INTRODUCTION
California ranks among the top poultry and egg producing states in the nation. Much of California’s poultry production exists near heavily urbanized areas of the state. With continuous urban encroachment on commercial poultry farms, fly control is one of the most challenging management problems facing poultry producers. Intensified urbanization has resulted in increasing social and regulatory pressures to further reduce fly numbers each year.

The potential impact of flies on human and animal health has always been a concern. Most flies are able to transmit causative agents of several human and animal diseases under experimental conditions. However, in developed countries the actual role of flies as vectors of human disease is probably minor. Epidemiologic studies of the United States’ Newcastle disease outbreak in chickens, turkeys, game birds and companion birds in the early 1970’s have suggested that flies may have played a role in the transmission of the virus between flocks.

Today, we are mainly concerned about flies because they are a nuisance. Flies, in large enough numbers, can prevent us from enjoying our environment. When this occurs, complaints are usually made to local health departments which enforce public health regulations that limit fly breeding. Violation of these regulations can be costly due to fines but, perhaps more importantly, due to deterioration of community relations.

Control can best be achieved by an integrated program that reduces conditions that attract flies or are favorable to fly breeding and development. The most effective and efficient programs integrate cultural control methods with biological and chemical control methods. Cultural control refers to management practices (other than chemical or biological) that reduce or alter fly breeding conditions in a way that minimizes or eliminates adult fly emergence and attraction. Biological and chemical control methods focus on the direct reduction of immature and adult stages through the action of fly natural enemies (mainly parasites and predators), and insecticides respectively. In poultry systems manure management is critical. It should be remembered, however, that nearly all moist organic materials can support fly development, including practically any decomposing, moist animal
or plant material. All significant sources of fly breeding habitat must be managed for a program to be most effective.

In the past, and in some circumstances today, pest control measures have relied heavily on pesticides to keep pest populations below perceived nuisance thresholds. Excessive or improper use of pesticides can result in the reduction or elimination of beneficial insects, early development of pesticide resistance, harmful or illegal residues in meat and eggs, and environmental contamination. Loss of beneficial insects and increased pesticide resistance may result in larger pest populations, increased pesticide use, and, ultimately, higher control costs. Integrated pest management (IPM), an alternative approach to control that combines cultural, biological, and chemical control tactics will help reduce many of the problems which have been associated with methods that rely totally on pesticides to control flies.

An IPM program combines a variety of compatible techniques for prevention or suppression of pests while minimizing adverse impacts on human health, the environment and non-target organisms. Principal components of IPM programs include pest identification, monitoring methods and treatment thresholds, reliance on biological and cultural controls when possible, and selective use of pesticides. In an IPM program for flies in poultry houses, this is achieved primarily by using practices that reduce optimal fly breeding conditions, increase the populations of natural enemies of flies, and limit the use of insecticides to situations where monitoring results indicate they are required for control.

The use of pesticides alone is usually not the most efficacious or cost-effective control program. Elimination of fly breeding areas by frequent removal and/or rapid drying of manure, combined with the encouragement of the flies' natural enemies are needed to achieve the most efficient control. This will result in less frequent need for insecticides, which in turn, should prolong the effective life of chemical control agents. Pesticides should be used only when necessary to supplement these more effective cultural and biological control methods.

Different types of poultry housing situations require different husbandry practices. Nearly all table egg chickens are kept in cages. This concentrates the manure into a small area and denies the birds direct access to the manure. Turkeys, broiler chickens and some breeder and table egg pullet flocks are reared on litter floors. With this system birds are allowed to move throughout the house; not only is the manure less concentrated, it is disturbed and mixed with the litter, and the birds have access to developing larvae which they will eat. Typically, farms with poultry on litter floors cause fewer fly complaints than those farms where the flock does not have access to the manure. While the general principles of fly biology and control contained in this publication apply to all poultry farms, much of our discussion is directed to those facilities which keep poultry in cages.

Important considerations when carrying out an IPM program for controlling flies on poultry farms include
FLY BIOLOGY

While there are several kinds of flies found in and around poultry houses, in California *Musca domestica* (common house fly) and *Fannia canicularis* (little house fly) are most commonly associated with nuisance complaints. Even though small numbers of both species of flies may be capable of movement up to several miles from their breeding most are found no more than a few hundred yards from their source.

All flies pass through four life stages: egg, larva, pupa and adult. Female flies deposit small, white elongated eggs on moist decaying organic material, where larvae develop. Mature larvae crawl out of this material and move to a drier place for pupation. Following pupation, the adult fly emerges from the pupal case and seeks a location to expand and dry its wings in order to fly. The mature adult then seeks food and proceeds to mate. On the poultry farm, adult flies feed on a wide range of materials including manure, decaying organic material from animal and plant sources, broken eggs, and spilled feed. They use this for their own nutritional needs and to develop eggs. A newly-emerged female fly must feed for a few days before her eggs are mature and ready to be laid. Fertile eggs are laid in the manure, thus completing the life cycle. Flies can be present in the poultry house year round if temperatures are warm enough.

*Musca domestica* (House Fly)

*Musca domestica* is widely distributed and is commonly associated with humans and domesticated animals. Studies have shown that *M. domestica* can transmit the causative agents of several poultry and human diseases and can serve as the intermediate host for the common tapeworm in chickens. House flies can cause serious annoyance to residents in nearby communities, therefore its control is important.

Adult flies are about one quarter to one third inch in length, have sponging mouthparts and are gray, with four dark stripes down the back.

Each female fly can produce up to six batches of 75 to 200 eggs during its relatively short life. Eggs are laid at 3- to 4-day intervals beginning 3 to 8 days following emergence. Eggs are deposited in cracks and crevices on the surface of the breeding material which can be nearly any organic substance (including manure). Moisture levels of 65 to 75% are ideal...
for *M. domestica* larvae, but larval development is hampered or prevented at moisture levels much below 60%. Larvae hatch from eggs in about one day. They are white and shaped somewhat like a small carrot with the head at the tapered end. The blunt end has two respiratory openings (spiracles), which can be useful in the identification of larvae or pupae. In summer at temperatures between 85 and 95°F, flies can complete their larval stage in as little as 4 to 7 days, passing through three stages (instars) as they increase in size. Areas of high larval density in moist poultry manure often have a characteristic “coffee ground” appearance due to the churning activity of the larvae. Disturbing these areas reveals the whitish larvae only one-fourth inch or so beneath the surface of the manure.

Mature larvae migrate to drier portions of the breeding material and form a dark reddish-brown hardened case, called a puparium, within which they develop into adults. The duration of the pupal stage may vary in length considerably, but in warm weather (85°F to 95°F) it usually lasts 3 to 4 days, with an adult fly emerging to complete the cycle. The total fly life cycle is temperature-dependent, requiring 10 days at 85°F, 21 days at 70°F, and 45 days at 60°F. Development stops at temperatures below 54°F but larvae can still survive. Under ideal conditions a pair of flies and their offspring, theoretically, could produce over 100 quintillion flies in a single season. In nature, however, only a small fraction of these survive the counter balancing effects of natural predators, parasites, infectious diseases and lack of nutrition and habitat.

