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Handbook of Small Hive Beetle IPM

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Worker honey bee, *Apis mellifera* L. , attempting to grasp and remove from hive an adult small hive beetle, *Aethina tumida* Murray. Photo by Wm. Michael Hood

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INTRODUCTION. This booklet provides the beekeeper fundamental and important information about the management of small hive beetles. Topics covered include small hive beetle biology, economic importance, control recommendations, and current tools that are available for beetle control. Small hive beetles are now found on three continents and their eventual spread to other regions of the world is imminent. In the US, small hive beetles are well known for their destructive effects on honey bee colonies, especially in the southern region of the country. The primary scope of this booklet is to introduce beekeepers to this latest honey bee pest to enter the US and to discuss practical, safe, and sustainable means of control.

HISTORY. The first discovery of small hive beetles, *Aethina tumida* Murray, in North America occurred in 1996 in the city of Charleston, South Carolina. Beetle specimens were collected by a small-scale beekeeper from a managed honey bee colony that had been established from a swarm of bees captured from a tree located in the city of Charleston in the summer of 1996. Later in the summer and the fall, the beekeeper noticed a few small black beetles inside the hive. He collected a sample of the beetles and forwarded them to Clemson University for identification in fall of 1996. An insect taxonomist attempted to identify the beetles, but he could only identify them to family, Nitidulidae, because keys were not available to further identify them to genus and species. In 1998, an apiary of managed honey bee colonies in Florida were decimated by beetles that were properly identified as small hive beetles. The adult beetle specimens collected earlier in South Carolina in 1996 were later confirmed as *Aethina tumida*. This was the first time these beetles had been discovered on any continent except Africa. They quickly spread throughout the southern US and are now found in most other states. As of 2011, small hive beetles have now been found also in Australia, Canada and Mexico.

BIOLOGY. The small hive beetle is in the family Nitidulidae which there are about 200 species found in North America. Most species of this family are found where plant fluids are fermenting or souring such as around decaying fruits, melons, flowing sap, or fungi. Many nitidulids are pests of fruit and stored food, and some like the small hive beetle have a close association with social hymenoptera such as bees, wasps and ants.

Adult small hive beetles average 5.7 mm in length and 3.2 mm in width. Adult beetles vary in size which is likely dependent on food quality and climate. Adult female beetles slightly outnumber and are heavier than adult males in local populations as reported by a two-state survey conducted in the southeastern US (Ellis, et al. 2002a). Adult small hive beetles are strong fliers and are capable of flying several kilometers which aids in their natural spread. Beetles fly before or after dusk and

males have been reported to fly earlier than females. They are thought to be attracted to honey bee colony odors especially the honey bee alarm pheromone, but they may also be attracted to beetle pheromones which have not been identified. In olfactometric and flight-tunnel bioassays, adult small hive beetles were found to be attracted to volatiles from adult worker bees, freshly collected pollen, unripe honey and slumgum (Suazo et al. 2003).



Dorsal view of small hive beetle adult.

Source: Jamie Ellis, University of Florida, Gainesville, FL



Dorsal view of small hive beetle adult with appendages pulled underneath body.
Source: Natasha Wright, Florida Dept. Agriculture and Consumer Services, Bugwood.org.



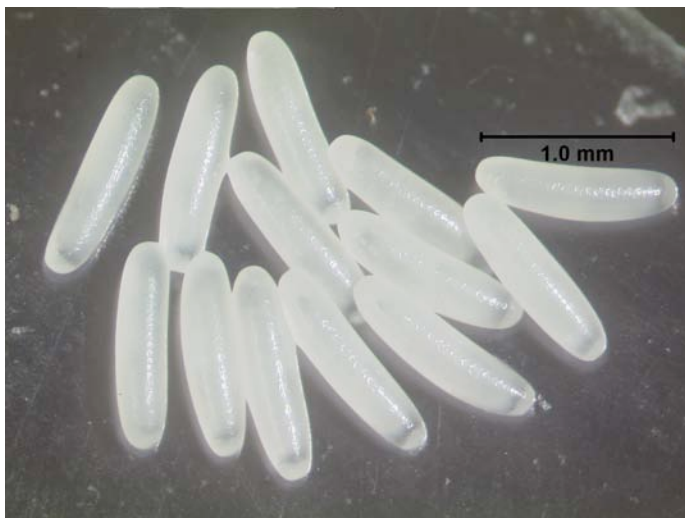
Lateral view of a small hive beetle adult.

Source: Pest and Diseases Image Library, Bugwood.org.

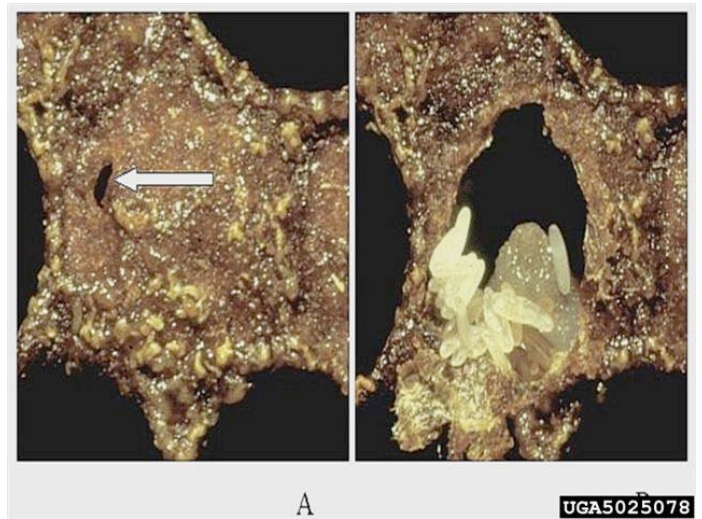


Ventral side view of a small hive beetle adult (one middle leg missing). Source: Pest and Diseases Image Library, Bugwood.org.

Small hive beetles are sexually mature at about 1 week following emergence from the soil. Adult females will oviposit directly on pollen or brood comb if unhindered by worker bees. It has been estimated that female beetles may potentially lay up to 1,000 eggs in their 4-6 month lifetime, although other estimates range up to 2,000 eggs. In a research project which 5-frame honey bee colonies were inundated with small hive beetles, female beetles were observed chewing holes in capped bee brood and ovipositing eggs on bee pupae (Ellis 2004). In addition, adult beetles were reported to oviposit in capped bee brood through slits they chewed in the side of adjacent empty cells. Small hive beetle eggs are normally laid in clusters and are pearly white in color; the eggs are about 1.4 mm long and 0.26 mm wide. Female beetles lay eggs in cracks and crevices around the periphery of the inside of a highly populated bee colony, but they will lay eggs in the brood area or on pollen, if



Small hive beetle eggs. Source: Jamie Ellis, University of Florida, Gainesville, FL.



