FLIES

The order Diptera, the flies, is one of the largest and most dynamic orders of insects. Adult insects in this vast order are characterized by having only one pair of wings and one pair of **halteres**, which are small knoblike structures located behind the wings. Mosquitoes (see Chapter 3) are also in this order. Because of the large number of pests in this group, flies are often referred to by family name, for example, Tabanidae for horse flies or Calliphoridae for blow flies. Some family names are provided in this chapter.

Flies create some of the most common public-health insect problems. Important around the world as vectors of major diseases such as sleeping sickness, leishmaniasis and typhoid fever, in the U.S. they can be a major source of mechanically transmitted diarrheal illnesses and occasional cuticular disorders, such as pinkeye. Because they can be associated with human excreta, flies can become involved in enteric (intestinal) disease cycles. Besides being annoying, some biting fly species may transmit **pathogens** that cause tularemia.

Some **species** deposit eggs or larvae on the flesh of living animals. Larvae then invade host tissues producing a condition known as **myiasis**, which occurs infrequently in humans in the U.S. Through sheer numbers, some domestic nonbiting flies can be a nuisance to people in their work, home or recreational environment. Several species of flies and gnats are important household pests, not only because of the general annoyance, but also because of their association with filth and ability to harbor pathogenic organisms on their mouth and body parts.

I. DEVELOPMENTAL STAGES

Eggs. Most species of flies lay eggs, but a few species, such as flesh flies (Sarcophagidae), retain the eggs in the body and give birth to **larvae**. Flies are very specific in selecting **oviposition** sites. Such selectivity causes many females to oviposit at the same site, for example, many filth flies oviposit preferentially on manure. This mass oviposition results in large egg clusters and concentrations of larvae in isolated spots instead of uniform distribution throughout the breeding media.

Larvae. Larvae of most flies are thin-skinned, legless, cylindrically tapered maggots with a pair of mouth hooks at the tapered end and a pair of breathing spiracles at the blunt end. Larvae can be identified to family and sometimes to species by the characteristic shape of the posterior spiracle. The mouth hooks are used primarily for tunneling. Larvae are able to eat solid food only after it has been liquefied by being predigested externally with secreted enzymes. The larvae, after reaching full development by going through several **instars** (usually three), migrate to a drier habitat if the medium is too moist and enter a prepupal state in which they cease to feed before actually pupating. Larvae of most species will burrow about an inch into the soil to pupate. This burrowing ability is well-developed. Larvae of certain species can easily tunnel to the surface when buried under 1 to 4 feet of soil.

Pupae. During the prepupal stage, the larval skin contracts and hardens into a protective shell for the fly developing within. This shell, called a puparium, is usually capsule-shaped and brown. The fly, after undergoing **metamorphosis**, escapes the puparium by breaking off a section at one end of the puparium. House flies and most larger filth-inhabiting flies escape with the aid of an inflated balloonlike sac, called a ptilinum, that protrudes from the frontal portion of the head between the eyes. This sac, which is used to apply pressure to break the puparium, is withdrawn into the head after use. Newly emerged flies have shriveled wings and are usually pale and soft-bodied. They do not acquire their typical

colors and shape until they have had sufficient time to dry and harden. The soft-bodied condition of newly emerged flies aids them in working their way through crevices in the soil. Newly emerged flies can easily reach the surface after being buried under 1 to 4 feet of moderately packed soil.

Adults. With a few exceptions, adults have in common the single pairs of wings and **halteres**. Many flies have lapping-sponging mouthparts that require all solid food to be liquefied before ingestion. However, many other species are blood feeders and have various specialized **piercing-sucking** mouthparts adapted to their needs.

In some groups both sexes feed on blood, whereas in others only the females do so. They use the protein for egg production. Flies have from one to several generations per year and exhibit a wide variation in this parameter, dependent on species and environmental conditions.

II. BIONOMICS AND HABITAT

Filth-breeding Flies

Flies in the **genus** *Musca* (family Muscidae) have long been known as transmitters of filth and disease. Flies alight upon and frequently eat almost any kind of filth. Then, being strong fliers, they may visit human food or walk over the face, eyes and lips of infants or sleeping adults, shedding bacteria and other pathogens as they go. Because of their **sponging** mouthparts, these flies can take only liquid food and typically dissolve solids either in saliva or regurgitated stomach contents. They have a keen sense of smell, a thirst for most liquids and are capable of flying up to 20 miles in a day. They are a nuisance in homes, dairies, stables, poultry houses and other animal buildings, particularly under unsanitary conditions.