*M. domestica* are killed by freezing temperatures but are usually present in the poultry house environment year round. However, when temperatures drop below 54°F they tend to become dormant until temperatures rise above the minimum threshold temperature for development.

*M. domestica* adults may live for several weeks, but the average fly usually lives less than a week in nature. They are most active during the day when temperatures are between 80°F-90°F, and become inactive at night when temperatures drop below about 50°F. Flies often rest at night under the eaves or the underside of poultry house roofs. Preferred resting places are indicated by accumulated "fly specks" which are spots formed by regurgitated food and fecal deposits.

*M. domestica* move mainly by flying and can be assisted by wind currents. Distribution by vehicles and animals can be a minor means of movement. Under rare conditions flies may migrate up to 2 miles, however flies are usually most abundant in the immediate vicinity of their breeding site.

**Fannia species**

Fannia is the genus of several species of flies that are about one-half to three-quarters the length of *M. domestica*. The two species most common in California poultry systems are *Fannia canicularis*, the little house fly, and *F. femoralis*, sometimes called the coastal fly. *Fannia canicularis* is widespread in the United States but can reach especially high numbers on poultry farms in California and is a major pest fly in the state. On the other hand *F. femoralis* is not a significant pest because it stays near its development site. Interestingly, in
inland southern California poultry manure, F. femoralis larvae usually are far more abundant than those of F. canicularis. A 2-year study in inland southern California showed that 97% of emerging Fannia spp. in poultry manure were F. femoralis. Many times F. femoralis is mistakenly identified as F. canicularis on poultry farms because the larvae look similar. However F. canicularis is the Fannia species pest management programs should be directed against.

Fannia canicularis is the predominant winter-spring pest fly in California because it prefers cooler temperatures than do Musca spp. Fannia canicularis has a slender, grayish body and three brown stripes on its back. Adults are about 1/8” to 3/16” long, dark brown to black in color. They may invade nearby residential areas, with males forming hovering groups in protected areas such as in entryways, garages, etc.; hence another common name -- shade flies. Female flies are less active and are observed most often on manure where they feed and lay their eggs. Since this fly is less tolerant of hot summer temperatures (above 85°F), its numbers typically decline in the late spring as house fly populations begin to increase.

The life cycle of F. canicularis is similar to that of M. domestica. Eggs are deposited in poultry manure and in decaying organic material (garbage, composting vegetation, etc.). F. canicularis requires less moisture in the breeding material than M. domestica. It can survive and develop in poultry manure with moisture levels at least as low as 50%. Larvae hatch from eggs in 2 1/2 days at 80°F to 6 days at 55°F. Fannia sp. larvae are quite different from M. domestica larvae. They are cream (young larvae) to brown (older larvae) in color, flattened, and have small spines radiating from their edges back and sides. They move more slowly than M. domestica and may be found somewhat deeper in the manure. Larvae require at least eight days for development, depending on temperature and manure conditions. At 55°F larval development takes about 30 days. Larvae of the little house fly can continue to develop, although very slowly, at temperatures as low as 35-40°F, whereas house fly (M. domestica) larvae cease development at about 55°F. Pupae resemble the larvae in shape but are darker in appearance and last about eight days at 85°F, 16 days at 65°F or 28 days at 55°F. Egg-to-adult developmental time ranges from 25 days at 85°F to 52 days at 55°F. Temperatures above 85°F are lethal to exposed eggs and early stage larvae, which may explain the low numbers of F. canicularis during the summer. Adults live a few days to two weeks, although the life span may be longer under ideal conditions. The hovering activity of adult males begins as temperatures exceed 45 to 50°F.

The development of F. femoralis requires less time than that of F. canicularis. At 72°F F. femoralis develops from egg to adult in about 21 days, compared with 27 days for F. canicularis. F. femoralis also tolerates higher temperatures, but still does poorly at temperatures above 85°F. The larvae and pupae of the two species appear similar.

**HOUSING**

The type of housing used for poultry plays an important role in manure drying and, therefore, fly control. Manure in poultry houses is a potential substrate for fly development. Because pest flies cannot develop well in manure with much less than 50%
moisture, manure that remains in the house for prolonged periods of time should be maintained as dry as possible.

Open-type houses rely on natural air currents to provide oxygen to the birds and to exhaust gases and moisture from the house. Anything that obstructs this flow of air can result in poor flock performance as well as poor manure drying and more fly problems. Houses should be properly spaced to allow entry of air.

Enclosed houses use solid walls and fan ventilation for air distribution to the birds. In such houses, air entry or exit is controlled by fans or inlet/outlet areas. In general, air speed through fan openings is in excess of 1,000 feet per minute and may flow into or out of the house. With exhaust fans, this air flow rate is enough to prevent flies from entering the building. When fans are not operating, louvers close and flies are excluded. Inlet areas, however, may allow the entry of flies because they are designed to minimize air restriction. It is impractical to install fly screen in inlets because of dust build-up which reduces air flow. Most California enclosed housing is evaporatively cooled, using wet pads that are installed in the inlet. These systems are essentially fly-tight. If adult flies enter an enclosed house, they can be temporarily controlled with the use of insecticidal sprays. They may establish a breeding population in the house, however, and repeated use of such sprays is likely to lead to insecticide resistance.

High-rise houses are designed to store manure on the ground floor and to house the flock on the second floor. Manure drops through the cages to the ground and can be stored for long periods of time (1-7 years). Most producers though, choose to remove the manure following each flock for disease prevention reasons. In a well operated house, dry manure may reach heights of 6 feet or more. Because the manure remains in the house so long, this type of system is especially compatible with biological control methods. If wet manure problems occur, the installation of fans in the manure collection area will improve drying. New ventilation systems direct air flow from the second story through narrow manure slots in the floor resulting in large cones of manure with directed air flow “bathing” the piles for rapid drying of manure.

New stacked cage systems, with 4 or more decks, incorporate manure scraping systems and belt conveyor systems to facilitate the removal of manure. Several designs include an air delivery system to increase the drying of manure directly under each cage row.

**MONITORING FLY POPULATIONS**

Systematic monitoring procedures for measuring the success or failure of a fly control program can serve as an early warning system so that changes can be made before a crisis occurs. Reliance on casual observations may be misleading and thus fail to signal farm management of an emerging problem.

**Adult fly populations**

Regular monitoring of adult fly populations is an important component of an IPM program. Assessment of adult numbers provides information on efficacy of control programs and...
provides information about the potential for additional fly breeding. Tools for monitoring populations of adult flies include speck cards, resting counts, sticky tape and baited jug-traps.

- Speck cards are 3 by 5 inch white index cards which are placed in locations where flies prefer to rest in a poultry house. Flies rest on the cards and leave spots where they have defecated and regurgitated. The cards are removed after several days of exposure and the spots are counted. The counts provide an index of the adult fly population. Speck cards do not permit determination of fly species, however.

