The

Connecticut

Agricultural

Experiment

Station,

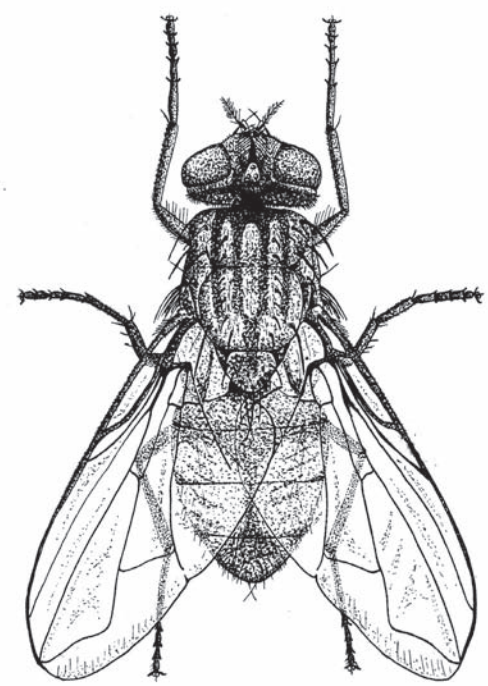
New Haven

Bulletin 1013

May 2008

Fly Management Handbook

A Guide to Biology, Dispersal, and Management of the House Fly and Related Flies for Farmers, Municipalities, and Public Health Officials



KIRBY C. STAFFORD III, PH.D.

Vice Director, State Entomologist

The Connecticut Agricultural Experiment Station

New Haven, CT 06504

GENERAL ACKNOWLEDGEMENTS

Thanks are given to Joyce Meader, Connecticut Cooperative Extension Service, Dr. Bruce Sherman, Connecticut Department of Agriculture, Patricia M. Beckenhaupt, Director of Health of the Northeast District Department of Health, and Dr. Louis A. Magnarelli, The Connecticut Agricultural Experiment Station (CAES), for reviewing the handbook. Their comments and suggestions were sincerely appreciated. I extend a particular thank you to James Rock (emeritus), Connecticut Cooperative Extension Service, for his considerable input and support. Thanks are also extended to Rose Bonito (CAES) for scanning illustrations and pictures and Vickie Bomba-Lewandoski (CAES) for publication and printing assistance. Much of the material on cluster flies is from a CAES fact sheet by Gale E. Ridge (available on the CAES website, www.ct.gov/caes). Thank you, Gale. Several portions on poultry IPM are based on Special Circular 338, Poultry Pest Management for Pennsylvania and the Northeast (1986), by Kirby C. Stafford III and Clarence A. Collison.

ACKNOWLEDGEMENT FOR FIGURES

Most sources for the pictures and illustrations are noted in the figure captions. Requests for use of photographs and illustrations by the author or CAES may be directed to the author. Permission to use any other material must be obtained from the original source. The historical 1916 illustration of the unsanitary conditions in the introduction is from the Centers for Disease Control and Prevention Public Health Image Library (8264); the stable fly and green-bottle fly in Figure 6 and 8, respectively, are from United States Department of Agriculture Farmer's Bulletin 1408. *M. raptor* (k9933-2) and house fly puparia (k9933-3) in Figures 17-18 are from the USDA-Agricultural Research Service Image Gallery; Figure 5 is the work of Gale E. Ridge; the graph in Figure 12 used with permission Weather Underground; all other photographs and drawings in the figures are by Kirby Stafford.

Disclaimer

Mention of a product or company is for informational purposes only and does not constitute an endorsement by The Connecticut Agricultural Experiment Station.

TABLE OF CONTENTS

Table of Contents……………………………………………………………………………….…..1
List of Figures………………………………………………………………………………… 2
Introduction……………………………………………………………………………………3
General Fly Biology……………………………………………………………………...……... 4
House Fly…………………………………………………………..………....……….5
Little House Fly……………………………………………………………………….………6
Stable Fly………………………………………………………………………………...7
Black Garbage Fly……………………………………………………………………….7
Bottle or Blow Flies……………………………………………………………………... 8
Flesh Flies…………………………………………………………………….…………. 8
Cluster Fly………………………………………………………………………………...9
Temperature, Moisture, and Fly Development………………………………………….……..10
Adult Fly Dispersal……………………………………………………………………………12
Public Health and Fly Management in Residential Communities………………………………14
Laws Pertaining to Fly Nuisance Problem ……………………………………….……..14
Farm and Animals……………………………………………………………………….16
Manure Management………………………………………………………………...…..17
Pathogens Associated with Flies and Manure …………………………………………..18
Role of Local Health Officials ………………………..…………………………..……..19
Homeowner Options to Address Fly Problems……………..…………………………..…19
Mechanical Control and Fly Traps………………………………………………….…...20
Residual Sprays for Outdoor Use and Fly Baits……………………………………….…...22
Integrated Fly Management in Poultry Operations…………………………………...…..23
Mechanical Control…………………………………………………………………….....23
Cultural Control…………………………………………………………….…........24
Biological Control………………………………………………….………...…......25
Chemical Control…………………………………………………………………..……27
References…………………………………………………………………………………......31

LIST OF FIGURES

Cover. Adult house fly

Figure 1. Historic 1916 diagram showing unsanitary privy attracting flies used to train public health workers of the Minnesota Board of Health……………………………………………………... 3

Figure 2. Life cycle of the house fly……………………………………………………………….5

Figure 3. Head of the house fly showing sponging mouthparts ………………………………………..6

Figure 4. House fly life cycle: eggs with 2 puparia, two larvae (maggots), and two adult flies ……........6

Figure 5. Little house fly adult (left) and larva (right)……………………………………………………7

Figure 6. Stable fly. ……………………………………………………………………………………7

Firgure 7. Adult black garbage……………………………………………………………………….8

Figure 8. Green-bottle fly, *Luscilia* spp ……………………………………………………………...8

Figure 9. Adult cluster fly…………………………………………………………………………….9

Figure 10. Microclimate outdoor manure pile and manure inside a poultry house………………………12

Figure 11. Diagrammatic presentation showing house fly dispersal distances………………..…13

Figure 12. Temperature diagram shows the normal high and low temperatures (blue) and record high and low temperatures (purple) for a town in eastern Connecticut………………………………..17

Figure 13. Storage of manure piles using a black plastic cover held in place with tires ………………....18

Figure 14. Fly traps. A) adhesive ribbon, B) jug or bottle trap, C) two styles bag trap ………………….21

Figure 15. Cross-section of a high-rise poultry house…………………………………………….....23

Figure 16-17. Poultry manure accumulations with poor moisture control (left) and good moisture control (right)……………………………………………………………..……………………24

Figure 18-20. Macrochelid mites, *Macrocheles muscaedomesticae* feeding on house flies (left), dorsal view of *M. muscaedomesticae* under the microscope (center), and Uropodid mite *Fuscurpoda vegetans* (right) ……………………………………………………………………………...25

Figure 21. Hister beetle, *Carcinops pumilio* (right), feeding on house fly eggs……………………….…26

Figure 22. Pteromalid wasps on fly pupa……………………………………………………………26

Figure 23-24. *Muscidifurax raptor* female laying eggs through house fly puparium (left) and opened house fly puparium showing a *Spalangia endius* wasp larva feeding on house fly pupa (right)……………………………………………………………….…………………..27

Figure 25-26. Opened house fly puparium showing *Spalangia endius* wasp pupa (left) and house fly puparia, each with a hole from which a single wasp emerged after feeding on the pupa (right)……………………………………………………………………………..…….27

Figure 27. Fly spot card for monitoring fly activity…………………………….……………….…30

INTRODUCTION

I'd rather have ten snakes in the house than one fly.
- Mark Twain, Letter to Albert B. Paine, March 1910

The cosmopolitan house fly, *Musca domestica* Linnaeus (Diptera: Muscidae), is the major pest species associated with accumulated animal manure and a major concern for dairy, swine and poultry operations as residential areas develop in rural farming communities. In the early part of the twentieth century, flies from horse manure, sewage, and garbage were a concern [4]. Today, the increasing contact of agricultural centers with expanding residential areas may create a significant nuisance around nearby communities resulting in poor community relations, intervention by public health officials, and threats of litigation. The use of manure from concentrated animal feeding operations (CAFO) as fertilizer and an increasing difficulty in disposing of the accumulating manure adds to issues in managing pest populations as rapid accumulations of manure provide an excellent breeding medium for flies. Utilization of no-till and minimum-till practices in the disposal of manure in the field may increase the probability of dispersal into nearby communities. Some flies can still emerge even when plowed under.

House flies are associated with poultry farms, cattle and dairy sheds, horse stables, and pig farms. House flies and some other flies can also breed in decaying organic matter in garbage, animal bedding, and human excrement when sanitary conditions are inadequate. These flies have historically been called “filth” flies because of their long association with garbage, manure, and other similar materials (Fig. 1). While house flies are primarily a nuisance, human disease causing microorganisms in animal manure have increasingly become an issue as well. House flies may be either biological or mechanical vectors of over 100 human and animal pathogenic organisms though disease transmission generally results from lower standards of hygiene and environmental sanitation. As one writer noted, one study of flies showed the average fly in slum districts carried 3,683,000 bacteria, but those in cleaner communities could take heart as a fly there carried only 1,941,000 bacteria [5].

Figure 1. Historic 1916 diagram showing unsanitary privy attracting flies used to train public health workers of the Minnesota Board of Health (CDC).

Although the house fly is the major filth fly species associated with man, a number of other filth breeding and related flies may also be found around the farm and home. The little house fly and black garbage fly are also common in poultry manure and may disperse from spread manure. Blow flies (bottle flies in the family Calliphoridae) and flesh flies (family Sarcophagidae) often develop in dead animals and organic material in garbage. Some of these flies have taken to invading animal tissues (myiasis) and feeding on necrotic or living flesh. Cluster flies, *Pollenia rudis* (Fabricus), can be a nuisance in the home as they seek protected areas to spend the winter, often walls, attics, and basements. There are also a number of smaller flies such as fruit flies (family Drosophilidae), moth flies (Pyschodidae), phorid flies (family Phoridae), and “fungus gnats” (family Mycetophilidae, Sciaridae, and others) that can be a nuisance in the home, but are not covered here.

This handbook will provide some background on the biology, development, dispersal of filth and related flies, focusing mainly on the house fly, and the management of these flies and manure to assist in handling fly dispersal complaints between livestock facilities, treated fields, and residential areas. The handbook focuses on integrated fly management from both a residential and community perspective and for livestock operations, particularly poultry farms.

GENERAL FLY BIOLOGY

"*The fecundity of house-flies is proverbial…. how many descendents one pair might have in a single summer, if all survived. I… decided that a layer of such thickness [47 ft] would cover only an area the size of Germany [not the world]: but that is still a lot of flies.*"

– Harold Oldroyd, The Natural History of Flies [6]

Flies are insects. The several species of pestiferous flies that may be found on the farm and in the home are found among several different related families in the Order Diptera (true flies), which means "two-winged". There are around 20,000 species of flies in North America, only a few of which are of medical or veterinary concern. To many people the word "fly" means the house fly and some related flies commonly found around the home. In fact, mosquitoes, biting midges, gnats, black flies, horse flies, fruit flies, horn flies and face flies on cattle, and bot flies are all true flies and information on those flies may be found in other publications. The flies reviewed in this handbook are called muscoid flies, filth flies, or synanthropic flies that capitalize on food, waste, and habitats created by agricultural and other human activities and are closely associated with people (Table 1) [7, 8]. The common house fly is the major species covered in this handbook. It is helpful to know that the scientific name of flies, like other organisms, is given in two parts: genus (capitalized, often abbreviated by the first letter, e.g. *M. domestica*) and species (not capitalized) sometimes followed by the name of the person who described the organism (given in parenthesis if the genus name is later changed). Using the house fly as an example, flies are classified as follows: Class Insecta, Order Diptera, Family Muscidae (hence term muscoid flies), Genus *Musca*, species *domestica*, describer Linneaus (abbreviated L).

Table 1. Summary of filth and related flies covered in this handbook.

Family	Common name	Genus & species
Muscidae	House fly, stable fly	*Musca domestica* L., *Stomoxys calcitrans* L.
Fanniidae	Little house fly	*Fannia canicularis* (L.)
Muscidae	Black garbage fly	*Hydrotaea aenescens* (Weidemann)
Sarcophagidae	Flesh flies	*Sarcophaga* spp.
Calliphoridae	Blow flies	*Lucilia* spp., *Phaenicia* spp., *Phormia regina* (Meigan)
Calliphoridae	Cluster flies	*Pollenia rudis* (Fabricus)

Flies have what entomologists term holometabolous development where the immature stage is strikingly different from the adult. The stages are egg, larva (maggot), pupa, and adult (Fig. 2). While most of these flies lay eggs, the eggs hatch internally in some flesh flies that will then deposit young larvae. The larvae of filth flies are what people generally call maggots, most of which have a cylindrical shape tapering anteriorly. They pass through several stages or instars before pupating. The maggots can often be identified by the form of the slits in rear spiracular plate where they breathe (Fig. 2). Larvae of the house fly, little house fly and stable fly are saprophages, feeding on filtered bacteria, yeast, and small organic particles in their semi-liquid habitat. Other larvae may be predacious or feed on dead or living tissue. A third-instar larvae forms a puparium (pupal case). The fly pupates within the puparium. When ready to emerge, the young adult fly pushes open the anterior end of the puparium with a temporary inflated sac called the ptilinum that extends from the front of the head of the fly (Fig. 2). It can also help the fly work up through loose soil. It is permanently retracted after the fly emerges.

Adult flies may have only a single pair of wings, but their flight capabilities are well known. The second pair of wings is not absent. They have been modified into short knobbed stalks called halteres that function like a gyroscope and help stabilize flight – hence the house fly's somersault to land onto the ceiling. As insects, they have six legs, each which end a segment called a tarsus. A small claw and fleshy little sticky pad on the tarsus permit flies to hang upside down and cling to smooth surfaces. With the exception of the biting stable fly, the nonbiting flies covered in this publication have sponging-sucking type mouthparts used for ingesting liquid food (Fig. 3). It consists of a fleshy two-lobed labellum on the proboscis with food channels leading to the mouth. The mouthparts can be extended or retracted as needed. They cannot penetrate the skin. The flies ingest food by sucking up liquid food or moistening the surface with regurgitated, enzyme-containing saliva and liquid vomit in order to then ingest a liquefied material. While the antennae are used to detect air-borne odors, flies actually taste with their feet. The compound eyes are widely separated in the female fly and often touch or are very narrowly separated in the male fly.

