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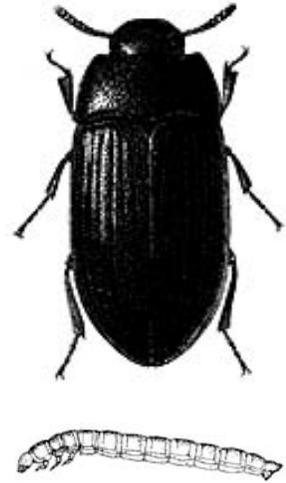
Vector Abatement Plan - Darkling Beetles

Jesse Adams

Poultry operations cannot allow ectoparasitic and nuisance insects to interfere with production, nor can they afford high pest control expenses. For production to be profitable, poultry production must be managed to reduce the incidence of insect pests.

A Georgia survey in 1996 (Table 1 & 2) gives an indication how costly insect damages and control in the livestock industry.

In the past years, litter beetles (especially the lesser mealworm [*Alphitobius diaperinus*]), have become the most serious pest affecting several types of poultry production systems. Entomologists who work with arthropod pests of poultry give priority to litter beetles because they have a high reproductive rate, are difficult to control, are vectors of disease, cause considerable damage to insulation in poultry facilities, and may migrate from litter disposal sites to urban housing areas where they are a nuisance. They also may consume considerable amounts of poultry feed if they are very numerous.



Litter beetles are known to harbor a number of disease organisms that affect poultry. Included are fowl pox, *E. coli*, salmonella sp., Marck's disease, avian influenza, fowl pox, botulism, coccidiosis, newcastle disease, avian leukosis virus and infectious bursal disease virus (IBDV). The beetle has also been identified as the intermediate host of poultry tapeworms and cecal worms. One adult or larva harboring salmonella or IBDV eaten by one-day-old chicks is sufficient to infect the chick. Through eating infected beetles a number of pathogens are transmitted that can affect bird health and performance. The beetles are known to harbor pathogens for at least 14 days and still remain infectious to broiler chicks if eaten. The presence of abundant disease organisms is particularly troublesome in floor-litter systems such as broiler, breeder, and turkey housing where the birds can consume large quantities of beetles, especially in the first week or so after placement. Consumption of large numbers of beetles also has adverse effects on these young birds.

Litter beetles are known to cause a great amount of damage to insulation (polystyrene, polyisocyanurate, and fiberglass) in poultry houses. Damage results when larvae bore into the insulation to find safe areas in which to pupate. Adult beetles will eat the pupae and soon enlarge the larval tunnels as they search for an easy meal. Additional damage is done by birds and mice that chew into the insulation to get at adult beetles, larvae and pupae. It has been estimated that a

severe litter beetle infestation can result in the loss of as much as 25 percent of the insulation in a poultry house in one year. Energy costs in beetle-damaged broiler houses have been reported to be more than 60 percent higher than in buildings without damage.

Continued population growth and current lifestyle choices will increase the potential for conflict over land access, land use and increase the likelihood of situations where livestock production may be perceived as a nuisance. Invasions of homes or buildings by thousands of beetles has resulted in extreme actions to control the insects and even lawsuits filed against producers by homeowners. Typically, this occurs when litter or manure from heavily-infested poultry houses has been spread over fields. If done when temperatures are warm, the beetles will fly from the field and may appear suddenly on and in homes. At night, beetles are attracted to lights ranging in intensity from a single candle to headlights of a car. They seem most likely to fly between 8 pm and midnight. Darkling beetles will fly approximately ½ mile. Neighbors have a right to enjoy their property without the nuisance of insects. Please review a news article about a \$25 million law suit in Ohio involving Darkling beetles that appeared in The Columbus Dispatch on September 17, 1998. As more people move to the rural areas and wanting the best of rural living, they will not be tolerant of odors or insects. When asked or visited be sure to show everyone what efforts you are making to prevent odor and fly and darkling beetle problems. **Be a good neighbor!**