- Resting counts provide quantitative information about changes in adult populations over time. Resting counts are simply observations of adult fly numbers at selected locations but may be biased by the time of day the counts are made, since flies move in response to environmental changes over time. For best results, counts should be made at the same locations and at the same time of the day. This method also does not permit accurate determination of fly species, and the observer must be present each time the counts are made.

- Sticky tape counts use commercially available fly tapes placed in the flight path of flies, to collect samples of the adult fly population over a prescribed period of time. Numbers of trapped flies serve as an index of fly populations, indicating whether populations are increasing or decreasing. The tapes also permit the determination of fly species. The tapes are messy to handle and can rapidly lose their adhesiveness as they become coated with dust and debris. A modification of this technique is to hold an extended (fresh) tape and walk a regular route in a poultry house. Flies are disturbed and some get caught on the tape, providing a fly count for that period.

- Baited jug traps are constructed from one gallon plastic milk jugs with four holes (3 in. diameter) cut around the circumference in the upper third of the jug. About one tablespoon of toxic fly bait containing muscalure is placed in the bottom to attract flies. Once flies enter and feed on the insecticidal bait, they die in the jug and the numbers of flies can be counted and identified on a regular basis. The resulting information can be used to determine whether populations are changing. This method has the drawbacks that it is effective mainly for *M. domestica* and requires regular handling of the insecticidal bait.

Immature Stages

Monitoring numbers of fly larvae and pupae warns of impending adult numbers as well as identifying sites which require special attention to prevent fly emergence. Locating larval development sites takes time and effort, but is essential to locate problem areas so that cultural or chemical interventions can be made. Manure in each house should be regularly inspected. Experience provides background as to the appearance of breeding spots where concentrations of larvae and pupae may be found. Once these sites have been identified, they can be given special attention.
Fly larvae typically live in the upper inch or two of manure. The surface of the manure should be turned using a trowel, and the moist manure examined for larvae. Manure should be inspected routinely by walking the length of each cage row looking for breeding areas. M. domestica larvae will be noticeable as white maggots. They are nearly always abundant in warm weather in or near the wettest areas of the manure. Areas of high activity often have the “coffee ground” appearance. F. canicularis larvae are more difficult to see because they are brown and flattened. However, living larvae will be noticeable because they are moving. Fannia larvae are most abundant in cool weather when the manure is uniformly more moist. The larvae therefore tend to be more evenly distributed relative to M. domestica.

Pupae of M. domestica are found in drier areas of the manure, for example along the edges of walkways at the base of accumulated manure cones. Pupae of F. canicularis can be found in similar areas. If the majority of the manure is merely moist, and not wet, pupae of both species may be found in a wide range of manure locations.

Accumulations of fly pupae may provide a valuable record of fly development on the site. Pupal cases completely open at one end are an indication of fly emergence. Parasite-killed fly pupae have a small hole in the end (pin diameter) where the parasite emerged, and living pupae are intact with no opening.

MANURE MANAGEMENT

Fresh poultry manure (less than 4 hours old) has between 75 and 80% moisture. Manure moisture between 65 and 75% is ideal for M. domestica larvae, but Fannia spp. can survive and develop well in manure with a moisture content below 50%. Manure moisture is dependent upon many factors including: age and strain of the flock, rate of lay, water consumption, nutrition, health, house humidity, temperature and airflow factors, water system leaks, frequency of fogging and elevation of the manure. Many of these factors are beyond the control of farm management; however, special attention should be paid to those which can be controlled.

Manure management is an important farm practice requiring as much attention as other routine management chores. The two general systems used for managing manure are frequent clean-out and build-up systems. The choice of system to use depends on housing design, ventilation, proximity of neighbors, availability of space and equipment, and the ultimate end use of the manure. All well-planned programs should:

- Minimize fly production to avoid public complaints and to improve public relations.
- Reduce public nuisances associated with odors, dust, and feathers.
- Avoid pollution of surface and ground water.
- Maintain fertilizer value of poultry manure.

Frequent Clean-out Systems
Frequent clean-out (1-7 day intervals) is a popular practice where rapid under cage drying is impractical. New designs for lay houses, equipment (manure belts and scrapers), clean-out machines, liquid systems, and methods of manure processing make frequent clean-out economically feasible on many poultry farms. For effective fly control, manure should be cleaned out frequently enough to prevent adult fly emergence. This usually requires that the manure be removed before late stage larval development has occurred. The schedule of operations depends on final manure disposition, regional climatic conditions, and the predominant fly species being controlled.

The two species of flies (Musca domestica and Fannia canicularis) of concern in California differ in temperatures required for optimal growth, development, and survival. If a thin-bed drying operation (see U.C. publication 2658) is being used in conjunction with a frequent clean-out system, the manure should be removed frequently enough to prevent late instar larval development and pupation. Late stage larvae and especially pupae, are probably less susceptible to the lethal effects of sunlight and drying. Fannia canicularis, which has its highest populations in the spring (and sometimes fall) when temperatures are relatively cool, develops more slowly than Musca domestica, and can reach late instar development in approximately 10 to 12 days following oviposition under ideal conditions. Musca domestica achieves its highest populations during the warm summer period, and under ideal conditions can reach late instar stages within 4 to 6 days following oviposition. To prevent adult fly emergence, manure should be removed more frequently during the hot summer months, when Musca domestica is the predominant fly, than during the spring and fall months, when Fannia canicularis predominates. Manure removal every 7 to 10 days, coupled with good thin-bed drying, should control F. canicularis or even M. domestica in cool or moderate temperatures (<75°F). At temperatures above 80°F, removal at least every 3 to 4 days may be required to prevent M. domestica development.

If frequent clean-out is used, houses should be constructed to allow thorough cleaning of all manure from the cage row. Failure to clean out the manure thoroughly can result in high adult fly populations that in turn will breed and thus perpetuate the problem. Converting older houses with dirt floors to a frequent clean out system is usually less effective because thorough removal of the manure is not practical, and significant fly development will likely occur in the soil/manure mixture beneath the cages.

Fresh poultry droppings are potential sources of fly production, because they consist of 75-80% moisture. Since manure that is either dried quickly or immediately liquefied does not support fly development, poultry producers must decide whether a dry or liquid manure system will be best for their operation. The system should be designed to address the primary needs—short-term fly-free storage and eventual utilization of the manure.

Dry (solid) Manure Systems
Dry manure systems are popular in California because they provide an economical approach to fly control and produce a manure product that can be immediately applied to soils for fertilization. Approximately 85% of California’s poultry manure is managed using dry...
manure systems. These systems vary according to farm design, location, and climatic conditions. The systems include:

- Frequent removal with mechanical equipment in conjunction with thin-bed drying over a large area and short term dry pile storage.
- Frequent clean-out and removal from the farm.
- Frequent removal with immediate on-site processing in a manure drier or compost system.

There are two basic types of houses designed for frequent manure removal. Houses that allow the manure to accumulate on the floor beneath the cage row are constructed with concrete flooring, and cages are typically suspended from the trusses of the house. This type of house allows for efficient and complete removal of manure with clean-out equipment due to the absence of posts under the cage rows. The manure on the floor is scraped with a specially designed mobile machine.