This section would not be complete without a note on a few terms. The term filth fly has already been explained. Flies that coexist with humans and their domestic animals are called synanthropic species and range in their degree of association with our environment. The house fly is very dependent upon human community for its needs and a record of its association with civilization goes back to 3000 B.C.[9] Needless to say, flies in various cultures generally had a negative image. Other flies may take advantage of what we provide, but are not dependent on us for food and other resources. Most muscoid flies are exophilic, reluctant to enter buildings. The most pestiferous species are often endophilic and readily enter buildings. Some other terms will be defined further in the text.

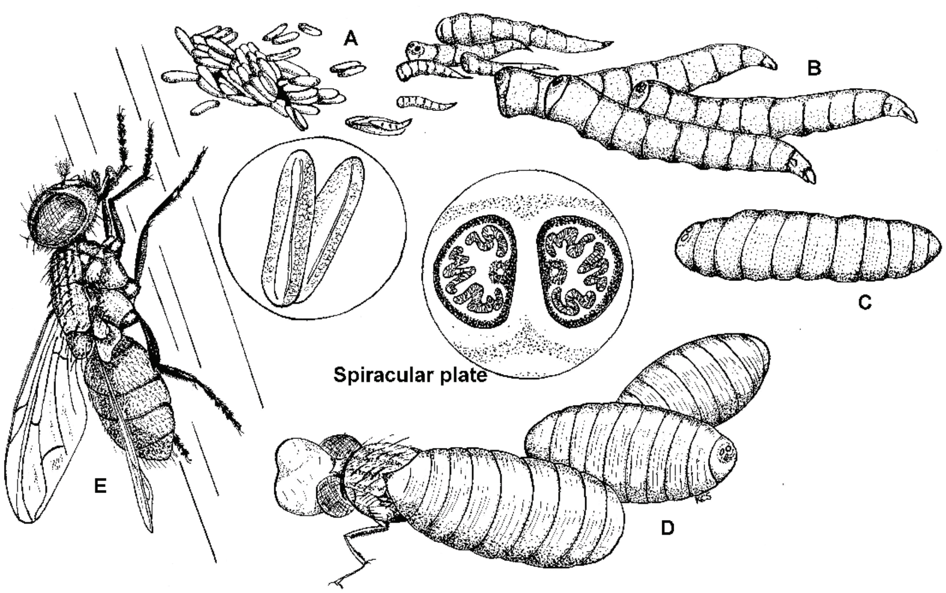


Figure 2. The life cycle of the house fly is typical of muscoid type of development: A = eggs (also shown enlarged), B = larvae (maggots), C = larva forming a puparium, D = puparia (pupae) [note inflatable organ (ptilinum) to help the young fly break out of the puparium], E = adult. The distinctive spiracular plate of a third-instar larva house fly is also shown (K. Stafford).

House Fly, *Musca domestica* L.

House flies (Family Muscidae) are nonbiting flies about ¼ inch (6-7 mm) long, mostly dull gray in color with four dark longitudinal stripes on the thorax (Fig. 3) [1, 10]. The abdomen has pale yellow sides with a dark median line. House flies have the typical four stages in the life cycle; egg, larva (maggot), pupa, and adult (Fig. 1 and 2). There are overlapping generations with all stages being present at the same time. It is the major pestiferous filth fly species farmers, homeowners, and health departments may have to deal with. House flies breed in animal manure, human excrement, spilled feeds and a wide diversity of other moist, warm decaying organic material. They readily enter human habitations and settle on our food (a true synanthrope). For many people today, the fly may be more of a picnic or park pest than a house pest unless they live near livestock or other similar agricultural operations.

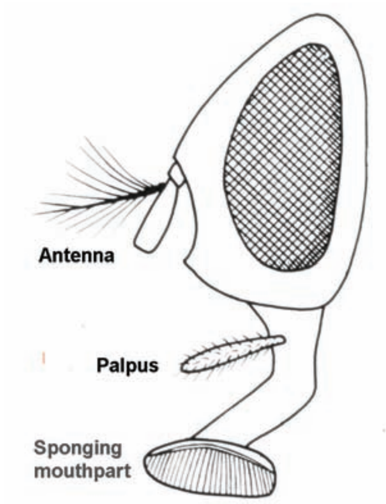


Figure 3. Side view head of the house fly showing antenna, palpus, and sponging mouthparts (CDC).

Figure 4. House fly life cycle: eggs with 2 puparia, two larvae (maggots), and two adults.

Male house flies are attracted by the female produced pheromone called muscalure, (Z)-9-tricosene. Female house flies normally mate only once. Each female fly can produce up to 6 batches of 75-200 eggs at 3- to 4- day intervals, inserting the eggs into suitable breeding material. Larvae hatch from the eggs in 12-24 hours and complete their development in 4-7 days. Cooler weather, a dry medium, or scarce food may extend development to 2 weeks or more. Larvae pass through three growth stages or instars as they increase in size. Mature larvae are about 3/8-inch in length. They form a dark, hardened case called a puparium and the house fly pupa develops within this reddish-brown case. The pupal stage lasts 3-4 days in the summer and weeks or months during the winter. An adult fly emerges to complete the cycle. Adult flies live an average of 2-4 weeks in summer and longer in cooler weather. Adult flies are most active during the day at temperatures of 80-90°F and become inactive at night and at temperatures less that 45-50°F. Resting adults can be seen on the ceiling, the rafters, walls, posts and other surfaces inside an animal facility and beneath roof overhangs, on walls, fences and vegetation outside [1, 4]. The eyes are separated in both sexes, but much closer in the male.

Little House Fly, *Fannia canicularis* (L.)

The little house fly (Family Fannidae) may occur in great numbers on poultry farms and can become the predominant pest in some locations. It resembles the house fly, but is smaller (about 3/16 inch or 4.8 mm) and has three brown stripes on its thorax (Fig. 5). This fly is normally associated with litter-type floor housing and open window ventilation. Like the house fly, the little house fly is endophilic and may invade homes in nearby residential areas, but it tends to be slightly less annoying since it doesn't settle as readily on food or people. Inside animal facilities, male flies are easy to recognize by their swarming behavior; they fly slowly in circles, hover, and can be seen circling walkways or animal pens. Both sexes can be found resting on weeds, branches, or sides of buildings. This fly is less tolerant of hot, midsummer temperatures than the house fly and numbers tend to peak in the early spring, decline in midsummer, and pick up again in late fall. While *F. canicularis* is the most common in confined animal facilities, other species that may be encountered are *F. femoralis*, *F. pusio*, and *F. scalaris*, which is a more exophilic fly and associated more with privies hence its name the latrine fly.

The little house fly's life cycle is similar to that of the house fly, but slightly longer. Eggs are deposited on decaying organic material, especially excrement of poultry, cattle, and humans. The larvae are brown, flattened, and spiny (Fig. 35). Pupae resemble the larvae. The life-cycle typically takes 18 to 22 days, but may be longer depending on temperature.

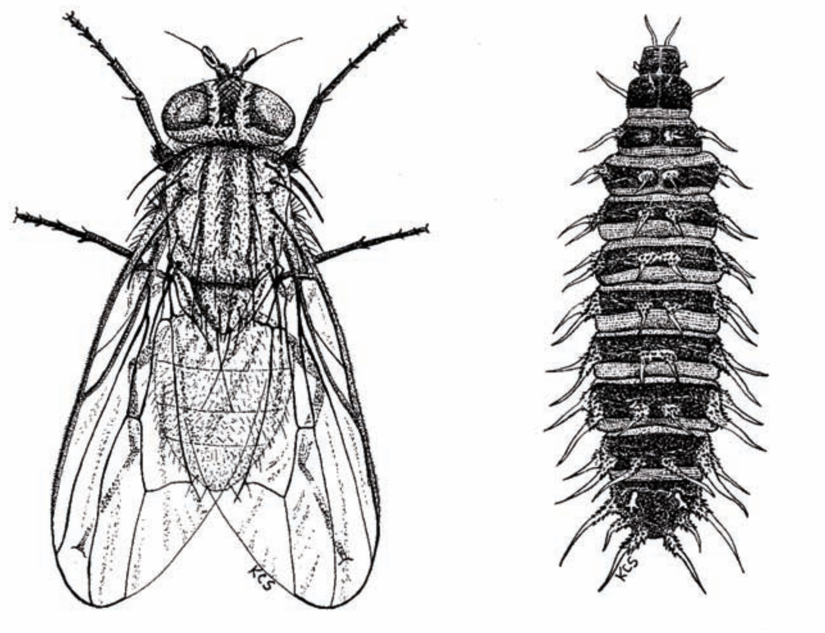


Figure 5. Adult little house fly (left) and larvae of the little house fly (right) (K. Stafford).

Stable Fly, *Stomoxys calcitrans* L.

The stable fly closely resembles the house fly and is sometimes mistaken for the house fly. However, it has a broader abdomen that is slightly checkered. Both the male and female are blood feeders. The proboscis of the stable fly is a long bayonet-like structure easily visible projecting from the front of the fly and is lowered during use (Fig. 6). The proboscis terminates in a small labellum with rasping denticles or teeth that is forced into the skin. It is a vicious biter and is often known as the biting house fly. Other names for this fly are dog fly and beach fly.

The larvae of this fly breed in decaying material like straw bedding, particularly if fermenting or mixed with cattle or horse manure or urine, wet hay, feed, and grass clippings, wet rows of seaweed, and algal mats. The material must be moist for larval development. The stable fly feeds on many species of mammals. It can be abundant around feedlots, dairy barns, and horse stables. While often a livestock pest, they will readily attack and annoy people. It can be a common pest along sandy lake shores and the seashore where vegetation or seaweed has accumulated. It can fly many miles and has been a problem in a number of vacation and shore resort settings. While generally found outdoors, it can enter homes. Stable flies will congregate on sunny light-covered surfaces, especially near areas where animals are kept. The entire life cycle from egg to adult requires around 33 to 36 days at 70°C.

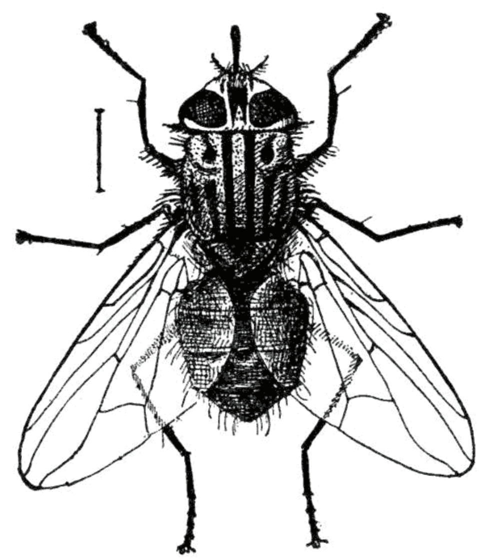


Figure 6. Stable fly (USDA).

Black Garbage Fly, *Hydrotaea aenescens* (Weidemann)

These are shiny black flies, a little smaller than house flies, which may be found in large numbers around poultry facilities (Fig. 7). The life-cycle is similar to that of the house fly. Larvae may breed in manure, garbage, and other decaying organic matter, including carrion. They are also called dump flies from their association with garbage dumps. However, the larvae are also facultative predators and may switch to prey on other fly larvae. Black garbage flies can be beneficial in poultry houses as they have been known to exterminate or suppress house fly populations. The flies tend to stay on or near manure and they are not a common community nuisance. However, they can also develop large numbers and disperse as adults into nearby communities. Two other species of garbage flies, *H. ignava (= leucostoma)* and *H. capensis*, may be found on poultry farms in the northeast.

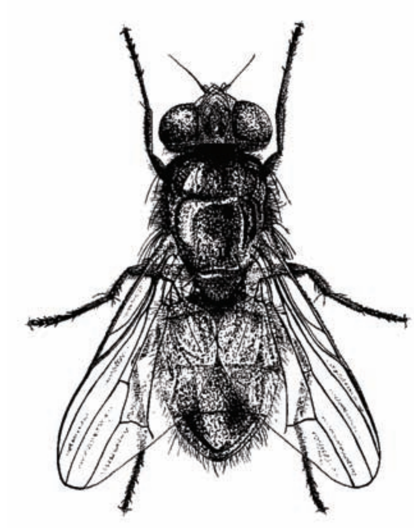


Figure 7. Black garbage fly (K. Stafford).

Bottle or Blow Flies, Family Calliphoridae

Blue-bottle, green-bottle and related flies are scavengers associated primarily with dead animals (Fig. 8). In urban areas, they are also associated with garbage and pet feces. The name bottle flies came from their iridescent colors that were similar to colored bottles. Blow flies are quite common, but they usually are not abundant due to good community sanitation practices. In the wild, these flies are important in the decay and recycling of dead animals. Large numbers of these flies in the home, however, usually indicates a dead animal, such as a mouse or bird inside the structure. Animals can be trapped in chimneys for example and flies enter the home through the fireplace. The succession of flies coming to a human body (carcass) and their development is used by forensic entomologists to assist in determining the location and time of death.

Figure 8. Green-bottle fly, *Lucilia spp.* (USDA).

The predominant flies in a survey in New Haven, CT from 1942-1944 were *Phaenicia sericata* (Meigan), *Lucilia illustris* (Meigan), and *Phormia regina* (Meigen) [11]. *P. sericata* is a greenish metallic fly generally found outdoors, but can have a strong propensity to enter homes. *Lucilia illustris* is also of a metallic blue-green color with bronze shades. By contrast, the black blow fly, *P. regina*, is black with a bluish-green luster. This fly feeds on a broad array of materials. Some blow flies, including *P. sericata* and *P. regina*, can be attracted to the odors of normal body openings (nose, ears, anus, urogential tracts) or wounds and larvae will infest tissue and feed on living, necrotic or dead tissue. Infestation with fly maggots is termed “myiasis.” It is uncommon in the United States, but cases do occur. The larvae of the American primary screwworm fly, *Cocliomyia hominivorax* (Coquerell), consume living flesh. Eggs are laid around open wounds, even very small ones like scratches and tick bites. Untreated cases in livestock were often fatal. The fly was eliminated from the U.S., Mexico, and northern portions of central America by the release of sterile male flies. Maggots of the screwworm were identified by The Connecticut Agricultural Experiment Station from a young lady who was attacked by screwworm flies in South America. The maggots were recovered from the scalp by her New Haven pediatrician after she returned to the United States.