House fly. The house fly, *Musca domestica* (Figure 6.1), causes complaints in residential and commercial areas near sanitary landfills, poultry farms, dairies or other sources of rotting organic matter of plant or animal origin that attract oviposition. It breeds primarily in garbage and fresh, accumulated, wet poultry and dairy manure and occasionally in carrion. Breeding in household garbage containers can be a source of house fly infestation if garbage pickup is less than twice weekly. This fly enters homes freely and is highly attracted to fresh food.

Figure 6.1. House fly

Although house flies are opportunistic breeders, they are specific in selecting a suitable microhabitat for oviposition. Thus, they may not breed uniformly in accumulated manure but are found clustered in large aggregations in isolated wet spots. Breeding at dairies often occurs in wet, accumulated manure under fence lines of cattle pens but generally not in individual cow dung pats. Knowledge of these preferences is helpful when control is required.

House fly maggots hatch and pass through three developmental stages during a three- to five-day period before migrating from the moist area and changing into an oval-shaped, reddish-brown **pupa**. The adult fly develops and emerges after about a week or less. At summer temperatures the life cycle may be completed in seven to 10 days, and the adult may survive for several weeks. This rapid development accounts for the great increase in house fly numbers that occurs when breeding sites are available during warm weather.

Adult house flies have stout grayish-colored bodies about ¼ inch in length and one pair of clear, unmarked wings. They are most numerous around areas where animals are kept, especially during the

summer months, but are aggressive foragers and visit a wide variety of habitats. They are commonly seen resting on posts, walls and ceilings around lights, or searching for food from various organic sources.

Lesser house flies. Along with house flies the lesser house flies, *Fannia* spp., are generally the most prevalent flies found within the home in certain parts of the U.S. *Fannia canicularis* males hover in midair in the center of a room or enclosure, lending the name "hover fly" to this group, and are persistently annoying. Oviposition occurs in a wide variety of animal manure and decaying materials. The larvae live in decaying vegetable and animal matter including human excrement, animal manure and rotting grass piles. Duration of larval development averages seven days during the summer, and the entire life cycle can be completed in 15 to 30 days under favorable conditions. *Fannia* larvae have been known to cause **myiasis** in humans. In addition, food contamination can occur as a result of their association with filth.

Face fly. The face fly, *Musca autumnalis*, looks very much like the house fly and lays its eggs in the open on fresh cattle manure pats, where the larvae develop. This fly's life cycle takes about two weeks. Unlike the house fly, face flies are pests of cattle in pastures during the warm months. Their mouthparts can rasp soft tissue and cause ocular damage in livestock. They transmit pinkeye and annoy cattle to the point of bunching, which causes economic losses. Face flies are facultative blood feeders and will quickly leave cattle to feed on blood in wounds on humans. In the fall they migrate to houses, where they pass the winter. During warmer days in late winter and early spring, some may come out of their hiding places in attics and walls and appear in windows, particularly on the south side of structures.

Dog dung fly. The dog dung fly, *Musca sorbens*, is a close relative of the house fly. Found in Hawaii, it is not the most prevalent species in residential areas, but it generates the most complaints because of its annoying and persistent attraction to the human body. This fly usually does not enter homes or darkened areas and is not particularly attracted to fresh food. The fly feeds primarily on dog and dairy cow dung and is only moderately attracted to garbage. It is attracted to sores and will often rasp at the scab formed on wounds to feed on the exuding fluids. Breeding occurs almost exclusively on dog dung and individual cow dung pats and not on accumulated poultry or dairy manure.

The dog dung fly resembles a half-sized house fly but is distinguished by its shiny, two-striped thorax. It can also be recognized by its persistent efforts to alight on one's body. About 15 days after the larvae hatch, the resulting females are ready to produce eggs and typically live another two to three weeks.

Blow flies. Blow flies (Figure 6.2) are members of the family Calliphoridae. The bronze bottle fly, *Phaenicia caprina,* is the most prevalent home-invading species in residential areas. It is usually this fly that is referred to when complainants claim that hordes of flies appear on their window screens while they are cooking. Sudden appearance of many adults inside a house indicates previous breeding in an unemptied kitchen trash can or other indoor source. Larvae usually crawl out of the trash can and pupate in carpets or other areas. This fly also breeds and feeds on carrion and garbage but not on animal dung. It is not strongly attracted to fresh food as it prefers slightly decayed or fermented food. Many blow fly species cause myiasis in animals and humans.