The second design typically has cages supported from the floor and allows the manure to collect on either dropping boards or mechanical manure conveyer belts. Manure is scraped from the dropping boards into a cart, or conveyed by belt to the end of the cage row. In most cases the manure must be removed from the dropping boards or belts every 3 to 4 days due to the accumulated weight from the manure (25 pounds per 100 birds per day). Modern cage systems are available with special air delivery or drying systems that direct air flow to the manure accumulating on the belt, thus drying the manure within the house prior to removal. In these modern systems the manure may need to be removed only weekly because of the reduced weight. One disadvantage to these systems is the expense associated with operating these air delivery systems.

The advantages of dry manure systems are: good fly control, simplicity, use of commonly available equipment, manure marketability, availability of manure in bulk to growers, reduced weight and volume for transportation, and higher fertilizer value. Disadvantages include the need for specialized and often expensive equipment which is subject to mechanical breakdown, additional land requirement (1 acre for 50,000 birds when utilizing a thin-bed drying operation), feather and dust problems, poor drying of manure during cool and rainy seasons, and additional labor.

Liquid Manure Systems
Less than 15% of California manure is handled in liquid systems. Poultry manure may be liquefied to control fly breeding, to facilitate clean out under cages, and to reduce the labor required for loading and spreading. Holding ponds or tanks are used for short and long term storage. While these systems virtually eliminate all fly breeding, growers need to be aware that liquid manure often produces odors which may be more offensive to neighbors than odors from dry manure.

Flush-out System
Flush-out systems are used to remove manure from cage houses with a minimum of labor. A shallow concrete gutter is constructed under the cage rows and large volumes of water are flushed through the gutters to remove the manure into a holding pond or lagoon. To avoid over-filling of the pond, water used for flush-out is usually recirculated. A flow rate of 80 gallons per minute per foot of gutter width is often used for this purpose. Houses are usually flushed daily to avoid manure build up and adhesion to the floor. This is an excellent system for controlling flies because of the thoroughness of manure removal.

Tank Liquification
Manure can be removed from houses with belt conveyors or cable scrapers and deposited into tanks which are usually located at the end of the house below floor level. Water is added to form a slurry which will not support fly development. These tanks can provide temporary manure storage. This can be very useful when weather conditions are unfavorable for spreading or thin-bed drying. The slurry can then be spread on a drying pad, spread directly on crop land, or placed in a holding pond. When thin spread, this material dries quickly. Even though water content is higher than fresh manure, it can be spread very uniformly in a thin layer without the lumps which occur in mechanically removed manure.

Manure Ponds or Lagoons
Ponds or lagoons are used to receive and store the discharged manure from flush-out systems. Manure ponds or lagoons were originally developed as destruction ponds where manure would be broken down by microbial action. Experience soon demonstrated that salt and other mineral levels build up in manure ponds. To control this, 1) manure must be periodically removed as a liquid (usually applied to fields as a fertilizer) and fresh water added or, 2) the pond must be pumped out and the sludge dried and removed.

Multiple ponds are often constructed so that they can be used in rotation. It is necessary to maintain reserve capacity in ponds sufficient to handle winter rainfall. Pond sites should be graded with raised perimeter levees to prevent any surface drainage entering the pond and the levee should have adequate width to support an eight-foot-wide roadway for inspection and maintenance. The lagoon side of the levee should be as steep as the soil will safely permit. Often a 1:1 slope is used. Manure ponds should only be constructed in impervious soils or the bottom should be sealed with appropriate materials to prevent leaching into ground water. Ponds should not be constructed in areas with high water tables or within 150 feet of wells. No overflow from manure ponds should be allowed to enter surface drains or streams. In most California locations, plans for manure ponds must be approved by the Regional Water Quality Control Board and/or county Planning Departments.

Ponds are often used for temporary manure storage during the rainy season. An acre of shallow lagoon (5-7 feet deep) will accommodate the manure produced from 15,000 to 40,000 hens if all manure is to be put into the lagoon with occasional dilution or alternate pond use and cleaning. Excessive loading rates often result in offensive odors and complaints from area residents. Mechanical surface aeration can be used to reduce odor problems, but operating costs are dramatically increased. Ponds should be located at least a
quarter mile from neighbors. A grit trap should be provided on the inflow or the accumulation of grit and sludge will need to be removed from the inflow site frequently to keep the pond operating efficiently.

The advantages of liquid systems are elimination of fly breeding by rapid liquefication of the manure, use of manure as a liquid fertilizer, no problems from leaky watering or fogging systems, labor efficiency, as well as the use of these systems not being restricted by climatic conditions. Disadvantages may include the amount of adjacent cropland needed for use of the liquid fertilizer, potential problems in the production of gnats and mosquitoes, odors, possible reduction of manure sales, water cost, and additional transportation cost for the application of the liquid product. Liquid systems are not practical if the liquid manure must be transported long distances from the production site.

The frequency of manure removal for both dry and liquid systems should be determined based upon the predominant species of fly being controlled and its rate of development.

Build-up Systems
Build-up systems are used to allow manure to accumulate in the poultry house for extended periods of time. Build-up systems are commonly used on farms located in regions that can take advantage of climatic conditions that favor rapid in-house drying of manure. Farms utilizing a build-up system of manure management typically allow the manure to accumulate under the cage row for several months or more in single story houses to a year or more in high-rise houses. Through the use of natural or mechanical ventilation, the manure is allowed to dry into cone-shaped piles within the house. Build-up systems rely on a combination of maintaining low adult fly populations, increasing the biological activity of fly predators and parasites, and ventilation to enhance manure drying to discourage fly oviposition and prevent the emergence of adult flies. Manure is eventually removed from the house at a time compatible with prevailing weather conditions and disposal opportunities. A 4 to 8 inch pad of dry manure may be left under the cage rows to encourage drying and coning of subsequent droppings. Following removal from the house, the manure is either stockpiled or removed immediately for use as fertilizer.

While manure removal is often used as a fly control method, the fly life cycle must be broken for control efforts to be effective. The temptation to remove manure with active fly development from one site to another should be resisted, since this will only relocate the problem. Proper manure management reduces fly buildup and maximizes activity of beneficial predators and parasites. Manure that accumulates in the week or two immediately following clean-out is ideal for larval development, partially explaining why severe fly outbreaks often occur 2 to 6 weeks after clean-out. Beneficial arthropods also are removed at manure clean-out and often require several weeks or months to reach numbers high enough to significantly reduce fly populations.

Leaving a pad of dry manure as a base after a manure clean-out has been shown to reduce subsequent fly numbers compared with cleaning all the manure down to the floor level. Two factors contribute to this. First, the pad encourages manure drying. This is due in
part to elevating the fresh manure off the floor, where it can dry significantly faster. Manure elevated by only 5 inches has been shown to be significantly drier after 1 week in the summer and even drier in the late fall compared with fresh manure which drops directly to the floor. Second, leaving a pad of dry manure may also aid in the re-establishment of beneficial mite and insect populations.