Flesh Flies, Family Sarcophagidae

These are medium-sized grayish flies with thoracic stripes and checkered pattern on the abdomen. The female flies do not lay eggs, but deposit larvae directly onto the food material. *Sarcophaga* species are mainly scavengers, associated with dead animals (carrion) and excrement, but some may occasionally cause myiasis. Flies in the genus *Wohlfahrtia* are primary tissue invaders laying larvae at scratches, wounds, or natural openings. Another group of flesh flies are parasitic on other insects and other arthropods. Some flesh flies are quite common, but like blow flies, they usually are not abundant due to good community sanitation practices.

Cluster Fly, *Pollenia rudis* (Fabricus)

The cluster fly is a member of the Calliphoridae and, although it is not a filth-breeding or myiasis producing fly, it can be an annoyance in homes and other buildings. The larvae of the cluster fly are parasites of several species of earthworm in the genus *Allolobophthora*. They feed within the earthworm, killing it, and pupate in the soil. The emerging adult flies are slightly larger than the house fly (Fig. 9). The fly overlaps its wings at rest while the house fly does not. There are numerous short crinkly golden hairs on the sides of the body. Adult cluster flies may become a nuisance in homes as they have a habit of aggregating in buildings during late summer and fall to overwinter. The name is derived from tight clusters made by hibernating individuals in wall voids or attics. They are sometimes called attic flies. They are sluggish flyers, buzzing loudly while flying aimlessly in circles in buildings. This cluster fly is found throughout Europe, Canada, and most of the United States.

During the spring, single eggs are laid in soil cracks by the female fly where they may encounter an earthworm. The maggots hatch, seek out earthworms, enter the earthworm body, and begin to feed for 13 to 22 days. The maggots leave the body of the earthworm and pupate, producing an adult fly about 11 to 14 days later. The entire life cycle from egg to adult is about 27 to 39 days. There are usually four generations per year. Through the summer months, the adult flies feed on fruit juices and flower nectar.

Figure 9. Adult cluster fly (G. Ridge).

In the late summer (around mid-August) and early fall, the adult flies of both sexes seek a protected place to spend the winter, frequently inside homes. They show a landing preference for sunny sides of light colored buildings. Structures located on open hilltops, near large lawns and meadows appear more attractive to the flies. They enter through small opening, such as gaps under eves, as well as open doors and windows, congregating in walls, attics, and basements. These insects may become active during winter warm spells when temperatures rise above 54°F. They may cluster at windows or lights during these warm spells. The flies leave once spring arrives to repeat the cycle. The flies do not breed or establish in buildings and do not cause structural damage. However, they can occupy the same building to over winter every year.

Flies found inside can be vacuumed up or collected in a dustpan and discarded. Fly traps are not effective. Sealing entry points, such as cracks around windows, doors, utility lines, air vents, rooflines, gaps in siding, and other holes can reduce entry, as can screens in good condition. Aerosol sprays available for homeowners or licensed pest control operators, can be applied around openings to help prevent fly entry. For cluster flies, insecticides can be applied on siding, under eaves, and around windows and doors, paying particular attention to south-facing surfaces. In winter, interior crack, crevice and void treatments may help reduce infestations. Cluster flies inside wall voids can be difficult to control. For more information, see the CAES fact sheet on cluster flies [12].

TEMPERATURE, MOISTURE, AND FLY DEVELOPMENT

Do what we can, summer will have its flies. – Ralph Waldo Emerson, "Prudence"

The house fly life-cycle is temperature dependent requiring roughly 10 days at 85°F, 21 days at 70°F and 45 days at 60°F [1, 13] (Table 1). No flies are generally produced at temperatures less than 50-53°F. In areas with cold winters, house flies do not overwinter in the immature stage or survive as adults out of doors. There is no diapause (suspended development) stage. However, house flies will overwinter inside buildings with only a reduction in breeding activity if suitable conditions are available. While exact values vary slightly, adult fly activity may begin around an average temperature of 44°F (6.7°C), but the flies are still relatively inactive or crawl only slightly from 45-48°F (7.2-8.9°C) and can fly at 53°F (11.6°C) (Table 2). This suggests a threshold of around 50°F or a little less for outdoor fly activity [1, 10]. Adult house flies appear to seek temperatures above 60°F (15.6°C) when possible. However, lower temperatures are associated with longer survival.

Table 1. Days required for house fly development at various temperatures [1, 13].

Temperature °F	°C	Egg Hours to hatch	Larva Days to pupation	Pupa Days to adult	Days (range) total life cycle
61	16	49	11-26	18-21	44.8 (40-49)
64	18	33	10-14	12-15	26.7 (23-30)
68	20	23	8-10	10-11	20.5 (19-22)
77	25	14	7-8	7-9	16.1 (14-18)
86	30	10	5-6	4-5	10.4 (9-11)
95	35	8	3-4	3-4	7.0 (6-8)

Table 2. Summary of temperature effects on adult house fly activity [10].

Activity	Temperature °F	Temperature °C
Crawling activity begins	39.2-44.6	4-7
Flight, mating, oviposition begin	50.0-59.0	10-15
Range activity gradually increases	77.0-86.0	25-30
Preferred resting temperature	95.0-104.0	35-40
Lethal effects begin	113.0-116.6	45-47

House fly production is dependent upon the temperature of both the breeding media and air temperature and the dynamics can get complex. Temperatures fluctuate through the day and through the year. There is a close association between inside air temperatures and manure temperatures in high-rise poultry houses. I found pit air temperatures in Pennsylvania high-rise poultry houses dropped below house fly reproductive thresholds (55.9°F or 13.3°C for egg development) for several weeks in the winter, but were adequate for their survival all year around [3]. There is evidence that fewer female flies actually lay eggs because of lower temperatures. The arrest of egg development in the female fly occurs even if suitable breeding material is available [14].

Manure temperatures in contained livestock facilities may be suitable for fly development nearly all year around. The acceptable temperature range in the breeding media for house fly larvae is broad, roughly 50-107°F, with an optimum of around 89.6°F (32°C). Eggs will not develop below 50°F (10°C) or above 108°F (42°C). The threshold for larval development is about 46°F (8°C). Temperatures recorded at various areas of poultry manure are generally within this range for most of the year. In one study, I found manure temperatures from various locations in a shallow-pit Texas poultry house ranged from 58.6-109.2°F with an average of 78.4°F and moisture levels ranged 21.0-88.2% with an average of 68.7% [2]. Poultry manure usually will contain 75-80% moisture. Moisture levels less than 30% are generally necessary to prevent fly breeding. In another study in Pennsylvania poultry houses, I found manure temperatures cycled to some degree with the seasons and varied significantly between individual poultry houses depending on their manure profiles and other characteristics. Manure temperatures were affected principally by the shape and depth of the accumulating material and secondarily by seasonal air temperature patterns (Table 3) [3]. Deeper manure piles generated higher temperatures. Shallow manure profiles averaged 60.8-66.2°F (16-19°C) while deep manure piles averaged 86.0-104°F (30-40°C) with the highest temperatures generally in the middle of the accumulating manure. Fly development would require 22-34 days at the lower temperatures and only 6-7 days at the warmer temperatures.

Table 3. Temperature (°F) levels recorded in poultry manure in high-rise poultry houses in Pennsylvania with hygrothermographs showing temperature differences between shallow and deep manure accumulations [3].

Depth manure	Area sampled	No. Farms	Mean temperature	Maximum temperature	Minimum temperature
Shallow	Top	1	61.5	74.8	53.0
	Middle	2	64.9-66.4	91.9-95.0	45.5-55.0
	Bottom	2	61.7-65.1	79.0-86.0	42.0-54.0
Deep	Top	2	85.1-96.4	100.0-120.0	70.0-71.0
	Middle	2	100.9-101.8	111.9-120.0	70.0-87.1
	Bottom	1	102.9	120.0	72.0

Piles of manure that are turned or composted can generate heat lethal to most house fly larvae and, consequently, fly breeding is generally restricted to the outer 4 inches or so of such manure piles. Turning the manure will prevent fly larvae from pupating and emerging by bringing them into contact with the hot interior of the pile [15]. Composed poultry manure is not suitable for fly oviposition. In accumulating piles that are not composted, there may be an initial rise in temperature followed by a decrease in temperature. Fly breeding will be reduced at subsurface levels as temperatures approach 122°F (50°C) and the larvae will migrate to surface layers or out of the manure pile (Fig. 10). While a temperature of 120°F (48.9°C) is generally lethal and larvae will die within a minute at 129.2°F (54°C), they can develop at 110-116°F (43.3-46.6°C) if the medium is sufficiently moist [1]. Also as they get older, the larvae will tend to migrate to areas with lower temperatures until just prior to pupation. Fly pupae will survive and give rise to flies at temperatures too low for larval development. One study listed 59°F (15°C) as the preferred temperature for pupation and another recorded flies emerging from cow manure at 43-51.6°F at a RH of 78%.

As an alternative to composting, the temperature of stored manure can be increased by covering the manure. For example, a 1939 study found that 60 lb roofing paper overlapped 3 inches over a manure pile and held down by bricks raised the temperature of the manure surface 40°F higher than the surrounding air and when air temperature exceeded 80°F (26.7°C) for 5 hours, all house fly larvae were killed [16]. Today, plastic sheeting is often used to cover a manure pile (see section on fly management in residential communities).

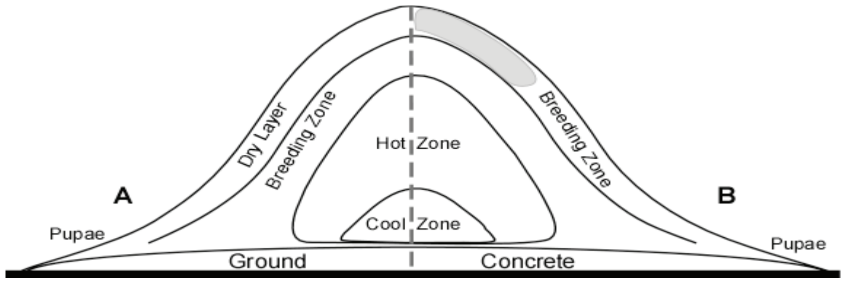


Figure 10. Microclimates in an outside manure pile (A) and manure cone inside poultry house (B). Fly breeding zone depends upon location, depth, moisture, and air temperature and may be in the outer 4 inches or deeper if surface is dry. Leaking water in a poultry house can create breeding zone anywhere on the surface. Fly predators generally forage on peak surface of the manure cone (shaded gray) in a poultry house (see section on Poultry IPM) where fresh manure is deposited (modified after West [1] and based on Stafford [2, 3]).

ADULT FLY DISPERSAL

*And there came a grievous swarm of flies into the house of Pharaoh, and into his servants' houses, and into all the lands of Egyp*t. – Exodus 8:24

How far do house flies travel and where do they come from? Most flies seem to stay within a half-mile or mile from their breeding place (Figure 11). The effective dispersal range of house flies appears to generally be less than 2 miles (Table 4). Maximum distances of 10-20 miles have been recorded, but house flies are not migratory by nature and generally do not make long flights. They move around to explore their environment, but tend to remain within a radius of 328-1,640 feet from their breeding site as long as they find suitable food, breeding sites, and shelter. Much of the information on house fly dispersal is based on trapping of marked house flies at various distances from their point of release from studies conducted mainly in the 1950s and 1960s or earlier. The proportion recovered is very small and it is not clear by what route flies arrived at the traps. Wind may affect the direction of dispersion to some extent, but most studies have recovered flies in all directions from a release point.

Some major conclusions from the house fly dispersal studies:

- House flies will disperse all directions from a single source in urban areas; they tend to wander
- Dispersal is tied to food availability and flies tend to stay at food source
  (only 8-30% disperse beyond source dairy or poultry facility)
  (38% disperse beyond 1 mile or more from woodland release site)
- Facility clean-out and spreading manure on fields can be major times for fly dispersal
- Rate of dispersal increases above 53° F and when breeding materials are scarce
- Flies move upwind with steady 2-7 mph wind as they move towards attractive sites, otherwise movement is non-directional "random"; another study threshold was 10 mph for directed movement
- House flies can disperse at least a half mile in 3 to 8 to 24 hours
- Concentrated animal feeding operations (CAFO) can increase local fly densities

Figure 11. Diagrammatic presentation showing general house fly dispersal distances at ½ mile, 1 mile, and 2 miles from a release point (K. Stafford).

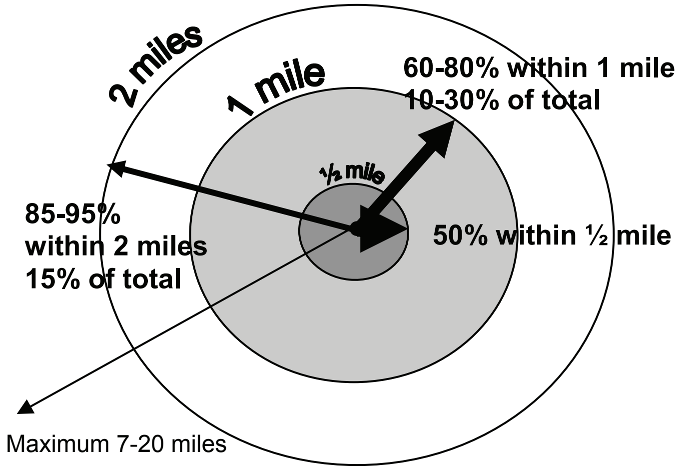


Table 4. House fly release dispersal studies in rural, farm, and urban environments [9, 17].