White arrow points to hole in capping that female beetle ovipositor entered to lay eggs on honey bee pre-pupa as shown on right when capping has been removed. Source: Keith Delaplane, University of Georgia, Bugwood.org.

unhindered by adult bees. Most beetle eggs hatch in about 3 days but incubation period can continue for up to 6 days. Egg hatching viability is affected by relative humidity. Beetle larvae are creamy-white in color and emerge from the egg through longitudinal slits made at the anterior end of the egg. The larval period lasts an average 13.3 days inside the bee colony and 3 more days in the soil. One US bee scientist reported beetle larvae completing maturity in 5-6 days under favorable conditions (Eischen 1999). Beetle larvae are about 1 cm in length when fully grown. The length of mature larvae is variable with smaller larvae maturing slower and reaching less length on poorer diets. Beetle larvae have characteristic rows of spines on the back and have three pair of small prolegs near the head which distinguishes them from greater wax moth larvae. Another distinguishing characteristic of the two pests is that wax moth larvae leave behind a webbing mass and webbing is absent when only beetle larvae are present. Small hive beetles leave behind a slimy appearance on comb. Wax moth larvae and small hive beetle larvae are found often in the same colony.



Greater wax moth larva on top and small hive beetle larva on bottom.
Source: Keith Delaplane, University of Georgia.



Small hive beetle larva showing three pair of prolegs below and spines on top. Source: Pest and Diseases Image Library, Bugwood.org.

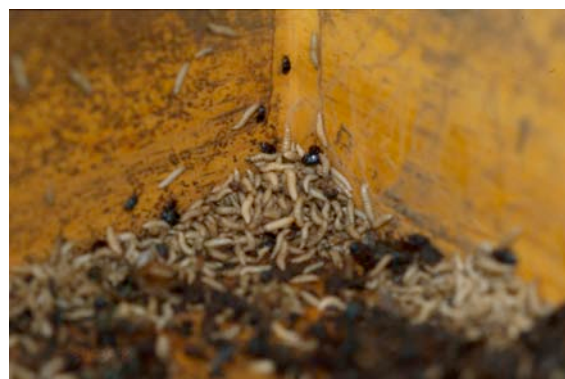


Small hive beetle larvae on honey comb. Source: Jamie D. Ellis, University of Florida. Bugwood.org.

Both beetle larvae and adults prefer to eat bee eggs and brood but they also eat pollen and honey. Mature larvae exit the hive in late evening from 1900-2200 hrs with peak activity at 2100 hrs. In the honey house, the relative humidity plays a key role in beetle larval development, so the manipulation of the air moisture level ($\leq 50\%$) could be easily integrated into an effective small hive beetle management program.



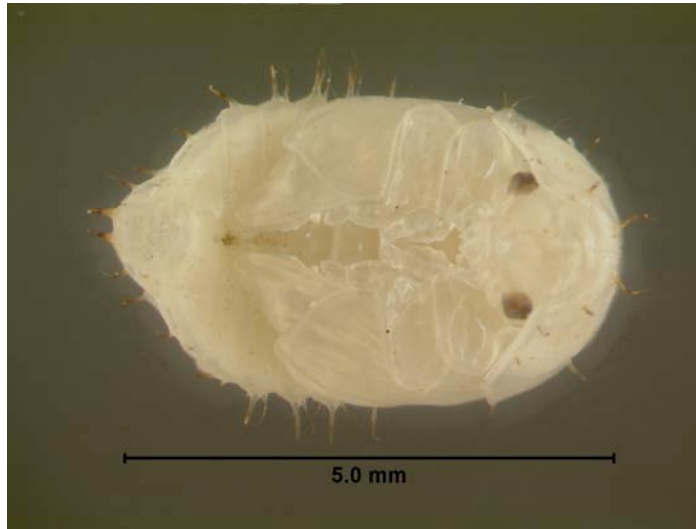
Small hive beetle larvae in cells.
Source: Jeffrey W. Lotz, Florida Department of Agriculture & Consumer Services. Bugwood.org.



Mature small hive beetle larvae in corner of brood box just prior to exiting hive entrance to pupate in the soil. Hood photo.

After exiting the colony, mature small hive beetle larvae enter the soil normally within about 0.6 m (2 feet) radius of the colony entrance to pupate. However, small hive beetle larvae are very mobile and could traverse a greater distance from the colony to find suitable soil to pupate. The pupal stage lasts about 8 days or longer depending on environmental conditions. Female beetles pupate slightly faster than males. Young pupae are white to brown in color and are mostly affected by soil moisture rather than soil type. Soil type was found to have little effect on pupation survivability (Ellis 2004). Drier soils impede pupation success rates. Pupation rates ranged from 92-98% in various soil types provided the soil was moist. This implies that beetle pest problems can be expected regardless of soil type in areas where soil moisture remains high. Therefore, soil

moisture appears to be a major limiting factor in beetle regeneration thus population buildup. This may explain partly why small hive beetles are not a major problem in honey bee colonies in sub-Saharan Africa because much of Africa (except equatorial Africa) is semi-arid to arid. The dryer soil conditions would be expected to have a negative effect on beetle pupation rates. Soil density was found to affect pupation rates also with high density soils having a negative effect on pupation rates. Possible affect of soil temperature on pupation success has not been investigated.



Small hive beetle pupa.

Source: Jamie Ellis, University of Florida, Gainesville, FL.

Massive numbers of small hive beetles perhaps produced from feral bee colonies have been known to invade and disrupt apparently healthy colonies. Beetle longevity and ability to mass reproduce on food materials found inside honey bee colonies have been investigated. A single mated female beetle reared on a diet of only pollen produced 591 larvae (Ellis et al. 2002). Beetle adults survived 180-188 days when fed honey and pollen but only 19 days when fed water and beeswax. Adults feeding on honey have been reported to survive 176 days but are not likely to reproduce. Various results were reported from studies on small hive beetle longevity when beetles were deprived of food and water; results of 2 days and 10 days were reported; seven days longevity were reported when adults emerged from the soil and were deprived of food and water. This suggests that beetles newly emerged from the soil may live for several days in search of a new host bee colony or other food source. Small hive beetles normally overwinter only in the adult stage in temperate regions and are found within the center of the honey bee colony cluster where they find food and warmth. If an overwintering bee colony dies from starvation, the adult beetles die too from cold temperatures

because they are unable to fly and invade nearby colonies in winter.



