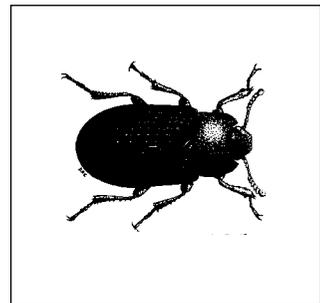
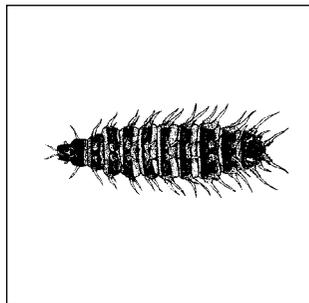
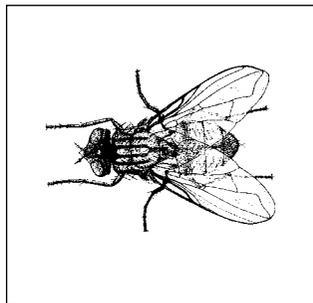
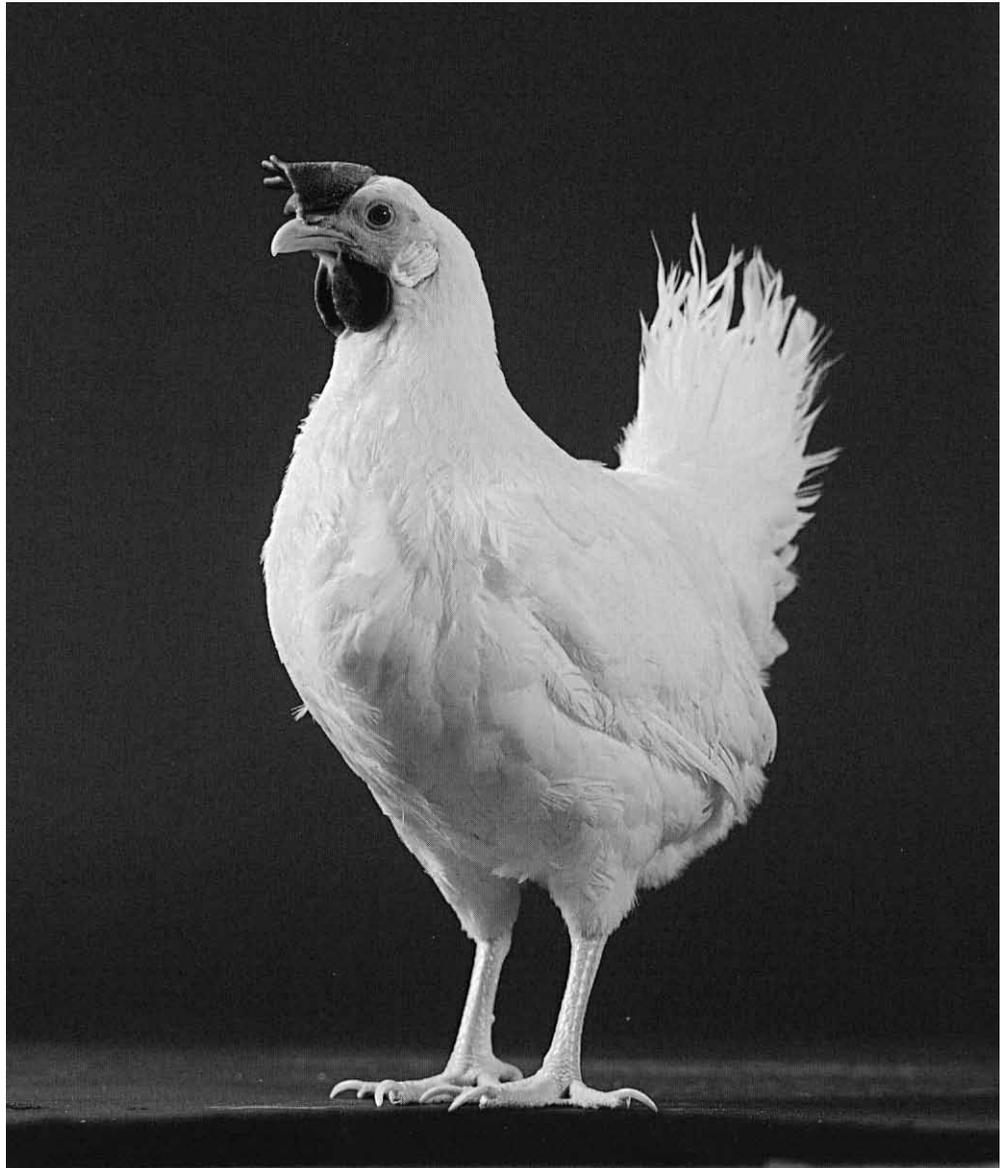


Pest Management Recommendations for Poultry



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Pest Management Recommendations for Poultry

INTRODUCTION

Flies, beetles, and mites are often major concerns for commercial poultry operators in the northeastern United States. The high-density, confined housing systems used in poultry production create conditions that favor the development of manure-breeding flies, beetles associated with poultry litter accumulations, and northern fowl mites. Fly populations may create a public health nuisance around the farm and in nearby communities, resulting in poor community relations and threats of litigation. Two species of beetles associated with poultry litter and manure accumulations can cause structural damage to poultry housing, serve as potential disease reservoirs, and create community problems at the time of house cleanout. Large northern fowl mite populations can cause direct economic losses by affecting bird health and production.

In addition to flies, beetles, and mites, several beneficial insects and mites are often associated with accumulations of poultry manure. Predaceous mites, hister beetles, and parasitoids are all important biological control agents in suppressing fly populations.

In the past, pest control measures relied almost exclusively on pesticides to keep pest populations below economic injury levels or nuisance thresholds. Since these thresholds are not well defined, control practices generally were carried out when the pests were observed on the birds or in the poultry house. Extensive or improper use of pesticides results in the destruction of biological control agents and the development of pesticide resistance. It can also create harmful and illegal residues in meat and eggs, and can contaminate the environment. Destruction of biological control agents and pesticide resistance result in larger pest populations, increased pesticide use, and higher control costs.

An alternative control strategy is an integrated approach to pest management. Integrated pest management (IPM) programs for poultry combine cultural, biological, and chemical control tactics. The objectives of IPM programs are:

1. To monitor pest and biological control agent populations
2. To use appropriate management techniques and biological control agents to suppress fly populations

3. To allow producers to decide if a pesticide application is needed to control pests and to apply the pesticide at the proper time and place
4. To avoid unnecessary and unprofitable pesticide applications

Producers are encouraged to incorporate multiple pest management strategies into their production practices. Manure management, moisture control, sanitation, and pesticide applications are integrated with sound flock management practices to keep pest populations below economically damaging or nuisance levels. To ensure the effectiveness of any program, producers must correctly identify the pest and the biological control agents, and understand their basic life cycles and potential damage. They must also monitor pest and biological control agent population levels and know which pesticides are registered for use in poultry operations. Effective IPM programs result in better community relations, improved flock performance, reduced control costs, and fewer chances for structural damage.

