The Boll Weevil in Missouri: History, Biology and Management

The cotton boll weevil, *Anthonomus grandis grandis*, was the most important pest of cotton in much of America's Cotton Belt. Fortunately, it was eradicated in the United States by a U.S. Department of Agriculture (USDA) program in cooperation with state agencies and cotton farmers. In Missouri, the eradication started in 2001 and lasted seven years. The weevil's importance was due not only to the considerable damage it does but also to its disruption of management programs that target other pests.

High numbers of boll weevils caused repeated insecticide applications during the growing season because the boll weevil went through several overlapping generations during every crop season, reproduced quickly, moved often and could be controlled with insecticides only during its adult stage. Applying insecticides reduced populations of organisms that regulate the populations of other cotton pests, such as aphids, plant bugs and the bollworm complex. The presence of significant boll weevil populations dictated, to some extent, the management of other pests.

History and distribution

The boll weevil is not native to the United States. It originated in Mexico and Central America where it fed on native tree cottons. It probably adapted to domesticated cottons in Central America in pre-Columbian times.

It was first detected in the United States in Texas, about 1892. The boll weevil spread across the Cotton Belt at an average rate of about 60 miles a year and made it to the Carolinas by 1922. It was first detected in Missouri about 1913.

Today, the boll weevil has been eradicated in the United States. The last states to eradicate the weevil were the mid-South cotton-production region, which is Arkansas, Louisiana, Missouri, Mississippi and Tennessee, and in Texas, New Mexico and parts of Alabama. States that successfully eradicated the boll weevil earlier were North Carolina, South Carolina, California, Florida, Georgia and parts of Alabama. Another subspecies of the boll weevil was found in Arizona, but it feeds predominantly on a wild relative of cotton.

The boll weevil was found throughout the Missouri cotton-production region, and cotton was the only host of the boll weevil in the state. It appeared to be most abundant along Crowley's Ridge, a north-south ridge extending from the Ozarks south into Arkansas, and in areas near major waterways (Figure 1). Researchers worked to definitively establish the distribution in the state.

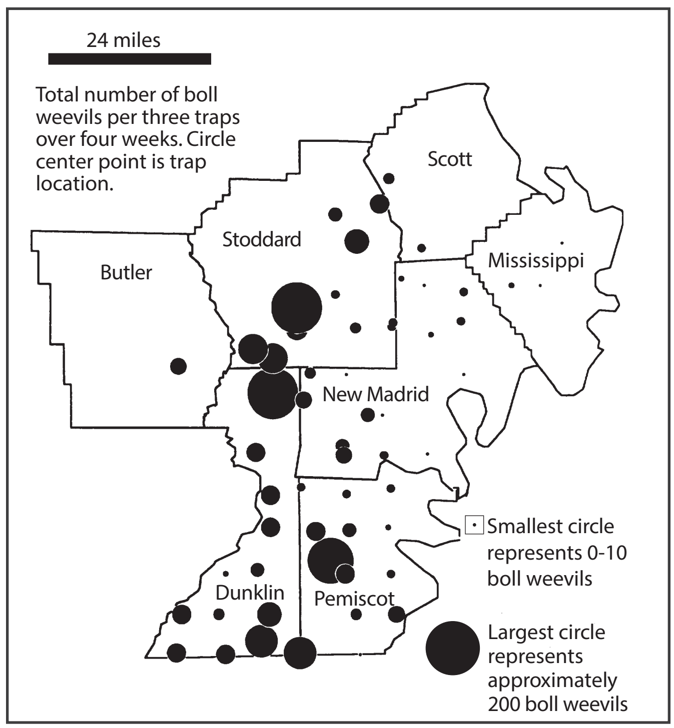

Figure 1. Distribution of boll weevils in southern Missouri.

The insect's life cycle

The boll weevil, like all beetles, underwent complete metamorphosis. Female boll weevils deposited eggs in cotton flower buds, called squares, and in small bolls.

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Each female produced as many as 200 eggs during her life span. The female sealed the oviposition hole with frass, or droppings, leaving a characteristic brown, raised area at the site. The bracts of infested squares usually turned yellow and flared, and the squares dropped from the plant. Infested bolls may or may not have dropped.

Larvae hatching from the eggs fed on the square or boll tissue for approximately seven days to 14 days (depending on temperature) and then pupated. The pupal stage lasted about five days, after which the new adult emerged. Newly emerged adults fed on squares, pollen or bolls. Females began laying eggs three days to five days after they emerged. Generation time from egg to egg averaged about 18 days to 21 days, although it could be shorter or longer depending on environmental conditions. Figure 2 illustrates the life cycle of the boll weevil.