Frame from dead bee colony due to starvation and low temperatures in upstate South Carolina. Hood photo.



Closeup view of dead bees with dead adult small hive beetles in center cells. Hood photo.

ECONOMIC IMPORTANCE. The small hive beetle is considered to be of little economic importance in its native range of southern Africa where it is listed as a threat only to weakened or stressed colonies. African bees are capable of preventing the beetle from breeding in the hive as long as colonies remain strong. In contrast, beetle infestations in the southeastern US have affected even robust bee colonies which required control measures by the beekeeper. Beetles feed on honey, pollen and brood in bee colonies and have been implicated often in both colony mortality and increased absconding rates. A quarantine on movement of honey bee colonies was established in Florida in June 1998, but it was soon withdrawn by the Florida Department of Agriculture and Consumer Services (Fore 1998).



Small hive beetle adults alongside honey bee workers. Source: Jessica Lawrence, Eurofins Agrosience Services, Bugwood.org.

There has been some concern that honey bee colonies may suffer from multiple stress factors making them susceptible to possible additive or synergistic effects. Research was conducted to manipulate varying levels of small hive beetle and varroa mite infestations (Delaplane et al. 2010). Increasing densities of either pest when manipulated alone in colonies resulted in a predictable increase in colony demise. However, when both pests were manipulated in same colonies, varroa mites levels decreased as apiary-wide small hive beetles levels increased. These results were unexpected and indicated that small hive beetle and varroa mite infestation levels do not interact such that damage by one was affected by changing levels of the other.

Small hive beetles have the potential to vector and transmit viruses from infected bees to healthy bees. Investigations have been conducted that showed that small hive beetles can transmit deformed wing virus (DWV) by becoming virus positive by feeding on DWV infected honey bees and virus contaminated foods such as honey and pollen. Test results also indicated that DWV could replicate in small hive beetles and thereby have the potential of transmitting the virus from infected beetles to healthy bees (Eyer et al. 2008).

The estimated losses to small hive beetles experienced by beekeepers in the US in 1998 were (US) \$3 million (Elzen et al. 2001). Losses were in the form of colony destruction and damage to stored honey supers in honey houses. Some commercial beekeepers in the US reported losing thousands of bee colonies and associated equipment to beetles the first few years following their discovery.



Slimmed frame top bars as a result of small hive beetle damage. Hood photo.



Brood frame destroyed by small hive beetles. Notice fermented honey. Hood photo.

Mixed reports are coming from Australia as to the level of damage the small hive beetle is causing in that country. Strategies for prevention and management of beetle have been developed and provided to the beekeeping industry. Initial reports indicate that beetles have not caused significant damage in Australia when compared to damage caused in the US, especially coastal southeastern US. A beetle survey conducted in managed honey bee colonies from October 2002 to January 2003 in the New South Wales area reported 120 positive detections out of more than 1,000 samples received (Gillespie et al. 2003). More recent reports indicate that small hive beetles have been found in far north Queensland and the beetle has killed about a third of individual keepers hives in New South Wales to the south and has caused an estimated (A) \$10 million damage in Southern Queensland. Seven drought years in the Australian beetle-infested areas restricted movement of colonies which may have resulted in slowing the spread of the beetle initially, but since then the beetle appears to be showing up in new areas and causing greater damage. The major losses have been a result of the negative effect on overseas and domestic package and queen bee markets. One report from Australia claimed that stressed bee colonies suffering from European foulbrood are prone to result in major small hive beetle problems (White 2003).

The US queen and package bee production industry has been negatively impacted by small hive beetles. Beekeepers have concern over beetles spread in queen cages and packages. Concern over spread of small hive beetles to the UK has been reported. Favorable conditions required for beetle survival are met in many areas of the UK. Therefore, the risk management recommendations for small hive beetles in the UK include prohibition of bee imports from infested countries (Brown et al. 2002).

Concern over possible small hive beetle damage to other commodities such as fruit has been raised. Scientists have investigated beetle reproduction on alternate food sources (Ellis et al. 2002). Beetles regenerated when offered a diet of avocado, cantaloupe or grapefruit in confinement. Laboratory reared beetle adults were fed rotten and fresh kei apples, *Dovyalis caffra*, and survived an average 58.6 days and 63.9 days, respectively. Average number of offspring produced from three mating beetle pairs after feeding on rotten Kei apples in laboratory tests were significantly less than the average number of offspring produced from three mating beetle pairs feeding on pollen comb (10.6 vs. 1,096.4). The poor reproductive success of beetles feeding on fruits is likely a result of minimum nutritional requirements being met, but there is the possibility of beetle regeneration on fruit in the wild when no bee colonies are present. Although, no record exists which reports successful beetle regeneration on fruits or vegetables in field conditions. Since small hive beetles can survive for several days on various fruits, there exists a strong possibility that beetles can be transported by fruit truck or cargo shipments to non-infested regions of the world.

Bumble bees and other non-*Apis* species are additional concerns as possible threat to small hive beetle invasion and may serve as alternative hosts (Hoffman et al. 2008). In controlled studies, small hive beetles regenerated on colonies of bumble bees (Spiewok and Neumann 2006). These investigations were conducted in confinement and no one has reported finding small hive beetles in natural bumble bee colonies, but surveys have not been conducted to refute this possibility. When beekeepers move beetle-infested honey bee colonies from location to location for commercial pollination purposes, they may leave behind great quantities of beetle pupae in the soil which emerge to seek and find a suitable food source. Fortunately, it appears small hive beetles are host specific to honey bee colonies and if the emerging beetles do not find a new host colony soon, they will likely perish. There is, however, the possibility that small hive beetles may be attracted to ground nesting bumble bees because of similar odors (bee brood and honey) as honey bee colonies. This could prove detrimental to bumble bee colonies during the warmer seasons of the year. Although bumble bees do not overwinter as colonies in many regions of world, the beetles presumably would perish along with the colonies for lack of food and warmth.