POULTRY HOUSING AND PEST PROBLEMS

Each of the three poultry facility types principally used in poultry production (caged-layer, broiler, and breeder houses) has its own pest problems and unique management needs. While this publication is oriented primarily toward environmentally controlled, deep-pit, caged-layer operations (also referred to as high-rise houses), some material is also relevant for broiler, breeder, and other caged-layer operations.

Caged-layer houses are widely used for commercial egg production. These houses consist of two to four tiers of cages on the sides of an aisle, with each cage containing several birds. Of the three types of facilities, these present the greatest fly-breeding potential because of manure accumulation under the cages.

Broiler houses are wide-span structures with litter (wood shavings) covering the floor and the birds running free. Little fly breeding occurs because of the dry litter, but high populations of beetles may occur in the litter. Breeder or broiler-breeder houses are also wide-span structures with birds running free on a slat-litter floor. The outer two-thirds of the house has a slatted floor 2 to 3 feet above ground level, with a litter-covered floor in the center third of the house. Generally, fly breeding occurs in the manure that accumulates under the slatted floor on which the feeders and waterers are located. In breeder houses, northern fowl mites can spread rapidly because of direct bird-to-bird contact.

FLIES ASSOCIATED WITH MANURE

Manure-breeding muscid flies, particularly the house fly, *Musca domestica*, and occasionally the little house fly, *Fannia canicularis*, and the black garbage fly, *Hydrotaea aeneascens*, are a serious problem for poultry producers in the northeastern United States. Other flies commonly associated with northeastern poultry operations, but rarely noticed, are small dung flies of the family Sphaeroceridae.

HOUSE FLY, *Musca domestica*

The house fly is the major pest species associated with poultry manure, especially in caged-layer operations. Suitable fly-breeding conditions are present year-round in high-rise houses because of long-term manure accumulation and controlled temperatures. Even though flies appear to have no direct effect on production, they are a concern to poultry producers because they can cause public health problems resulting in poor community relations and possible legal action. The effective house fly dispersal range appears to be ½ to 2 miles, but distances as great as 10 to 20 miles have been reported. Generally, flies disperse either across wind or into wind with nuisance densities highest closest to the source.

House flies can transmit more than 100 human and animal disease-causing organisms, including protozoa, bacteria, viruses, rickettsia, fungi, and worms. House flies are considered intermediate hosts for tapeworms and may transmit ascarids to caged birds. Flies mechanically carry ascarid and other nematode eggs on their feet from manure to pens, feed, and water. Fly maggots ingest tapeworm and ascarid eggs from the poultry manure and retain them in the gut until maturity. In turn, infected flies are ingested by the feeding bird. Although it appears that avian influenza is spread principally by contaminated shoes, clothes, and equipment, the virus has been isolated from adult house flies.

House flies are nonbiting flies about ¼ inch long, mostly dull gray in color, with four black stripes on the thorax (Fig. 1). Mouthparts are spongelike and are used for ingesting liquid foods. House flies breed in manure, spilled feeds, and other moist, warm, decaying organic material. Each female can produce up to six batches of 75 to 200 eggs at 3- to 4-day intervals, laying the eggs in cracks and crevices under the surface of the breeding material. Larvae (maggots) hatch from the eggs in 12 to 24 hours. They are white and cylindrical, tapering in the front. Maggots complete

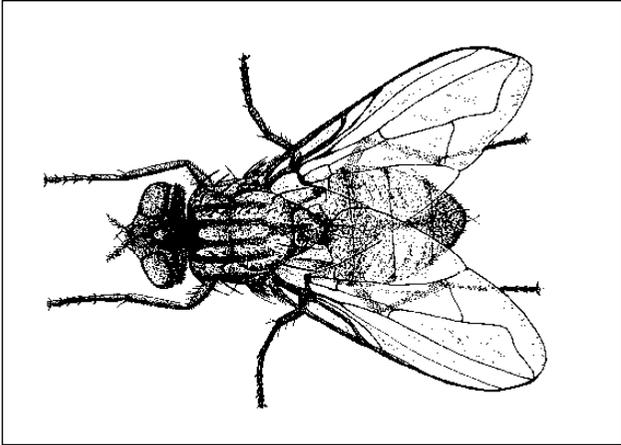


Figure 1. Adult female house fly.

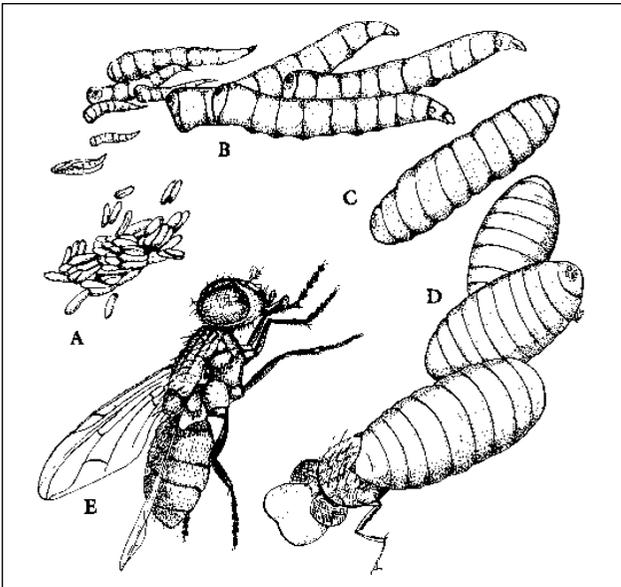


Figure 2. House fly life cycle: (A) eggs, (B) larvae (maggots), (C) larva-forming puparium, (D) pupae, (E) adult.

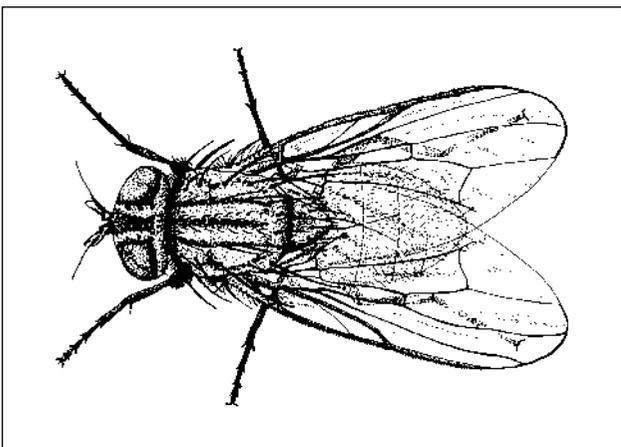


Figure 3. Adult female little house fly.

their development in 4 to 7 days, passing through three growth stages, or instars, as they grow larger. Mature larvae form a dark reddish-brown hardened case, called a puparium, from the larval skin and then pupate. The pupal stage usually lasts 3 to 4 days, after which an adult fly emerges to complete the cycle (Fig. 2). Generations overlap; all stages are present at the same time. The life cycle is temperature dependent, requiring 10 days at 85°F, 21 days at 70°F, and 45 days at 60°F.