Toward the end of summer, as cotton plants matured and days grew shorter, most emerging adult weevils entered a pre-diapause state. Diapause was a resting state comparable to hibernation that adult boll weevils entered to survive winter. Pre-diapause boll weevils typically didn't mate but instead spent a great deal of time feeding to build up fat reserves for the winter. During this phase of the annual cycle, boll weevils traveled great distances. Individual insects may have moved more than 30 miles in search of remaining food or wintering habitat.

Diapausing boll weevils generally spent the winter in leaf litter in wooded areas near cotton fields. However, a few overwintered in fence rows, grass banks and other sites. Survival was highest in hardwood litter sites. The boll weevils remained in these overwintering sites until warming temperatures, lengthening days and perhaps moisture triggered the break of diapause.

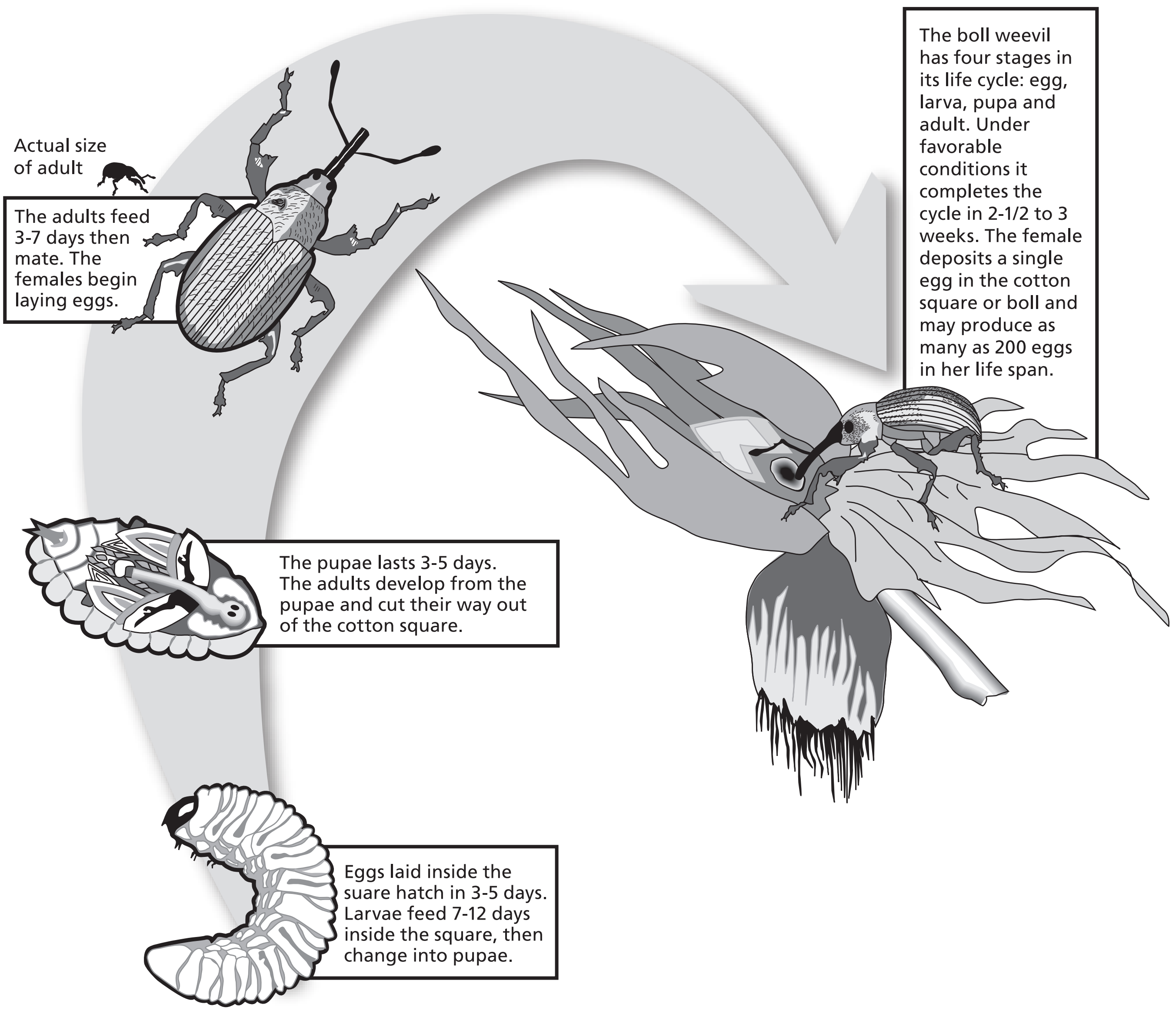

Figure 2. The life cycle of the boll weevil.