Release site	Effective dispersal range	Maximum dispersal range	Approximate dispersal rate
Rural (TX)	-	13 miles	7.1 mi/24 hr
Farm (OR)	-	12 miles	-
Urban (AZ)	< 1 mile	5 miles	4 mi /3 days
Rural (GA)	< 3 miles	10 miles	5 mi < 24 hr
Urban (GA)	½ to > 1 mile	7.6 miles	5.2 mi /24 hr
Urban (AZ)	½ to > 2 miles	7.2-8.3 miles	5.2 mi /24 hr
Farm (NJ)	½ to 2.5 miles	6.5 miles	-
Farm (MD)	½ to > 1 mile	-	½ mi / 4 hr
CAFO (OH)	2 to 4 miles	4 miles (limit study)	-

One of the earliest release studies was conducted in a small city in Montana with flies recaptured from 50 yards to two miles from the release point [18]. In an urbanized substandard residential zone in Phoenix, Arizona, researchers concluded dispersal was essentially "random" (i.e., non-directional) [19]. Approximately 52% of released flies were recovered within 0.5 mile of the release site and 65-89% was captured within 0.5 miles of several secondary release sites. Based on a follow-up study, the effective dispersal range under city conditions was 2.0 miles and influenced by the attractiveness of an area as the flies search for food and breeding places [20]. Dispersal was rapid with most flies recovered in a 0.1-1.1 mile zone in 24 hours. Flies released from within Savannah, Ga., and at several fly producing sites outside the city (e.g. city dump, 2 dairies, and a slaughterhouse) dispersed in all directions [21]. Most were trapped within 0.5 miles of the release site, though some traveled 7.6 miles. Fly dispersion from privies on Grand Turk Island was found to be rapid and occurred in all directions [22]. The researchers concluded that flies find sites by wandering rather than actual attraction from great distances. Bishopp and Laake found that most of the released house flies had a tendency to go with the wind, but also traveled against it [23]. They concluded that the influence of moderate winds on dissemination is not that important.

Within the rural agricultural community, it was again found that flies dispersed in all directions from release sites [21]. No detectable influence due to wind was observed. A central high fly density farm where a release was made apparently contributed a high percentage of flies to the neighboring farms.

Released flies were recovered at all farms in a 1 mile zone and at the maximum trap distance of 8.25 miles. Correcting on the basis of increasing area away from the release site suggested most of the flies actually moved beyond the 1 mile zone. Morris and Hansen also did not find any clear evidence for the influence of wind [24]. Flies were recovered in various numbers from surrounding farms at distances of 0.5-6.5 miles in all directions though the recoveries at a few distant farms suggested a trend in the direction of farms favorable to large fly populations. By contrast, adult house flies orientated on wind borne odors from farms [25]. Although most of the marked flies were caught at the dairy barn where they were released, the majority of dispersing flies from this release and from an open field release were recovered upwind. Similarly, marked flies tended to disperse upwind when a steady 2-7 mph wind blew from only one quarter, but dispersed 'randomly' when winds were variable [26].

Within a farm, most flies tend to stay put near the breeding source. Movement between open buildings within a farm appears unrestricted while dispersal between farms is limited [27]. Dispersal between adjacent closed buildings was indirect requiring more than one generation. Another study found that after 5 days, 53 and 60% of marked flies released in two separate poultry houses stayed there and 13% moved to nearby dairies [28]. A similar number remained in the dairy, but 19 and 34% moved to non-breeding sites on both farms, respectively. By contrast, a recent study in Ohio reported that the number of house flies was significantly higher up to 4 miles from large commercial egg-layer facility (2.5 million chickens) and a severe nuisance up to 2 miles in distance [17]. Again, the number of flies generally declined with distance. In summary, flies tend to remain close to the breeding source and the maximum dispersal distance for most of the fly population is about 2 miles.

PUBLIC HEALTH AND FLY MANAGEMENT IN RESIDENTIAL COMMUNITIES

"What sort of insects do you rejoice in, where you come from?" the Gnat inquired.
"I don't rejoice in insects at all," Alice explained,…

- Lewis Carroll, Through the Looking Glass

By the most painstaking care one may prevent all fly breeding on his premises, but it will avail him little if his neighbors are not equally careful. Some sort of cooperation is necessary.

- L. O. Howard & R. H. Hutchison, 1922 [4]

Laws Pertaining to Nuisance Fly Problems

Statutes and laws pertaining to farms, flies or related nuisances, and public health vary tremendously from state to state in the northeast. Like most northeastern states, Connecticut State Statutes do not directly address issues related to nuisance fly problems. Many states provide definitions of farming, have some form of right to farm laws or recognition of the importance of farming, and may exempt farms from nuisance actions related to odors, dust, noise, and use of chemicals when operations are within generally accepted farming practices or regulations. Regulation of farm manure waste also varies between states. Fly issues come broadly, sometimes specifically, under public health regulations pertaining to public nuisance or hazards to human health.

In Connecticut, farming practices are under the jurisdiction of the Department of Agriculture. The Connecticut statute pertaining to nuisance is one example of a "right to farm" law:

Sec. 19a-341 - Agricultural or farming operation not deemed a nuisance; exceptions. Spring or well water collection operation not deemed a nuisance. (a) Notwithstanding any general statute or municipal ordinance or regulation pertaining to nuisances to the contrary, no agricultural or farming operation, place, establishment or facility, or any of its appurtenances, or the operation thereof, shall be deemed to constitute a nuisance, either public or private, due to alleged objectionable (1) odor from livestock, manure, fertilizer or feed, (2) noise from livestock or farm equipment used in normal, generally acceptable farming procedures, (3) dust created during plowing or cultivation operations, (4) use of chemicals, provided such chemicals and the method of their application conform to practices approved by the Commissioner of Environmental Protection or, where applicable, the Commissioner of Public Health, or (5) water pollution from livestock or crop production activities, except the pollution of public or private drinking water supplies, provided such activities conform to acceptable management practices for pollution control approved by the Commissioner of Environmental Protection; provided such agricultural or farming operation, place, establishment or facility has been in operation for one year or more and has not been substantially changed, and such operation follows generally accepted agricultural practices. Inspection and approval of the agricultural or farming operation, place, establishment or facility by the Commissioner of Agriculture or his designee shall be prima facie evidence that such operation follows generally accepted agricultural practices.

The Commissioner of Agriculture regulates and inspects intensive poultry operations (> 20,000 fowl) and may "adopt regulations…..concerning acceptable management practices of intensive poultry farming including transportation of poultry waste on public roads" (Sec. 22-326d). The Commissioner may take action against an intensive poultry operation necessary to prevent the introduction or spread of an environmental or health hazard.

In Connecticut, municipal directors of public health have a broad responsibility to "examine all nuisances and sources of filth injurious to the public health, cause such nuisances to be abated and cause to be removed all filth which in their judgment may endanger the health of the inhabitants" and "any local director of health or his authorized agent or a sanitarian authorized by such director may enter all places within his jurisdiction where there is just cause to suspect any nuisance or source of filth exists, and abate or cause to be abated such nuisance and remove or cause to be removed such filth" (Sec. 19a-206**)**. There may be a number of potential fly breeding sources associated with residential filth fly problems including landfills, sewage treatment facilities, trash transfer stations, camps with poor sanitary measures (i.e., latrines, garbage handling areas, mess halls), and various farm and livestock operations. The Connecticut Public Health Code, a compilation of the regulations that pertain to the Department of Public Health as mandated pursuant to Section 19a-36 of the General Statutes of Connecticut, specifically addresses fly problems and abatement in several sections under public nuisances as follows:

Reg. No. 19-13-B1. Conditions specifically declared to constitute public nuisances.

- (c) Barns or stables, hogpens, chicken yards or manure piles or accumulations of organic material so maintained as to be a breeding place for flies.
- (d) The discharge or exposure of sewage, garbage or any other organic filth into or on any public place in such a way that transmission of infective material may result thereby.
- (e) Privies not screened against flies in populous districts and privies likely to pollute the ground or surface water from which water supply is obtained.
- (f) Transportation of garbage, night soil or other organic filth except in tight, covered wagons which prevent leakage or access of flies.

Reg. No. 19-13-B2. Abatement of nuisance

- (a) Any local director of health, upon information of the existence of a nuisance or any pollution occurring within his jurisdiction, or when any such nuisance or pollution comes to his attention, shall, within a reasonable time, investigate and, upon finding such nuisance or pollution exists, shall issue his order in writing for the abatement of the same.
- (b) Such order shall specify the nature of such nuisance or pollution and shall designate the time within which such abatement or discontinuance shall be accomplished; and if such order is not complied with within the time specified, the facts shall be submitted to the prosecuting authority. Copies of all orders shall be kept on file by the director of health in his office and copies of the same shall be furnished by the state commissioner of health on request.

19-13-B21. Garbage and refuse

(a) The owner of premises upon which persons reside or which are frequented for pleasure or business shall keep such premises free from accumulations of garbage, rubbish, rags, tin cans, paper, empty barrels, boxes or any material which, because of its character, condition or improper storage, may invite the breeding or collection of flies, mosquitoes or rodents, or which may in any other prejudice the public health.

(b) In populous districts stable manure shall be kept in a covered water-tight pit or chamber and shall be removed at least once a week during the period from May first to October first and during the other months at intervals sufficiently frequent to maintain a sanitary condition satisfactory to director of health. Manure on farms or isolated premises other than dairy farms need not be so protected and removed unless ordered by the director of health.

Farms and Animals

Dairy, poultry, cattle, sheep, horses, and hogs are all part of New England's and Connecticut's valuable diversified agricultural enterprises. Some measure of New England and Connecticut livestock production can be obtained from a few statistics for 2006 from the New England Agriculture Statistics Service, USDA. We had 7.5 million egg-laying birds in New England. Connecticut ranked first in density and second for total number of egg-laying chickens. Maine led in production with 1,064 million eggs, but Connecticut followed with 791 million eggs with a value of $33.8 million dollars. Although dairies have been declining, Connecticut had around 19,000 milk cows out of 224,100 animals throughout New England in 2006. Connecticut milk production was valued at $52.85 million dollars. In 2005, Connecticut had 12,000 beef cattle on 770 farms, 4,800 sheep on 250 farms, and 4,200 hogs on 200 farms. In addition, we ranked first in the country for density of horses with 1 animal for every 58 people [29]. The amount of manure produced at a concentrated animal feeding operation (CAFO) can equal that of a small town of several thousand people.

The manure produced on farms and particularly CAFOs will need proper disposal [30]. The most common and usually most desirable and economical method of disposing of livestock manure is application to cropland or pasture because of the value of the nutrients and organic matter as fertilizer. However, with the size of some farms and volume of manure produced, disposal can sometimes exceed land capacity, create problems with run-off and require transport over longer distances. Manure is usually collected and stored for some variable amount of time before being applied to the cropland or pasture. Farmers in urbanizing settings can experience problems during manure hauling when accessing fields near urban developments. There can be increased travel distance and restricted time periods for applications to the field. A great source of flies can be neglected piles of manure on a farm prior to application. If daily or immediate application is not feasible, proper storage at the delivery site is essential. Proper storage of manure will allow spreading at an appropriate time, retain nutrient value, and prevent fly breeding (see next section).

The major issues usually addressed in manure management plans relate to nutrient balance, water quality, and public health. The timing and methods of application can minimize movement to ground water of soil, organic materials, nutrients and pathogens from land where manure is applied. Flies tend to be a public health aspect overlooked in manure management plans and become a community issue. For example, an EPA risk assessment for CAFOs related to manure covers nutrient loading, nutrient management, watershed issues, pathogens, presence of hormones and antibiotics, and manure handling among other things for cattle, dairy, poultry and swine operations [as do many cooperative extension publications on manure management and handling], but does not address flies [30].

Improper land application of manure to cropland or pasture can result in over-fertilization (particularly phosphorus with poultry manure, 50% of nitrogen can be lost as volatile ammonia) and contamination of water resources, introduction of pathogens into water or food, and the presence and dispersal of flies and other insects into the community. These issues can become relevant to local health departments and increase complaints. Disease outbreaks have been recorded when rains washed manure with *E. coli* and *Campylobacter* into well water. The other issue is the presence of filth flies, primarily the house fly, and dispersal from either the farm site or from manure applied to fields. As people move out of cities to suburban areas and suburban areas expand into rural areas, there is potential for an escalation of manure and fly related conflicts. The development and adherence to a manure management and pest management plan, application of best management practices (BMPs), and good community communications are essential elements in limiting problems. Producers need an environmentally friendly method to dispose of animal manures and some farmers will seek animal manure for their fields. However, nutrient loads, product bulk, hauling and spreading costs may not justify its use in some cases.

Manure Management

Sanitation of areas where larvae breed and adult flies feed is the one most important factor in fly control (for poultry operations, see the integrated fly management section). The dispersal of flies from poultry, dairy, and other manure distributed in fields as fertilizer will depend upon:

- the fly burden in manure
- the stage of fly present in the manure
- conditions upon delivery and/or spreading of the manure
- distance to residential areas

Few flies will disperse directly from a poultry house or dairy facility unless populations are high. House flies can breed in manure in facilities most of the year, begin to move at temperatures near or above 50°C, and they will effectively disperse within 1-2 miles from a source point. Spreading manure on agricultural fields can dry the manure sufficiently to kill eggs and larvae. However, flies that have pupated may continue to develop and emerge. Even in manure mixed in soil, some fly breeding can occur from 1 to >12 inches below the surface [31]. Consequently, the key to preventing fly problems in residential areas is managing fly populations at the source, checking manure for the presence of fly larvae or pupae before or at delivery, and distributing manure on fields when conditions are not suitable for fly development or dispersal. However, if there are few flies in the manure, timing is less critical of an issue. In Connecticut, the fly season generally runs roughly from May 1 through the end of September and perhaps a few weeks into October (Fig. 12). With increasingly milder winters, the effective fly season may be longer.

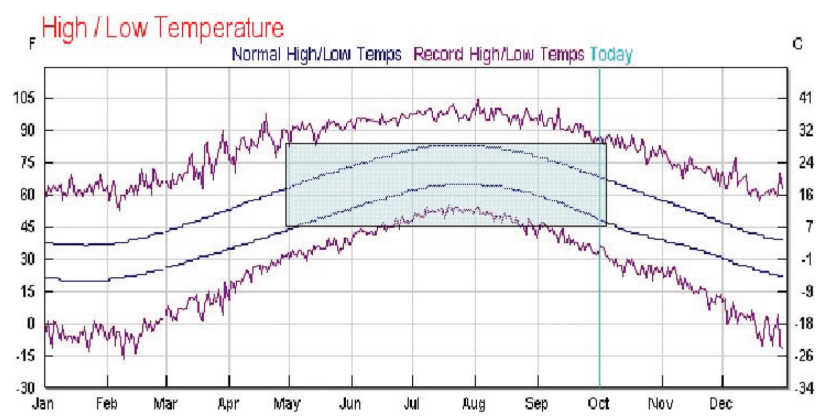


Figure 12. Temperature diagram shows the normal high and low temperatures (blue) and record high and low temperatures (purple) for a town in eastern Connecticut. The blue box brackets when temperatures would be suitable for the dispersal of flies from manure spread in fields based on normal average temperatures. However, record highs and lows indicate a wider potential range of suitable conditions are possible for fly dispersal (Used by permission Weather Underground).