SMALL HIVE BEETLE CONTROL

There are many options available to beekeepers to practice integrated pest management (IPM) of small hive beetles which have become a troublesome pest, especially in the southern US when conditions are favorable for their reproduction (Hood 2010). Although we do not know all the answers to what conditions favor small hive beetle reproduction, we have developed an arsenal of control recommendations and tools for controlling this hive pest. In the remainder of this booklet, we are going to discuss the integrated management of small hive beetles in the context of the eight basic IPM beekeeping principles (Hood 2009) that include: acceptable pest levels, preventive cultural practices, monitoring practices, genetic control, mechanical control, physical control, biological control, and chemical control.

Acceptable Pest Levels. Although attempts have been made to develop a treatment threshold for small hive beetles in managed colonies, there has yet to be one published. Research is also needed to develop an effective beetle sampling tool which will estimate the total number of beetles in a colony without having to conduct a whole colony beetle count. We are somewhat handicapped in our IPM approach to control this hive pest without a treatment threshold system. However, there are some general guidelines that we recommend to manage this hive pest.

The beekeeper must resist the temptation of treating the colony with a pesticide when only a few beetles are present in the hive or treating when it is obvious the colony collapse level has been reached. We now have several practical tools in our small hive beetle control toolbox which offer the beekeeper some help in maintaining low beetle populations.

Preventive Cultural Practices. Beekeepers are advised to maintain strong, healthy colonies in areas where small hive beetles are found. Beekeepers should practice good colony management to help the bees defend their colony from the negative effects of pests such as the small hive beetle. Good colony management starts with a good laying queen that can regulate the colony population to maximize their chances of survival. Her genetic makeup is paramount in that her progeny must be able to sustain the colony in the presence of various diseases and pests, including small hive beetles. ***In general, a high bee-to-comb ratio is recommended for small hive beetle control.***



Strong, healthy colony recommended for small hive beetle control (high bee-to-comb ratio). Hood photo.

Another cultural technique recommended for beetle control is the placement of colonies in full sun to create drier soil conditions to help prevent successful beetle pupation in the ground. Beetles need moist soil to pupate and the placement of colonies in a shady, damp location is not recommended. This recommendation runs counter to what most beekeepers were taught in the past: to place colonies in locations that offer early morning sun and afternoon shade, particularly in the hot summer months. Beekeepers should also be careful in placement of their colonies in or near irrigated crops which are often grown in damp soil conditions.



These two sites would not be good apiary sites, if beetles were present. Hood photos.

Minimum Manipulation. Honey bees have their own method of defending the colony from small hive beetles. Worker bees chase and corral the adult beetles into confined areas inside the beehive which prevents the beetles from freely roaming the hive and laying eggs on or near stored pollen and bee brood. The beetles need the pollen and brood as a source of protein for sustained nourishment and growth. Without the necessary protein in their diet, beetle reproduction is hampered.

When beekeepers open their colonies, beetles often escape confinement and freely roam the colony again. If the colony is showing signs of stress, the bees may not be able to re-corral the beetles, which may lead to an increase in beetle reproduction. Beekeepers should not open their colonies unnecessarily. This is particularly true during times of the year when beetle populations tend to increase which begins as early as May in the southern US and may continue till early fall. New beekeepers should resist the temptation to over manipulate their colonies. The queen simply does not have to be checked on a daily basis. Leaving beehives open during colony inspections can also lead to stress from robber bees from nearby colonies, especially during times of dearth.

In beekeeping operations that have a history of beetle problems, it is recommended not to use hive inner covers or frame spacers as they provide additional hiding places for the beetles to hide and avoid bee contact and imprisonment.

Monitoring Practices. If small hive beetles are present in a colony, their presence is normally obvious when the beekeeper removes the hive top and carefully inspects underneath the top and exposed frame top bars. Beetles do not care for light conditions and will seek refuge quickly. So, the beekeeper can often get a good idea of the number of beetles present in the colony simply by checking for beetles in the top of a hive. If there are many beetles in the top of a hive, a further inspection of the brood chamber is highly recommended to get a better idea of the total beetle population.

Another quick beetle monitoring population tool is to lift the top super off the colony and bounce it gently a couple of times on an overturned telescoping hive top which the beekeeper has placed on the ground. If beetles are present in the super, some will dislodge and fall to the hive top inner surface below.

A tell-tale sign of a major beetle problem in a hive is when the entrance landing board is soiled with residues of fermented honey which has oozed from frames inside the hive. This is normally a sign that the bee colony has reached the colony collapse level or the colony has succumbed to major beetles activities. "Leaking" is the term that is commonly used to identify this beetle damage stage. Immediate hive removal and treatment of the soil left behind is recommended.



Collapsed honey bee colony showing signs of "leaking" caused by major small hive beetle damage. Hood photo.

Genetic control. Scientists have discovered that African worker bees readily remove unprotected small hive beetle eggs and larvae. This behavioral trait likely plays an important role in the apparent resistance of African bees to beetle infestation. Cape honey bees which only live in the southern tip of Africa have shown the ability to identify capped bee brood cells that the female adult beetles have made a slit and oviposited their eggs. The bees tear into the cells and remove the cell contents including beetle eggs and larvae. These traits likely occur in our European bees at a much reduced level, however these hygienic behavioral traits may possibly be incorporated in a selection program.

Bees often use prisons constructed of propolis to confine adult beetles. African bees are known to collect and utilize more propolis than other bee races, therefore this activity is another possible reason that African bees show resistance to small hive beetles. Selection of bees that utilize more propolis may contribute to beetle resistance.



Several small hive beetles confined in a propolis prison in corner of hive inner cover. Hood photo.



Small hive beetle begging for food from a worker bee. Hood photo.



Several small hive beetles confined in a prison lined with propolis. Hood photo.



Adult honey bees guarding a small hive beetle.
Source: James D. Ellis, University of Florida,
Bugwood.org.

Mechanical Control. Several mechanical trapping devices have been developed in the US and Australia to control small hive beetles. Most of these beetle traps use either vegetable or mineral oil as the beetle killing agent. Caution should be used in the use of these oils because they can also be deadly to your honey bees. After use, these oils should be recycled or disposed of properly to prevent environmental contamination.

Small hive beetle traps should play a major role in the integrated management of this hive pest because of their safety in providing control without fear of hive product contamination. Traps provide a low cost form of sustained beetle control as long as there is little chance of mass beetle immigration into the apiary. The major disadvantage of most beetle traps is regular trap service is necessary.