Figure 6.2. Blow fly

The bronze bottle fly is metallic green with a bronze sheen. Newly emerged adults are usually greener than older flies that have accumulated filth on their bodies. The black thoracic spiracles separate

this species from *Chrysomya* and *Phormia* species. The life cycle is similar to that of the house fly but closer to 14 days.

The oriental blowfly, *Chrysomya megacephala*, aggregates in large numbers following emergence from animal carcasses or garbage, and adults can be seen resting on walls or fences waiting for their bodies to harden. Complaints of hordes of large green flies in the garage or basement usually indicate breeding from a dead rat or dead pet. This husky, bright metallic green calliphorid with large, red eyes resembles *C. rufifacies* and *P. regina* except that its thoracic spiracles are light brown on the upper half and dark brown on the lower half. This fly rarely enters homes since it is not particularly attracted to fresh food. Breeding in residential areas occurs primarily in garbage and carrion. Animal farm breeding occurs in semiliquid chicken manure and on scum around edges of piggery effluent ponds but not much at dairies. Maggots of this species are able to survive in semiliquid material that would drown most other species. It has a short life cycle, reaching the adult stage in about eight days, but then survives up to six weeks or more.

Attic or cluster flies. The cluster fly (*Pollenia rudis*) is also in the family Calliphoridae. Cluster flies — along with house flies, face flies, some blow flies and flesh flies — normally overwinter as adults. The small fly is slightly more than ¼ inch long with gray or yellowish hairs on the thorax and no stripes. Its abdomen is dark gray with light patches.

In nature, overwintering locations are under bark and in hollow parts of trees. The flies begin seeking shelter at the end of the hot part of summer. If they begin investigating structure walls in their search for winter harborage, their upward movement often brings them to openings under siding and ventilators, weep holes in masonry, cracks around windows, wire penetrations, wall voids and openings around the roof. There and in unused attics they settle down to overwinter. Flies hidden in attic cracks will begin flying to windows on warm winter days. They often make their way down through closets and chimney cracks into living spaces of the house. This same behavior takes place in office buildings, hospitals and other structures.

Flesh flies. Flesh flies (Figure 6.3) belong to the family Sarcophagidae. They are similar to blow flies in both larval and adults habits. Adult flesh flies are grayish with black stripes running the length of the top surface of the thorax. They look like oversized house flies. Flesh flies found in the home may have been attracted to odors of decay or were simply seeking shelter. The adult flies of this large group normally do not enter homes. The larvae of most species live in animal matter. Many are parasites of insects, but some live in manure, particularly dog feces. A few species can be involved in **myiasis**.

Figure 6.3.
Flesh fly

Fruit flies. *Drosophila* and members of the family Phoridae are small flies from two different fly families that are often mistaken for each other. They are about ⅛ inch long and somewhat similar looking, but their biologies are very different.

Figure 6.4
Fruit fly

Fruit flies, *Drosophila* spp. (Figure 6.4), are attracted to nearly any material that is fermented by yeast. These small flies commonly have bright red eyes, although some species' eyes are dull dark red. In a common fruit fly infestation, flies are attracted to the sweet odor of fermentation in ripe fruit, such as bananas, where they oviposit in the cracks of the peel. Fruit fly larvae hatch, then feed on yeast cells in the fruit. The life cycle can be completed in not much more than a week.

Newly emerged adults are attracted to lights, but egg-laying females will not leave fermenting materials. Fruits, vegetables, beer, fermenting water from refrigerators, humidifiers, sink drains, sour mops and rags, and fermenting pet food are examples of oviposition sites. Infestations are common in orchards, breweries, restaurants, supermarkets, canneries, hospitals and homes.

Phorid flies. Phorids or humpbacked flies are about the same size as fruit flies or a little smaller. They are dark brown and look humpbacked because the small head is located low on the front bulge of the thorax. Phorids run in short jerks. These flies become problems when they infest decomposing plant or animal matter. Buried animals, garbage or broken sewer lines support large numbers of phorids. Phorids also infest bodies in mausoleums.

Adults are able to emerge from the underground infestation site upward through several feet of soil. If broken sewer lines are under buildings, phorids can come up through cracks in concrete floors or around floor drains. When water and sewage wash out cavities in the soil around the pipe, immense numbers of flies are produced.