To minimize problems while trucking manure, options include avoiding busy roads and heavy traffic and going around heavily populated centers if possible [32]. For storage of smaller amounts of manure that is not immediately applied to the field, select an out-of-site location and an area in which runoff will not impact streams, roads or other sensitive areas. Heavy-gauge (6-mil) black plastic sheeting to cover the manure pile can raise its temperature, prevent fly access, and help retain nutrient value (Fig. 13). The black plastic can be placed over a manure pile or windrow (even out gaps between the piles to avoid pockets that may hold water) and held in place with rope or old tires approximately 2-3 feet apart across the pile and every 8-10 down the length to prevent wind damage. The edge of the plastic can be wrapped around timbers at the base and secured with nails or with soil. Black plastic can be reused if it isn't too dirty and then eventually disposed of in the trash. It can be difficult to recycle as recyclers cannot clean it and there sometimes is no market for plastic film, though efforts are being made to recycle agricultural plastics [33].

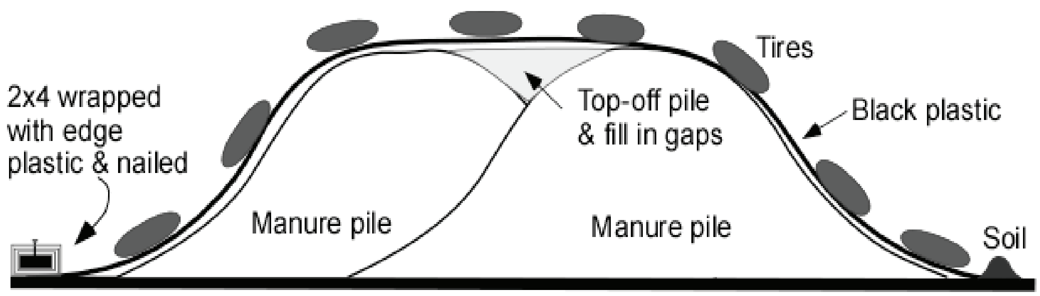


Figure 13. Storage of manure piles using a black plastic cover held in place with tires.

Pathogens Associated with Flies and Manure

Historically, flies were a health issue as vectors of disease agents when raw sewage, latrines, and open garbage were accessible. Walter Reed's Typhoid Commission found flies contributed to the spread of typhoid fever in filthy U.S. military camps for soldiers awaiting orders during the Spanish-American War [34]. Unsanitary conditions can still be a problem in many areas of the world. In the United States today, however, many fly-associated human pathogens have been linked more or less directly to animal manure rather than flies per se. Manure can contain potentially pathogenic organisms. These pathogens generally threaten humans who have direct contact with manure or consume food or water contaminated with infected manure. For example, recent cases in the literature were associated with contamination from runoff from livestock facilities or excessive land application of manure. Nevertheless, flies are natural carriers of pathogens, including food-borne disease agents, and can be important in spreading viruses, fungi, bacteria, and protozoa. Over 100 pathogenic microorganisms have been associated with house flies and other filth-breeding flies [7, 35]. House flies may be vectors of *Escherichia coli*, *Campylobacter* spp., *Klebsiella* spp., *Staphylococcus aureus*, *Salmonella* spp., *Vibro* spp., *Crytosporidium parvum*, and many enteroviruses, among others [36-38]. Incrimination of the house fly as an agent for disease is based on the fact that it freely feeds on food and excrement; readily picks up pathogens on its sponging mouthparts and hairs on multiple parts of its body; and pathogen loads can be high. Adult flies may transmit human pathogens by physically carrying them on their body, fecal deposition (fecal spots), or regurgitation. However, it is still unclear how readily flies actually transmit many of these pathogens to humans. Pathogens do not survive the change from a larva (maggot) to an adult fly. Nevertheless, applications to the soil surface can present both a fly and pathogen issue. Manure left on the surface provides an opportunity for pathogen dispersal through flies or surface run-off, odor problems, and potential fly dispersal problems. However, pathogen concentration will decrease upon exposure to UV light and as manure dries out. While the incorporation of manure into the soil can prolong pathogen viability after application, pathogens incorporated into the soil appear to present little threat to public health.

Role of Local Public Health Officials

As noted previously, municipal directors of public health have a broad responsibility to examine all sources of filth injurious to the public health under the public health code and abate nuisances. Interpreting the information related to a fly problem can be a daunting task for a local health department. Outside professional help from state health, agricultural/environmental agencies, and the Cooperative Extension System may be needed [17]. In the case of a nuisance that may potentially involve some legal action or public health code enforcement, some of the factors that need to be taken into account include:

- Tolerance of the local citizens for house flies in their environment
- Proximity to villages, cities, and urban areas (to farms and agricultural fields)
- Professional inspections of complainant homes
- Number of complainants and over what time period
- Specific identification of the nuisance flies as house flies or other fly species
- Other possible sources of house flies
- Time of year
- Number of samples taken and over what time period
- Existence of a properly executed house fly control plan at a farm or CAFO

Homeowner Options to Address Fly Problems

Good communication between farmers and homeowners can prevent many problems. Most farmers are conscientious about good community relations and seek to prevent problems. However, flies may still occasionally become a problem. Sometimes the origin may be unclear or source reduction and sanitation may not be an immediately effective option for an existing situation. The source may not necessarily be a farm operation or the nearest one. The first step is for the homeowner to get the flies identified as actions will depend upon the fly species. Major nuisance fly problems may be brought to the attention of the local health department. Residents can expect a sanitarian to follow a few steps to investigate the problem and provide assistance.

- Listen and ask questions concerning the problem (when problem started, suspected sources, etc.)
- Collect specimens of the flies, if possible (specimens will be labeled with name, locality and date; chain of custody of these samples is important); multiple samples may be taken over time
- Get the fly or flies identified by appropriate authority (even if the homeowner has already had samples identified, a health department sample may be needed to confirm the identification, especially if there could be potential health code enforcement or legal action)
- Determine if situation requires a health department investigation or response (e.g., cluster flies or flesh flies from an isolated dead animal in a home are not a health department issue, but an individual pest control issue and pest control operators can handle it for a fee); complaints violating the Public Health Code and CT General Statutes are subject to enforcement procedures
- Check if there are other related complaints and over what time period
- Provide information on flies and their control (fact sheets, bulletins or other literature)
- If the fly is potentially a community nuisance or health issue based on species or numbers, the sanitarian will investigate and identify possible sources based on known biology and flight range of the fly (potential sources could be on the property or nearby fields, farms, or waste handling areas, etc.)
- If a possible source is identified, suggest or mandate remedies to source owner in order to correct the current problem as conditions warrant and to help prevent future problems (homeowners should understand that it can sometimes be difficult to determine, much less prove, the actual

source of a fly problem though circumstantial evidence such as timing, location, and breeding material may put a source high on the suspect list); additional assistance from state agricultural agencies and cooperative extension may be obtained

- Keep you informed on what, if any, actions may be taken to resolve the problem or prevent a recurrence. If the problem is more widespread or affecting a neighborhood, wider methods for the dissemination of information may be used (newspaper, town meeting, health department website)

When a specific source reduction and sanitation situation is beyond a homeowner or immediate municipal control, strategies to mitigate fly problems include exclusion (i.e. screens, tight fitting windows and doors, calking of potential entry points, air blowers for industrial settings), fly traps, and pesticides (use may be limited). Again, identification of the fly species is important. Garbage, pet feces, manure, wet organic materials, and dead animals (blow flies) can be major sources of flies around the home. Garbage should be wrapped or bagged and placed in containers with tight fitting lids. Food and certain organic materials can be composted. However, organic kitchen garbage and pet feces are not appropriate for open-sided, slow composting bins or piles, which can then produce flies. In this case, solid-sided, tight lid bins and hot aerobic composting (turned regularly and heats up) is more appropriate [39, 40]. Pet feces need to be promptly picked up and disposed of by flushing down the toilet, drying and placing in a hot compost pile, wrapping and placing in the garbage can or burying it. Other organic yard waste such as wet grass clippings can also serve as a fly breeding material.

Mechanical Control & Fly Traps

The fly swatter is the time-honored, classic method of dealing with individual flies. Properly fitting window screens and screen doors are the primary barrier in keeping flies out of a building. For a small number of flies, various sticky or adhesive traps are appropriate (Fig. 14 A). However, if fly numbers are high or the environment is dusty, they can quickly become ineffective and have to be replaced. Insect electrocuting traps or “bug zappers” are sometimes used around the home to control flying insects. The devices consist of a fluorescent or ultraviolet light to attract flying insects and a high voltage electric grid or mesh. However, the devices kill many non-target insects, scatter insect parts, and stimulate the release of bacteria or viruses found on the fly surface [41-43].

Baited fly traps can be quite effective for handling larger numbers of flies and help suppress flies from an outbreak event. Flies are strongly attracted to odors and traps are an option for homes, commercial and industrial facilities, barns and other animal areas, dumps, and trash transfer centers. The traps work for both house flies and blow flies. Traps may be homemade and baited with household materials or purchased commercially (Table 5).

Commercial bag, jar, or bottle style traps are generally easy to use – just add water to the bait provided (Fig 14 B-C). In some traps, the bait is added to the trap before filling with water to the fill line and in others you just add water. Flies enter through access points in the lid and/or bottom and drown in the water added to the trap. Insecticides are generally not used and most rely on propriety bait or lure consisting of several strong smelling feeding stimulants and sometimes a fly sex attractant (pheromone). The female house fly sex attractant (Z)-9-tricosene is strongly attractive to male flies and odorless. Traps using the sex attractant alone may be an option for inside barns, kennels, and other indoor areas. Traps may be disposable or re-usable, vary in capacity and generally are designed for either indoor and/or outdoor use and may be set on a surface or hung out of the reach of children. Some replacement baits may also be used with any fly trap, including homemade traps. Traps with smelly bait are best used outdoors. Indoors, trap effectiveness can be increased with placement near a light or window.

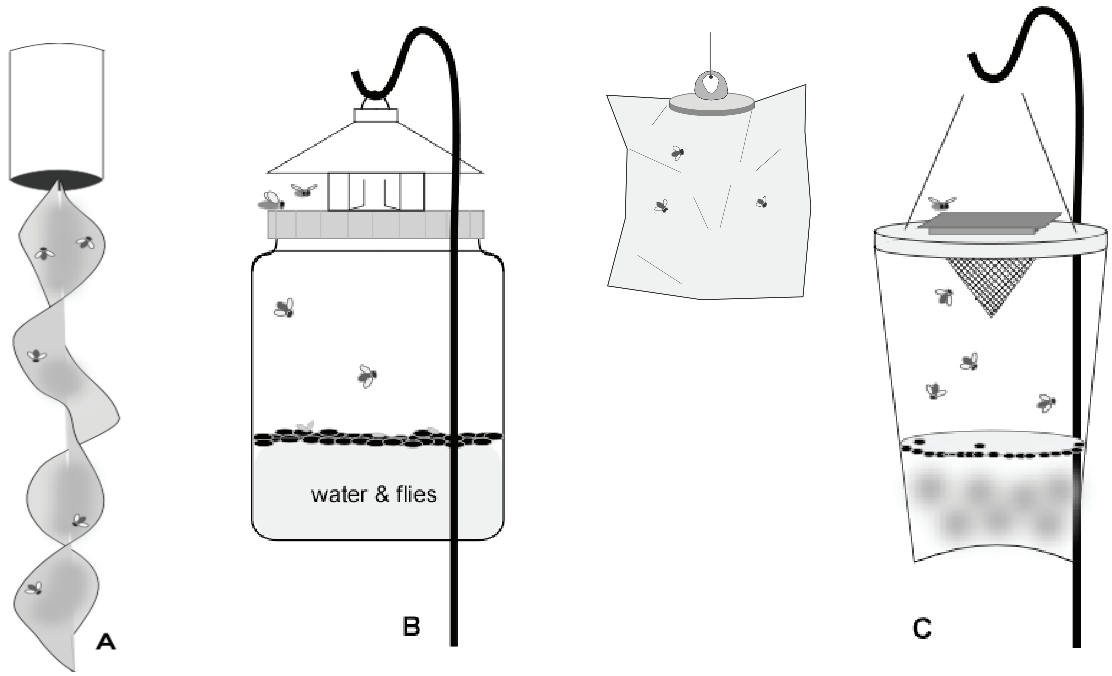


Figure 14. Fly traps. (A) Adhesive ribbon, (B) jug or bottle trap, and (C) two styles of bag trap. Actual appearance and form will vary between brands of traps (K. Stafford).

Follow the instructions for use for each specific trap. Generally, one baited trap is used approximately every 20-30 feet around the perimeter of where the flies are resting in the morning and afternoon. Traps are generally set at about 2 feet, up to 5 feet, from ground level. They generally attract flies from a distance of 30-40 feet. The jar or bottle traps are re-usable – remove the dead flies, rebait the trap if necessary, add water, and re-hang the trap. The bait lasts through multiple trapping cycles so often you need to just add water back to the fill line after dumping the dead flies. However, replacement baits are available. The traps are emptied when about one-third full. The dead flies can be placed into plastic bag and disposed of or buried under the soil as fertilizer. However, trap contents in a sealed, air-tight container will continue to decompose, generate gases, and could explode.

The bag style traps are disposable and are an option if you can't mix bait or empty jars full of dead flies. At a recent pest management workshop [44], several studies were presented in the filth fly session of evaluations of commercial fly traps. The Farnum Fly Terminator Trap followed by Troy Bioscience Final Flight, Victor Fly Magnet, and Combined Distributors Flies-Be-Gone generally captured the most house flies. A fly trap can also be made from milk jugs by cutting holes in the side or from disposable 1-liter soda and water bottles by cutting off the top and inverting it to form a cone into the bottle, which traps the flies. The bottle or jug can be baited with spoiling fruit, meal or other foods, bait made with water, grain, molasses, milk and bananas, or commercial bait or lure available separately. The bottle can be disposed of when it becomes too full to be effective.