Biology and Behavior

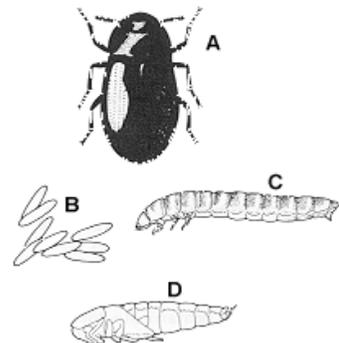
Lesser mealworms usually are not distributed evenly throughout a house. They tend to congregate in areas that are most favorable for them. Usually, this is where there is adequate moisture or where the litter is looser and deeper. The larvae and adults tend to accumulate under anything laying on or just under the surface of the litter. Floor feeders provide excellent places for them to hide. If nothing is available, they will stay around the edges of caked litter. Mealworm larvae and adults avoid very dry or very wet areas but do need some moisture to survive.

The life cycle from egg to adult under farm conditions will range from 35 to 60 days for darkling beetles. Ohio State(42 to 97 days) and Arkansas (35 to 60 days) reports different life cycle lengths.

Egg & Larva

Eggs are approximately 1/16 inch long and creamy white to tan. They have slightly rounded ends and are slender. Eggs are layed individually or in clusters of up to 12. Eggs hatch in 4 to 7 days under typical room temperatures into larvae. There is little egg hatching below 60°F or above 100°F.

Larvae are yellowish-brown and resemble wire worms. They may



Lesser mealworm.
A, Darkling beetle. B, Eggs.
C, Lesser mealworm. D, Pupa.

reach 3/4 inch in length before they pupate. Larvae cluster in dark corners under manure or litter, under feed sacks or under feed in feed storage areas. Larvae may congregate in areas of higher temperature and moisture, such as near waterers or wet feed. This stage may last 40-70 days and, during that time, six to ten larval instars may occur. Late instar larvae may migrate upward and pupate in the insulation of the building. The average time from egg to adult takes about 80 days. The beetles can develop when the temperature is between 60°F and 90° F

Pupa

The pupal stage lasts 5 to 10 days or more and then an adult. The pupae are 1/4 inch long and are creamy white to light brown. The pupae will wiggle when disturbed and lay motionless otherwise. These pupae can be found in lower, compressed litter, dry manure, or in the soil. They can also be found in the insulation and the result is extensive damage to all types of insulation.

Adult

Adult litter beetles are approximately 1/4 inch long and shiny black. Newly emerged adults are reddish-brown but turn black within 3-5 days. Their bodies are oval and slightly flattened.

The adults are very active and burrow into litter when disturbed. They may also be found crawling on walls, hiding in cracks and crevices, or feeding on the underside of bird carcasses. Adult beetles can fly for approximately 1/2 mile.

After mating, within six to ten days, a female beetle has the potential to lay more than 2,000 eggs in the manure and litter, especially under feed and water lines. Adults can live more than three to twelve months, continuing to produce eggs most of their life at one to five day intervals.

Both adults and larvae are very active and quickly burrow into the litter when disturbed. They clump (aggregate) in groups throughout the house, feed on almost anything (decaying litter, poultry feed, bird carcasses and even each other - cannibalistic).

Darkling Beetle Control in Poultry Operations

Despite many changes in the livestock and poultry industry which have helped with the control of insects, the industry still faces problems. Insect control is not a simple matter and takes a dedicated effort on producer's part to be successful. Each farm may have different problems. Insect control measures that work on one farm may not work on another. In the final analysis the success or failure of a Darkling beetle control program depends on the efforts of the producer.

The key to Darkling beetle control is management. Management must understand the biology, ecology and behavior of the beetle. Management must see that waste is handled in a way to minimize Darkling beetle breeding. Darkling beetle populations should be managed for prevention and control. Control can be divided into residual and contact sprays, baits, and traps. No insecticide can be effective against Darkling beetles around poultry facilities as long as breeding sites exist.