Several small hive beetle trap investigations were begun in the US starting in 1998. Plastic bucket traps containing pollen, honey, bee brood, and live bees were placed in apiaries to investigate their effectiveness in trapping beetles (Elzen et al. 1999). Although some beetles were captured in the bucket traps, the traps proved to be little competition for the more attractive odors from nearby managed honey bee colonies.



Bucket trap investigations in coastal Georgia near Savannah in 1998. Hood photo.

Another beetle trap has been developed for use outside hives, but it has been used only to monitor beetle movement into an area (Arbogast et al. 2007). The trap was made of a 25.5 cm section of black PVC pipe with 7.5 cm interior diameter with both ends of the pipe covered with 18-mesh screen cones. A bait made of pollen dough conditioned by allowing male small hive beetles to feed on it for 3 days was placed inside the pipe which was suspended about 1 meter above ground. The traps were found to be attractive to beetles preferably when the traps were placed in shade. Few beetles were captured in the

traps when placed in full sun. These traps are not marketed and may not compete well with nearby bee colonies for attractancy. However, there are many in-hive traps presently marketed, but most have not been compared for trapping efficiency with other traps.

A “jar-bottom board small hive beetle trap” was designed and investigated at Clemson University (Hood 2006). The trap consisted of a 2.5 lb. (1.15 kg) square glass honey jar with lid secured by three screws underneath a beehive wood bottom board. The jar exterior was painted black to simulate the dark conditions inside a beehive. A 1.5 inch (3.8 cm) hole was drilled through the hive bottom board and jar lid. The hole was positioned in the center and 5.5 inches (14 cm) from the back of the hive bottom. A screen funnel (“conical bee escape,” Brushy Mountain Bee Farm, Moravian Falls, NC, US) was secured by staples to the lower rim of the hole, allowing the small end of the funnel to protrude down into the jar to impede beetle escape. A 4 x 4 inch (10 x 10 cm) piece of corrugated plastic was secured with staples over the hole on the hive bottom to impede honey bee entry, but provide beetle harborage and entry into the jar below. The jar was filled one-third with cider vinegar as a beetle-attractant.



Black painted 2.5 lb. (1.15 kg) square glass jar fastened under hive bottom board. Hood photo.

The West beetle trap was the first beetle trap marketed in the US. The West trap is a hive bottom trap that includes a removable plastic tray partially filled with vegetable oil that beetles enter and die. A slotted cover fits tightly over the tray which prevents bees from entering. The trap was designed to be serviced through the hive entrance which can be disruptive to the colony. A modified version of the West beetle trap is now available which can be serviced from the hive rear. A similar

hive bottom trap known as the Freeman trap has been developed recently which also utilizes a removable plastic tray with vegetable oil. The Freeman trap is conveniently serviced from the back of the hive. The Freeman trap comes with a screened bottom that allows beetles to enter the tray and excludes bees. The Freeman trap is available in varying sizes that fit ten or eight frame hives. Go to www.freemanbeetletrap.com for more information. A “screened bottom with rear trap” known as the Beetle Jail is available for ten, eight, or five frame hives. Go to www.beetlejail.com for additional information. For any of the bottom-board traps mentioned above, periodic service is required according to the manufacturer’s recommendation. Lack of service may result in a buildup of pollen and other hive products which will contribute to beetle reproduction.

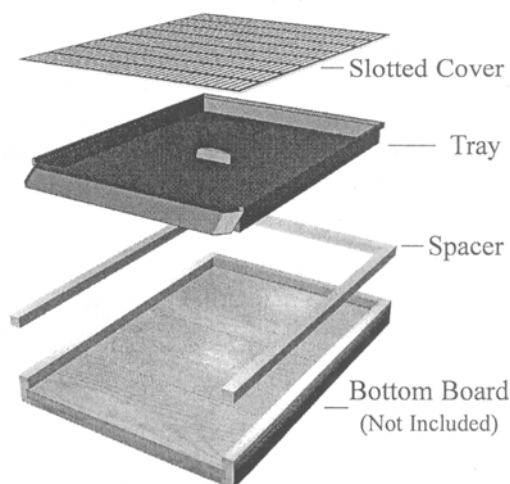
One major advantage of these bottom hive traps that incorporate the use of oils is that they also kill varroa mites, ants, and wax moth larvae which fall into the oil tray. However, oil can be messy to work with and can also kill bees if they enter the tray. A tight fitting tray is a must and the beehive should be level to prevent oil from overflowing. In some areas where animals are present such as skunks, a removable tray with recycled vegetable oil must be secured to prevent animal-intervention and possible tray destruction. The use of new vegetable oil prevents this problem.



Freeman Beetle Trap with removable tray half-filled with vegetable oil removed from hive rear. Hood photo.



Beetle Jail Bottom with Rear Trap.
Source: David Miller



West Beetle Trap. Source: Dadant & Sons, Inc.

The Hood beetle trap was developed at Clemson University and is a plastic box trap with three separate compartments that can be partially filled with various lethal agents and attractants. The best readily available attractant that I have found is apple cider vinegar which should be placed in the middle compartment and the two side compartments should be half-filled with food grade mineral oil. The trap should be secured inside an empty hive frame and placed in frame position number one or ten. Beetles enter the one-way beetle trap and become immobilized in the mineral oil and die. At Clemson University, our research with the Hood trap indicated that roughly the same number of beetles can be trapped in the top super as can be trapped in the brood chamber (Nolan and Hood 2008). However, placement of the trap in the brood chamber has an added advantage of doubling as a drone brood/varroa mite trap. Bees will construct only drone brood cells in the void area of the frame and the

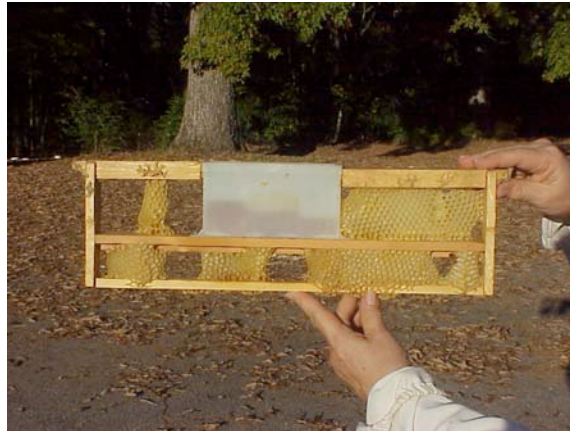
queen will lay drone eggs in the cells. When the brood is about two-thirds capped, the beekeeper should simply cut out the comb and place it in a freezer to kill the varroa which were attracted to the drone brood. If you forget to cut out the capped drone pupae, you have likely increased your varroa mite population. One disadvantage to the Hood trap is the bees will sometimes propolize the trap entrance, however a hive tool can be used to quickly remove the propolis.