Table 5. Examples of commercial sticky and baited, disposable or reusable fly traps.

Fly trap	Manufacturer	Usage	Comments
Sticky Traps			
Aeroxon Fly Catchers	Roxide International, Inc.	Disposable	Adhesive ribbon, odorless,
Terro Fly Catcher	Senoret Chemical Co. Inc.	Disposable	Adhesive ribbon, odorless,
EZ Trap®	Farnum Companies, Inc.	Disposable	Adhesive, odorless, indoor/outdoor
Musca-Stik™	Farnum Companies, Inc.	Disposable	Adhesive, odorless, indoor/outdoor
Container Traps			
Fly Terminator® Pro	Farnum Companies, Inc.	Reusable	Jar, outdoor use, surface or hang
Fly Relief™	Farnum Companies, Inc.	Disposible	Bag, outdoor use, hang
Musca-Doom®	Farnum Companies, Inc.	Disposable	Jar, outdoor, surface or hang
Rescue!® Fly Trap	Sterling International Inc.	Resusable	Jar, outdoor use, surface or hang
Rescue!® Fly Trap	Sterling International Inc.	Disposable	Bag, outdoor use, hang
Final Flight	Troy Biosciences	Reusable	1 qt. jar with lure, outdoor use
Fermone® Big Boy	Troy Biosciences	Reusable	Jar, indoor/outdoor use, pheromone
Victor Fly Magnet	Woodstream	Disposable	Jar, var. sizes, & bag, outdoor use
Monster Flies-Be-Gone	Combined Distributors, Inc.	Disposable	Bag, outdoor use, hang
ISCA Ball Trap	ISCA Technologies, Inc.	Resusable	Plastic container
Advantage Fly Trap	J.F. Oaks	Reusable	Jar, outdoor use, removable liner
Oak Stump Fly Trap	SpringStar USA Inc.	Reusable	Jar

The list of traps and vendors is not comprehensive and does not constitute an endorsement by The Connecticut Agricultural Experiment Station. Many traps listed are based on evaluations reported in a filth fly symposium held as part of a 2007 Dept. of Defense Pest Management Workshop [44].

Residual Sprays for Outdoor Use and Fly Baits

Long-lasting residual sprays of insecticides can be used for killing flies outside the home or business. Sprays can be applied to porches, patios, garages, doghouses, kennels, garbage cans and other fly resting areas. Follow label directions. This is a short-term solution and sanitation should be considered the first and primary method of fly management. Unlike the traps and lures, ready-to-use dry fly baits contain an insecticide and are generally meant for commercial agricultural production areas, processing plants, and fenced commercial refuse dumpsters. Fly baits are more commonly used around livestock operations such as poultry houses. **Fly baits should not be used in any area with access to food animals, pets or children.** More information on fly baits is provided in the poultry pest management section.

INTEGRATED FLY MANAGEMENT IN POULTRY OPERATIONS

Kill a fly in July, You've just killed one fly.
Kill a fly in June, They'll be scarce soon.
Kill a fly in May, You've kept thousands away
– Old English rhyme

High fly densities can not only be an issue for neighbors, they can annoy employees and cause a reduction in egg production of hens at the farm. Integrated pest management (IPM) system approaches are particularly appropriate for confined-animal high density production systems like poultry operations where pests species are few, but can develop tremendous numbers [45, 46]. The system is artificial and can be manipulated. Four basic management strategies (mechanical, cultural, biological, and chemical) can be integrated into a successful fly control or integrated pest management program. However, fly management at the source farm is mainly a cultural one of sanitation and water management. Manure may be dried or liquefied (used in some dairy operations) to prevent fly development. Manure must be dried to below 40% moisture or mixed with water in a liquid manure system to lower solids to below 10% or more than 85% moisture (used in some cattle, dairy, and swine operations). Dry manure is easier to handle, has less volume, and less odor than wet manure. Dry manure also reduces the suitability for fly oviposition and larval development, and provides a desirable habitat for beneficial predators and parasites.

Three types of facilities are most commonly used in poultry production: caged-layer, broiler, and breeder houses, each with its own pest problems and management needs. Caged-layer houses are widely used for commercial egg production. A two-story house consists of two to four or more tiers of cages on the sides of an aisle with each cage containing several birds (Fig. 15). Manure accumulation under the cages presents the greatest fly breeding potential among the three types of facilities. This section is oriented primarily towards environmentally controlled, deep-pit or high-rise caged-layer operations widely used for table egg production though some material is applicable to other types of poultry operations. The two types in the northeast, deep-pit (high-rise) and shallow-pit are environmentally controlled facilities with ventilating fans and closed walls. The majority of poultry houses in the northeast are caged-layer, high-rise facilities with concrete floors.

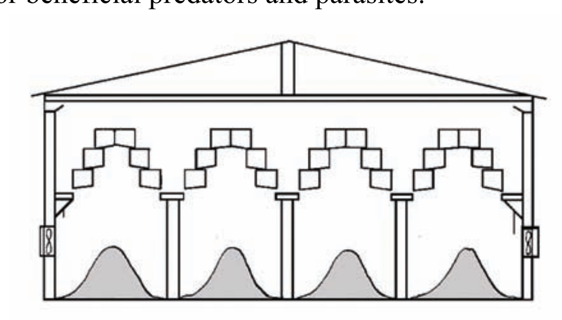


Figure 15. Cross-section of a high-rise poultry house showing accumulated manure below cages (shaded). Fans are located on the sides (K. Stafford).

The major manure breeding muscoid flies associated with poultry operations are the house fly, occasionally the little house fly, and black garbage fly. The objectives of a good integrated pest management (IPM) program are: 1) to use best management practices to handle manure, 2) to monitor pest and beneficial populations, 2) to utilize appropriate management techniques and beneficial arthropods to suppress fly populations, and 3) to properly use pesticide applications and avoid unnecessary chemical use [46, 47]. An effective pest management program may lead to better community relations, improved flock performance, and reduced control costs. Again, the four basic management strategies that can be integrated into a successful fly control program are a variety of mechanical, cultural, biological and chemical control methods.

Mechanical Control

Mechanical control involves the use of devices to control flies. This may include physical exclusion with screens or fans to prevent entry into food processing areas, manure removal equipment, fly traps, and electric insect killers or "bug zappers" (covered earlier). Electrocuting traps would not be practical for the control of high fly numbers due to the number of units and cost required, but might be applicable in some smaller adjacent product handling, office, and related areas. A zone of about 2-m (or about 6 feet) from areas where eggs are handled is sufficient to avoid dismembered parts of house flies electrocuted by the traps [48].

Manure is normally removed from a high-rise poultry house with a small front loader or skid loader and either stored or promptly spread on agricultural fields. Newer automatic manure removal belt systems and manure drying systems can improve handling and reduce flies. Warm air directed to the manure drying belts over the cage row can reduce moisture. The belts deliver manure to the end of the cage row where it is removed from the house. With the availability of in-house composting machines, composting the manure in high-rise poultry houses is another option for managing the manure. This approach is a combination of mechanical and cultural control and is discussed in the next section on cultural control.

Cultural Control

The keys to cultural control are moisture management, sanitation, and manure removal. Moist poultry manure is highly attractive to adult flies and provides ideal conditions for fly development. Therefore, manure moisture level is the most important factor in fly control. 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, improper ventilation, and seepage from the exterior. Leaking water is the major source of wet manure conditions. Therefore, in-house management practices include checking watering equipment once if not twice daily, maintaining manufacturer's recommended water pressure in the watering equipment, keeping the watering equipment clean and free of debris and food, and inspecting the pit daily for water leaks [32].

If dry conditions are maintained in high-rise houses, 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 there are water leaks (Figs. 16 and 17). Manure management will be successful if the surface of the manure mound can dry to about 30% or less by moving air across the manure and stopping drinking water from spilling into the pit. 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. Fans placed on both sides of the pit can help reduce moisture. Regular cleaning and maintenance of the fans will provide maximum air flow over the manure.

Figure 16-17. Poultry manure accumulations with poor moisture control (left) and good moisture control (right). The left house has aisles with lots of wet manure from leaking water and a huge fly problem. The operation on the right had fewer fly and other pest problems (K. Stafford).

Manure removal is often used as a fly-control tactic, but the fly life cycle must be broken for control efforts to be effective. Manure is generally cleaned out once or twice a year in high-rise houses (sometimes longer intervals). Manure is removed from shallow-pit houses on a shorter frequency schedule ranging from 1 to 6 weeks. Frequent and thorough manure removal every 5 days or less can provide satisfactory control that can be particularly appropriate for shallow-pit houses [49]. 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 clean-out is ideal for fly breeding. A severe fly outbreak often occurs 2 to 3 weeks after a clean-out during the fly season. If possible, remove manure in cooler months when flies are less active. Beneficial arthropods can be conserved and their populations maximized by allowing manure to accumulate for long periods.

In-house composting reduces manure volume and weight and results in decreased moisture content, less odor, reduced nitrogen, and a friable nutrient-improved product with better handling characteristics that makes a good soil amendment [50]. Composting also produces sufficient heat to kill immature stages of the house fly and has been shown to significantly reduce fly numbers [51]. Structural pests, such as lesser mealworms, *Alphitobius diaperinus* (Panzer) and hide beetles, *Dermestes maculates* (DeGeer) were also eliminated from the manure. However, there are other considerations. Higher ammonia levels may be produced. Careful consideration needs to be given to fly larvae migrating to cool zones and accumulating fly pupae between the windrowed manure or in other areas and incorporating them into the composting manure pile [52]. In addition, the mechanical turning of the manure prevents establishment of fly predators. Composting must be continued and there may be a limit to the manure volume that can be processed, which may then require clean-out to avoid an explosion in the fly population. Of course, flies can be present even with good manure management practices and be considered under relatively good control. These flies may not cause a problem within the farm or neighbors, but still could become an issue if spread on fields during the fly season.

Biological Control

Proper cultural practices encourage poultry manure accumulations containing large populations of beneficial predators and parasites that can suppress house fly populations [53]. In the Northeast, several mites and hister beetles are the major predators in caged-layer operations. Parasite or rather parasitoid populations, of major importance in the southern United States, are present at lower densities than the two predators. Less is known about the role of natural wasp parasites in suppressing fly populations in poultry houses in the North, but the wasps can be released to enhance parasitism levels. Members of three families of mites; Macrochelidae, Uropodidae, and Parasitidae, actively prey on house fly eggs and first-

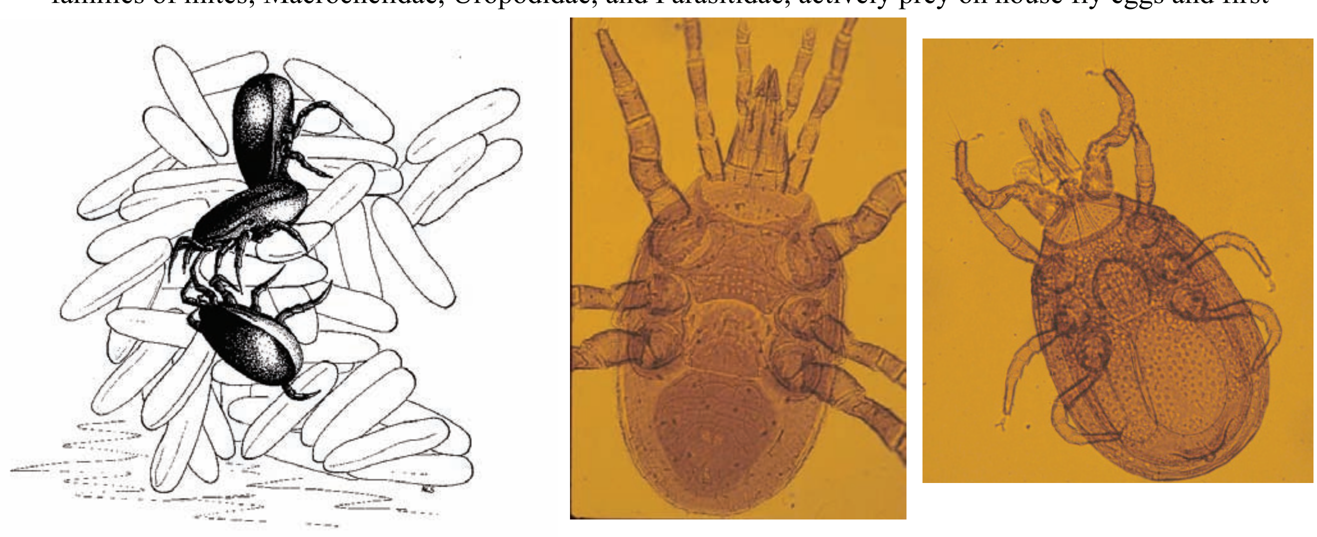


Figure 18-20. Macrochelid mites, *Macrocheles muscaedomesticae* feeding on house fly eggs (left), dorsal view of *M. muscaedomesticae* under the microscope (center), and Uropodid mite *Fuscurpoda vegetans* (right) (K. Stafford).

instar larvae in poultry and other animal manure. The macrochelid mite, *Macrocheles muscaedomesticae*, is the most important mite in poultry manure and is frequently very abundant (Fig. 18-19). The life stages are egg, a 6-legged larva, and the 8-legged protonymph, deutonymph, and adult. The yellow-brown mite is slightly less than 1/16 inch (1.6 mm) in size. The first pair of legs are sensory in function and are used to explore the environment. The adult macrochelid mite is phoretic (i.e. travels) on adult flies and consequently moved to new areas. It attaches to the flies with its chelicerae (jaw-like mouthparts). Other macrochelid mites are *M. glaber* (Müeller) and *Glyptholapis confusa* Foa. Mites are found on the outermost layer of the manure, particularly its peak. Macrochelids can consume up to 20 house fly eggs per day and cause substantial reductions in house fly numbers, but large mite populations are required for any appreciable impact. Efforts, therefore, should be made to conserve natural populations present in the manure. About 3 to 4 weeks of manure accumulation is necessary for mites to become established [54]. Another common mite that may be found in poultry manure is the uropodid mite, *Fuscuropoda vegetans* (DeGeer). It is an oval, reddish-brown, slower moving, heavily built mite with a slight beetle-like appearance (Fig. 20). 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. However, it has a long live cycle and may take 8-12 weeks before it becomes abundant.

