at night and search for food both on the soil and on plants. During the day they hide in soil crevices and thus are seldom seen. *L. riparia* is found along the East Coast to Florida and west to California.

Prey: Earwigs are important predators of eggs, larvae, and pupae of many different kinds of moths and beetles.

General Biology: Females deposit eggs in nests constructed in the soil and care for the eggs and nymphs. Development of egg to adult requires about 4 months, and there are 1 or 2 generations per year. Studies in Georgia found *L. riparia* less common in cotton fields where fire ants were present.

Adult earwig tending eggs

Adult earwig

Rove Beetles

Family:Staphylinidae

Characteristics: Adults are tiny to small, black to brown slender beetles which run and fly rapidly. The wings are very small, leaving much of the abdomen exposed. The tip of the abdomen may be curled forward, much like a scorpion, when the beetles are disturbed, although the beetles have no stinger. Larvae are elongate with well developed legs.

Prey: Adults and larvae feed on a variety of small, soft-bodied insects and insect eggs. Some species feed on aphids, others on caterpillars or spiders. Little is known about the species present in cotton. Larvae commonly live in the soil while larvae of some species are parasites of insects.

General Biology: The rove beetle family contains a large number of species. Little is known about most species, especially those found in cotton. One species common in the Southeast can be found in cotton blooms.

Adult rove beetle (note short wing covers)

Damsel Bugs

Nabis roseipennis
Nabis capsiformis
Nabis americoferus
Nabis ferus
Nabis alternatus
Nabicula species

Characteristics: Damsel bugs, also called nabids, are slender, dull tan to gray, sometimes black, insects about 3/8 to 1/2 inch long with long antennae and legs, and prominent eyes. Damsel bugs are shaped like some assassin bugs but are smaller and less colorful. Like assassin bugs, damsel bugs have a narrow head and a long beak and can inflict a painful bite. However, unlike assassin bugs, the damsel bug's neck is wider than its head. Nymphs look like small adults without wings. Damsel bugs of various species occur throughout the Cotton Belt.

Prey: Damsel bugs feed on moth eggs and small larvae, aphids, fleahoppers, lygus and tarnished plant bugs, whiteflies, mites and occasionally other predatory insects such as lacewing larvae, pirate bugs, and big-eyed bugs.

General Biology: Eggs are white and cylindrical, and are inserted into stems with only the egg's end (or cap) visible above the surface. Eggs hatch in 8-12 days and nymphs develop in 3-4 weeks. Females produce 150-300 eggs. There are 2 or 3 generations per year and adults overwinter in a variety of sheltered areas.

Damsel bug adult and nymph

Spined Soldier Bug

Podisus maculiventris

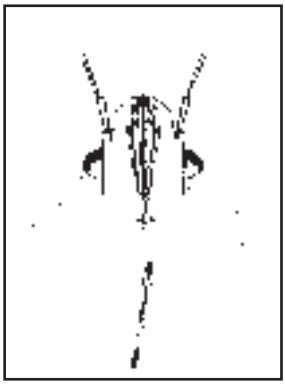
Characteristics: Adults of this stink bug are pale brown, about 3/8 to 1/2 inch long and look like other stink bugs. This insect is named for the single, large spine on each "shoulder." Adults resemble members of the plant-feeding brown stink bug group *(Euschistus)* but the shoulder spines are more pronounced on the spined soldier bug than on most brown stink bugs. There are some pest species, however, that closely resemble this predator. The most reliable way to distinguish between plant-feeding and predatory stink bugs is to examine the straw-like mouthparts (beak). Flip the stink bug over and look at its mouthparts (see drawings on the next page). If the mouthparts are broad (roughly twice the width of an antenna) and stout, it is a predatory species. If the mouthparts are slender (about the width of an antenna) then it is a plant-feeding stink bug.

Like other stink bugs, *Podisus* emits a strong odor when disturbed. Eggs of the spined soldier bug are metallic silver or gold, with a fringe or crown of hairs about the top. Nymphs are oval-shaped and black with bands of red, yellow-orange and cream on the abdomen. This predator occurs throughout the Cotton Belt.

Prey: Adults and nymphs feed primarily on caterpillars. Occasionally they may attack beneficial insects and spiders in cotton. Young nymphs often "gang up" on larger prey.

Eggs of the spined soldier bug

Predatory stinkbug



Plant-feeding stinkbug

Spined Soldier Bug

(Continued)

General Biology: Eggs are barrel-shaped and laid in tight clusters of 20-30 on leaves and twigs. Newly hatched nymphs remain clustered around the egg mass before dispersing. Young nymphs feed only on plant sap while older nymphs and adults feed on insects. Development from egg to adult requires about 3 weeks. Adults live 1-2 months and females deposit 200-300 eggs. Spined soldier bugs are more common when caterpillars are present.

Nymph of the spined soldier bug

Adult spined soldier bug feeding on a bollworm

Spined Assassin Bugs

Sinea diadema

Characteristics: Spined assassin bugs are slow moving, medium to large bugs (1/2 to 3/4 inch long) with a long, curved beak held beneath the body. The front legs are enlarged and spined for grasping prey, and spines are also present on the thorax. Color varies from black to reddish-brown. The head is narrow and antennae and legs are long and slender. Nymphs resemble adults but lack wings. When disturbed, these bugs will often arch back, pulling their forelegs up and back in a defensive posture. The spined assassin bug, *Sinea diadema*, is found throughout the Cotton Belt. Other species of *Sinea* that may be found in cotton include *S. confusa, S. complexa* and *S. spinipes*.

Prey: Assassin bug nymphs and adults eat a variety of prey including caterpillars, aphids and many other insects, such as lady beetle adults and spiders.

General Biology: Eggs resemble those of the leafhopper assassin bug — they are barrel-shaped and laid upright in tight clusters or in rows on leaves or stems. However, the top or cap of the egg may be shaped in bizarre shapes or ornamentations, unlike that of the leafhopper assassin bug. Eggs hatch in about 14 days, and nymphs require 25-35 days to complete development. Adults live 1-2 months and females lay up to 300 eggs. These

predators typically sit and wait to attack passing prey.