Integrated Pest Management

Integrated Pest Management (IPM) is the ecological approach to pest control. It uses all suitable techniques to reduce the pest below economic levels. The purpose of IPM is not to do away with chemicals. If anything, IPM is designed to protect chemicals from being lost or becoming ineffective. When insect pest populations reach economic threshold levels, control measures must be taken. The ultimate line of defense against insect enemies is the use of chemicals. This cost can be very expensive, but the cost of not controlling could be very destructive. With IPM, chemicals are used only when necessary; facts replace hunches.

Indiscriminate use of insecticides also destroys beneficial insects. This can cause minor or secondary pests to become major pests and reach serious levels earlier. Overuse of insecticides may also contribute to a resistance buildup by the pests and make control even harder.

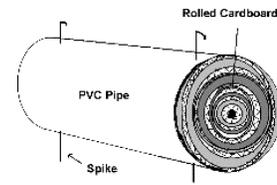
IPM should include sanitation or cultural control, biological control, mechanical control, and the timely use of insecticides. Economic thresholds can be defined as the pest population levels at which controls are employed to prevent the population from exceeding the economic injury level.

Producers have been using IPM and economic thresholds to determine when to spray to prevent crop losses greater than the cost of control. Economic thresholds may be affected by many factors such as location, population of insects, presence of beneficial insects, time of growing season, stage of growth, and the size and condition of the crop plant. Economic thresholds are continually changing.

When the darkling beetle population explodes on a farm, they can migrate approximately ½ mile in search of food, shelter and breeding sites. A regulatory agency may set a threshold that is acceptable to the community. Close attention should be paid to monitoring darkling beetle populations to prevent a neighborhood invasion of darkling beetles from poultry operations. When asked or visited be sure to show everyone what efforts you are making to prevent odor and fly and darkling beetle problems. **Be a good neighbor!**

Weekly monitoring should be done by visual observation from the time the birds are placed in the building until the birds are removed. Look for beetles in litter, under feeders, edges of caked litter, cracks and crevices, around equipment, under dead birds and in insulation. Dig 2 to 3 inches deep in litter every 20-30 feet the length of the building.

Traps can be used to monitor Darkling beetle infestations. They can be made of 2 inch diameter schedule 40 PVC pipe. Each trap should be 10-12 inches long with a roll of corrugated cardboard (brooder guard) inside. Six traps should be evenly distributed between the wall, feeder, and brooder locations from one end of the house to the other end. It is best to stake the traps down to prevent birds from moving them around. Remove the cardboard once a week and count the beetles. A rapid increase in the number of beetles and larvae may indicate a need for treatment.



Cultural Management

Effective litter management can slow the development of these beetles and reduce the chances of having excessive buildups of their numbers. Here are some practices to keep in mind.

- ◆ Water is a key need for mealworm beetles so check pipes and waterers for leaks. All measures to keep the litter dry will help to keep beetle numbers down.
- ◆ Feed storage areas or spilled feed outside the houses can be a starting point for infestations by beetles. Sanitation is very important.
- ◆ Move feeders and waterers when practical to pack down loose litter and make it less suitable for the insects. It is also helpful to prevent extremely wet spots under waterers by either using spare waterers while the litter dries or by occasionally changing the waterers' positions.
- ◆ Regular clean out and disposal of litter can eliminate large numbers of beetles. It is best to do this when temperatures are low enough (near or below freezing) to kill most of the insects. All stages of darkling beetles are killed by temperature below 30°F. Most beetles can be eliminated from poultry housing by opening the building and exposing them to sub-freezing temperatures for a week or more.

In broiler and turkey houses, complete removal of litter and replacement with fresh shaving greatly reduces beetle population compared to the practice of top-dressing old litter with fresh shaving between flocks. Frequent removal of manure from a caged-layer house greatly reduces beetle problems.

Cold weather is the most effective method of beetle control. As a cultural control measure, when cleaning out houses during cold weather, the curtains should be completely lowered for several days. This will allow the house to drop below 45°F which kills the beetle eggs. All stages of the beetle are killed by temperatures below 30°F. Be sure to drain the water lines if houses are vacant during an extended period of cold weather. Temperatures in the teens will destroy many beetles in the manure, litter, soil and other protected places.