Adult flies live an average of 3 to 4 weeks, but they can live twice this long. They are most active during the day at temperatures of 80 to 90°F and become inactive at night and at temperatures below 45°F. Resting adults can be seen on ceilings, walls, post, and other surfaces inside a poultry house, as well as outside beneath roof overhangs and on walls, fences, and vegetation. Preferred resting places can be detected by the accumulation of "fly specks," light-colored spots formed from regurgitated fluid and darker fecal spots.

LITTLE HOUSE FLY, *Fannia canicularis*

High populations of the little house fly may occur on poultry farms, and it may become the predominant fly pest in some areas. The little house fly resembles the house fly but is smaller (about $\frac{3}{16}$ inch) and has three brown stripes on the thorax (Fig. 3). This fly is normally associated with housing that has litter-covered floors and open-window ventilation. Like the house fly, the little house fly may invade homes in nearby residential areas, but it tends to be less annoying since it does not settle as readily on food or people. Both sexes can be found resting on weeds, branches, or sides of buildings.

Adult males show a distinctive aimless hovering or circling flight behavior of long duration within the poultry house or outside in shaded areas. Female flies are less active and are more often found near breeding sites. Since this fly is less tolerant of hot, midsummer temperatures than the house fly, it often emerges in large numbers in early spring, declines in midsummer, and may peak again in late fall.

The little house fly's life cycle is similar to that of the house fly. Eggs are deposited on decaying organic material, especially excrement from poultry, cattle, and humans. Larvae hatch from the eggs in 36 to 48 hours. Unlike house fly larvae, the little house fly larvae are

brown, flattened, and spiny (Fig. 4). Larvae require 8 days or more for development, depending on temperature and manure conditions. Pupae resemble the larvae in appearance and last about 8 days. The egg-to-adult life cycle typically ranges from 18 to 22 days but may be longer depending on temperature.

BLACK GARBAGE FLY, *Hydrotaea aenescens*

Black garbage flies, found in large numbers around poultry facilities, are shiny bronze-black and are a little smaller than house flies (Fig. 5). The life cycle is similar to that of the house fly and ranges in duration from 14 to 45 days. Black garbage fly larvae, which closely resemble house fly larvae, hatch from the egg in 12 to 16 hours. Larvae develop in a minimum of 5 days and may prey on other fly larvae. The pupal stage requires at least 4 days. Adults live an average of 14 to 20 days. Although no overwintering stage is capable of withstanding freezing temperatures, all stages are found throughout the year under suitable conditions in poultry houses.

Unlike the house fly and little house fly, black garbage flies tend to stay on their food source at night rather than rest on the ceiling or on outdoor vegeta-

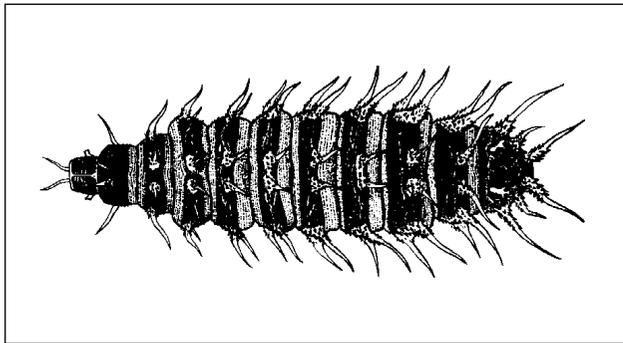


Figure 4. Larva of a little house fly.

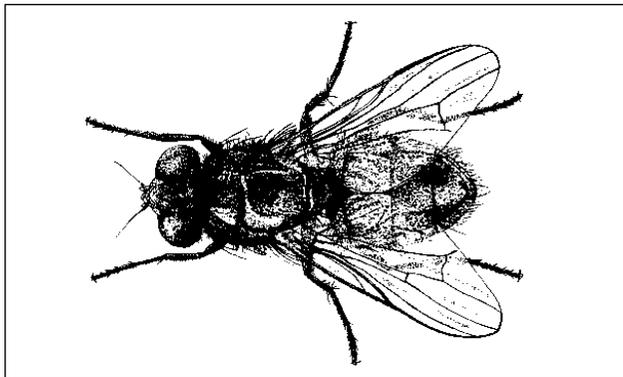


Figure 5. Adult female black garbage fly.

tion. Female flies seem to have limited flight activity, yet they have been reported up to 4 miles from their breeding areas. While black garbage fly larvae have been known to exterminate house fly populations under extremely wet conditions, they cannot generally be considered beneficial because of their large numbers on the farm and their ability to disperse as adults into nearby communities. Two other species of black garbage flies, *H. leucostoma*, a widely distributed species, and *H. capensis*, also may be found on poultry farms in the Northeast.

SMALL DUNG FLY, SPHAEROCERID

Small dung flies are very small, blackish or brownish flies that breed in manure and other decaying materials. They often occur in large numbers in poultry manure but generally are not a nuisance on the farm or in nearby communities. Sphaerocerids are among the first arrivals at new manure. Adult sphaerocerids forage over a broad range of manure moisture content, but they predominate at the peak of the manure cone where moisture content is higher. Larval development occurs where moisture exceeds 50 percent. Control efforts are discouraged because sphaerocerids are generally not pests and may be used as an alternative food source by beneficial hister beetles.

FLY MANAGEMENT

Fly control is basically a manure management strategy. Dry manure, 50 percent moisture or less, reduces the suitability for fly oviposition and larval development. It also provides a desirable habitat for beneficial predators and parasitoids. Three basic management strategies (cultural/physical, biological, and chemical) can be integrated into a successful fly control program.

CULTURAL/PHYSICAL CONTROL

The keys to cultural/physical control are moisture management, sanitation, and manure removal. The manure moisture level is the most important factor in fly control. Moist poultry manure is highly attractive to adult flies and provides ideal conditions for fly development. Fresh poultry manure is approximately 75 to 80 percent moisture, and flies can breed in manure with a moisture content of 50 to 85 percent. Moisture levels are affected by leaking waterers, condensation from noninsulated overhead water lines, improper ventilation, and seepage from the exterior. Leaking waterers are the major source of wet manure condi-

tions, so waterers should be inspected daily. Inspection can be done effectively only by walking the manure pit on a daily basis and looking for wet spots.

If dry conditions are maintained, manure will form a cone-shaped mound as it accumulates and only fresh additions at the manure cone peak will be suitable for fly breeding. Houses with scraper boards usually have drier manure accumulations than those without, but scraper boards are not effective if water leaks exist.

Ventilation (airflow) reduces manure moisture while also maintaining desirable air temperatures, removing gases such as ammonia, and providing fresh air. Exhaust fans located in the manure pit walls provide ventilation for environmentally controlled high-rise houses. With adequate insulation, proper temperatures (60 to 75°F) can be maintained in cold weather. Fresh air is brought in from ceiling inlets and circulated through the chickens and over the manure in the pit. Fans placed on both sides of the pit can help reduce moisture.