The decision of whether to completely remove the manure, or to leave a 4-8 inch pad will depend on several factors including floor construction, manure removal equipment and the need for biosecurity (consult your veterinarian). Old manure from the previous flock can serve as a source of viral or bacterial contamination of the poultry house and therefore may not be an acceptable option for some poultry producers.

Farms with open-type houses (without solid side walls) most commonly rely on natural ventilation to dry the manure. Some farms augment the natural air flow with circulation fans hung from the ceiling or at the end of cage rows. Many open-type houses, particularly those built in the 1950's, were constructed with dirt floors instead of concrete beneath the cages. Some farms have engineered specialized equipment to periodically mix and turn the accumulating manure to enhance manure drying. Whenever possible, the manure should be managed in a way to favor the establishment of beneficial fly predators and those insects that parasitize fly pupae. The purchase and release of parasites from a reputable commercial insectary may aid in their establishment in the manure, particularly after a complete manure clean-out. Adequate space between adjacent houses should be provided so as not to impede air flow. Houses should be oriented so that the prevailing wind direction is perpendicular to the width of the house. The following are important management components for this type of system:

- Frequent monitoring of watering and fogging systems for water leaks
- Removal of obstructions to air flow (weeds, shrubs, debris, etc.)
- Prevention of standing water inside and outside of the house
- Prevention of rain entry into the house
- Prevention of contaminating the manure with insecticides
- Elimination of wet manure spots
- Continuous attention to adult fly control on the farm

Advantages of buildup systems in open-type housing include low housing and equipment cost, low electrical cost, and reduced labor. The disadvantages of this type of system are possible occurrences of fly development in wet spots, increased use of pesticides to reduce adult flies, problems with maintaining beneficial insect populations in the manure, and ineffective manure drying during cool or rainy periods.

Enclosed houses (environmental) require fans for ventilation of the birds and manure, and usually restrict fly movement either into or out of the house (see section on Housing Considerations for a more detailed discussion). Some of the advantages of enclosed buildup systems are reduced manure handling labor, sometimes improved potential for
biological control, and restriction of fly movement. One disadvantage to this system is increased ventilation and housing cost. Relatively stable temperature conditions may extend the effective activity period of fly predators and parasites, but also may lead to extended seasonal production of flies if the manure does not dry and cone well.

**System Combinations**

It is not uncommon for a farm to utilize a combination of systems for manure management when appropriate house design, equipment, and space are available. Multiple systems are usually employed to provide manure storage capability during periods of inclement weather when manure drying is ineffective or when the manure is not in demand. Some of the possible combinations of management systems that could be used are:

- Frequent removal with thin-bed drying during the warm dry season and buildup under the cage row during cold and rainy months
- Tank liquification system with direct application to farm land during the crop growing season, and lagoon system for storage during the winter months
- Tank liquification system with thin-bed drying during the warm dry season, and using a lagoon system during the cold and rainy months

**WATER MANAGEMENT**

In dry manure management systems, it is essential that the manure dry as rapidly as possible. For this reason, the addition of water from watering system leakage, malfunctioning cooling systems, and the entry of rain or surface drainage must be avoided.

Houses should be built on elevated sites so that surface drainage does not enter the house and adequate roof overhangs must be provided to keep rainwater off the outer rows of manure. Manure drying pads should be properly graded so that rainwater does not accumulate in the storage or drying areas, and drainage channels should be provided to divert surface water away from all manure. Water run-off from manure storage or processing areas must be contained on the site to avoid pollution of streams or lakes.

Water systems require careful installation and maintenance to provide the flock with an adequate water supply without leakage. Filters should be used to exclude foreign particles from watering devices and water pressure should be carefully managed to assure tight seals of valves.

Routine monitoring of the watering system is essential to avoid problems. Leaking valves should be replaced as soon as possible. Any wet manure resulting from leaking water should be removed and replaced with nearby dry manure. This wet manure should then be properly handled to avoid fly breeding. This could include thin-bed spreading for rapid drying, treatment with a larvicide, or tarping, depending upon the amount of manure and the presence of immature stages of flies.
When fogging is required during hot weather, the dripping of nozzles should be prevented. Fogger nozzles should be installed in a way to avoid obstructions to the pathway of the mist. If wires, cages, trusses, etc. are in the way, water will precipitate and eventually fall onto the manure. A properly installed system should include drain and check valves and a water treatment system to prevent the build-up of scale which could contribute to leakage. Daily monitoring of the system is essential to correct nozzle problems.

If roof sprinkling is used, nozzles should be installed to avoid directing the spray into the houses. Roof run-off should be diverted away from the house, and roofing material must be adequately maintained to prevent leakage into the house.

**FARM SANITATION**

Good housekeeping is important throughout the entire farm, including the egg processing plant, and around feed storage bins, equipment sheds, and the farm residence. General farm cleanup practices should be part of the manure management program. Pay particular attention to the following:

- Remove dead birds daily from their cages and dispose of them either by composting them on the farm or by sending them to a renderer. Dead birds should be stored in fly-tight containers prior to removal from the farm.
- Control weed growth around poultry houses and other buildings. Weeds can impede air movement and sun penetration into the house, both of which help dry the manure. Weed removal also lessens the opportunity for weed seed to become mixed in with the manure, reduces resting sites for adult flies and reduces harborage for rodents.
- Remove damp or spilled feed. This material is a good food source for flies, pestiferous beetles, and rodents and competes as an attractant with chemical baits.
- Do not discard broken eggs in the manure. Flies prefer to breed in such locations.

**BIOLOGICAL CONTROL**

Biological control, or the suppression of pests by their natural enemies, is one component of a complete management program for keeping nuisance flies at low levels. It is an attractive tool due to its lack of adverse environmental impact, its specificity for flies, its often low cost, and its potential for long-term benefits. Large populations of predators and parasites can have a suppressive effect on house fly populations, eliminating 90% or more of *M. domestica* before they emerge as adults. Efforts, therefore, should be made to conserve natural populations of beneficial insects that are present in the manure. To take most advantage of biological control within an IPM program, farms must reduce or eliminate practices (such as the use of broad spectrum pesticides applied directly to the manure) that prevent the survival of beneficial insects. If pesticide applications are required, their impact on beneficial insects can be minimized by 1) using fly-selective insecticides (growth regulator-type activity), 2) spot-treating wet places only, and 3) avoiding long-term and frequent use of larvicides. Well-established populations of parasitic wasps can sometimes withstand occasional larvicide applications if part of the parasite population is developing within the protective fly pupal case at the time of the application. Other natural enemies,
such as predaceous mites and beetles, are common in surface manure and are susceptible to
even single applications of broad-spectrum larvicides. Applications of pesticides for control
of northern fowl mites also may adversely affect natural enemies in the manure beneath the
hens if excess runoff occurs.