Spined assassin bug, *Sinea diadema*

Leafhopper Assassin Bug

Zelus renardii
Zelus species

Characteristics: This assassin bug, *Zelus renardii*, is slender, about 1/2 inch long, and yellowish-green to red and brown in color. The head is very narrow and is armed with a large, strong beak. The nymph resembles the adult but is smaller and lacks wings. Other related assassin bug species include *Zelus exsanguis, Z. cervicalis, Z. socius, Z. tetracanthus* and *Z. bilobus*.

Prey: Assassin bugs attack moving prey and both adults and nymphs eat a variety of insects, both pest and beneficial. Assassin bugs are one of the few predators in cotton that can capture large caterpillars and adult boll weevils.

General Biology: Eggs are dark shiny brown with white caps and laid in tight clusters on cotton plants. The front legs of nymphs and adults are coated with a sticky substance believed to be used for capturing prey. They often have debris stuck to these legs. These predators are usually only abundant after mid-summer.

Egg mass of *Zelus renardii*

Leafhopper assassin bug feeding on boll-worm

Big-eyed Bugs

Geocoris punctipes
Geocoris uliginosus
Geocoris pallens

Characteristics: Adults and nymphs have broad heads and large, bulging eyes. *Geocoris punctipes* is common throughout the Cotton Belt. Adults of *Geocoris punctipes* are about 3/16 inch long and silvery grey. Adults of *Geocoris uliginosus* are smaller (1/8 inch long), oval and black to reddish-black. *Geocoris pallens* is slender, varies in color from buff to yellow-brown to black and is found from Arkansas to California. Nymphs of all species look like small adults without wings and can be mistaken for chinch bugs. Big-eyed bug nymphs, when crushed, release a strong, offensive "stink bug" odor. Both adults and nymphs run rapidly with a distinctive "swagger" and often fall from the plant when disturbed.

Prey: Big-eyed bug adults and nymphs are important predators of many cotton insect pests including bollworm and budworm eggs, small caterpillars, whiteflies, plant bugs, aphids and mites. Big-eyed bugs feed on cotton nectar and occasionally plant sap.

General Biology: Eggs are deposited singly and are easily seen on leaves and stems of the cotton plant. Eggs are grayish-white to pink and shaped like a hot-dog. A bright red eyespot develops a few days after the egg is laid. Eggs hatch in 5-8 days. Development from egg to adult requires about 3-4 weeks. Females produce 150-300 eggs and live 3-4 weeks. All species overwinter as adults.

Adult big-eyed bug, *Geocoris punctipes*

Nymph of *Geocoris punctipes* feeding on bollworm eggs

Big-eyed bug, *Geocoris uliginosus*, feeding on caterpillar

Hover or Syrphid Fly

Syrphus species

Characteristics: The larva is a green to brown slug-like maggot with no legs and no obvious head. The tiny head is located at the small end of the tapered body. Although they have no legs, larvae can move well, stretching out their bodies in a looping action. Full grown larvae are about 1/4-1/2 inch long. Adults vary in size (from 1/4 to 1/2 inch long) and are striped with bright yellow and black. Some species have a slender, striped body, while others have a broad, striped abdomen and look like a bee. When at rest, the wings are held out at an angle from the body, unlike bees and wasps which fold their wings over their backs. Adults fly quickly and can often be seen hovering near plants and flowers, hence their common name.

Prey: Hover fly larvae pierce their prey and suck out the body fluids. They feed most commonly on aphids, but may also consume moth eggs and sometimes small caterpillars. The adult flies feed only on nectar and honeydew.

General Biology: Eggs are white, sculptured, and elongate, and are laid on leaves near aphid colonies. Larvae swing their heads from side to side until they touch and seize an aphid. The larva then lifts the aphid into the air and holds it the while the aphid is sucked dry. Larvae feed for 2-3 weeks and large larvae can eat as many as 50 aphids per day. Larvae feed at night and rest near aphid colonies during the day. The pupa is pear-shaped and fastened to leaves, stems, or

ground debris. The winter is spent in the pupal stage. Hover flies are most abundant when aphid numbers are high.

Adult syrphid fly

Larva of a syrphid fly

Pupa of a syrphid fly

Long-legged Fly

Family: Dolichopodidae

Characteristics: These are small (1/8 inch), slender flies with long, stilt-like legs. They are metallic blue, red or green and are often seen resting on leaves in the sunlight. They move rapidly on and among leaves, running and flying quickly. The wings are typically held out from the body at about a 45 degree angle.

Prey: Adult flies and larvae feed on small insects. Long-legged flies are not known to be an important predator of any cotton pest but are often noted in the field.

General Biology: Very little is known about this insect family. Adults are predaceous on other small insects, and the larvae are also assumed to be predaceous, although this is not known for most species. The adult flies can be very abundant, particularly from mid-season to harvest.

Long-legged fly

Insidious Flower Bug

Orius insidious

Minute Pirate Bug

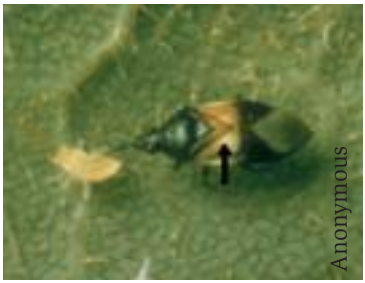
Orius tristicolor

Characteristics: The insidious flower bug is more common in the Southeast and mid-South while the minute pirate bug is the dominant *Orius* species in the Southwest. Their distributions overlap through central Texas and Oklahoma. Adults are very small, 1/8 inch long, flat and oval shaped. They are black with a white X pattern on the back and have a prominent, forward projecting beak. Adults of the minute pirate bug typically have a black clavus ("V" shaped mark on back) and a faint gray spot on the wing membrane. Insidious flower bug adults have a white clavus and light yellow-tan wings. Young nymphs of both species are yellow-orange with a distinct orange scent gland on the abdomen. Older nymphs are tan to dark brown. Nymphs run quickly and can be confused with thrips and fleahopper or plant bug nymphs.

Prey: Both species are important predators of many cotton pests. Adults and nymphs use their beaks to pierce and suck the fluids from thrips, mites, aphids, whiteflies, and eggs and small larvae of budworms, bollworms, loopers, and armyworms. *Orius* are very effective egg predators. Both species also feed on pollen.