Supplemental drying fans can be installed above the manure rows. Three-blade, 36-inch, direct-drive fans should be suspended every 50 feet in a serpentine configuration and hung at approximately a 15-degree angle from the vertical. Because chickens usually begin to produce droppings just before the lights come on in the morning, fans typically are run during daylight hours. No definitive cycle exists, though, and producers should operate the fans to obtain optimum results. Obstructions will greatly decrease fan efficiency, so covers should be cleaned as soon as any debris collects on them. Supplemental fans will greatly increase the drying of the manure—often to below 50 percent moisture content—and will reduce the number of house flies produced in the pit.

In-house composting is an additional tool that producers can use to manage insect populations in high-rise layer houses. Manure is agitated to incorporate oxygen and possibly a carbon source to aid in the composting process. This agitation results in increased temperature, an increased ammonia level, and decreased moisture content, all of which help reduce insect populations. The agitation can be accomplished in several ways, but the most practical uses a commercial hydraulic-powered manure turner such as the "Brown Bear." Turning the manure pile twice a week is usually adequate, but the best way to determine need is to take the pile temperature with a compost thermometer. The temperature should be at least 120°F before turning is implemented.

Composting has some drawbacks. Ammonia is released in high concentrations during the turning process, so appropriate protective devices should be used. Composting eliminates beneficial insects, so ceasing to compost once you have begun can cause large house fly outbreaks. Finally, because the "Brown Bear" cannot continually turn high piles, you must clean out when the pile approaches 2 feet in height.

Another successful moisture-control tactic, employed in the first 8 weeks of manure accumulation, involves using a snowblower, vacuum leaf mulcher, or shovel to transport dry materials and feathers from the pit aisles onto the top of the accumulating manure cone.

Sound sanitation practices are also important in fly control. Dead birds must be removed daily and disposed of properly. Spilled feed and broken eggs left on the manure attract adult flies and pest beetles. Mowing grass and weeds adjacent to the poultry house eliminates resting areas for adult flies and allows full airflow through the fans.

Finally, proper manure management reduces fly buildup and maximizes the development of beneficial predator and parasite populations. Fresh manure that accumulates within 2 days after house cleanout is ideal for fly breeding, often causing a severe fly outbreak to occur 3 to 6 weeks after a cleanout during the fly season. Remove manure only in cooler months when flies are less active. Allowing manure to accumulate for long periods conserves beneficial arthropods and maximizes their populations.

During spring and summer, when fly and beetle dispersal is a major concern, manure that must be removed from the building can be piled and tarped to kill developing pests. It is important that the manure be sealed completely under the tarp and the pile be placed in direct sunlight. Seal the tarp by filling 4-foot-long sections of 4-inch PVC pipe with sand, capping them, and placing them on the edges of the tarp around the base of the pile. When uncovering the manure pile, take care to avoid inhaling the excessive gas that accumulates under the tarp. Following a minimum of 2 weeks under the tarp, manure can be spread on fields without concern for pest dispersal.

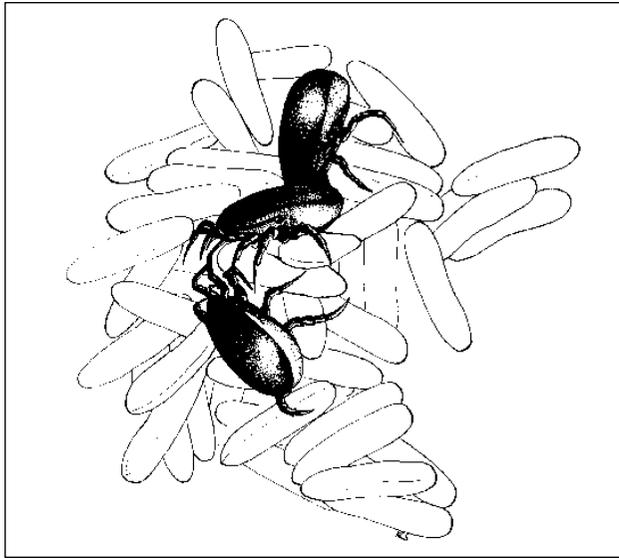


Figure 6. Macrochelid mites feeding on house fly eggs.

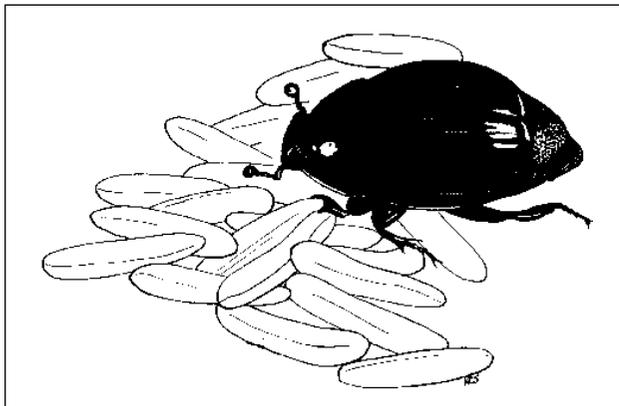


Figure 7. Hister beetle feeding on house fly eggs.

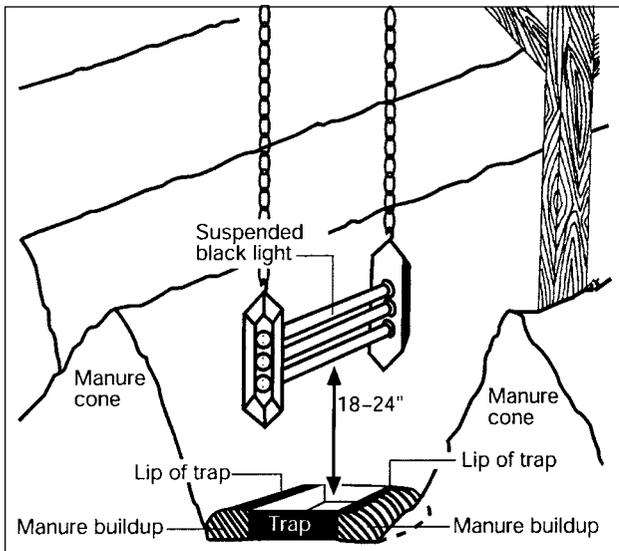


Figure 8. Black light pitfall traps can be used to catch and move hister beetles among poultry houses on a farm.

BIOLOGICAL CONTROL

Proper cultural/physical practices encourage poultry manure accumulations containing large populations of beneficial predators and parasitoids that can suppress house fly populations. In the Northeast, macrochelid mites and hister beetles are the major predators in caged-layer operations. Parasitoid populations are present at densities lower than those of the two predators.

The macrochelid mite, *Macrocheles muscae domesticae*, is the most common mite in poultry manure (Fig. 6). The reddish-brown mite, slightly less than $\frac{1}{16}$ inch in size, feeds on house fly eggs and first-instar larvae. It can consume up to 20 house fly eggs per day. Mites are found on the outermost layer of the manure, particularly its peak. Macrochelids can cause substantial reductions in house fly numbers, but large mite populations are required for any appreciable impact. Efforts should be made, therefore, to conserve natural populations present in the manure. About 3 to 4 weeks of manure accumulation is necessary for mites to become established.