Filter flies. Moth flies, drain flies or filter flies (Figure 6.5) belong to the family Psychodidae. These small, dark flies are about ⅛ inch long with wings covered by tiny hairs and held in rooflike fashion over the body. Filter flies have long, drooping antennae. Larvae live in the gelatinous material in sink drain traps and sewers. Where sinks regularly overflow, these flies build up in the overflow pipe. When drain traps of sinks, commodes and floor drains dry out, large numbers can enter dwellings from the sewer.

Figure 6.5. Filter fly

Drain traps should be cleaned mechanically or with drain cleaners because without larval control, adults will constantly emerge. In sewage treatment plants, drain flies feed on the gelatinous material that collects on stones in trickling filter beds. Over time, however, cast skins from these filter flies can slow down water drainage. When sewage treatment plant filter beds malfunction or become "out of balance," the moth flies can become problems in nearby neighborhoods. The filter bed should be cleaned by reverse- or back-flushing.

Fungus gnats. Fungus gnats are slender, delicate, dark-winged, mosquitolike insects of the families Mycetophilidae and Sciaridae. Their larvae infest moist soil and feed on fungi associated with decaying vegetation. Indoors, fungus gnats infest the highly organic soil of potted plants. They also build up in pigeon droppings on outside ledges, then enter dwellings through nearby windows.

Figure 6.6. Eye gnat

Eye gnats. Eye gnats, *Hippelates* spp. (Figure 6.6), are small flies that hover around the head and persistently try to settle on the moisture present in the membranes around the eyes. Larvae of these pests are found in wet silage in crop harvesting areas and in corn and wheat stubble that has been plowed into the soil. They can be present is very large numbers and in addition to the annoyance created, they can transmit pinkeye and other bacterial infections in humans.

Midges. Often called blind mosquitoes, midges look very much like mosquitoes but do not bite. They belong in the family Chironomidae. The larvae live in water, especially in the quiet, still water of lakes and ponds. Adult midges often emerge in droves and are attracted to the light of dwellings, where

they cause considerable nuisance by entering homes and degrading recently painted surfaces. The larvae of some midges are indicators of pollution problems.

Blood-feeding Flies

Each year throughout the U.S., rivers, lakes and wetlands produce enormous hordes of bloodsucking **dipterans** that are strong fliers and aggressive biters. Many dipteran families include closely related species that emerge sequentially throughout the spring and continue into the summer and fall (and some into and through the winter period in the South), leaving little time between waves for either human or animal relief. Seldom is pathogen transmission an issue, but the severity of attacks is indicated by the fact that wild and domestic animals can be stampeded by these biting flies and many records exist of animal suffocation resulting from the overwhelming onslaught of these pests. Years of severe activity tend to coincide with or follow periods of above average rainfall that causes elevated surface water levels and an expansion of breeding habitat.

Black flies. Black flies (family Simuliidae) are found throughout the U.S. For example, more than 30 species are found in the state of New York. They are also called turkey gnats and buffalo gnats. At least one species is known to be a mechanical vector of tularemia in humans, and they transmit some serious disease organisms to turkeys and ducks. Only the females are capable of taking a blood meal. When black flies bite with their bladelike mouthparts, most people react rather violently to the anticoagulants pumped into the wound. The bite may cause itching and swelling that sometimes persists for a week or more. Black flies are often present in very large numbers.

The eggs of black flies are dropped during flight into streams, where they settle to the bottom and accumulate in the quiet eddies and pools of the stream, or they are laid in the stream on rocks or other objects over which a very thin film of water flows. Some eggs hatch within a few days, and others may not hatch for months or until the next spring. Eggs survive even when the streams dry up and then hatch almost as soon as the streams start to flow. The **larvae** are found in great numbers attached to vegetation, stones and sticks that trail in the water.

Although most of the species prefer turbulent streams, a few are more abundant in slow-moving streams. The larvae attach themselves to a rock or plant and move about either by attaching to small pads of silk they secrete or by hanging to a silken thread. Large mouth brushes screen food from flowing water. The food is largely bacteria, algae and protozoa. The mature larvae spin a slipper-shaped cocoon that is attached to the surface on which they are fastened. Within the cocoon the larvae transform into **pupae**. In a few days the pupae transform into **adults**.

The adult black flies emerge from the cocoons and rise quickly to the surface of the water. They can immediately fly away and with large flight muscles are strong fliers. They disperse rapidly and flights of more than a mile are common. Some species have a single brood each year that may emerge very early in the spring or in early summer. Species that produce several broods each year are commonly found in the warmer streams.