General Biology: Eggs are inserted in leaves and other soft plant tissue and hatch after 3

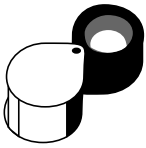
days. Nymphs become adults in 12-20 days; adults live 2-3 weeks and females lay about 100 eggs. Both species move into cotton early in the season to feed on thrips and spider mites. Later in the season they are often found in terminals and blooms. Insidious flower bugs are common in corn silks.



Insidious flower bug adult

Minute pirate bug adult (arrow points to clavus)

Orius nymph



Scymnus Lady Beetle

Scymnus loewii
Scymnus creperus
Scymnus medionotans
Scymnus terminatus

Characteristics: *Scymnus* lady beetles are very small, dull orange to brown beetles. One species, *S. loewii*, has a black center line forming a "V" pattern on the wing covers. Larvae are covered with long, white streamers of wax. These fuzzy, white larvae are sometimes confused with mealybugs. Species of *Scymnus* are found throughout the Cotton Belt.

Prey: Adults and larvae feed primarily on aphids, but may also feed on spider mites in cotton.

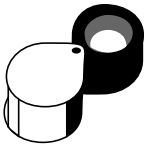
General Biology: Eggs are tiny, barrel-shaped and golden and laid singly in tight spots on the plant such as at the base of cotton leaves where the hairs are dense. Eggs hatch in 3-4 days and larvae develop in 14-17 days. Pupae resemble larvae in that they are covered with wax but unlike larvae do not move. Adults emerge from pupae after 5-8 days and live 3-6 weeks. There are typically 2 or 3 generations per year in cotton and numbers are greatest when aphids are present. The wax covering may provide *Scymnus* larvae some protection from fire ants as they are not attacked by ants as readily as other aphid predators.

Eggs of *Scymnus* on leaf

Larva of a *Scymnus* lady beetle

Scymnus lady beetle adult

Pupa of *Scymnus* lady beetle



Stethorus Lady Beetle

Stethorus picipes

Characteristics: The adult is jet black and very small, about the size of a pinhead and commonly seen in spider mite colonies. The adults run rapidly when disturbed. Larvae are dark brown to black and covered with fine hairs.

Prey: Both adults and larvae feed on spider mites and their eggs.

General Biology: *Stethorus* lady beetles appear in cotton when spider mites are present. Eggs are laid in spider mite colonies.

Adult
Stethorus
lady beetle

Larva of
Stethorus

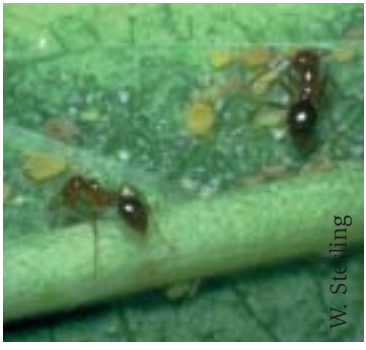
Fire Ants

Solenopsis invicta
Solenopsis geminata
Solenopsis xyloni
Solenopsis richteri

Characteristics: The red imported fire ant is a reddish-brown to black ant identified by its very painful sting which results in the formation of an itching, white pustule. Red imported fire ants are found throughout the southern U.S. from North Carolina to central Texas. Related species include the black imported fire ant, found in northern Mississippi and Alabama; the tropical fire ant, found along the Gulf Coast and north to South Carolina; and the southern fire ant, distributed along the southern U.S. from California to North Carolina. All of these related species can be found in cotton but have often been displaced by the red imported fire ant.

Prey: Fire ants are voracious predators of bollworm and budworm eggs and small caterpillars, fleahoppers, boll weevils and other insects. Fire ants often search cotton plants during the night and thus go unobserved. Studies in Texas found that a fire ant may take up to 0.3 bollworm or budworm eggs and 0.1 small worms per day. Fire ants quickly recruit nest mates to overcome large caterpillars and other prey. Fire ants are the only predators of boll weevil larvae and will chew into fallen squares to butcher and carry away weevil grubs. However, fire ants readily feed on aphid honeydew and "farm" aphids by driving away or killing predators and parasites that attack aphids. As a result, large numbers of fire ants can contribute to increases in aphid infestations. Fire ants probably have little impact on populations of predatory insects or spiders in cotton, except those feeding on aphids.

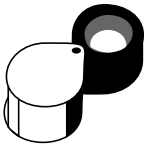
General Biology: Imported fire ants reside in large colonies in the soil consisting of 100,000 to more than 500,000 ants. Colonies may construct large mounds, especially after rains. During dry weather, mounds may not be visible. Fire ants may be more abundant along field margins and in reduced tillage fields where colonies escape cultivation. Fire ants are active throughout the season.



Fire ants "farming" aphids

Red imported fire ants attacking pink bollworm

Red imported fire ant eating moth egg



Six-spotted Thrips

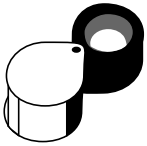
Scolothrips sexmaculatus

Characteristics: Like plant-feeding species, the predatory six-spotted thrips is a tiny (1/16 inch), slender straw colored insect with short antennae. It is named for the six black spots on its wings which are held folded above the abdomen. Larvae lack wings and are white to yellow and cigar-shaped. The six-spotted thrips is commonly found in spider mite colonies.

Prey: Adults and larvae feed on plant-feeding spider mites and their eggs. Six-spotted thrips are well adapted to penetrating the silk webbing made by plant-feeding mites and have been credited with reducing spider mite outbreaks in Arkansas in some years. In laboratory studies, females killed more than 1,700 mite eggs during their 45-day lifespan.

General Biology: Eggs are inserted into leaf tissue and hatch in about 7 days. Larvae feed for about 5-6 days and then enter the pupal stage in the mite colony. Development from egg to adult requires about 2 weeks.

Adult six-spotted thrips



Predatory Mites

Galendromus (= Metaseiulus) occidentalis
Amblyseius californicus

Characteristics: Predatory mites are larger than plant-feeding mites and are pear-shaped. They are reddish-tan in color, have long legs and run quickly when disturbed. The two species listed above are found in California but their distribution and that of other predatory mite species in cotton are not well known.

Prey: Predatory mites feed on plant feeding spider mites and their eggs.

General Biology: The western predatory mite, *G. occidentalis* and *A. californicus* are common in vineyards and alfalfa in California. Numbers of predatory mites in cotton often do not increase early enough to control spider mites. Releasing predatory mites has shown promise for controlling spider mites in California.