Another mite that may be found in poultry manure is the uropodid mite, *Fuscuropoda vegetans*. It feeds only on first-instar house fly larvae deeper in the manure, complementing the egg-feeding activity of the macrochelid mite on the manure surface.

The principal hister beetle in northeastern poultry houses is *Carcinops pumilio*, a small black beetle approximately $\frac{1}{8}$ inch long (Fig. 7). Both adult and larvae feed on house fly eggs and first-instar larvae. Its impact as a predator has been well demonstrated. Adult and immature hister beetles live in the surface layers of manure and forage for fly and mite prey. Like macrochelid mites, hister beetles do not seem attracted to fresh manure, and it may take 6 weeks for significant populations to develop. Another hister beetle, *Gnathoncus nanus*, is also present at lower numbers on poultry farms in the Northeast.

During the spring, hister beetles appear to enter a state of dispersal and become attracted to black lights. Using pitfall traps placed directly under these lights, you can collect hister beetles in large numbers and release them into recently cleaned houses on the same farm. Construct pitfall traps of smooth-sided containers such as shallow pans that prevent trapped beetles from crawling out (Fig. 8). Place traps on the surface of the litter in walkway aisles between manure piles, and suspend black lights approximately 18 to 24 inches directly above the traps. Building manure ramps along the sides of the pitfall trap allows beetles to climb to the

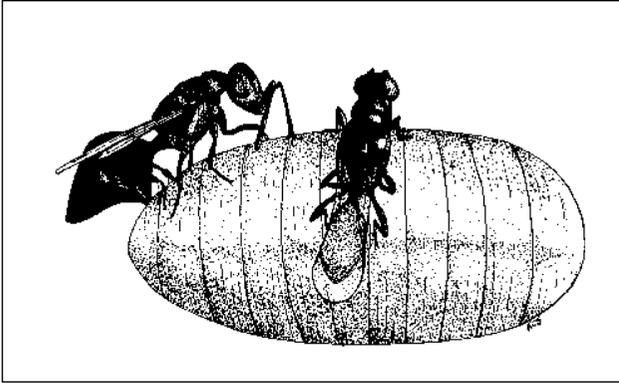


Figure 9. Parasites on a house fly puparium. The one on the left is laying an egg within the puparium.

edge and subsequently fall in. The lip of the collection pan must be ½ inch wide and free of manure to prevent immature litter beetles from falling into the collection pan. If it is necessary to exclude larger litter beetles, cover the trap with number 12 or 14 mesh or pass trap contents through a number 14 sieve. Collect trapped beetles at least every 3 days. Alternatively, beetles can be collected with commercially available traps.

Houses with manure older than 24 weeks often have high populations of hister beetles to allow successful trapping. Beetles can be either transferred directly from a source house to a release house on the same farm or held at 45 to 50°F for up to 8 weeks. Beetles that are overcrowded, have too much moisture, or are held at too high or low a temperature will

have decreased survival. Beetles in storage should be checked at least weekly. *Carcinops pumilio* can carry several poultry diseases; therefore, producers must not transfer beetles from houses with known disease problems. Captured beetles should be transferred only within a poultry farm.

Tiny, stingless parasitoids (parasitic wasps) attack most of the common manure-breeding flies (Fig. 9). Parasitoids are rarely noticed because they are extremely small (1/16 to 1/8 inch) and occur naturally in low numbers on many farms. They live in manure or other decaying organic matter and search for fly pupae. Adult female parasitoids lay an egg on the fly pupa within the puparium. Here the developing larva kills and consumes the pupa and emerges as an adult parasitoid.

Because of naturally low parasitism levels, control programs are sometimes based on mass releases of commercially reared parasitoids. Parasitoids are currently available from commercial insectaries and must be climatically adapted to the planned release area. For a release program to be successful, the producer needs to consider which species and strains, and in what numbers, to release (Table 1). Releases of *Muscidifurax raptor* have been successful in northeastern poultry facilities. Another parasitoid, *Muscidifurax raptorellus*, may also be effective in caged-layer production systems. Releases of parasitoids from commercial insectaries such as Beneficial Insectary, Oak Run, California (916-472-3715) and IPM Laboratories Inc., Locke, New York (315-497-2063) have been effective in Penn State and Cornell IPM programs. Producers must concentrate on conserving both their native and

Table 1. Comparison of *Muscidifurax raptor* and *M. raptorellus* life history.

Features	<i>Muscidifurax raptor</i>	<i>Muscidifurax raptorellus</i>
Breeding area	House fly pupae	House fly pupae
Movement	Up to 50 feet	Up to 15 feet
Fecundity	Female lays 20 eggs per day; about 200–300 eggs over her lifetime	Female lays 20 eggs per day; about 150 eggs over her lifetime
Eggs per pupa	1	4 to 8
Development	Egg to adult in 17 days	Egg to adult in 16 days
Life span	2 weeks as an adult	2 weeks as an adult
Generations	About 15	About 15
Release level	2 to 4 pupae/bird/week for first 8 to 10 weeks	1 pupa/bird/week for first 8 to 10 weeks

released predator and parasitoid populations by using proper manure management techniques and minimizing insecticide use.

Parasitoids purchased from commercial insectaries arrive within days of expected adult emergence and should be released immediately into the poultry house. An effective release technique is to pour parasitoids (still in fly pupal cases) into paper cups and place the cups at the base of structural support posts. Distribute the parasitoids equally among the cups, and place a cup at every second or third post. If a particular "hot spot" of fly development is discovered, placing a few extra cups near the breeding area should aid in killing more of those fly pupae. Another method for releasing parasitoids involves hanging portions of the weekly shipment, in cheesecloth bags, from the manure pit rafters throughout the house. Release bags should be left in place for at least 3 weeks.

Proposed release schedules appear in Tables 2 and 3. It should be noted that the intensive release schedule presented is best suited for houses where

flies have been a problem in the past and for farms in sensitive areas. Large releases may not be necessary in the fall and winter when fly dispersal is unlikely. Also, producers should consider releasing combinations of *M. raptor* and *M. raptorellus*.

CHEMICAL CONTROL

Producers must monitor fly populations on a regular basis to evaluate their fly management program and to decide when insecticide applications are required. Accurate insecticide and application rate records must be kept. Insecticides can play an important role in integrated fly management programs; however, improper timing and indiscriminate insecticide use, combined with poor manure management, poor moisture control, and poor sanitation practices, will increase fly populations and the need for additional insecticide applications. Although most fly insecticides are toxic to predators and parasitoids and can result in their destruction if used indiscriminately, selective application of insecticides can avoid killing these beneficials.

Table 2. *M. raptorellus* release schedule for late spring and summer cleanout.