Hood Trap mounted on a hive body frame. Hood photo.



Drone pupae cut from around a Hood Trap on a hive body frame to be placed in freezer to kill varroa mites. Hood photo.



Hood Beetle Trap mounted on shallow honey super frame with middle compartment filled with cider vinegar and two side compartments half-filled with food-grade mineral oil. Hood photo.

A beehive entrance trap has been developed for catching small hive beetles before they enter the colony. The Beetle Jail entrance trap is supplied with a removable reservoir that should be partially filled with vegetable oil. The reservoir can be removed and serviced easily without opening the beehive. The trap is available in various sizes to fit 10-frame, 8-frame, or 5-frame beehives. For more information on this trap, go to www.beetlejail.com.



Beetle Jail Entrance Trap. Source: David Miller

AJ's Beetle Eater trap was developed by an Australian beekeeper and is marketed in the US. The trap is a two-piece longitudinal plastic trap that should be partially filled with vegetable oil and suspended between two frame top bars. Laurence Cutts, former Florida State Apiarist, has developed a similar beetle trap, the Better Beetle Blaster. This disposable plastic trap is also designed to be placed between two frame top bars and should be half-filled with vegetable oil. Go to betterbeetleblaster.com for more information. The Better Beetle Blaster and AJs Beetle Eater traps can be placed between frame top bars in the bottom brood chamber or supers above or both. Another plastic beetle trap for placement between two frames is named the Beetle Jail Jr. developed by David Miller in Tennessee. The trap has three compartments and should be filled 1/3 to 1/2 full with vegetable or mineral oil with a small amount of vinegar to attract beetles. The trap has an arm which can be used to secure it to an adjacent frame.



Better Beetle Blaster Trap placed between frames no. 1 and no. 2. Hood photo.



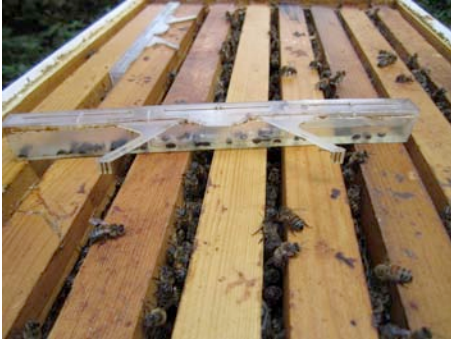
AJ's Beetle Eater trap placed between two hive frame top bars. Hood photo.



Better Beetle Blaster Trap with several small hive beetle adults in the vegetable oil. Hood photo.



Beetle Jail Jr. plastic trap with three compartments fastened to hive frame. Source: David Miller



Beetle Jail Jr. showing trapped adult beetles in oil. Source: David Miller

A simple method of trapping small hive beetles without the use of oils inside the hive is the use of a 2.5 inch x 22 inch piece of plastic corrugation with approximately 1/8 inch openings placed in the hive entrance for two days. Schafer et al. (2008) used this method in Australia to monitor the number of beetles in managed colonies. The adult beetles enter the corrugations for a hiding place and the beekeeper removes the trap and raps the trap a few times inside a 5 gal. bucket that has a small amount of oil or some other killing agent in the bottom. Our research conducted at Clemson University using this trap yielded varying results. A clean hive bottom board with all debris removed is a must when using this trap because beetles will hide underneath the trap if the trap is not lying flat.



Beekeeper carefully inserting plastic corrugation trap into a beehive entrance. Hood photo.



Rapping the sides of the trap a couple of times on the side of bucket to dislodge the beetles that fall into the oil and die. Hood photo.

Other forms of mechanical hive measures have been investigated that have not proven to provide beetle control. Bottom screens tend to increase hive ventilation and light conditions near the bottom of a hive, but have not proven to increase or decrease the beetle population. No studies have shown diatomaceous earth to provide beetle control mainly because the beetle larvae have a tough exterior.

Physical Control. Beekeepers often smash small hive beetles with their hive tools as a form of physical control. If a beekeeper has the time and patience, this activity can reduce the beetle population and contribute to holding the beetle population in check. Battery operated vacuums are also available for beetle removal, however this form of control is for the small-scale beekeeper who only has a few bee colonies. These activities can give the beekeeper a tremendous sense of gratification, but it can be a futile effort when colonies are overrun with beetles.



Hive tool: beetle smasher. Hood photo.



Battery operated beetle vacuum. Hood photo.

A modified hive entrance in the form of restricting the hive entrance to a single polyvinyl chloride (PVC) pipe has been investigated in an attempt to control small hive beetles. The upper hive entrance did not prove to reduce the small hive beetle numbers in one investigation (Hood and Miller 2005) and two other investigations (Ellis et al. 2002, 2003) reported inconsistent results. These investigations reported a reduction in bee brood production which would also negate this integrated approach.



Test apiary with beehives fitted with 3.5 cm (interior diameter) PVC pipe upper entrances. Hood photo.



Beehive fitted with a 1.9 cm (interior diameter) PVC pipe entrance. Source: J.D. Ellis.

In some of our small hive beetle research conducted at Clemson University, we have used vacuums and aspirators to remove beetles from colonies in the fall (before bees begin to cluster) to obtain a total colony beetle count. This is a laborious and time consuming task that requires a minimum of two people, but may pay big dividends for the small-scale beekeeper to reduce the number of overwintering beetles. The procedure begins by finding and placing the queen in a cage for safe keeping. Then each hive frame is removed and shaken on an 8x3 feet white plastic table to free bees and beetles. Next, the frame top bar edge is lightly bounced a couple of times on the table top to free any remaining beetles that are hiding in the cells. The frame is then turned over and the frame top bar bounced again on the table top to remove any beetles from the other side. One person manipulates the frames as another person stands on the opposite side of the table and vacuums or uses an aspirator to collect the beetles from the table top, counts beetles and brushes bees to the side. The boxes, bottom, and hive top should also be bounced on the table to remove and capture beetles. After all the equipment has been processed in this manner, the frames are reloaded into the hive, queen released, and bees remaining on the table brushed back into the hive. For research purposes, we released the captured beetles back into the hive to continue the project.