Predatory mite feeding on two-spotted spider mite

Archytas marmoratus

Family: Tachinidae

Characteristics: *Archytas marmoratus* is a large, stocky fly about 1/2 inch long with long black bristles on its abdomen and thorax. The silvery-white "face" is characteristic of this species which is found throughout the southern U.S.

Hosts: *A. marmoratus* is an important parasite of the larval stage of the bollworm, budworm, black cutworm, fall armyworm and related moth species in cotton, alfalfa and corn. Medium to large larvae, 4-5th instars, are most commonly parasitized.

General Biology: The adult fly deposits maggots, rather than eggs, on cotton leaves where bollworms and budworms are feeding. The bluish-green maggots can lie in wait several days and quickly attach themselves to bollworms or other caterpillars that crawl within reach. The maggot penetrates the bollworm/budworm larva but does not begin to eat or develop. Parasitized bollworms continue to feed and develop normally. Once the bollworm or budworm has entered the soil and pupated, the fly maggot begins to consume the pupa. The maggot feeds for 6-10 days and then pupates. A single adult fly emerges about 8-10 days after the host pupates. A female can produce 2,000 or more maggots during her lifespan of 50-70 days. Winter is spent in the adult stage.

Adult *Archytas marmoratus*

Face of female *A. marmoratus* showing silver-white face

Scanning electron micrograph of larva (planidium) of *Archytas* waiting on a leaf to parasitize passing caterpillar

Tachinid Flies

Lespesia archippivora
Eucelatoria bryani

Characteristics: The large tachinid (about 1/2 inch long) with a silvery-white face is *Archytas marmoratus* and is discussed in detail on the previous page. Some other important tachinid species belong to the genera *Lespesia* and *Eucelatoria. Lespesia* is a small (4-8 mm) gray fly which runs and flies quickly and is found throughout the Cotton Belt. *Eucelatoria bryani* is an active, grayish black fly about 1/4 inch long with a reddish tinge at the tip of its abdomen and is found from Mississippi west to Arizona. A related species, *E. armigera* is found in California and Arizona.

Hosts: *Lespesia archippivora* parasitizes many different kinds of caterpillars, including bollworm, fall armyworm, beet armyworm, cabbage looper and black cutworm. *E. bryani* is a common parasitoid of bollworm, budworm and fall armyworm larvae.

General Biology: While some tachinid flies lay their eggs on leaves, the female *Eucelatoria* alights on a bollworm or budworm larva and using a sharp barb on her abdomen, rips open a hole in the caterpillar's skin. She then deposits up to 20 maggots into the caterpillar. The maggots feed inside the larva for 4-5 days. Once the bollworm or budworm has completed feeding and tunneled into the soil in preparation for pupating, the maggots emerge from the now dead caterpillar and pupate. The adult flies emerge about

10 days later and live for several weeks. Adults overwinter.

Lespesia females land on the caterpillar and deposit their eggs on the caterpillar's body. The fly eggs hatch in about 20 minutes and the grubs tunnel into the armyworm. The grubs feed internally for 10-16 days, finally causing the death of the armyworm. Mature grubs emerge from the dead host and pupate. Adults flies live for several weeks and produce about 100-200 eggs.

An adult tachinid fly

Macrocentrus grandii

Family: Braconidae

Characteristics: *Macrocentrus grandii* is a small wasp, about 1/4 inch long, with long antennae and a very long (1/4 inch) "stinger" or ovipositor. The head is dark while the thorax and legs are red-orange. The abdomen is lighter with several black bands.

Hosts: *M. grandii* is an important parasitoid of European corn borer larvae in cotton and other crops.

General Biology: Adult female wasps sting European corn borer larvae and deposit a single egg inside the corn borer. The egg divides and yields about 25 or more grubs which feed internally. Once the grubs are full grown, they emerge from the now dead corn borer and spin white cocoons near the remains of the host. About 20 adult wasps will emerge from each parasitized European corn borer larva. Corn borer larvae are not killed until after they have completed feeding, thus parasitism helps limit the following generation. Studies in North Carolina found *M. grandii* parasitized about 50 percent of the European corn borer larvae in cotton.

M. Scott, Illinois Natural History Survey

Adult
Macrocentrus grandii

Microplitis croceipes

Family: Braconidae

Characteristics: Adults are large dark brown to black wasps about 1/3 inch long. The abdomen and legs are yellow to red and the wings are dark. The cocoons are off white to yellowish and smooth with long ridges. *M. croceipes* is found throughout the Cotton Belt except it is not reported from California.

Hosts: In some areas, *M. croceipes* is one of the most common parasites of bollworm larvae in cotton. As many as 50 percent of bollworm larvae may be parasitized by this wasp. All stages of larvae are attacked but 3rd and 4th instars are preferred. Budworm larvae are also parasitized. *M. croceipes* parasitizes bollworms infesting alfalfa, sorghum, tomato, wild hosts and corn in the whorl stage but not in the ear stage.

General Biology: The adult female stings the bollworm larva and deposits her eggs inside the caterpillar. Third instar larvae are most commonly parasitized. Larger larvae often drive off the parasite before it can sting. The wasp's egg hatches into a grub which feeds inside the bollworm for about 8 days. The parasitized bollworm soon stops feeding. Once full grown, the wasp grub bores out of the dead bollworm and spins a white cocoon. The adult wasp emerges from the cocoon in about a week. Development from egg to adult requires about 15 days at 86°F. There are 3 or 4 generations per year

and the wasps overwinter in the soil as mature larvae (prepupae) inside cocoons.

Adult *Microplitis croceipes* and cocoon near host larva

Larva of *M. croceipes* emerging from parasitized caterpillar

Cardiochiles nigriceps

Family: Braconidae

Characteristics: The adult wasps are about 1/4 inch long with long antennae and very dark wings. The head and thorax are black while the abdomen and middle and hind legs are red. *C. nigriceps* is sometimes called the "red-tailed" wasp because of the red abdomen. The ovipositor (stinger) is short and black and often not visible. This parasite is widely distributed across the southeastern Cotton Belt west to Oklahoma and Texas. These brightly colored wasps may be seen hovering about cotton plants in search of caterpillars to parasitize. They can be very common in some fields, averaging 1-2 wasps per meter (yard) of row.