Week Post-Cleanout	Number of Parasitoids/Bird	Number of Pupae/Bird	Number of Colonies/ Bird House/Week*
1, 2	2/1	1/2	5
3, 4, 5	8/1	2/1	20
6, 7, 8	4/1	1/1	10
9, 10	2/1	1/2	5
11+	if necessary	if necessary	—
			Total: 110 colonies
*One colony = 10,000 parasitized fly pupae			

Table 3. *M. raptor* release schedule for late spring and summer cleanout.

Week Post-Cleanout	Number of Parasitoids/Bird	Number of Pupae/Bird	Number of Colonies/ Bird House/Week*
1, 2	2/1	2/1	20
3, 4, 5	8/1	8/1	80
6, 7, 8	4/1	4/1	40
9, 10	2/1	2/1	20
11+	if necessary	if necessary	—
			Total: 440 colonies
*One colony = 10,000 parasitized fly pupae			

Insecticide applications may be classified by targeted fly stage (adulticides and larvicides) or method of application (sprays, baits, and feed additives). *WARNING: Always read product labels carefully before applying any pesticide; mix and apply as directed, do not overdose, do not treat too often, and follow all precautions exactly. Remember that improper practices can lead to illegal residues even when proper materials are used. It is illegal to use a pesticide in any manner inconsistent with the label.*

Space sprays containing synergized pyrethrins provide a quick knockdown of adult flies in an enclosed air space. Because space sprays have very little residual activity, resistance to these insecticides is still relatively low among fly populations in the Northeast. Unfortunately, resistance has become a rather severe problem in poultry operations where pyrethrins are applied with automated dispensing systems. These poultry producers experienced loss of effective fly control in only one fly season. The key to successful fly management with automated dispensing systems is to use them sparingly. If you must use an insecticide, pyrethrins are currently your best choice for use as a space spray in an IPM program.

Baits are excellent selective adulticides for suppressing low fly populations and maintaining them at a low level. Baits are also especially effective when combined with space sprays. Place baits upstairs in a high-rise house since scattering bait in the pit will destroy parasitoid and predator populations. Baits should be used so that they will not be eaten accidentally by birds or mixed into their feed.

Using feed additives to make manure toxic to fly larvae was once considered an attractive method of fly control because it is easy. Only one material, the insect growth regulator cyromazine, is currently registered for use in laying hens. While cyromazine does not affect predators and parasitoids, it can be expensive to use and has led to severe and long-lasting resistance in flies. In recent studies in New York, fly resistance to cyromazine was found to be widespread in poultry operations with a history of cyromazine use. Therefore, cyromazine should never be used as a replacement for other insecticides or proper manure management practices.

Larvicides (pesticides applied directly to the manure surface to kill maggots) should never be used, except for spot treatments, since they will destroy the predators and parasitoids associated with the manure. Cyromazine spot treatments of small areas with high numbers of maggots can be effective and yet have a minimal effect on the overall biological control agent population and fly resistance development in the manure.

Treatment of building surfaces with residual sprays has been a very popular fly control strategy over the years. Unfortunately, exceptionally high levels of fly resistance to insecticides used as residual sprays are now very common. Residual spray materials must be used sparingly and only as a last resort to control fly outbreaks that cannot be managed with other techniques.

MONITORING METHODS FOR FLY POPULATIONS

A standardized, quantitative method for monitoring fly numbers should be used for making control decisions. Visual appraisals of fly populations are subjective and can be misleading. Several sampling methods are available: the baited-jug trap, sticky ribbons, and spot cards.

A baited-jug trap can be made easily from a gallon plastic milk jug with four access holes (2 to 2.5 inches in diameter) cut equidistant around the upper part of the jug (Fig. 10). A wire is attached to the screwtop for hanging. About 1 ounce of commercial fly bait is placed on the inside bottom of the jug; a bait containing the fly pheromone muscalure (Muscamone, Z-9-tricosene) is most effective.

The trap location is important for effectiveness and accessibility. In a high-rise house, baited-jug traps should be hung equidistant around the pit periphery about 3 feet above the floor. In a shallow-pit house, traps should be hung in a similar fashion from the ceiling or braces at the ends and outside aisles of the house. Traps should be examined weekly, the flies counted and removed, old bait removed, and fresh

bait added to the jug. An average count of 250 flies per week per jug may indicate the need for fly control measures. The trap is most effective for house flies, but little house flies and black garbage flies will also be recovered. Baited-jug traps are more expensive to operate than other sampling methods, but they offer greater sensitivity to fly population changes.

Sticky fly ribbons hung upstairs along the aisles are another monitoring method. The captured flies are counted weekly, and the ribbons replaced. A weekly count of 100 per ribbon indicates the need for fly control, although this level may be adjusted to fit the circumstances. Ribbons have several disadvantages. They can become ineffective after a few days because of the covering of flies and dust. They are messy to use, and their positioning is important. Never place fly ribbons near exhaust fans or light bulbs, as these can give you an incorrect estimate of fly densities.

Spot cards are 3-by-5-inch white file cards placed in the manure pit and fastened flush against braces, upper walls, or other fly resting areas (areas with large numbers of fly fecal and regurgitation spots). Cards should be left for a period of several days to a week, and the number of fly specks counted. One hundred or more spots per card per week indicates the need for fly control measures. The greatest advantage of the spot card is economy; however, the positioning of the cards is critical, and cards should be placed in the same position at each renewal.

Although all of these monitoring devices are effective, spot cards have the additional virtue of providing long-term historical records of fly activity. Old spot cards can be particularly helpful in resolving conflicts with neighbors over claims of increased fly abundance.



Fig. 10. Baited jug trap for monitoring fly populations.

SUMMARY OF FLY IPM STRATEGIES

The following summary and schedule outline a truly integrated program for fly management. Producers should evaluate their own facilities and determine which combinations of the following management tactics maximize fly control. It may not be necessary to use all of the strategies presented in your facility.

CULTURAL

Moisture control

- Repair leaks in water system.
- Provide adequate ventilation.
- Provide proper grading and drainage.
- Use pit fans.
- Perform in-house composting.

Manure management

- Allow accumulation to enhance the development of biological control agents (parasitoids and predators).
- Limit manure removal during the fly season.

BIOLOGICAL

Enhance natural populations of parasitoids and predators.

- Use proper cultural practices to encourage maximum manure cone formation.
- Use insecticides selectively.

Introduce predators and parasitoids.

- Release parasitoids.
- Trap and release predators.

CHEMICAL

Adulticides

- Use space sprays or mists occasionally.
- Use baits.
- Use residual sprays selectively.

Feed additives—larvicides

- Not recommended.
- Use spot treatments only if necessary.

FLY MANAGEMENT SCHEDULE

BEFORE CLEANOUT

Capture *Carcinops pumilio* and store in 50°F cooler (refer to pp. 6–7 for instructions).

BEFORE BIRD PLACEMENT

- Start with a clean house.
- Treat posts and walls with a residual insecticide to control flies and litter beetles.
- Install manure drying fans every 60 feet down each aisle between manure rows.

BIRD PLACEMENT

- Place chickens in poultry house.
- Immediately after placing birds in house, check for leaking waterers in the pit that may have been caused by placing the birds in the facility.
- Turn manure drying fans on.