Remove manure or litter from the house as soon as possible after bird removal. Beetles will migrate to protected areas of the house within a few days once the house is empty. If fresh manure or litter is spread on crop land and fields, incorporate it immediately into the soil to limit

beetle migration. Avoid spreading beetle infested manure near neighboring fields and residences. Turn stockpiled or composed litter every two weeks to promote multiple heating which will kill the beetle life stages. Covering manure piles with tarps and black plastic sheets effectively kills these insects by the heat and gases generated within the pile.

Chemical Control

Insecticides can be used in several different ways to control adult beetles when the IPM program indicates the need for treatment. Spot treatment is not effective if treatment is delayed until thousands of beetles are present over large areas. Be constantly aware of insecticide resistance problems.

Insecticide impregnated baits can be used in certain areas for suppression. This method may be very expensive. It should be used where beetles congregate.

None of the insecticides currently registered for litter beetles will consistently control beetles for more than one flock. Treatment timing and method of chemical application are very important.

Regardless of the formulation used, timing of the application is critical for two important reasons. First, insecticides used for beetle control are not designed to remain active for much more than a week under conditions in a typical poultry house. Chemical treatments applied to the litter, however, cannot be expected to provide effective residual control over a long period of time, since most insecticides readily combine with the high organic content of the litter. Second, beetles and larvae do remain in the upper layer of the litter for more than a few days after the birds have been removed. Since most of the registered insecticides are intended for use while houses are empty, it is difficult to bring beetles into contact with a compound before it loses its effectiveness.

The only way to overcome this problem is to apply insecticides within 24 to 48 hours after birds have been removed. If possible, clean the houses on the first day and treat the houses immediately and delay other activities until the following day. Residual insecticides should be applied to the soil after the litter is removed and in areas where migration occurs. Disinfectants and insecticides should not be applied at the same time because each may destroy the toxic property of the other. Apply one, wait 10-14 days, then apply the other. Insecticides should be rotated periodically, i.e., a carbamate such as Sevin® could be rotated with a phosphate (Rabon®) and then with a pyrethroid (cyfluthrion-Tempo®) which will delay or inhibit the onset of resistance (both to the beetles and to filth flies).

Residual treatments can be affected by sunlight, high temperatures, and rain. This may require repeated applications in two to three weeks.

A second treatment just before placement of birds also helps to reduce beetle infestations, especially when they are severe. Insecticides applied to the walls and litter will retain their activity enough to suppress beetles that escape earlier treatment and will help delay the onset of the next infestation.

Finally, the timing of bait applications while birds are present is particularly important. Start when numbers are relatively low but show signs of increasing, as determined by monitoring. Small larvae and isolated concentrations of beetles are easier to control with baits. More than one application will be needed even if treatment is initiated early. Bait is ineffective when larvae are large or the infestation has become well established over large areas of the house.

Beetles are controlled with insecticides for various reasons. This method has the potential to breed insecticide resistant beetles. Also, beneficial insects are often killed along with the beetle adults and larva. **READ, UNDERSTAND, AND FOLLOW ALL INSECTICIDE LABEL PRECAUTIONS.**

Insecticide resistance

Insecticide resistance develops rapidly when insects are in continuous exposure to the insecticide. Resistance can be built into insect populations in as little as two years. All three of the following insecticides systems had resistance in the field in two years: (1) livestock insect control systems to residual pyrethroid spray, (2) cyromazine feed-through for house flies, and insecticide cattle ear tags for horn flies. Resistance is genetic in nature, developing more quickly under heavy doses of pesticide or very frequent application. Insects resistant to one insecticide can be cross-resistant to other insecticides of the same class or even having a similar mode of action. When used as discontinuous systems, those same chemicals could have been used on the same insects in the field with much lower resistance or no resistance. Continuous exposure wastes the resource of insect susceptibility, especially when insects have short generation times. The only proven solution to resistance problems is to rotate the use of different classes of insecticides.