Abundance from year to year varied dramatically because of fluctuations in the severity of winters. Spring-emerging boll weevils searched for the nearest cotton field and searched for squares there. Those emerging before squares were available may have fed on the terminal buds of cotton plants or on the pollen of flowering plants around the field. The boll weevil, however, had to have cotton pollen available to successfully mate.

Once males fed on squares, they produced a pheromone, released in their frass, that was attractive to both females and males. Females were attracted because pheromone identified not only an oviposition resource but a food source as well. Females knew that males couldn't produce the pheromone until they had found squares. Males were attracted to the pheromone because it identified food and possible mates. Once females responded to the pheromone, the insects mated and the annual cycle started again. The insects could produce three generations to five generations a year in southeastern Missouri.

Mortality factors

Over the course of a year, many factors contributed to boll weevil mortality in Missouri. These factors included predation, parasitism, disease, weather and others.

Predation was a relatively minor component in boll weevil population dynamics compared with other insect pests. Because most of the life cycle was spent inside the square, weevils tended to be safe from predators. However, studies have shown that some ants, especially fire ants, were effective predators of boll weevils. A number of insects, spiders, birds and other animals ate adult boll weevils, but these predators only had a minor effect on infestations.

Parasites also had little effect on boll weevil populations. Several native parasitic wasps did attack weevil larvae but rarely in numbers high enough to reduce populations. An exotic parasitic wasp, *Catolaccus grandis*, was effective, but it could not overwinter at these latitudes. It may have been useful in release programs, though.

Disease organisms did kill some boll weevils, but again, normally not at levels that would have controlled infestations.

Suicidal emergence could have been a significant factor. In some years, many boll weevils came out of diapause long before cotton squares were available. Because most (but not all) emerging weevils lived for only about two weeks without cotton pollen, most of these early emergers died without reproducing.

Weather was probably the most important cause of boll weevil death in Missouri (and much of the rest of the Cotton Belt). Because the boll weevil is a tropical insect that traveled north, it was not well adapted to the climate of much of the United States. Boll weevils started to die at about 23 degrees Fahrenheit; the percentage that died increased as the temperature dropped. Research we've conducted showed that most boll weevils don't survive after an hour at 5 degrees Fahrenheit. Because overwintering boll weevils were insulated by leaf litter, air temperatures usually have to drop lower than the values mentioned above. Snow or ice cover also insulated effectively and protected boll weevils from lethal temperatures.

In most years in Missouri, less than 10% of the boll weevils that entered wintering habitat survived to spring. A series of severe winters in the late 1970s virtually eradicated the weevil in Missouri; populations did not recover until the late 1980s. High heat, drought and cultivation may have killed some larvae during the growing season. The impact of these factors has not been measured in the mid-South growing region.

The boll weevil's damage

Most damage to cotton by the boll weevil was caused by females laying eggs and larvae feeding. In heavy infestations, nearly every square received an egg as soon as it was large enough to support the development of a larva (when squares were roughly the size of a pencil eraser); under these conditions, virtually no fruit could be set. The potential for damage was greater because of the boll weevil's short generation time. Two or more generations could occur during viable fruit set. You would lose more than 50% of your crop to boll weevils; complete crop failures occurred.

Squares and small bolls fed on by adult boll weevils typically dropped from the plant. Larger bolls may not have dropped but may have been more susceptible to invasion by boll-rot organisms.

Adults fed on terminals of seedling cotton before squares were available. In rare instances, this feeding caused enough injury to reduce stand or retard plant growth.

Management

Before the eradication program, winter was probably the most effective killer of boll weevils each year in Missouri. Unfortunately, you couldn't modify the weather or wintering habitat in this area. However, you could manage boll weevil populations through a combination of cultural and chemical control strategies.

An important tool for boll weevil management was the pheromone trap. This trap used a synthetic version of the pheromone produced by male boll weevils to attract weevils of both sexes. These traps gave good information on the activity and the number of weevils in a cotton field.

Cultural control

Cultivation destroyed some of the larvae in squares that had fallen off the plant, but other practices were more useful. Managing a crop for earliness established much of the fruit before boll weevil numbers rose, and reduced the time the crop was vulnerable to the insect. Early planting (as soil temperatures allowed), early-maturing varieties, fertility management to prevent lush, late-season growth, using growth regulators such as Pix (mepiquat chloride) and other earliness practices helped reduce boll weevil impact.