Hosts: *C. nigriceps* is one of the most important parasitoids of the budworm. It can only successfully parasitize budworm larvae and a related species, *H. subflexa,* which is not a cotton pest. Wasps will sting bollworm larvae but the parasite eggs do not develop and the bollworm survives. Also, beet armyworm larvae are occasionally parasitized by this wasp. All sizes of budworm larvae are attacked but late second and third instars are preferred.

General Biology: Adult female wasps sting budworm larvae and deposit eggs internally. Eggs hatch into grubs which feed internally for about 2 weeks. Small budworm larvae continue to grow once parasitized while those in the 4-5 instar do not. Once full grown, the parasitoid grub emerges from the dead bud-

worm larva and spins a cocoon in the soil. The adult wasp emerges in about 2 weeks and lives for about 2 weeks. There are about 3 or 4 generations per year and wasps overwinter as pupae in the soil.

Adult *Cardiochiles nigriceps*

Chelonus insularis

Family: Braconidae

Characteristics: This small (1/8 inch) robust wasp has a small white patch on each side of the front of the abdomen *C. insularis* is found throughout the Cotton Belt.

Hosts: *C. insularis* parasitizes eggs of the bollworm, beet armyworm, fall armyworm and several other armyworm species.

General Biology: The female places her egg inside the bollworm or armyworm larva while the larva is still inside the egg. The larva hatches and develops normally for several days but soon appears shrunken and dry as the *Chelonus* larva feeds internally. The parasitized host larva then spins a fine-meshed, yellow silk cocoon, called the "death-cell", around itself. About 2 days later the armyworm larva dies. A day later, the full grown *Chelonus* larva emerges from the shriveled body of the armyworm and pupates nearby.

Adult *Chelonus* stinging (parasitizing) a moth egg

Bracon mellitor

Family: Braconidae

Characteristics: The adult *B. mellitor* is a brownish-orange wasp about 1/16-3/16 inch long. The dark eyes, antennae and legs and the dusky areas on the wings give it a black appearance. The abdomen is broad and the female has a black ovipositor (stinger) almost as long as her body. *Bracon mellitor* is native to the U.S. and found throughout the Cotton Belt and northern Mexico. *Bracon hebetor* is a related species.

Hosts: *B. mellitor* parasitizes boll weevil grubs. It is often the most common insect parasite of the boll weevil. It also parasitizes other weevil species and some caterpillars, including the pink bollworm. Adult wasps feed on nectar produced at the base of cotton squares.

General Biology: The female *Bracon mellitor* searches cotton squares and bolls and probes the fruit with her ovipositor to detect weevil grubs inside. Once a grub is located, the female drills through the fruit and paralyzes the grub by stinging it. A single egg is then placed on the grub or nearby in the grub's cavity. The egg hatches in a day and the tiny parasite larva pierces the paralyzed weevil grub and feeds on its body fluids. After 4-5 days, the parasite larva is full grown and it spins a white silk cocoon in which it pupates inside the weevil's cell. The adult wasp emerges from the cocoon in about 3-6 days and escapes from the weevil's cell by chewing through the square or boll. Female wasps live

about 3 weeks and produce about 160 eggs each. Winter is spent as a mature larva (pre-pupa) inside the cocoon.

Adult *Bracon mellitor*

Hyposoter Parasite

Family: Ichneumonidae

Characteristics: These are slender, elongate wasps (1/4 inch long), with mostly orange abdomens that are flattened on the sides. The abdomen is narrowly attached to the thorax. Cocoons are attached to leaves, are shaped like short fat sausages, and are typically banded in silver/grey and black. Although *Hyposoter* spp. are reported throughout the Cotton Belt, they are more prevalent from Texas westward.

Hosts: *Hyposoter* wasps attack a wide range of caterpillars, including bollworms, budworms and armyworms.

General Biology: The adult female attacks small caterpillars, laying a single egg inside. The parasite grub emerges from the larva after 8-10 days and spins a cocoon on the leaf. The adult parasite emerges from the cocoon 5-7 days later.

Hyposoter cocoon near remains of parasitized caterpillar

Armyworm torn apart, revealing *Hyposoter* larva

Adult and cocoon

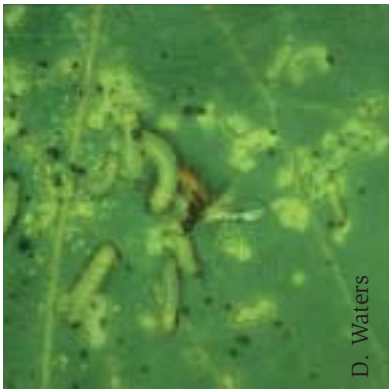
Cotesia marginiventris

Family: Braconidae

Characteristics: *Cotesia marginiventris* is a small wasp, about 1/8 inch long, slender and black. The white cocoons, containing *Cotesia* pupae, are commonly seen on cotton leaves. The cocoons are solitary and resemble a fuzzy grain of rice attached to the leaf.

Hosts: *Cotesia* parasitizes larvae of bollworms, budworms, loopers and beet, fall and southern armyworms in cotton and other field crops. This parasite is particularly effective against beet armyworms.

General Biology: The adult wasp lays her egg inside the host caterpillar. The egg hatches in 1-2 days and the parasite grub feeds inside the caterpillar for about 6 days. The full grown grub then bores out of the caterpillar, causing it to die, and spins a white cocoon around itself. The adult wasp emerges from the cocoon about 4-5 days later. A single female can parasitize (kill) 200-300 host caterpillars during its 10- to 14-day life. There may be 4 to 6 generations per year.



Adult *Cotesia marginiventris* parasitizing beet armyworm larva

Cocoon of *Cotesia marginiventris* on leaf

Cocoons of *Cotesia* on leaf adjacent to beet armyworm damage

Catolaccus grandis

Family: Pteromalidae

Characteristics: *C. grandis* is a medium sized wasp (3/16 inch) with large eyes, a broad thorax, short antennae and an abdomen which tapers to a point. It is native to Mexico and although released into the U.S., it has not established due to its inability to survive the winter. As a result, *C. grandis* is not naturally present in the U.S. *Catolaccus hunteri* is a related species native to the U.S.