It is normally best to use a combination of pesticide applications such as residual wall sprays, space or aerosol sprays, and baits. Because insecticide resistance is always a possibility, it is best to rotate different chemical family insecticides, especially when one group begins to lose effectiveness. Consider alternating synthetic pyrethroids such as cyfluthrin (Tempo) to organophosphates such as coumaphos (Co-Ral) or tetrachlorvinphos (Rabon) to carbamates such as carbaryl (Sevin) or to boric acid (SafeCide). Do not wait for heavy populations. It is much easier and less expensive to prevent a heavy buildup than to control heavy populations after the buildup. As populations begin to build up, take time to treat, and treat regularly.

Pests are killed by different modes of action often according to Chemical Class. Pesticide rotations minimize problems of building up resistant pests.

ORGANOPHOSPHATES	- tetrachlorvinphos, dichlorvos
CARBAMATE	- carbaryl
PYRETHROIDS	- cyfluthrin, permethrin
BORATES	- boric acid

Each livestock unit is different and there may be darkling beetle breeding occurring in only two or three locations. Manure management and sanitation can be expensive, but is a required practice in livestock production. The benefits (reduced risk of nuisance lawsuits, better working conditions for the employees, more efficient use of insecticides) may offset the expense.

To help you design an effective control program, Ohio State recommends the following six steps:

- Identify darkling infestation sites; don't forget to check areas around feed bins, compost pits and exterior house perimeters.
- Clean the house thoroughly and haul litter away immediately.
- Use a pesticide and a formulation which are suitable for the type and location of the treatment.
- Follow label rates. This ensures proper application and subsequent pesticide efficacy.
- High chronic populations may require multiple applications to reduce populations to manageable levels.
- Consider spot treating areas that darkling beetles prefer, such as under feeders and water lines and interior perimeters.

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Lesser Mealworm Facts from Ohio State University

In native Africa, beetles were nest scavengers, consuming bits of feed, nest litter, portions of manure, dead plant and animal material.

In USA, poultry operations, beetles eat feed, litter, manure solids, and even portions of dead and dying birds.

Highly active both through running and, at night, through flight. (Prefer a dark daytime hiding place).

Congregate in areas where there are warm, moist conditions.

Sensitive to freezing and high temperatures with dehydration occurring in environments not containing enough moisture.

Tend to avoid excessively wet areas, especially where anaerobic microbial activity is high (fermentation of wet feed or soupy manure).

All life stages tend to clump together in close contact in areas where food, water, and environmental conditions are best for survival.

Darkling beetles will move out of the chicken area of these buildings and into insulation.

Have no natural enemies and carry a large variety of avian viruses, bacteria, fungi, and parasites without observable negative effects on the beetles. They are exceptionally sturdy and durable.

Cannibalistic at all stages, and can actually lower their own populations through predation when conditions are too dry or food is in short supply.

Conditions favoring beetle cannibalism, often stimulates their migration. This results in them becoming pests in insulation or in other buildings near poultry operations.

They cannot survive freezing or temperatures above 90°F for any length of time unless they have access to free moisture.

They can consume large quantities of feed in a short period of time.

Through their active consumption of edible organic matter and their burrowing, these beetles do help recycle poultry wastes and remove material that otherwise would be excellent for fly development.

Low to moderate beetle populations can have a very positive effect on controlling fly populations in large, caged-layer houses where manure and litter are allowed to build up.

Both adults and larvae are nocturnal and remain active 24 hours a day, favoring dark interiors of buildings during the day.

Beetles are actively attracted to artificial light sources at night. Security lights around poultry facilities may help control nocturnal migration to a slight extent by keeping them in an area and preventing them from detecting distant light sources.