The principal predatory beetle in northeastern poultry houses is the hister beetle, *Carcinops pumilio*, a small black beetle (Family Histeridae) approximately 1/8 inch (3.2 mm) long (Fig. 21). It feeds on house fly eggs and first-instar larvae. Its potential as a predator is similar to that of the macrochelid mite. 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 while it may take 6 weeks for significant populations to develop, their numbers can steadily increase. Another hister beetle, *Gnathoncus nanus*, is also present at lower numbers on poultry farms in the Northeast.

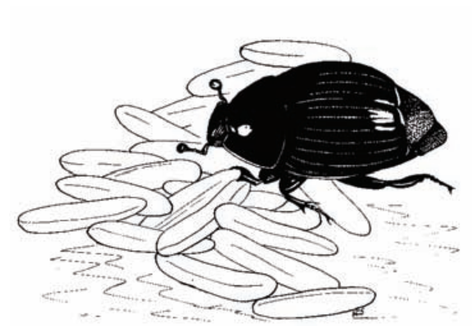


Figure 21. Hister beetle, *Carcinops pumilio*, feeding on house fly eggs (K. Stafford).

Tiny, stingless, parasitic wasps of the family Pteromalidae attack most of the common manure breeding flies. These parasites (technically called parasitoids because they kill the host fly) are rarely noticed because they are extremely small (1/16- to 1/8-inch or 1.6-3.2 mm) and appear naturally in low numbers on many farms. They live in manure or other decaying organic matter in search of fly pupae (Fig. 22). Adult female wasps lay an egg on the fly pupa (Fig. 23) within the puparium where the developing wasp larva consumes the fly pupa (Fig. 24), pupates (Fig. 25) and emerges as an adult wasp leaving holes in the puparium (Fig. 26). The major species found in poultry in the northeast include *Muscidifurax raptor*, *Spalangia cameroni*, and *Nasonia vitripennis*. Because of naturally low parasitism levels, fly control programs have been based on mass releases of laboratory reared parasites. Critical considerations necessary for a successful release program include decisions on parasite species and strains and the numbers to be released. Some of the parasites currently offered by commercial insectaries, including *M. raptorellus*, have been found effective in an IPM program study in New York poultry facilities with overall parasitism stabilizing around 60% [55]. Scattering parasitized pupae on the manure appeared to be more effective than placement of mesh bags containing the pupae. Release rates were 2, 4, or 6 parasitoids per bird on a staggered schedule. In addition, producers should concentrate on conserving and

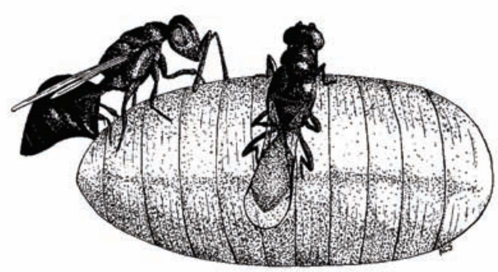


Figure 22. Pteromalid wasps on a fly pupa (K. Stafford)

building their native predator and parasite populations by proper management techniques and by minimizing insecticide use.

Figure 23-24. *Muscidifurax raptor* female laying eggs through house fly puparium (left) and opened house fly puparium showing *Spalangia endius* wasp larva feeding on house fly pupa (right) (USDA & K. Stafford, respectively).

Figure 25-26. Opened house fly puparium showing *Spalangia endius* wasp pupa (left) and house fly puparia, each with a hole from which a single wasp emerged after feeding on the pupa (right) (Stafford & USDA, respectively).

Another potential biological control approach is the use of entomopathogenic fungi such as *Metarhizium anisopliae* and *Beauveria bassiana* [37]. These pathogens are common in house flies and laboratory and field tests have shown them to be effective. However, no mycoinsecticides for fly control have yet been commercially developed. There appears to be substantial strain differences as well, but some strains of *B. bassiana* provide over 90% control in 15 days [56, 57]. *M. anisopliae* is also highly pathogenic to house flies, killing 100% of flies within 6 to 8 days, and effectively delivered in a bait [58, 59]. Application of a *B. bassiana* product in New York high-rise, caged layer poultry farms resulted in lower adult house fly populations and did not adversely affect the predator *C. pumilio* [60, 61].

Chemical Control

Chemical treatments are often necessary to complement a well-managed poultry operation. The producer must monitor fly populations on a regular basis in order to evaluate the fly management program and decide when insecticide applications are required. Accurate records should be kept on chemicals and dosage rates used. Improper timing and indiscriminate insecticide use combined with poor manure management, poor moisture control, and poor sanitation practices, increase the pest populations and the need for additional insecticide applications. Not all products may be available in all states. A New York study found levels of fly resistance to a number of insecticides varied a lot from one poultry farm to another and were generally correlated with use of a particular insecticide at the facility [62]. This suggests that resistance can be successfully managed. The use of a variety of insecticide types - organophosphates (e.g., tetrachlorvinphos, dichlorvos, dimethoate), carbamates (e.g., methomyl), pyrethroids (e.g., permethrin, cyfluthrin), and neonicotinoids (imidacloprid, dinotefuran, nithiazine) - can help minimize the development of resistance. Resistance levels against permethrin, cyfluthrin, and tetrachlorvinphos were generally high. While most fly insecticides are toxic to predators and parasites and indiscriminant use can result in their destruction, selective application of insecticides to fly resting areas can avoid predators and parasites. Insecticide applications may be classified by targeted fly stage (adulticides and larvicides) or method of application (sprays, baits, and feed additives). Residual sprays, space sprays, and baits are the most commonly used for fly control (Table 6).

Read the label before using any insecticide and follow all instructions.

Residual spray applications on fly resting surfaces will reduce adult populations for a limited time with out destroying predators and parasites. Depending upon the type, formulation, and concentration of chemical used and the type of surface sprayed, treated areas may remain toxic for 2 to 15 weeks. Applications to areas where flies rest (generally on upper surfaces notable by vomit and fecal spots) should provide the most effective exposure. Poor residual activity is obtained on brick or concrete surfaces or in areas exposed to direct sunlight. With the flock in place, the application of a residual spray after the manure is removed is effective in reducing the fly buildup that usually follows clean-out of the house. A second residual application should be made in 5 to 6 weeks. An alternate approach is to make the first residual insecticide application about 3 weeks prior to manure removal and a second application 2 weeks afterward. In either case, two sprays are required. Residual sprays should not be applied to birds or surfaces that come in contact with food.

Space sprays or mist sprays can be effective for a rapid knockdown and kill of adult flies, but do not provide long-lasting control. There is no residual effect. The effects of space sprays on parasite populations are poorly understood, but it is likely to kill any adult parasites active at the time of treatment. Sometimes a build-in spray system with nozzles and timers may be installed in poultry houses, dairies or horse barns. A regular misting program would not be compatible with the use of wasp parasitoids and insecticide resistance may become an issue.

Baits are excellent selective adulticides for suppressing low fly populations and maintaining them at a low level. They are also especially effective when combined with residual insecticides. They are used as a scatterbait, in bait stations, or in some cases as a spray or paint-on application (where the included yellow dye can be tolerated) or strip. Baits should be generally placed upstairs in a high-rise house and placed in some kind of fly trap. The practice of scattering bait in the pit may destroy predator populations. Baits should be used so that they will not be accidentally eaten by the birds or mixed into the feed. Most bait available today contain the sex attractant (Z)-9-tricosene (Muscalure, Muscamone®) and an insecticide such as methomyl (a carbamate) or, in many cases, one of the new neo-nicotinoids (imidacloprid, dinotefuran, nithiazine or thiamentoxam) (Table 6). Spinosad in one product is fermentation-derived material from an actinomycete bacterium.

The use of feed additives to render the manure toxic to fly larvae is an attractive method of fly control to many producers because it is easy to use. Only one material, Larvadex® (cyromazine), an insect growth regulator available from Novartis Animal Health, is currently registered for oral use in laying hens. It is available as a 1% premix or technical concentrate. Another formulation (Neporex®) is for manure application. While Larvadex® is usually very effective and does not affect predators and parasites, extensive use is expensive, may lead to resistance in flies, and is contrary to label directions. It should be used as part of an integrated management program. Failure to provide fly control at some farms has been reported [49].

Table 6. Residual sprays, space sprays, and baits for fly control in poultry houses by chemical class and compound, and trade or common name.

Use and class	Insecticide	Trade or common names
Residual Sprays (or paint-on)		
Pyrethroids	Permethrin	Atroban®EC, Ectiban® EC, Gardstar®, Permethrin, Permectrin™ II, Permicide, Pounce, Overtime
	Cyfluthrin	Countdown 2 EC or 20 WP, Tempo®Ultra
Organophosphate	Tetrachlorvinphos	Rabon® EC, Rabon® 50WP, Gardona
	Tetrachlorvinophos + Dichlorovos	Ravap® EC*
	Dimethoate	Cygon 2EC
	lamda-cyhalothrin	OxyFly®10CS, Demand® CS, Grenade®
Neonicotinoid	Thiamentoxam	Agita® 10WG
Insect Grower Regulator	Pyriproxylen	Archer®
Other	Boric Acid	Safecide® IC
Space Sprays, Mists or Fogs		
Pyrethroids	Permethrin	Whitmire® Dairy & Farm,
Organophosphate	Dichlorovos (DDVP)	Vapona®
Botanical	Pyrethrins + piperonyl butoxide	Pyronyl™, Pyrocide®, Riptide, Martin's
	Plant essential oils	EcoEXEMPT®
Insect Grower Regulator	Pyriproxylen	Archer®
Manure Treatments		
Organophosphate	Tetrachlorvinphos	Rabon® (Gardona)
	Tetrachlorvinphos + DDVP	Ravap® EC*
	Dimethoate	Cygon 2E
Substituted melamine	Cyromazine	Larvadex®, Neporex®
Baits		
Carbamate	Methomyl* + (Z)-9-tricosene	Golden Malrin®, Stimukil® Fly Bait
Spinosyn, actinomycete	Spinosad + (Z)-9-tricosene	Spy® GB
Neonicotinoid	Imidacloprid + (Z)-9-tricosene	Maxforce® Granular, Maxforce® Fly Spot
	Dinotefuran + (Z)-9-tricosene	QuikStrike® Fly Scatter Bait
	Nithiazine	QuikStrike® Fly Abatement Stripe
	Thiamentoxam	Agita® GB

Mention of a product is for informational purposes only and does not constitute an endorsement by The Connecticut Agricultural Experiment Station. Active ingredients and brand names frequently change as new products are registered and others discontinued. Some products may not be registered in all states. Some products may not be used when birds are present in the facility. Some familiar products not listed may be for fly control only on the outside of structures or labeled for other poultry house pests like litter beetles. *Restricted Use Pesticide (RUP)

Larvicides, chemicals applied directly to the manure surface to kill maggots, are not recommended by most IPM specialists except as spot treatments since they are detrimental to the beneficial arthropods associated with the manure. Spot treatments of small areas with high numbers of maggots have a minimal effect on the overall house predator population. Larvicide applications to an entire house will only give short-term fly control and kill natural biological control agents that are present, initiating a repeated schedule of treatments. Poor penetration of the manure by the insecticide kills a small proportion of maggots. Adding moisture to the manure also makes it more suitable for fly breeding.

A standardized, quantitative method for monitoring house fly populations should be used for making control decisions and provide a record of fly activity. Visual appraisals of fly numbers are subjective and can be misleading. A baited trap, spot cards, and sticky ribbons may be used. Various traps were described earlier and, alternatively, a baited-jug trap can be made from a white, translucent 1-gallon plastic milk jug with 4 access holes (2- to 2.5-inch dia.) equidistant around the upper part of the jug. A wire is attached to the screwtop for hanging. A commercial fly bait is placed on the inside bottom of the jug. In a high-rise house, the traps should be hung equidistant around the pit periphery about 3 feet above the floor. In a shallow-pit house, the traps should be hung similarly around the ends and outside aisles of the house. Traps should be examined weekly and an average count of 250 flies per week may indicate the need for fly control.

Spot cards are 3-by-5 inch white file cards fastened flush against braces, ceilings, upper walls, feed troughs, or other fly resting areas (areas with large numbers of fly fecal and regurgitation spots) (Fig. 27). Positioning the cards is critical. Cards should be left for a period of several days to a week and the number of “fly specks” counted. The cards provide a good reflection of fly activity. Fifty or more specks per card per week indicate the need for fly control measures. Spot card counts of over 100 spots per card per week would indicate a high level of fly activity.

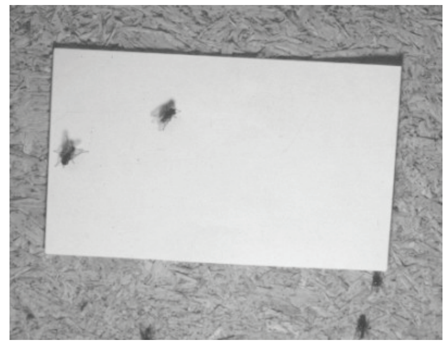


Figure 27. Fly spot card (K. Stafford).

Sticky ribbons hung along the aisles are a third approach. The captured flies are counted weekly and the ribbons replaced. A weekly count of 100 per ribbon indicates fly control may be required, although the action level of any monitoring method can be adjusted to fit circumstances. Obviously, rural producers can tolerate higher levels of flies than those near residential areas. Ribbons may become ineffective after 2-3 days because of captured flies and dust, they are messy to use, and frequent use may become more expensive.