In some years, a substantial number of weevils developed in a field after harvest, particularly if harvest was early and regrowth occurred. Farmers destroyed crop residues as soon as possible after harvest to reduce overwintering populations. Mowing with a flail or rotary mower was preferable to disking or otherwise trying to bury the residue. To be effective, they destroyed residue on an areawide basis. If only a few growers left residue standing through the fall, enough boll weevils could have been produced to infest neighboring growers' acreage the following spring.

Chemical control

Farmers used three types of insecticide applications during the cotton-growing season to reduce boll weevil populations. The first two types reduced populations during the growing season; the third reduced populations going into wintering habitat.

The first kind of boll weevil insecticide treatment frequently was called a "pin-head square" application. The application was timed to coincide with the appearance of the first squares, when they were about the size of a kitchen matchhead. A well-timed pin-head square application greatly reduced the number of boll weevil colonizers in a field and sometimes eliminated the need for more insecticide treatments later in the season. Pin-head applications were, therefore, the most important chemical "tools" available for boll weevil management. Decisions to make a pin-head application were based on pheromone-trap captures. Pheromone traps were placed when plants emerged at a rate of one trap per 10 acres to 20 acres. Crops were treated if, during a two-week period prior to the appearance of the first square, one weevil to two weevils were found in each trap each week.

The second type of boll weevil insecticide application was an "in-season," threshold-based treatment. These were directed at populations that had exceeded the economic threshold and that would have caused economic loss if left unchecked.

Missouri's threshold was 10% to 15% squares with boll weevil punctures. Scouts examined a minimum of 100 randomly selected squares before they decided whether to treat. They began scouting when the first squares were one-third grown (about the size of a pencil eraser), and continued weekly until cutout (when square production dropped off). In-season treatments repeated at four- to five-day intervals were necessary until the population was reduced. Late in the season (during and after cutout), they raised the threshold to reflect the increasing scarcity of squares. At this time the threshold was between 20% to 30% punctured squares, and you could examine small bolls for signs of adult feeding and egg laying.

The third type of insecticide treatment option used against boll weevils was the "diapause-control" spray. Its goal was to reduce the number of boll weevils entering wintering habitat. If you wanted the diapause-control treatment to be effective, you needed to make it part of an areawide program. Diapause-control sprays were applied to cotton fields after the crop was made but before boll weevils moved to wintering habitat (in Missouri, this would be about the beginning of September). You could spray several times prior to harvest at 10- to 14-day intervals. The process was discontinued when the crop residue was destroyed or killing frost occurred. The need for diapause treatments was based on damage rates in the field and pheromone trap captures.

Eradicating the boll weevil

The USDA, in cooperation with state governments and grower organizations, coordinated a nationwide effort to eradicate the boll weevil from U.S. cotton-production regions. The program used intensive pheromone trapping, pin-head applications based on pheromone trapping, in-season insecticide applications when needed and intensive diapause-control programs to reduce populations to far below economic significance.

As of 1994, boll weevils had been eradicated from North Carolina, South Carolina, Georgia, Florida, California, Arizona and parts of Alabama. Active programs are underway in Alabama, Texas and parts of Tennessee and Mississippi. In North Carolina, where the boll weevil has been eradicated the longest, cotton acreages have increased from fewer than 100,000 acres to more than 450,000 acres. Insecticide applications have been reduced by approximately 50%. In Georgia, insecticide applications have been cut from 10 to 12 per season to about four per season, and acreage has grown from fewer than 200,000 acres to almost 1,000,000 acres.

A regional plan was developed for eradicating the boll weevil from the mid-South growing region. Missouri cotton producers passed a referendum in the fall of 2000. The program began in 2001 and lasted seven years. Missouri, Arkansas and Tennessee were the last to come into the mid-South regional program. The rationale for this late entry was that waiting allowed for a severe winter, which could have reduced populations naturally.

Grower participation is mandatory if a program is established in an area. The decision to initiate the program is made by a vote of cotton growers in the proposed program area. State legislation is required to enable the program.

Costs of the programs have been shared; growers pay for 70% of the program, and the government picks up 30%. Eradication programs usually last at least three years; future programs will be five years long. The highest costs come during the first two years, but the payment structure usually is designed so that costs are spread out. Total costs have ranged from approximately $50 to $150 an acre. The range in costs is due to varying levels of boll weevil pressure in program regions and the timing of program initiation. We can expect costs in any program undertaken in Missouri to be lower than these rates because of relatively low boll weevil numbers and the concentration of cotton acreage in a relatively small area of the state.

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