Table 1: **1996 Survey of Georgia Estimates of Losses and Control Costs**

Rank	Insect	Cost of Control	Damage	Total
1	Darkling beetles	\$1,371,000	\$8,476,000	\$9,847,000
2	Horn fly	2,311,000	7,117,000	9,428,000
3	House fly	1,222,000	2,991,000	4,213,000
4	Stable fly	932,000	3,065,000	2,997,000
5	Lice	715,000	2,204,000	2,919,000
6	Northern fowl mite	451,000	797,000	1,248,000
7	Mites (animal)	222,000	557,000	797,000
8	Grubs and Bots	66,000	170,000	236,000
9	Face fly	43,000	137,000	180,000
10	Horse fly	29,000	42,000	71,000
	Total	\$7,362,000	\$25,575,000	\$32,937,000

M. P. Nolan, Jr. and D. C. Sheppard

Table 2: **Estimates of Losses and Control Cost for Poultry in Georgia in 1996**

Layers	Cost of Control	Damage	Total	No. Treatments Avg. Cost of Treatments
House Flies (60%)	\$754,200	\$1,341,000	\$2,095,200	1/bird \$0.075/layer
Northern Fowl Mites (35%)	439,950	782,250	1,220,200	
Darkling Beetles	62,850	111,750	174,600	
Broilers				
Darkling Beetles (100%)	\$1,292,000	\$8,343,000	\$9,635,000	1/bird \$0.0016/bird
Turkeys				
Darkling Beetles (60%)	\$16,000	\$21,600	\$37,600	4/bird \$0.10/bird
Northern Fowl Mites (40%)	\$11,000	\$14,400	\$25,400	

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Darkling Beetle

Genus *Alphitobius diaperinus*

Common Name: Darkling beetle, litter beetle, black bug, and black poultry bug

Distribution Lesser mealworms are found in grain bins, mills, and poultry houses throughout the world.

Food: Lesser mealworms feed in grains and flour, particularly in damp, musty sites. Poultry houses with deep litter are ideal breeding grounds. Adults have been found feeding on carcasses in poultry houses.

Breeding Media: feed, decaying litter and an occasional bird carcass

Optimum Life Stages

- Days** 35 to 97 Length of the life cycle depends on the temperatures and moisture.*
- Egg** 1/16 inch creamy white to tan. Individually or in clusters of up to 12
Laying is continuous at intervals of 1 to 5 days during the females 3 to 12 month live span. Eggs hatch 4 to 7 days into larva. There is little egg hatching below 60°F or above 100°F.
- Larva** Yellowish to brown up to 3/4 inch with distinct head and 6 small legs.
Five to nine stages called instars. Larval period lasts up to 7 weeks.
- Pupa** 1/4 inch creamy white to tan or light brown, legs appear to be tucked along side. Pupae wiggle when disturbed and otherwise still. Pupal stage last for 7 to 11 days.
- Adult** Approximately 1/4 inch long and shiny black. They emerge reddish-brown and turn black in 3-5 days. Bodies are oval and slightly flattened. Beetles live up to three months to 2 years. In the poultry house, the beetle can lay up to 800 eggs (with estimates up to 2000) in litter during a 42-day period.

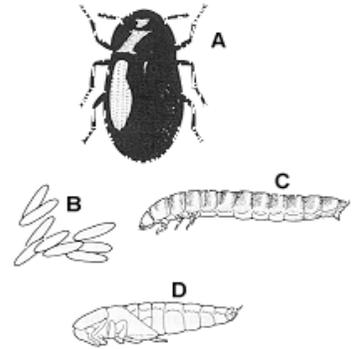
Other Habits: Darkling beetles are commonly found in woods or around feed bins. These beetles fly well and are attracted to lights at night but hide during the day.

Mature larvae seek a sheltered place to pupate because the darkling beetles prey on the lesser mealworms. Most of the damage to insulation is done by lesser mealworms seeking a safe place to pupate.

All stages of the darkling beetle are killed by temperatures below 30° F.

* Ohio State and Arkansas report different life cycle length. Ohio State(42 to 97 days)
Arkansas (35 to 60 days)

Ohio State Poultry Pest Management Bulletin 853



Lesser mealworm.
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