Table 7. Summary of Fly IPM Components for Poultry Operations and Other Fly Management Situations

Mechanical		
	Screens, fans and other entry barriers, drying fans	
	Sticky fly traps and other non-chemical traps, Insect electrocutor traps	
	Manure handling equipment (scrapers, belts, loaders, spreaders, in-house composting machines)	
Cultural		
	Moisture control	- Repair leaks in water systems
		- Provide adequate ventilation
		- Provide proper grading and drainage
	Manage manure	- Allow accumulation to enhance development of biological control agents
		- Limit manure removal during the fly season
Biological		
	Enhance natural population of parasites and predators	
	Use proper cultural practices to encourage maximum manure cone formation	
	Use insecticides selectively	
	Introduce predators and parasites; Release parasites	
Chemical		
	Adulticides	- Use space sprays or mists occasionally
		- Use baits
		- Use residual sprays selectively
	Feed Additives	
	Larvacides	- Minimize or avoid use
		- Use spot treatments only if necessary

REFERENCES

1. West, L.S., *The house fly: its natural history, medical importance, and control*. 1951, Ithaca, NY: Comstock Publ. Co. 584.
2. Stafford, K.C., III and D.E. Bay, *Dispersion pattern and association of house fly, Musca domestica (Diptera: Muscidae), larvae and both sexes of Macrocheles muscaedomesticae (Acari: Macrochelidae) in response to poultry manure moisture, temperature, and accumulation.* Environ. Entomol, 1986. 16: p. 159-164.
3. Stafford, K.C., III and C.H. Collison, *Manure pit temperatures and relative humidity of Pennsylvania high-rise poultry houses and their relationship to arthropod population development.* Poultry Sci., 1987. 66: p. 1603-1611.
4. Howard, L.O. and R.H. Hutchinson, *The House Fly*. 1922: USDA Farmers' Bulletin 851. 23.
5. Evans, H.E., *Life on a Little Known Planet*. 1966, New York: E. P. Dutton and Co., Inc. 318 p.
6. Oldroyd, H., *The Natural History of Flies*. 1964, New York: W. W. Norton & Co., Inc. 324.
7. Harwood, R.F. and M.T. James, *Entomology in Human and Animal Health, 7th Edition*. 1979, New York: Macmillan Publishing Co., Inc.
8. Kettle, D.S., *Medical and Veterinary Entomology, 2nd Edition*. 1995, Oxford, UK: CAB International.
9. Greenburg, B., *Flies and disease, Vol. 2. Biology and disease transmission*. Vol. 2. 1973, Princeton: Princeton University Press. 447.
10. Keiding, J., *The housefly - biology and control.* 1976, Rept. Wld. Hlth. Org. . p. 89.
11. Power, M.E. and J.L. Melnick, *A three-year survey of the fly population in New Haven during the epidemic and non-epidemic years for poliomyelitis.* Yale J. Biol. Med., 1945. 18(1): p. 55-69.
12. Ridge, G.E., *Cluster Flies Pollenia rudis (Fabricius).* Fact Sheet, Connecticut Agricultrual Experiment Station, 2000. EN018: p. 2.
13. Axtell, R.C., *Fly control in confined livestock and poultry production.* . 1986, Greensboro, NC: CIBA-GEIGY Corporation Tech. Monongraph. 59 p.
14. Black, W.C. and E.S. Krafsur, *Population biology and genetics of winter house fly (Diptera: Muscidae) populations.* Ann. Entomol. Soc. Am., 1986. 79: p. 636-644.
15. Eastwood, R.E., et al., *Investigations on fly control by composting poultry manures.* J. Econ. Entomol., 1967. 60(1): p. 88-98.
16. Fay, R.W., *A control for the larvae of houseflies in manure piles* J. Econ. Entomol., 1939. 32(6): p. 851-854.
17. Winpsinger, K.A., et al., *Spread of Musca domestica (Diptera: Muscidae), from two caged layer facilities to neighboring residences in rural Ohio.* J. Med. Entomol., 2005. 42(5): p. 732-738.
18. Parker, R.R., *Dispersion of Musca domestica Linneaus under city conditions in Montana.* J. Econ. Entomol., 1919. 12: p. 210-211.
19. Schoof, H.F. and R.E. Siverly, *Multiple release studies on the dispersion of Musca domestica at Phoenix, Arizona.* J. Econ. Entomol., 1954. 47: p. 830-838.
20. Schoof, H.F. and R.E. Siverly, *Urban fly dispersion studies with special reference to movement pattern of Musca domestica.* Amer. J. Trop. Med. Hyg., 1954. 3: p. 539-547.

21. Quarterman, K.D., J.W. Kilpatrick, and W. Mathis, *Fly dispersal in a rural area near Savannah, Geogia.* J. Econ. Entomol., 1954. 47: p. 405-412.
22. Murvosh, C.M. and C.W. Thaggard, *Ecological studies on the house fly.* Ann. Entomol. Soc. Am., 1966. 59: p. 533-547.
23. Bishopp, F.C. and E.W. Laake, *Dispersion of flies by flight.* J. Agricul. Res., 1921. 21(10): p. 729-766.
24. Morris, A.P. and E.J. Hansen, *Dispersal of insecticide-resistant populations of the house fly, Musca domestica L.* J. Econ. Entomol., 1966. 59: p. 45-50.
25. Hanec, W., *A study of the environmental factors affecting the dispersal of house flies (Musca domestica L.) in dairy community near Fort Whyte, Manitoba.* Canadian Entomol., 1956. 88: p. 270-272.
26. Pickens, L.G., et al., *Dispersal patterns and populations of the house fly affected by sanitation and weather in rural Maryland.* J. Econ. Entomol., 1967. 60: p. 1250-1255.
27. Denholm, I., R.M. Sawicki, and F.A. W., *Factors affecting resistance to insecticides in house flies, Musca domestica L. (Diptera: Muscidae). IV. The population biology of flies on animal-farms in south-eastern England and its implications for the management of resistance.* Bull. Entomol. Res., 1985. 75: p. 143-158.
28. Lysyk, T.J. and R.C. Axtell, *Movement and distribution of house flies (Diptera: Muscidae) between habitats in two livestock farms.* J. Econ. Entomol., 1986. 79(4): p. 993-998.
29. Cowan, W.A., *Agriculture in Connecticut 2005.* University of Connecticut fact sheet, 2006: p. 6.
30. EPA, *Risk management evaluation for concentrated animal feeding operations.* EPA/600/R-04/042, 2004: p. 138.
31. Hogsette, J.A., *Development of house flies, Musca domestica L., in sand containing varying amounts of manure solids and mositure.* J. Econ. Entomol., 1996. 89: p. 940-945.
32. Neyeloff, S., *Cultural methods of fly and odor control for poultry farms.* Cooperative Extension System, University of Connecticut, 1981. Bulletin 81-40.
33. Clougherty, S., *Solution for recycling ag plastics still sought in Va.* The Delmarva Farmer, 2007. 32(27): p. 1, 19.
34. Pierce, G.J., *Public and Private Voices: The Typhoid Fever Experience at Camp Thomas, 1898*, in *College of Arts and Sciences*. 2007, Georgia State University: Altanta. p. 338.
35. Greenberg, B., *Flies and Disease.* Sci. Amer., 1965. 213: p. 92-99.
36. Graczyk, T.K., et al., *The role of non-biting flies in the epidemiology of human infectious diseases.* Microbes and Infection, 2001. 3: p. 231-235.
37. Malik, A., N. Singh, and S. Satya, *House fly (Musca domestica): A review of control strategies for a challenging pest.* J. Environ. Sci. Health Part B, 2007. 42: p. 453-469.
38. Forster, M., et al., *Pilot study on synathropic flies (e.g. Musca, Sarcophaga, Calliphora, Fannia, Lucilia, Stomoxys) as vectors of pathogenic microorganisms.* Parasitol. Res., 2007. 101: p. 243-246.
39. Olkowski, H., W. Olkowski, and T. Javits, *The Integral Urban House*. 1979, San Francisco: Sierra Club Books. 494.
40. Olkowski, W., S. Daar, and H. Olkowski, *Filth Flies*, in *Common-Sense Pest Control*. 1991, The Taunton Press: Newtown, CT. p. 640-649.
41. Frick, T.B. and D.W. Tallamy, *Density and diversity of nontarget insects killed by suburban electric insect traps.* Entomol. News, 1996. 107: p. 77-82.

42. Tesch, M.J. and W.G. Goodman, *Dissemination of microbial contaminants from house flies electrocuted by five insect light traps.* Intern. J. Environ. Health Res., 1995. 5: p. 303-309.
43. Urban, J.E. and A. Broce, *Killing of flies in electrocuting insect traps releases bacteria and viruses.* Current Microbiol., 2000. 41(4): p. 267-270.
44. Szumlas, D., J.A. Hogsette, and C.J. Geden, *Filth Fly Session*. Pest Management: Meeting Force Health Protection Challenges and Supporting the Global Security Mission, ed. A.F.M. Board. 2007, Naval Air Station, Jacksonville, FL: www.afpmb.org/meetings/TriService2007/2007proceedings.
45. Axtell, R.C. *Livestock integrated pest management (IPM): Principals and prospects*. in *Systems Approach to Animal Health and Production: A Symposium, March 31-April 2*. 1981. Lexington, KY: University of Kentucky.
46. Axtell, R.C., *Poultry integrated pest management: Status and future.* Integrated Pest Mgmt. Rev., 1999. 4: p. 53-73.
47. Stafford, K.C. and C.H. Collison, *Poultry Pest Management for Pennsylvania and the Northeast*. Special Circular 338. 1987: The Pennsylvania State University. 10.
48. Pickens, L.G., *Factors affecting the distance of scatter of house flies (Diptera: Muscidae) from electronic traps.* J. Econ. Entomol., 1989. 82(1): p. 149-151.
49. Anderson, J.F., et al., *Control of house flies in commercial poultry houses in Connecticut.* Poultry Sci., 1986. 65: p. 837-844.
50. Thompson, S.A., et al., *Reduction in manure weight and volume using an in-house layer manure composting system under field conditions.* J. Appl. Poultry Res., 2001. 10: p. 255-261.
51. Pitts, C.W., et al., *In-house composting to reduce larval house fly, Musca domestica L., populations.* J. Appl. Poultry Res., 1998. 7: p. 180-188.
52. Webster, A.B., N. Hinkle, and S.A. Thompson, *Commercial egg tip: Can in-house composting reduce flies in high-rise layer houses?*, in *University of Georgia CES Poutry Tips*. 2005.
53. Axtell, R.C. *Use of predators and parasites in filth fly IPM programs in poultry housing*. in *Status of Biological Control of Filth Flies, Proc Workshop February 4-5*. 1981. Gainesville, FL: USDA.
54. Stafford, K.C., III and D.E. Bay, *Dispersion statistics and sample size estimates for house fly (Diptera: Muscidae) larvae and Macrocheles muscaedomesticae (Acari: Macrochelidae) in poultry manure.* J. Med. Entomol., 1994. 31(5): p. 732-737.
55. Kaufman, P.E., et al., *Population dynamics of manure inhabiting arthropods under an integrated pest managment (IPM) program in New York poultry facilities-3 case studies.* J. Appl. Poultry Res., 2002. 11: p. 90-103.
56. Geden, C.J., D.A. Rutz, and D. Steinkraus, *Virulence of different isolates and formulations of Beauveria bassiana for house flies and the parasitoid Muscidifurax raptor.* Biol. Control, 1995. 5: p. 615-621.
57. Lecunona, R.E., et al., *Microbial control of Musca domestica (Diptera: Muscidae) with selected strains of Beauveria bassiana.* J. Med. Entomol., 2005. 42(3): p. 332-336.
58. Barson, G., N. Renn, and A.F. Bywater, *Laboratory evaluation of six species of entomopathogenic fungi for the control of the house fly (Musca domestica L.), a pest of intensive animal units.* J. Invert. Pathol., 1994. 64: p. 107-113.

59. Renn, N., A.F. Bywater, and G. Barson, *A bait formulated with Metarhizium anisopliae for the control of Musca domestica L. (Dipt., Muscidae) assessed in large-scale laboratory enclosures.* J. Appl. Entomol., 1999. 123: p. 309-314.
60. Watson, D.W., et al., *Efficacy of Beauveria bassiana for controlling the housefly and stable fly.* Biol. Control, 1995. 5(3): p. 360-367.
61. Kaufman, P.E., et al., *Evaluation of Beauveria bassiana applications against adult house fly, Musca domestica, in commercial caged-layer poultry facilities in New York state.* Biol. Control, 2005. 33: p. 360-367.
62. Scott, J.G., et al., *Insecticide resistance in house flies from caged-layer poultry facilities.* Pest Mang. Sci., 2000. 56(2): p. 147-153.

NOTES

NOTES

About the Author

Dr. Kirby Stafford is a medical-veterinary entomologist whose research in Connecticut focuses on the ecology and control of the blacklegged tick. He received his B.S. in entomology and M.S. in veterinary entomology from Colorado State University and Kansas State University, respectively, and his Ph.D. in medical/veterinary entomology from Texas A&M University in 1985 on house flies and the distribution of fly predators. After working at Penn State on a poultry pest management program, he joined The Connecticut Agricultural Experiment Station in 1987 to work on ticks and Lyme disease. Dr. Stafford is currently Vice Director, Chief Entomologist and State Entomologist at The Connecticut Agricultural Experiment Station. His Tick Management Handbook is a widely used resource on ticks, tick-associated diseases, and tick control.

The Nation's First State Agricultural Experiment Station

The Connecticut Agricultural Experiment Station is a state-supported scientific research institution dedicated to improving the food, health, environment and well-being of Connecticut's citizens since 1875. The Connecticut Agricultural Experiment Station investigates the growth of plants and studies their pests, insects, including mosquitoes and arboviral disesases, ticks, soil and water quality, and food safety, and performs analyses for state agencies. Station staff members register and inspect nurseries, certify honey bee colonies, and inspect thousands of individual plants or other regulated material being shipped into or from Connecticut.

The Experiment Station first opened its doors in a laboratory in Wesleyan University in Middletown in October 1875. It was moved to Yale University in 1877 and to its current location in New Haven in 1882. Today, the Experiment Station is composed of one administrative and six scientific departments with around 100 scientists, technicians, and support staff. The Experiment Station also operates a 75-acre research farm in Hamden and a farm at its Valley Laboratory in Windsor, Connecticut. The newest addition in 2008 is state property in the Towns of Griswald and Voluntown. A research center will be developed there.

Among many information sheets and publications, The Experiment Station's web page (www.ct.gov/caes) features this handbook and an extensive electronic Plant Pest Handbook, which covers diseases, insects, cultural and nematode problems of Connecticut plants.

The Connecticut Agricultural Experiment Station

Putting Science to Work for Society

Founded 1875

This handbook is available in electronic format at www.ct.gov/caes

Printed by EPS Printing II, LLC, South Windsor, Connecticut