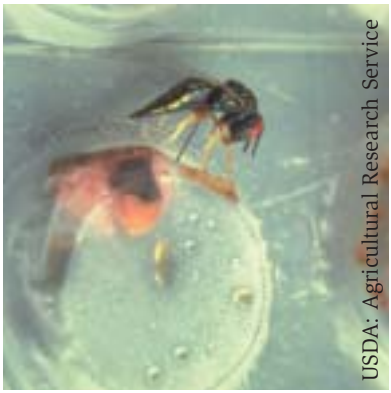
Hosts: *C. grandis* parasitizes larvae (grubs) of the boll weevil. Grubs in the third instar are most commonly parasitized. Also, more grubs in squares on the plant are attacked than are grubs in squares on the ground.

General Biology: The wasp searches squares, detecting weevil grubs inside. Wasps learn where squares have the most grubs and concentrate searching and stinging either on the plant or on the soil (fallen squares). The female wasp drills through the cotton square and paralyzes the boll weevil grub by stinging it. She then places an egg on the grub. The egg hatches and the parasite larva feeds externally on the paralyzed weevil grub for about 6 days. Once full grown, the larva pupates inside the cotton square or boll near the dead boll weevil grub. The adult wasp emerges about 5 days later. Development from egg to adult requires about 13 days at a temperature of 86°F. In lab studies, adult wasps lived about 45 days and each female parasitized 200-300 weevil grubs. Females also pierce weevil grubs and feed on their blood. Field

studies have shown releasing laboratory-reared *C. grandis* early in the season holds promise for controlling boll weevil. However, costs for rearing this parasite must be reduced to be economical. Research is ongoing to find inexpensive methods of mass rearing *C. grandis* for annual release in cotton for boll weevil control.

W. Sterling

Adult *Catolaccus grandis*



USDA: Agricultural Research Service

Adult *Catolaccus* stinging boll weevil in rearing cell

Meteorus Parasite

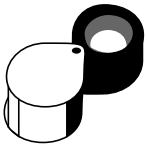
Braconidae: *Meteorus* species

Characteristics: The adult is a golden brown, slender wasp about 1/4 inch long. Females have a long stinger (ovipositor) projecting backward from the abdomen about the length of the abdomen. Cocoons are brown, about 1/3 inch long, shaped like a football and are suspended from the leaf on a filament.

Hosts: *Meteorus* attacks a wide range of caterpillars, including beet, fall and southern armyworms in a variety of crops and wild plants.

General Biology: *Meteorus* females lay eggs in nearly all larval stages of their hosts, although small larvae are most frequently parasitized. After feeding internally for 10-12 days, the parasite grub emerges from the host and spins its football-shaped cocoon while suspended from the leaf on a silken thread. The adult lives 3-6 weeks and is capable of parasitizing 150-300 hosts during its lifetime. There appear to be 3 or 4 generations per year.

Adult
Meteorus
parasite



Lysiphlebus testaceipes

Family: Braconidae

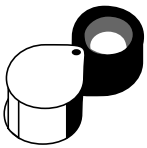
Characteristics: *Lysiphlebus testaceipes* is a shiny, slender black wasp about the size of a cotton aphid. Wasps can often be seen in aphid colonies as they sting (parasitize) aphids. More commonly, the parasitized aphid mummies are seen, evidence this parasite is active in the field. Aphid mummies are dead swollen aphids stuck to leaves. The mummies are tan to gold and contain a developing wasp or have a hole cut in the top through which the wasp emerged.

Hosts: *L. testaceipes* attacks the cotton aphid in cotton and other aphid pests such as greenbugs in wheat.

General Biology: The female pierces (stings) the cotton aphid and deposits an egg inside. The egg hatches in about 2 days and the parasitoid grub feeds internally on the living aphid. The grub is full grown in about a week at which time the aphid takes on a swollen, tan appearance and dies. The parasitized aphid is termed a "mummy" and is attached to the leaf. The grub enters the pupal stage and about 4-5 days later, the adult wasp emerges through a circular hole cut towards the back of the aphid mummy. Development from egg to adult requires about 2 weeks. A single female can parasitize about 100 aphids during her 4- to 5-day life span.

L. testaceipes adult

Aphid mummy showing exit hole cut by emerging adult wasp



Looper Parasite

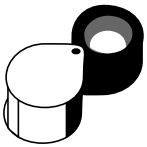
Encyrtidae: *Copidosoma* species

Characteristics: This tiny (1/16 inch) shiny black wasp resembles a small fly. Loopers parasitized by *Copidosoma* are most easily recognized after they spin their pupation cell on the underside of leaves. Unparasitized loopers form a green pupa that later darkens to brown. Parasitized loopers, in contrast, fail to pupate, but instead elongate, causing the head to fold into a hook shape under the body. The larva takes on a cream or light tan color, and appears to be made of styrofoam. Each of the "foam" cells in the caterpillar's body is actually a developing wasp. These parasites are found throughout the Cotton Belt.

Hosts: These wasps attack loopers, especially soybean loopers.

General Biology: Adult wasps sting looper eggs, laying a single egg in the host egg. After the looper hatches, the nucleus in the wasp egg divides repeatedly and each nuclei becomes a wasp larva. Up to 2,000 wasps can develop in a single host looper. The parasitized looper requires a bit longer to develop than an unparasitized looper and eats up to 50 percent more foliage than an unparasitized looper. Development from egg to adult requires about 17-27 days and there are 2 or 3 generations per year. A single female is capable of parasitizing 10-30 loopers. Late in the season, these parasites can practically eliminate a soybean looper population in a single generation.

A looper filled with hundreds of *Copidosoma* pupae. The silk cocoon spun by the dying looper has been removed



Stink Bug Egg Parasites

Family Scelionidae:*Telenomus* species
Trissolcus species

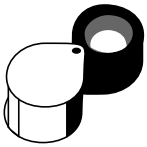
Characteristics: These are tiny (1/20-2/20 inch), shiny black wasps with antennae that are elbowed downward. The wings have very little venation. The shape of the body varies from slender and somewhat flattened top to bottom, to short and very stout. These parasites are found throughout the Cotton Belt.

Hosts: These wasps parasitize eggs of different stink bug species, including predaceous stink bugs in some cases. The species of stink bug attacked depends on the parasite species. Some attack many species of stink bugs while others parasitize only a few species. *Trissolcus basalis* is an important parasite of the southern green stink bug which can be a pest of cotton.