Shaking bees from frames and vacuuming or aspirating beetles. Hood photos.

This radical technique is no doubt very stressful to a colony, but has proven to remove at least 80% of the beetles, as reported by scientists who have used this approach. A few beetles will get by undetected and a few will fly away safely and return to a colony. This technique has been used to only count beetle numbers in bee colonies and its effectiveness as a control tool has not been investigated. As a beetle control technique, simply smashing beetles with a hive tool will likely be preferred as opposed to safely removing the beetles. The beekeeper can expect to kill a few bees during the process of eliminating the beetles.

Another physical control technique is to move beetle-infested colonies to a new location. Some migratory beekeepers report having few beetle problems, as long as they keep colonies on the move. Moving colonies simply breaks the beetle life cycle by

leaving the mature larvae and pupae behind in the soil. Leaving colonies in the same apiary where beetles have been a major problem for years is not recommended. The recommended minimum distance required to move beetle-infested colonies to a new location has not been investigated.

If it is evident that several hundred adult beetles are present in a colony and beetle larvae are present, the entire hive should be removed from the apiary and treated in a remote location. An alternative option is to place the hive and its contents into a freezer for a couple of days which will kill all beetle life stages. Regardless, the entire hive should be removed from the apiary before more larvae exit the hive to pupate in the soil. Remember to treat the soil left behind with a soil treatment to kill any pupae before they emerge as adults.

Anything that reduces the ratio of bees-to-comb surface when beetles are present can lead to major beetle problems. Over-supernumerary and swarming are two examples that can result in increased beetle problems, as well as wax moth or skunk problems.

In areas where beetles are problematic, beekeepers should not use a Porter bee escape to remove the honey crop. Honey supers left above a Porter bee escape for more than a day or two stand a high chance of destruction by beetles which thrive in warm locations that are free of bees. Pollen traps should also be serviced regularly and maintained carefully because the pollen serves as unprotected protein which can enhance beetle reproduction.

Freezing a few individual frames that contain beetle larvae from a live bee colony is recommended, but this will rarely result in successfully salvaging a colony that also shows signs of weakness and low morale. A close examination of these beetle larvae infested frames will often reveal wax moth larvae too. Two measures that may help increase the chance of success are: 1) to replace the beetle larvae-infested frames with frames filled with brood and hanging bees from other healthy colonies that show a high bee-to-comb ratio to boost the bee colony population or 2) to move the remaining beetle-free frames down to a nucleus-size (5 frame) box where the bees can better cover the frames.

When honey-filled supers are removed from colonies that are beetle-infested, it is highly recommended to extract the honey within 2 days. However, if this is not possible, the beekeeper is advised to maintain a relative humidity of 50% or less inside the honey house. The low humidity results in desiccation of beetle eggs and larvae that were transported into the honey house inside the honey supers. Beetle larvae can cause complete loss of the honey crop inside the honey house, if these guidelines

are not followed. Frames of honey which have been used in the past as brood frames are more vulnerable to beetle problems.

Beekeepers are also advised to practice good sanitation around the honey house to avoid beetle problems. Timely removal of bits of comb, cappings, and pollen is highly recommended because these materials are highly attractive to beetles.

A 50% bleach/water solution has been shown to kill beetle larvae in honey houses and for use in cleaning or salvaging larvae-infested comb after 4 hours of treatment (Park et al. 2002). Treated comb should be set aside for at least 24 hours to allow the bleach odor to dissipate.

Research was conducted at Clemson University to investigate the effects of feeding honey bee colonies pollen substitute patties in winter (Hood 2009). This activity is practiced by some beekeepers to supplement colony nutrition, particularly when little pollen is available. We discovered that female small hive beetles are capable of laying eggs in the patties which were located in the warm area just above the bee cluster. The eggs hatched and beetle larvae were found primarily in the patties. However, the beetle larvae were unable to survive when leaving the warm area of the hive as many mature dead larvae were found on the bottom board in their attempt to exit the hive to pupate. The results of these investigations indicated that there is low risk when beekeepers feed pollen substitute patties in the winter when conditions are unfavorable for beetle reproduction. However, beekeepers should be conservative in feeding pollen substitute patties when small hive beetles are present in late winter or early spring when mild temperatures may persist and result in successful beetle reproduction earlier than normal.



Pollen substitute patty placed over the bee cluster in winter. Hood photo.



Notice small hive beetle larvae in patty. Hood photo.

Biological Control. Research investigations have been conducted to find an effective form of biological control for small hive beetles (Ellis et al. 2010; Shapiro-Ilan et al. 2010). Infectivity tests under field conditions found that small hive beetle larvae were susceptible to soil infesting entomopathogenic nematodes (*Steinernema riobrave* or *Heterorhabditis indica*), but field tests have yet to confirm their sustained reliability in the field. Soil nematodes, *Heterorhabditis indica*, are available for purchase from Southeastern Insectaries, Inc., Perry, GA, ph. 877-967-6777 or email: sei@aaltel.net. Other research conducted in Mississippi reported a natural infestation of unidentified species of nematodes infesting small hive beetle adults that were collected from soil samples (Guzman et al. 2009). Entomopathogenic nematodes have the potential to be used as biological control agents against small hive beetles, but more research is needed to verify their reliability under varying conditions.

An infectious fungus (*Aspergillus flavus*) has been identified that infects small hive beetles, however the utilization of the fungus for beetle control has not proven to be safe because of its side effects on bees and fear of honey contamination (Ellis, J.D. 2004).



Beekeeper applying soil nematodes to control small hive beetle. Hood photo.

Imported fire ants (*Solenopsis invicta*) which are found throughout the southern US feed on soil infesting insects and likely feed on mature small hive beetle larvae when they enter the soil to pupate. Fire ants are opportunists and may play a role in conjunction with other IPM tools, but they have not been found to be relied upon as a stand-alone beetle control option, even when ant mounds are present in or near the apiary. Further research is needed to investigate this pest/predator interaction relationship.