Fly Parasites (Wasps)
Several species of wasps attack fly pupae. Wasps in the family Pteromalidae attack and
parasitize the pupae of flies in the manure and are important natural enemies. These wasps
are extremely small (1/16 to 1/8 inch). They spend their time in manure or other decaying
organic material, searching for fly pupae. These wasps do not sting or bother people.
Adult female wasps in the genera Muscidifurax and Spalangia sting fly pupal cases and lay
their eggs on the surface of fly pupae; as the wasp larva develops, it consumes and destroys
the immature developing fly. Approximately 3 to 4 weeks after the wasp lays its eggs (time
varies with temperature) the adult wasp emerges from the fly pupal case. Species of
Muscidifurax are regarded as better surface manure foragers, while Spalangia spp. are
better able to locate deeply buried fly pupae. Both genera parasitize pupae of M. domestica
and F. canicularis. While parasitic wasps occur naturally in poultry houses and other
locations where M. domestica and F. canicularis breed, producers sometimes choose to
augment their numbers by purchasing and releasing additional wasps. Fly parasites are
available from commercial insectaries.

Not all commercially available parasites are effective in every situation. The parasite
Nasonia vitripennis, for example, is easy to produce in large numbers in an insectary, but
its effectiveness in poultry houses has not been consistently demonstrated. Be aware that
some parasites are better suited for certain animal production facilities than others, or may
be adapted to certain climates. Also be aware that parasitism by the various species is
greatly influenced by season, location, the type of housing, the manure depth and structure,
the proximity to other fly breeding sites, and sanitation levels. Check with a qualified
entomologist regarding the appropriate parasite to use.

Releasing parasites does not always provide fly control. Parasite releases will not generally
be effective in situations where broad spectrum insecticides are being used or when poor
sanitation practices exist. Monitoring fly numbers and looking for parasitized fly pupae can
be useful in assessing whether parasite releases are having an impact. Parasite release
requires pre-planning. Start early, preferably by the beginning of the house fly season, or
shortly after a manure clean-out, and continue releasing weekly, until the house fly
population has been reduced to an acceptable level.

Parasites are sold as immature stages, developing within fly pupae. If they are shipped in
bags, these bags once opened can be stapled to posts or rafters near areas where fly
breeding is a problem. Loose pupae can be distributed around in protected areas, but
placing them in wire mesh containers attached to walls or posts will protect them from
being eaten by birds, mice, etc., and from being crushed by workers and equipment.
Emerging parasites will move to the manure to search for live fly pupae.
Parasite release rates and schedules will differ for every farm, therefore adjustments must be made to achieve effective and affordable control for each individual operation. Re-establishment of parasite populations are most cost effective when releases are made 0 to 2 weeks following a clean-out. Once the manure system is stable and fly numbers are lower, continued releases may not be warranted. If quality control is not effective at the insectary, the numbers of parasites obtained from a shipment may be much fewer than anticipated, or the culture may be contaminated by an ineffective species. It is a good idea to remove about 100 pupae from each bag, place them in a sealed jar and store at room temperature for a few weeks to determine rate of emergence from the sample. Good emergence is 55 to 70% of the pupae producing viable wasps.

Fly Predators (beetles and mites)
The main predators include a small black beetle (1/8 inch long) called Carcinops that eats fly eggs and small larvae, the slender black rove beetle (1/4-3/8 inch long) (Philonthus spp.), and macrochelid and uropodid mites. Densities of several hundred predators per quart of manure are not uncommon.

Several other beetles, including the ¼-inch long brown beetle known as the lesser mealworm (Alphitobius) also may be abundant in poultry manure. The lesser mealworm is a scavenger and may help aerate the manure through its tunneling activity, or even may eat flies occasionally. However, it can also cause serious structural damage to wood beams or insulation, and thus is usually considered a pest. Unfortunately fly predators are not commercially available, although some insectaries market parasites under the name “fly predators”.

The most effective predaceous mite in poultry manure is the macrochelid mite Macrocheles muscaeedomesticae, which is reddish-brown and less than 1/16-inch in length. Macrocheles has a very fast life cycle (only a few days) and can be transported on adult flies. Thus it is an important natural enemy, especially after a manure clean-out. This mite feeds on house fly eggs and first-instar larvae, consuming up to twenty house fly eggs per day, and can cause substantial reductions in house fly numbers, once large populations of mites have become established. They are usually found on the outermost layer of the manure pile. Another mite species, Fuscuropoda sp., can occur a bit deeper in the manure where it feeds on first-instar fly larvae but cannot eat fly eggs.

Both larvae and adult predaceous beetles eat fly eggs and larvae. These beetles have a long life cycle (1-2 months) and thus take longer to get established and can fly to colonize new manure deposits. The stout, black Carcinops may eat over 20 fly eggs or early stage larvae per day. It occurs almost exclusively in bird manure. There are several other beetles in the same family (Histeridae) which are probably also significant fly predators at times. In poultry manure, the larger, fast-moving rove beetles are less well known, but probably consume significant numbers of fly larvae.

Larvae of flies regarded as pests (Musca, Fannia) are also eaten by other fly larvae. The false stable fly, Muscina stabulans, and the black garbage fly, Hydrotaea (formerly
Ophyra) aenesens, will both eat pest fly larvae. They also feed on the manure itself and therefore do not absolutely need other fly larvae as food. Muscina larvae are most abundant in spring, while Hydrotaea are most common in summer. Adults of Muscina and Hydrotaea are not considered pests. Hydrotaea is seen only occasionally in poultry manure in California. Attempts to release Hydrotaea for control of Musca in the eastern U.S. have met with mixed success. To be effective, larvae of Hydrotaea must be as large as, or preferably larger than, their prey. Hydrotaea larvae are a bit thinner than those of Musca and feel firmer when rolled gently between the fingers.

**Fly Pathogens**

Flies are affected by several disease agents. Parasitic nematodes sometimes are sold as control agents for fly larvae, but have been shown to survive very poorly on or in poultry manure and are ineffective for control of flies. An interesting fungal disease, affecting flies only, is Entomophthora muscae. Growing within the fly, it can kill large numbers (up to 70-80%) of F. canicularis in late spring and M. domestica in the fall. Each fly species has its own fungus strain. Diseased flies take about a week to die, but lay almost no eggs during that period. Unfortunately, the pathogen functions best at high fly densities and is strictly limited by air temperatures above 80-85°F. The dead flies have a very lifelike pose, with wings, legs and mouthparts extended. The abdomens are swollen and whitish with fungal spores. They often fasten themselves to vertical structures (e.g. posts, cage wires, walls). A few hours after the fly has died, the fungus explodes its spores into the environment. Other flies that are in the vicinity of this explosion can then be infected. Spraying areas where large numbers of flies killed by the fungus are seen is not recommended.

There are several factors and management practices that can have adverse effects on the effectiveness of biological control. The use of broad spectrum insecticides, leaking water cups, poor house sanitation and manure removal can reduce or eliminate the effectiveness of biological control.