General Biology: The parasite females lay their eggs in the eggs of the stink bug, usually only one parasite egg per host egg. A single wasp develops in each egg. Parasitized stink bug eggs turn black within a few days of parasitism. The adult parasite emerges from the egg about 8-20 days after the parasite egg is placed in the stink bug egg. Adult parasites live about 2-6 weeks and can parasitize from 30 to over 100 stink bug eggs in a lifetime.

Adult *Trissolcus basalis* parasitizing eggs of the southern green stink bug

Another species of stink bug egg parasite. Note elbowed antennae



Whitefly Parasites

Family: Aphelinidae: *Eretmocerus* species
Encarsia species

Characteristics: Although these wasps are very tiny, about 1/25 inch long (1 mm), they are among the most important natural enemies of whiteflies. Because of their small size, adults are rarely seen. However, whitefly nymphs parasitized by these wasps can be identified by the circular hole cut in the top of the nymph through which the adult wasp escaped. Whitefly nymphs parasitized by some *Encarsia* species turn black while those parasitized by *Eretmocerus* do not. Both *Eretmocerus* and *Encarsia* are distributed throughout the Cotton Belt but the range of individual species is variable and often unknown. *Eretmocerus spp.* near *californicus* is an important native species in the Southwest. *Encarsia pergandiella* is an important native species while *E. formosa* is introduced into the U.S.

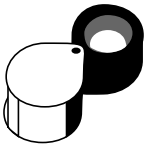
Hosts: These wasps parasitize nymphs of whiteflies. Adult wasps also act as predators as they sting whitefly nymphs, creating a hole and feeding on the body fluids that flow out.

General Biology: Adult wasps search for whitefly nymphs and lay an egg in the nymph (*Encarsia*) or under the nymph (*Eretmocerus*). The wasp larva feeds internally, killing the whitefly nymph. The parasite larva then pupates and later the adult wasp escapes through a hole cut in the top of the whitefly nymph. In contrast, whitefly pupae from which an adult whitefly emerged have a “T”

shaped slit in the pupal skin. Nymphs parasitized by *Eretmocerus* are a dark amber color compared to the lighter colored healthy nymphs. Development from egg to adult requires 18-25 days for *Eretmocerus* and somewhat less for *Encarsia*. A single female wasp parasitizes 40-50 whitefly nymphs and kills many other nymphs by direct feeding.

Eretmocerus adult stinging (parasitizing) a whitefly

Encarsia formosa adult



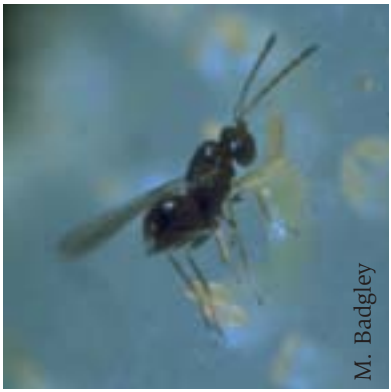
Mymarid Wasps

Family: Mymaridae: *Anaphes iole*

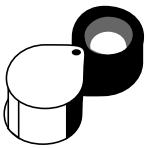
Characteristics: These very tiny wasps, less than 0.04 inch (0.6mm), have very slender hind wings. They may be captured in yellow pan traps or with sweep nets made of canvas or reared from lygus bug eggs collected from cotton and alfalfa. Parasitized lygus eggs are black. *Anaphes iole* is known to occur in Louisiana, California and Arizona and is probably present throughout most of Cotton Belt.

Hosts: *Anaphes iole* is an important parasite of eggs of the lygus bug, *Lygus hesperus* and the tarnished plant bug, *L. lineolaris. A. iole* also parasitizes eggs of some species of damsel bugs (p.56) in beans. However, studies in the Southwest showed *A. iole* did not attack damsel bug eggs in cotton.

General Biology: The adult parasite deposits her egg into the lygus eggs which are inserted into plant tissue. The wasp egg hatches into a grub which consumes the contents of the lygus egg and pupates. A single adult wasp later emerges from the lygus egg. Development from egg to adult requires about 15 days.



Anaphes iole, a parasite of lygus bug eggs



Trichogramma Wasps

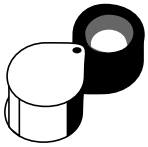
Trichogramma pretiosum
Trichogramma exiguum
Trichogramma minutum
Trichogrammatoidea bactrae

Characteristics: *Trichogramma* are extremely tiny wasps which develop inside the eggs of moths and butterflies. Adults are not seen in the field because of their small size. However, eggs of bollworms and budworms which are black indicate the presence of *Trichogramma* wasps. A powerful hand lens or microscope is necessary to clearly see these minute parasites. Adults are yellow and brown and the wings have only a few veins. *T. pretiosum* is found throughout most of the Cotton Belt. *T. exiguum* has been reported from Alabama, Arkansas and Texas and may be present in other areas also. Several species of *Trichogramma* are reared in commercial insectaries and promoted for control of bollworms and budworms. *T. bactrae* was introduced from Australia and is reared and sold for release against the pink bollworm. Identification of the species requires high magnification and specialized training. Bollworm/budworm eggs also turn black when parasitized by another tiny wasp named *Telenomus heliothidis* (Scelionidae). *Telenomus* are uniformly shiny black.

Hosts: *Trichogramma* parasitize eggs of bollworms, budworms, loopers and other caterpillar pests. Some species also parasitize eggs of green lacewings. Current studies indicate *Trichogramma* rarely parasitize beet army

Trichogramma wasp parasitizing a moth egg

Trichogramma wasp mounted on microscope slide



Trichogramma Wasps

(Continued)

worm or fall armyworm eggs which are covered by scales left by the female moth.

General Biology: The adult female places one or more eggs inside the host egg using her "stinger" (ovipositor). The egg(s) hatch in a day and the wasp larvae feed inside the egg for about 3 days and then pupate inside the host egg. At this time, dark deposits on the inside of the host egg cause it to turn black. After 4-5 days, the adult wasp cuts a hole in the side of the host egg and emerges. Development from egg to adult requires 8-10 days. Adults live about 10 days. *Trichogramma* will parasitize all stages of bollworm/ budworm eggs except those within a few hours of hatch (black-head stage). Adults are active throughout the season. Immature stages overwinter in host eggs and adults are active during warmer days of the winter in southern climates.