Chemical Control. There are two pesticides that are currently registered in many states for small hive beetle control in the US. Check Mite + is registered for in-hive beetle control but can only be used during non-nectar flow periods. A single strip of the product is cut in half and attached underneath a 4x4 inch piece of corrugated plastic or cardboard and placed near the back of the hive on the bottom board. The piece of plastic or cardboard serves as a hiding place or trap and the beetles receive a lethal dose of the pesticide upon contact. Varying results have been reported by beekeepers using this product. This product stands little chance of controlling beetles in late fall, winter, or early spring when adult beetles are normally in-active or confined to the bee cluster in many in many regions of the world. Beekeepers should carefully use this product only when other forms of control have failed. Beekeepers must follow the pesticides label directions and resist the temptation of using the product in other locations in the hive. The product must be removed from the hive in a timely manner, according to the directions.



Check Mite + fastened to 4x4 inch piece of plastic corrugation. Hood photo.



Gard Star: soil drench product. Hood photo.

Gard Star is marketed as a soil drench pesticide and is used to kill mature beetle larvae as they exit the hive to pupate in the soil. Care should be taken to avoid spraying this pesticide on the hive entrance which would result in killing bees. Gard Star can also be used to treat the soil underneath dead-out colonies to prevent beetles from emerging and entering other nearby colonies. Since this product is not used inside the hive, there is little chance of hive product contamination. Therefore, the use of this pesticide may be used more freely in an IPM program until we can find a more suitable and efficient biological agent for killing beetles in the soil. From a beetle reproductive control approach, Gard Star should be used only when beetle larvae are present in the colony. In my experiences in the southeastern US, I have seen very few beetle larvae in colonies in April and May in upstate South Carolina. June and July are normally the months when beetle reproduction increases dramatically when conditions are favorable, so beekeepers need to be more vigilant during these two months. However, one problem with the use of Gard Star is that we simply do not know how long the product remains lethal to beetles in the soil, which is likely

dependent on environmental and weather conditions such as temperature, soil type and rainfall. The other concern is that widespread overuse of Gard Star will likely lead to beetle tolerance or resistance to the product in a few years. This is similar to the current problem that we are having with varroa mite resistance to certain pesticide products in the U.S.

PRECAUTIONARY STATEMENT. Beekeepers should resist the temptation of using off-brand or unregistered pesticides for small hive beetle control. There are great risks involved when a beekeeper breaks the law (federal and state) when using a pesticide in a manner that is not consistent with the product label. The pesticide label is the law and should be followed carefully by the beekeeper. Beeswax readily absorbs chemicals and may harbor toxic materials for long periods of time. Using illegal pesticides for small hive beetle control may lead to contaminated hive products and can result in injury to the consumer as well as the beekeeper. Our beekeeping industry can ill afford the public outcry over the news of pesticide-contaminated honey.

Summary. Small hive beetles can be present in a honey bee colony in low numbers and not be a problem. However, beekeepers are advised to monitor their colonies closely and be prepared to take action, especially during certain times of the year when beetle reproduction tends to increase. Beetles do have the ability to reproduce quickly when conditions are favorable and colonies are stressed. There are many recommendations and IPM tools available to the beekeeper to manage this hive pest.

Sometimes when conditions are favorable for small hive beetle immigration and beetle reproduction is high, the beekeeper is in for a real challenge to control this hive pest. Large numbers of beetles have been reported to enter single bee colonies which can overcome the natural defenses of even a strong bee colony. There are a few reports in the literature of migrating swarms of beetles entering a single hive. Fortunately, this occurs very infrequently, so it is up to the beekeeper to help the bees in maintaining low beetle populations by using a combination of safe and effective IPM tools and recommendations. In most cases, the integrated management of small hive beetles will serve well to control this hive pest.

In South Carolina, beekeepers are advised to monitor their colonies for small hive beetles beginning in April and install traps if beetles are present. If the beetle population continues to increase during the months of May and June, a soil treatment is advised to break the life cycle by killing beetle larvae as they enter the soil to pupate. Check Mite + is available as a hive treatment but the product cannot be used when surplus honey supers are present. The best window of opportunity to use this product is later in the year in September

or October when the honey crop has been removed and the beetles are actively moving in the hive. From the months of late November to March, the small hive beetle overwinters within the colony cluster which makes current control recommendations ineffective.

Winter is a good time for you to sit back and evaluate how well your beetle management efforts worked last year. Maybe the beetle levels increased to the point of negatively impacting your colonies or perhaps colonies seemed to be overrun in some apiaries. On the other hand, beetles may have been present but in very low numbers. There are many IPM tools available for you to consider and maybe it is time to try a combination of control options and not depend on a single method. Good luck in your beetle management. For a quick review, here are a few recommendations on how to control small hive beetles:

Do's

- maintain healthy, strong colonies to promote high bee-to-comb ratio
- monitor colonies for beetle infestation levels
- do not use inner covers or Porter bee escapes as they provide harborage for beetles
- trap beetles using one or more of the trapping devices presently marketed
- service pollen traps often
- propagate from queens whose colonies show resistance to beetles
- physically kill or remove beetles when inspecting a colony, but do not leave equipment exposed for long periods of time which may lead to robbing
- remove weak colonies from an apiary when infested with beetle larvae and treat the soil
- extract honey from supers within 2 days of hive removal
- maintain good sanitary conditions inside and outside the honey house
- treat soil with Gard Star, if beetle larvae are present in the hive
- use CheckMite + in the hive as a last resort

Don't's

- do not place colonies in shady, damp locations
- do not stack beetle-infested supers on strong beetle-free colonies
- do not over-manipulate colonies when beetles are present
- do not leave colonies exposed during extended hive inspections
- do not over-super colonies when beetles are present
- do not hesitate to move colonies to a new location away from an old apiary which has a history of beetle problems

- do not use pesticides that are not registered for small hive beetle control

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DISCLAIMER STATEMENT.

Pesticides recommended in this publication were registered for the prescribed uses when printed. Pesticide registrations are continuously being reviewed and may be revoked for proper justification. Should registration of a recommended pesticide be canceled it would no longer be recommended by Clemson University.

Use of trade names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others which may be of similar, suitable quality or composition, nor does it guarantee or warrant the standard of the product.

This information is supplied with the understanding that no discrimination is intended and no endorsement by the Clemson University Cooperative Extension Service is implied. Brand names of pesticides are given as a convenience and are neither an endorsement nor guarantee of the product nor a suggestion that similar products are not effective. Use pesticides only according to the directions on the label. Follow all directions, precautions and restrictions that are listed.

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