WEEK ONE

- Walk pit daily to check for leaking waterers.
- Place spot cards.
- Order parasitoids (refer to pp. 7–8 for suggested release strategy).

WEEKS TWO THROUGH SIX

- Walk pit daily to check for leaking waterers.
- Change spot cards.
- Release parasitoids.
- Release *Carcinops*.
- Aid drying with snowblower, shovel system.

WEEKS SEVEN THROUGH TEN

- Walk pit daily to check for leaking waterers.
- Change spot cards.
- Release parasitoids.
- If spot card levels are below action threshold and *Carcinops* beetles are observed on the manure, turn fans off.

WEEKS ELEVEN+

- Walk pit daily to check for leaking waterers.
- Monitor fly populations with spot cards.
- Respond to fly outbreaks as needed.

PEST BEETLES ASSOCIATED WITH POULTRY LITTER

Two species of beetles associated with poultry manure and litter accumulations in the Northeast are the lesser mealworm or darkling beetle, *Alphitobius diaperinus*, a pest of stored grain products, and the hide beetle, *Dermestes maculatus*, long recognized as a pest of hides, skins, and furs. Adults and larvae of both species can become extremely abundant in poultry manure and litter.

Both beetles can cause excessive damage as the mature larvae bore into structural materials, apparently seeking a safe pupation site (Fig. 11). The lesser mealworm is also a vector (transmitter) and serves as a reservoir for several poultry disease pathogens such as acute leukosis (Marck's disease), fowl pox, numerous pathogenic *E. coli* serotypes, several *Salmonella* species, and tapeworms. Large beetle populations may become a public nuisance at cleanout time because of adult migration into nearby residential areas from the fields where the manure is spread.



Figure 11. Destruction of insulation by litter beetles.

LESSER MEALWORM, *Alphitobius diaperinus*

Adult lesser mealworms are dark brown or black in color and about ¼ inch long. The wireworm-like larvae are yellowish brown and up to ¾ inch long (Fig. 12). Lesser mealworms spend most of their time in the manure or litter. Adults feed on damp and moldy grain and are especially abundant in areas with spilled grain.

The life cycle is temperature dependent. There is a marked reduction in egg hatch below 70°F, and development time from egg to adult increases with decreasing temperature. Development requires 42 days at 100°F, 58 days at 80°F, and 97 days at 60°F. Eggs are laid in cracks and crevices in the manure or litter and hatch in 3 to 6 days. Most larvae develop through five to nine instars, the number increasing with lower temperatures. The last larval instar pupates in drier areas of the manure or litter and in cracks and crevices. Larvae also bore into wood posts, beams, paneling, drywall, and insulation. Small round holes about 1/4 inch in diameter are the first signs of damage. The pupal stage lasts 3 to 10 days. Adults live 3 months to a year. Generally, beetles are not observed in high numbers until manure has accumulated at least 20 to 24 weeks.

HIDE BEETLE, *Dermestes maculatus*

Hide beetles are larger than darkling beetles, about 1/3 inch long, and dark brown on the top with a mostly white undersurface. Hide beetle larvae are similarly colored, thickly covered with long brown hairs, and grow to about ½ inch long (Fig. 13). Scavenging hide beetles feed on bird carcasses, skins, hides, feathers, dead insects, and other animal and plant products. Broken eggs and dead birds in the manure enhance beetle populations, although large beetle populations may develop even with good sanitation.

Eggs are laid on manure and litter surfaces. Larvae hatch from eggs in 2 to 7 days, depending on the temperature and relative humidity, and pass through an average of seven instars in 23 to 41 days or more. Larvae normally remain in the manure, but large numbers will migrate from the pit to find a safer pupation site or to move away from unfavorable conditions in the manure. Larvae bore into wood posts, beams, paneling, dry wall, and insulation to create a protected pupation chamber. Adults are rarely involved in boring. Adults emerge in 6 to 15 days and live 60 to 90 days.

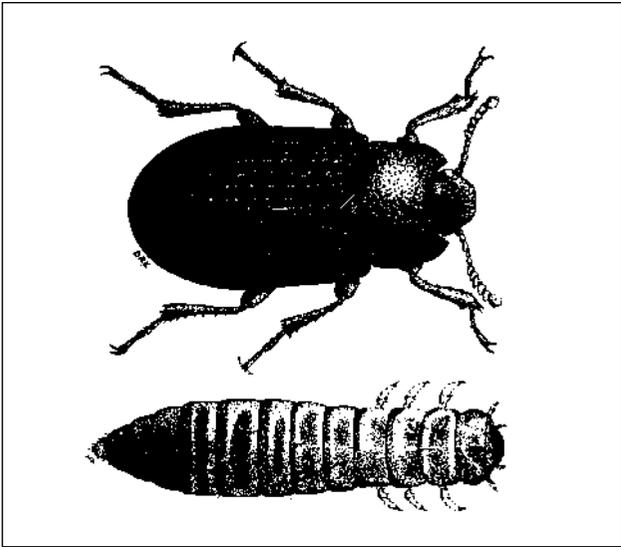


Figure 12. Lesser mealworm or darkling beetle adult and larva.

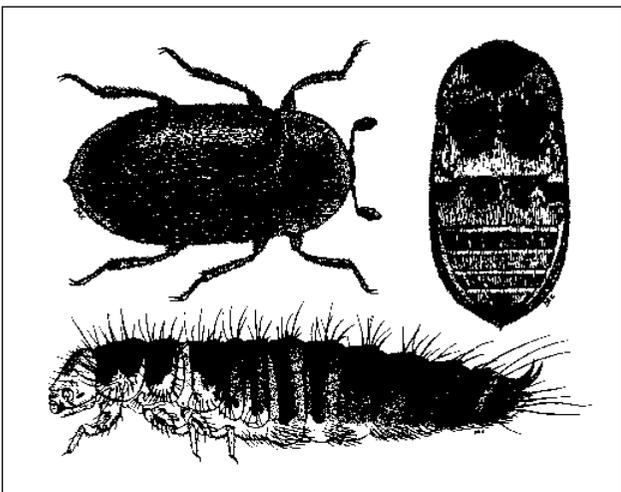


Figure 13. Hide beetle adult and larva.

BEETLE MANAGEMENT

Once a poultry house becomes infested, control is difficult since beetles migrate throughout the house and pupation occurs in wood and insulation. A thorough house cleaning, combined with chemical control when the birds are removed, will usually suppress the population for a short time. Migration may be reduced by applying insecticide sprays to the pit walls and posts. *WARNING: Always read product labels carefully before applying any pesticide; mix and apply as directed, do not overdose, do not treat too often, and follow all precautions exactly. Remember that improper practices can lead to illegal residues even when proper materials are used. It is illegal to use an insecticide in any manner inconsistent with the label.*

Applying dusts and sprays to manure and litter is fairly effective, but it can destroy any fly biological control agents present. Attaching well-sealed, angled, metal flashing to pit walls at the masonry-frame wall joints and to posts can help reduce beetle migration out of the pit. However, the rapid accumulation of dust and debris may make the flashing ineffective. Even if the flashing is effective, beetle dispersal into the community at cleanout time is a potential problem.