**Chemical Control**

Insecticides complement the other components of integrated pest management systems, and are sometimes necessary even in a well-managed poultry operation. Producers should monitor fly populations regularly (see section on monitoring) in order to evaluate the fly management program, to decide when insecticide applications are required, and to determine which chemicals are most effective. Fly monitoring records also serve to demonstrate that the producer is conscientiously surveying the farm for potential fly problems. Accurate records should be kept on formulations and rates of chemicals used, the name of the applicator, and the date of the application. The rotation of different insecticide types -- carbamates, organophosphates, pyrethroids -- can help delay or minimize the development of resistance. Most fly insecticides are toxic to predators and parasites and indiscriminate use may severely affect populations of non-target beneficial insects. However, applying insecticides carefully to fly resting sites or the use of insecticidal baits will directly target adult flies and spare their natural enemies.
Insecticides may be classified by the development stage of the targeted insect (adulticides and larvicides) or by the method of application (surface sprays, space sprays, baits). They may also be further classified by the chemical nature of the active ingredient (carbamate, organophosphate, pyrethroid, insect growth regulator), or by the duration of their pesticidal activity (residual or non-residual).

**Adulticides**
Observe adult flies to determine their resting places. Typically adult flies will congregate on the rafters or underside of the roof at night. Occasionally, flies will leave the house to roost in surrounding vegetation. These building surfaces and plants are excellent areas for treatment with a residual insecticide to decrease the number of adult flies. Because flies are cold-blooded, they require environmental warmth to raise their body temperatures. On cool mornings adult flies gather on the sunny sides of buildings to catch the warming sun rays; treatment of such resting areas with a residual insecticide can be effective. Residual insecticides are ineffective if the flies do not contact them.

**Larvicides**
Larvicides are chemicals that are directly applied to manure to kill larvae. They are most toxic to the early stage larvae. Most larvicides contain organophosphate insecticides which are non-selective, meaning they kill other organisms in the manure in addition to fly larvae. The section on Biological Control contains suggestions for minimizing adverse effects on natural enemies.

A relatively new group of insecticides, insect growth regulators (IGRs), can be applied to the manure to control developing flies. One of these IGRs, cyromazine, prevents normal development of the pupal case. Although pupae develop, they are misshapen and not viable. The main advantage of these compounds is that they are highly specific, affecting only the target pest. IGRs typically do not act as rapidly as do the organophosphates.

**Pesticide Formulations**
Emulsifiable concentrates (EC) are liquids that are designed to be diluted with water and thoroughly mixed before application as sprays. Wettable powders (WP) are mixed with water to form a suspension of insoluble particles in a liquid. Suspension solutions must be continually agitated during spray operations, otherwise separation may occur. Separation may result in concentrations too high for safe use or too low to be effective; it may also cause clogging of lines or nozzles. Aerosols are fine mists, intended to disperse throughout an enclosed area as a space spray. They can be effective for rapid knockdown and kill of adult flies but do not provide long-lasting control.

A bait is used to attract flies. Insecticidal baits are widely used for adult fly control. Such baits stimulate the flies to eat insecticide while consuming the food bait, such as sugar. Baits are excellent selective adulticides for suppressing low fly populations and maintaining them at a low level. They are particularly effective when used in conjunction with residual insecticides. Baits must not be used where they will accidentally be mixed in the feed or
eaten by the birds or other animals; they should not be scattered on the manure where they may adversely impact predators.

Homemade bait stations can be constructed at a minimal cost from readily available materials. The basic components are a container for the attractant (plastic or metal bucket or can) and a wire or plastic screen to which the pesticidal bait is attached. A hanger can be used to hang the station out of the way of workers.

Chemical Classes of Pesticides
There are three main classes of chemicals available for use on poultry facilities, pyrethroids, organophosphates, and carbamates. In addition, there are the natural pyrethrins which provide rapid knockdown of adult flies when used as a space spray, but provide almost no residual activity. The pyrethroids can be used as space sprays, but are also employed as residual insecticides. The organophosphates likewise include residual adulticides, space sprays for adult flies, and larvicides. The carbamate methomyl is used in formulations with sugar as a fly bait. Insect growth regulators have the advantage of being selective against flies, without harming predators and parasites. Other larvicides, chemicals applied directly to the manure to kill larvae, should be considered a last resort because they are detrimental to the beneficial arthropods associated with the manure. When used, they should be limited to small areas with high concentrations of larvae.

Table 1 Classes of chemicals and their modes of action against flies

<table>
<thead>
<tr>
<th>Class</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organophosphate</td>
<td>Increases nerve stimulation of muscle by inhibiting cholinesterase at the neuromuscular junction</td>
</tr>
<tr>
<td>Carbamate</td>
<td>Same as organophosphate</td>
</tr>
<tr>
<td>Pyrethroid</td>
<td>Interferes with nerve conduction</td>
</tr>
<tr>
<td>Insect Growth Regulator</td>
<td>Causes hormone-like interference with immature stage development and molting</td>
</tr>
</tbody>
</table>

Insecticide Resistance
Insecticide resistance is a change in susceptibility to specific insecticides within an insect population over time, so that rates of insecticides that were formerly effective are no longer effective. Resistance is the result of genetic selection and continued use of insecticides in the same chemical class can lead to its development within a population of exposed pests. Pesticide resistance may develop within any species of organism and is common among flies and northern fowl mites. An insect does not become resistant to an insecticide within its lifetime. Instead, insects that are susceptible to an insecticide are killed by the chemical, leaving only insects with some ability to survive the application available to reproduce. Their offspring are then more tolerant to the chemical, so a higher proportion of the population survives to pass along resistant genes. Because many insecticides (particularly carbamates and organophosphates) have the same mode of action, resistance to one member of either of these classes frequently confers resistance to both classes. For this reason, it is
important to minimize insecticide use, to rotate the use of chemicals with different modes of action and to integrate non-chemical control methods.

**MECHANICAL CONTROL METHODS**
Mechanical control methods include fly traps and electrical grids. Many types of fly traps and electrical grids are commercially available. They may trap or kill large numbers of flies, but when used alone seldom give satisfactory control of dense fly populations. Their primary usefulness is to supplement cultural, biological and chemical control measures. They are particularly useful in confined areas, e.g. egg rooms or similar areas where other control methods are either impractical or restricted. These devices should be placed in areas where flies congregate and should be moved to new locations periodically to determine the best sites.

**PESTICIDE SAFETY**
The use of any pesticide not clearly labeled "For Use on Poultry" can lead to illegal residues in meat or eggs, resulting in condemnation of the product, economic loss, litigation, and a tarnished image for the industry. Recommended pesticides should be used at the times, in the amounts, and by the methods prescribed on the label to avoid excessive residues. Never allow pesticides to contaminate feed, eggs or birds. All eggs should be removed from the cage rollout before applying pesticides within the poultry house. Avoid spraying areas above the chickens in order to prevent contamination of feed and water.