Bollworm egg parasitized by *Trichogramma*

Unparasitized bollworm egg

Cotton Aphid Fungus

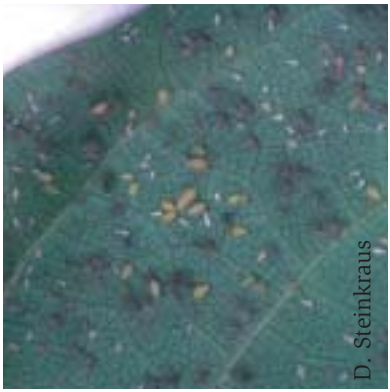
Neozygites fresenii

Characteristics: Cotton aphids recently killed by this fungus are covered with a velvety white or light gray growth. Close examination will show the dead aphids are still attached to the leaf with their mouthparts. Soon, other fungi begin to appear on the dead aphid, giving it a fuzzy olive-brown appearance. Fungus-killed aphids should not be confused with aphid "skins" which are white and shriveled or with parasitized aphids (p. 107). *N. fresenii* is found from Georgia to central Texas.

Hosts: *N. fresenii* is the most important natural enemy of the cotton aphid in the mid-South and Southeast when aphid populations reach high densities. Widespread outbreaks of this fungus, called epizootics, often occur when aphid numbers are high and can eliminate aphid infestations in 7-10 days in some areas. Epizootics can occur during relatively dry weather. This fungus only attacks aphids.

General Biology: Cotton aphids infected with *N. fresenii* produce fungal spores which land on leaves. The sticky spores attach to the legs of aphids as they walk across leaves. Once the spores contact an aphid, they germinate and penetrate the aphid's body. The fungus grows internally and the aphid dies in 3-4 days. The fungus then grows outside the dead aphid and shoots tiny spores which are carried on the wind. A single aphid can release 3,000 spores and up to 60,000 spores per cubic meter of air have been reported at night

in cotton fields during epizootics. The fungus completes its life cycle in 3 days, allowing rapid increase in the number of infected aphids. Cotton aphid infestations often crash 7-10 days after fuzzy aphids killed by *N. fresenii* are found in a field. Careful scouting to detect the fungus earlier can be used to predict epizootics and possibly avoid the need for aphicides. Resting spores survive in the soil. Winged aphids, infected yet still alive, can also carry the fungus.



Cotton aphids killed by *Neozygites* fungus on underside of cotton leaf

Neozygites spores and cotton aphid killed by *Neozygites* fungus

NPV Disease

Nuclear polyhedrosis virus

Characteristics: Insects killed by NPV are discolored and limp. They often hang from leaves attached only by one or two legs. Infected caterpillars are filled with a cloudy liquid inside and are easily broken open when handled. NPVs, also called baculoviruses, are found nearly everywhere. Different strains or "species" of virus occur and each tends to attack only a limited number of caterpillar species.

Hosts: NPVs infect more than 400 insect species. Caterpillars of moths and butterflies are commonly infected. In cotton, cabbage loopers are often attacked by NPV while beet armyworms, bollworms and budworms are less commonly infected.

General Biology: The liquid released from insects killed by NPV contains millions of virus particles which fall onto leaves. Other caterpillars ingest the virus particles while feeding on contaminated leaves and become infected. Virus particles can also enter through natural openings in the caterpillar, or be carried on the stinger (ovipositor) of a parasitic wasp. Two to five days after ingesting the virus, caterpillars become sluggish and eat less. Death follows in 5-12 days. Shortly before dying, the caterpillar may climb to the top of the plant and hang by its prolegs. The insect's body wall is easily ruptured, thereby releasing liquid and virus particles onto leaves. Other caterpillars contact the virus and the cycle is repeated.

Bollworm killed by NPV

Beauveria and other Fungi

Beauveria bassiana
Erynia species
Nomuraea rileyi

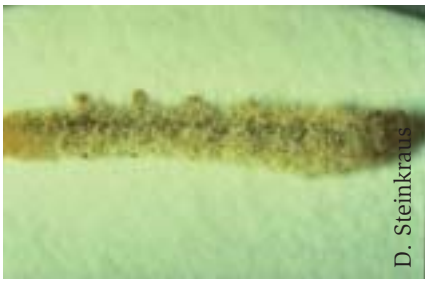
Characteristics: Insects killed by *Beauveria* become covered with a white, thick mass of fungal growth. The infected insect becomes stiff and if broken apart is found to be filled with a solid, fungal mass. *Beauveria bassiana* is found throughout the U.S. and is also formulated as an insecticide.

Erynia and *Nomuraea* are other fungal diseases of insects.

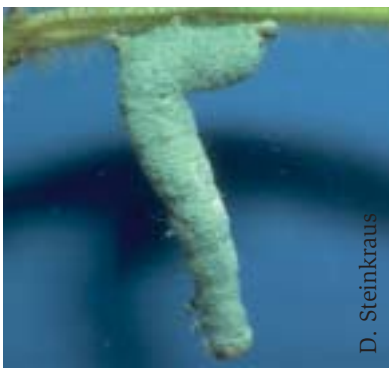
Hosts: *B. bassiana* attacks many different species of beetles, moth caterpillars and true bugs. In cotton, bollworms, boll weevils and and a variety of other pest and beneficial insects are sometimes infected with this disease. *Nomuraea* and *Erynia* attack caterpillars.

General Biology: Spores (conidia) of *B. bassiana* and other fungi occur in the soil and are released from infected insects. Spores that contact the insect germinate and grow through the body wall or enter the insect's body through natural openings. Spores which are eaten germinate on the insect's mouth parts or in the digestive tract and grow into the insect's body. The insect dies in a few days as its body is filled with fungal growth. The fungus then grows externally over the insect's body and releases spores to infect other insects.

Caterpillar killed by *Beauveria* fungus



Caterpillar killed by *Erynia* fungus



Soybean looper killed by fungus *Nomuraea rileyi*

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A hand lens is very helpful in identifying the many small predators and parasites described in this field guide. The following companies sell hand lenses, nets and other supplies and books for collecting, observing, and identifying insects. This listing is not exhaustive, and is for information purposes only. It should not be construed as an endorsement of the listed companies.

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