During spring and summer, when fly and beetle dispersal is a major concern, manure that must be removed from the building can be piled and tarped to kill developing pests. It is important that the manure be sealed completely under the tarp and the pile be placed in direct sunlight. Seal the tarp by filling 4-foot-long sections of 4-inch PVC pipe with sand, capping them, and placing them on the edges of the tarp around the base of the pile. When uncovering the manure pile, take care to avoid inhaling the excessive gas that accumulates under the tarp. Following a minimum of 2 weeks under the tarp, manure can be spread on fields without concern for pest dispersal.

NORTHERN FOWL MITES

The northern fowl mite, *Ornithonyssus sylviarum*, infests a wide variety of domestic fowl and wild birds and is the most important and common external parasite of poultry (Fig. 14). Mites feed on blood, and heavy mite infestations can irritate and stress the birds, reducing egg production by 10 to 15 percent. A production loss of this size can add up to significant losses over the total life of a caged laying hen. Heavy populations also can reduce weight gains and, in male birds, reduce seminal fluid volume. Mites also can annoy egg handlers and other personnel.

Mites congregate first on the vent, then the tail, back, and legs of female birds; they are more scattered on male birds. As the mite population increases, feathers become soiled from mite eggs, cast skins, dried blood, and excrement. The soiling produces the characteristic blackened feathers in the vent area (Figures 14a, 14b). Scabs also may form in the vent area. Although death due to actual anemia is rare, birds with heavy infestations (50,000 mites per bird) can lose 6 percent of their blood daily.

Mite populations can rise rapidly after a bird has been infested, especially during the cooler months and on young birds 20 to 30 weeks of age. Newly infested birds may support mite populations in excess of 20,000 per bird in 9 to 10 weeks. Mites do not become established on birds in large numbers until birds reach sexual maturity. Birds older than 40 weeks usually do not support many mites.

The northern fowl mite completes its entire life cycle on the bird, although it can survive off the host for 2 or 3 weeks under suitable conditions. Life cycle stages consist of egg, larva, two nymphal stages, and adult. The eight-legged adult is only $\frac{1}{26}$ of an inch long and is usually dark red to black. Females lay two to five eggs in the fluff of feathers after each blood meal. Eggs hatch into six-legged larvae within two days. All other mite stages possess eight legs. Nonfeeding larvae develop in approximately 9 hours and molt into blood-feeding nymphs that develop in 1 or 2 days. Second-stage nymphs, like the larvae, do not feed and molt to adults in less than a day. The entire life cycle can be completed within a week under favorable conditions.

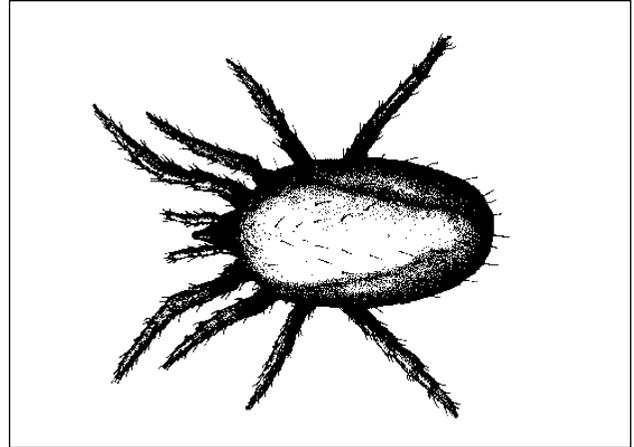


Figure 14. Northern fowl mite adult.



Figure 14a. Heavy infestation of northern fowl mites in the vent area of a chicken showing the blackened feathers.



Figure 14b. Close-up of northern fowl mites on feathers and skin surface.

MITE MANAGEMENT

Control of northern fowl mites in caged-layer operations is based on efforts to prevent infestation and to apply an acaricide when an infestation occurs. Regularly monitoring flocks for the presence of mites allows them to be detected while the population is low or isolated to a few birds.

A house should be clean and mite free before new birds are moved in, and the new flock should be mite free. Once the flock is in the house, care should be taken to prevent contamination from the clothing of workers and various equipment since mites can live for a few weeks off the host. Mites have been shown to be readily transferred from an infested house to an uninfested house by contaminated egg flats. Wild birds and rodents can harbor and disseminate northern fowl mites as well.

The detection of an initial low mite population that can be controlled effectively and economically is important in a mite-monitoring program. With early detection, only part of a caged-layer house may need to be treated. At least 10 randomly selected birds from each cage row in the entire house should be monitored weekly. The vent area should be examined under a bright light, and the feathers parted to reveal the mites. Single caged birds often have more mites than those caged in groups and, because of variation in susceptibility among birds, one bird may have mites while its cage mates are mite free.

The following index is effective for estimating infestation levels:

0 = no mites observed	6 = 301 to 999 mites
1 = 1 to 2 mites	7 = 1,000 to 3,000 mites
2 = 3 to 9 mites	8 = 3,001 to 9,999 mites
3 = 10 to 31 mites	9 = 10,000 to 32,000 mites
4 = 32 to 99 mites	10 = more than 32,000 mites
5 = 100 to 300 mites	

An average index of 5 or greater for all examined birds generally indicates the need for chemical treatment.

The actual decision to treat is influenced by flock age, time of year, and distribution of the infestation in the house. It is usually not economical to treat older birds because their mite populations are unlikely to increase. A population buildup is more likely in a young flock. Mite populations can be expected to increase in cooler months and decrease in warmer months. An infestation restricted to one part of the house may not spread, but the infested area should be closely monitored. Detection of mites in broiler-breeder operations generally means the entire flock must be treated.

Chemical control of northern fowl mites in caged-layer operations requires direct pesticide application to the vent region with sufficient pressure (minimum 100 to 125 psi) to penetrate the feathers. The spray will have to be directed upward from beneath the cages to reach the vent. A split treatment of a recommended active ingredient may increase effectiveness since water is held better when applied to wet feathers. Mix half the insecticide in the standard amount of water for the first application, spray, and then mix the other half in another standard amount of water for the second application. Dust formulations can be purchased ready to use and may be applied to caged layers with a power blower. Treatment is difficult in broiler-breeder operations where birds are not confined to cages. *Warning: Always read product labels carefully before applying any pesticide; mix and apply as directed, do not overdose, do not treat too often, and follow all precautions exactly. Remember that improper practices can lead to illegal residues even when proper materials are used. It is illegal to use an insecticide in any manner inconsistent with the label.*

Poison Control Centers

1-800-222-1222

Calling the toll-free National Poison Center hotline above will connect you to the nearest poison center. Pennsylvania residents are served by the Pittsburgh Poison Center and the Poison Control Center in Philadelphia.

A Cornell and Penn State Cooperative Extension publication



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College of Agricultural Sciences
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Penn State College of Agricultural Sciences research, extension, and resident education programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

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