It is always important to read and follow label directions when using any pesticide. Not only is this important for human and animal safety, but it ensures the most effective utilization of the product. The label should be read before purchasing the product to determine if the formulation is appropriate for the job and if the right application equipment is available. The label should be read again prior to applying the pesticide to determine the necessary protective equipment, special warnings and first aid measures, correct mixing, rate of application, timing of application, and use restrictions. All instructions should be followed regarding safety equipment, procedures for storing, mixing, and using the chemical. Mix only as much chemical as is needed to prevent having to dispose of leftover material. The University of California video "Safe Use of Pesticides on Poultry Farms" elaborates on procedures to follow in pesticide applications.

Keep pesticides out of reach of children, pets, and livestock. Pesticides should be stored in a locked area outside the house, away from food or feed, and should be stored in their original containers. Dispose of empty containers promptly and safely. Follow label instructions regarding rate of application. Exceeding label rates is not only illegal, it may be hazardous to human and animal health as well as harmful to the environment. In addition, such misuse may accelerate the development of pesticide resistance in the target population. Using lower rates than those stipulated on the label will likely be ineffective in controlling the pest and is uneconomical because of the additional time and effort required for repeated applications.
Never eat, drink, or use tobacco products while applying insecticides. Always wash hands immediately following handling pesticides. If pesticides are accidentally spilled on skin or clothing, remove the contaminated clothing immediately and wash the skin thoroughly. Following each pesticide application, promptly shower and change into clean clothing. Clothing should be washed before being worn again, and pesticide contaminated clothing should always be washed separately from the rest of the laundry.

Do not use your mouth to siphon liquids from containers or to blow out clogged lines or nozzles. Do not spray with leaking hoses. Do not work in the drift of a spray or dust. Do not contaminate food or drinking water during pesticide application. Common symptoms of pesticide poisoning are: skin rashes, nausea, vomiting, headache, blurred vision, dizziness, weakness, extreme thirst and heavy sweating. The type of symptoms will depend on the type of pesticide, the route of exposure and the amount of exposure. The time period between exposure and onset of symptoms can vary from almost immediate to several days or longer, depending on the amount of exposure and the type of pesticide. If symptoms of illness occur, call a physician and drive the affected individual to the hospital take the pesticide label along.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. According to the law, it is always the pesticide applicator’s responsibility to read and follow all current label directions and to follow all applicable laws for the specific pesticide being used. For current information on pesticide use and safety regulations, contact your local Agricultural Commissioner.

THE LABEL IS THE LAW. IT IS ALWAYS IMPORTANT TO READ THE LABEL AND FOLLOW ITS DIRECTIONS TO AVOID HAZARDS TO PEOPLE, ANIMALS, AND THE ENVIRONMENT.
GLOSSARY

Arthropods -- invertebrate animals with jointed appendages; includes insects (flies, beetles, wasps etc.) and arachnids (spiders and mites).

Bait -- a material that will attract a pest to a pesticide or to a trap.

Beneficial insects -- arthropods that are useful, including parasites and predators of pests.

Biological control -- suppression of pests by parasites, predators, pathogens, or competitors.

Botanical pesticide -- a pesticide that is derived or extracted from plants, such as pyrethrin.

Calibration -- measurement of the delivery rate of a sprayer or other application equipment.

Contact insecticide -- an insecticide applied for immediate pest knockdown.

Cultural control -- management practices (other than chemical or biological) that reduce pest numbers, breeding and attraction.

Emulsifiable concentrate -- a pesticide formulation produced by dissolving the active ingredient and an emulsifying agent in a solvent.

Flowable -- a pesticide formulation in which the active ingredient is impregnated on a diluent, such as clay, which is then finely ground and suspended in a small amount of liquid; the resulting "paste" or "slurry" is added to water in the spray tank and forms a suspension.

General treatment -- application to broad expanses of surfaces such as walls, floors, ceilings or as an outside treatment.

High-rise house -- a poultry house constructed such that the ground floor is used for manure storage from the birds located on the second story of the house in cages or on slat flooring.

Inert ingredients -- the carriers or diluents in a pesticide formulation that have no pesticidal activity.

Insect growth regulators -- naturally-occurring insect hormones or synthetic chemicals designed to mimic their activity or otherwise interfere with insect development.

Integrated Pest Management (IPM) -- an ecological approach to pest suppression in which all appropriate techniques are consolidated into a program so that pest populations can be managed to avoid economic damage and reduce adverse side effects.

Label -- the information printed on or attached to the pesticide container or wrapper.

Larva -- the immature stage of an insect that undergoes complete metamorphosis; the stage that emerges from the egg.

Larvae -- plural form of larva

Larvicide -- a pesticide used to kill larvae.

Metamorphosis -- a change in the shape, form and/or size of an insect during its development.

Microbial pesticides -- microorganisms (such as bacteria, viruses, or fungi) which cause disease in a given species of pests and which are intentionally introduced in sufficient quantities that a relatively high level of control becomes possible.

Molting -- the process in which insects and certain other animals shed their external covering.

Natural enemies -- the predators, parasites and pathogens that attack pest species.
Non-residual insecticides -- those that kill quickly without prolonged effect and are applied either as space or contact treatments.

Parasite -- an insect that is parasitic on other insects and kills a single host in the course of its development.

Pesticide -- a chemical used to directly control pest populations or to prevent or reduce pest damage; includes insecticides, herbicides, fungicides, etc.

Pupa -- the intermediate stage in insect metamorphosis between the larva and adult.

Pupae -- plural form of pupa

Pyrethrin -- the botanical insecticide derived from chrysanthemums.

Pyrethroid -- a class of synthetic insecticides, similar to pyrethrins.

Residual insecticides -- those having insecticidal effects lasting several days or longer and which are applied as general or spot treatments to surfaces.

Resistance -- the genetically-acquired ability of an insect population to tolerate the toxic effects of a pesticide.

Sanitation -- eliminating potential sources of infestation to prevent the development of a pest problem.

Solution -- a homogenous mixture of one or more substances (solutes) in another (solvent), which is usually a liquid.

Source reduction -- pest management technique of removing breeding habitats of immature insects.

Space sprays -- the dispersal of insecticides into the air by foggers, misters, aerosol devices, or vapor dispensers for control of flying insects and exposed crawling insects.

Surface sprays -- the application of a residual pesticide to a surface to the point of run-off for the purpose of killing insects that rest on that surface.

Spot treatment -- applies to the treatment of limited areas of the manure in which immature flies are present in high densities.

Thin-bed drying -- Spreading manure thinly (1 to 2 inches deep) on an outdoor drying pad of dirt or concrete for the purpose of air-drying.

Wettable powder -- a finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting and/or dispersing agent.

Table 1 Classes of chemicals and their modes of action against flies

<table>
<thead>
<tr>
<th>Class</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organophosphate</td>
<td>Increases nerve stimulation of muscle by inhibiting cholinesterase at the neuromuscular junction</td>
</tr>
<tr>
<td>Carbamate</td>
<td>Same as Organophosphate</td>
</tr>
<tr>
<td>Pyrethroid</td>
<td>Interferes with nerve conduction</td>
</tr>
<tr>
<td>Insect Growth Regulator</td>
<td>Causes hormone-like interference with immature stage development and molting</td>
</tr>
</tbody>
</table>