Tabanids. Horse flies are large, heavy-bodied flies that may reach up to 1 inch in length. Deer flies (yellow flies, green heads) are generally smaller (¼ to ½ inch long), and their wings are often patterned with characteristic light and dark areas. Both groups belong to the family Tabanidae, in which only the females take blood meals. Tabanids range from green to tan and black. They often have distinct markings and brightly colored or iridescent eyes. Their bites are painful, and species of at least one genus serve as mechanical vectors of tularemia.

The larvae of most species are aquatic or semiaquatic. They are often associated with moist situations such as marshes, swamps, and shorelines of lakes and ponds. Deer fly larvae feed primarily on decaying organic matter, whereas horse fly larvae prey upon a wide variety of invertebrates, including each other. The larvae may molt more than 10 times before pupating and emerging as adults.

Although strong fliers, adults are often found around the larval habitat. But they may move considerable distances to find a blood meal. Both sexes feed on plant nectar and pollen to obtain energy. The female feeds on blood to develop eggs. Mating takes place soon after emergence. Once mated, the female deposits an egg mass on plants, rocks, sticks or other similar objects usually over water or other favorable larval habitat. Egg masses are deposited throughout the life cycle of the female. Upon hatching, the larvae burrow into mud or moist earth and begin feeding. Depending upon the species and climatic region, there are usually one or two generations per year.

Stable fly. The stable fly or dog fly, *Stomoxys calcitrans*, is similar to the house fly in size and coloration, but the mouthparts of both sexes are adapted for piercing the skin and taking blood. Larvae and pupae are similar to those of the house fly. The life cycle of the stable fly is similar to that of the house fly but takes about twice as long under similar conditions. The stable fly breeds in urine-soaked straw, spilled green chop or manure if it contains a high proportion of straw, and in vegetation strewn along shorelines of lakes and bays. Accumulations of wet grass clippings from yards and golf courses, spilled straw, and compost piles also are breeding places. The stable fly prefers a moister breeding area than the house fly, and larval development takes 10 to 14 days.

Stable flies are capable of long distance movement, which occurs when they are picked up by weather fronts and carried for several hundred miles. Uninfested areas thus can become heavily infested almost overnight. This phenomenon can occur often and has been documented with observations of flies moving from Nebraska to Florida in this manner. These aggressive and painful biters can disrupt recreational activities and are capable of mechanical transmission of some animal disease pathogens.

Biting midges. These insects are tiny, but very aggravating biters sometimes called “no-see-ums,” “punkies” or “salt marsh sand flies.” Belonging to the genera *Culicoides* and *Leptoconops*, they breed in intermittently inundated fresh, brackish and saltwater habitats or in moist soil, often associated with specific marsh or pasture grasses. Intertidal areas along the coasts are prolific development sites for biting midges. Often there are enough species to ensure that at least one is actively foraging each morning, afternoon or evening of every day in every season in areas where climate allows continued breeding. Upland farm ponds provide breeding habitat along the edges. One species transmits blue tongue disease of cattle and sheep. Several may be vectors of tularemia. Only the females bite.

III. FLY SAMPLING AND SURVEILLANCE

Proper surveillance of fly populations requires an excellent understanding of the biology of the target insect. Visual observations of adult fly populations reveal which species are present and in what numbers, but not the origin of the flies. The most reliable method of finding the breeding sources often is by conducting larval surveys. Identification of the adult pest frequently provides the clues necessary to narrow the search for immatures through understanding of the breeding habits.

It must be emphasized that observations of large numbers of adult flies in an area should not be relied upon as conclusive evidence of nearby breeding — as the case of stable fly dispersal with weather fronts testifies. But when it is possible to detect nearby larval activity by visiting typical sites that appear favorable for breeding, further extensive sampling might be unnecessary.

Both biting and nonbiting flies have well-tuned sensory systems that guide them to preferred feeding and breeding locations. Filth flies often congregate in large numbers when highly attractive food or oviposition sites are present. Bloodsucking flies will predictably migrate from their breeding sources to whatever extent is required to obtain a bloodmeal.

Fly traps made of framed screening with a funnel entrance placed over an attractive bait can be highly productive for house flies, flesh flies and blow flies. But typically, the density of these insects is monitored by counting how many alight in one minute on a fly grid, which is a 2x2-foot square constructed with 16 parallel ¾-inch slats. Stable flies can be trapped on Alsynite® fiberglass panels treated with a sticky covering. Other biting flies, including black flies and biting midges, are responsive to carbon-dioxide-charged CDC traps (Figure 6.7). Standard landing and biting counts can provide permanent records of relative density.

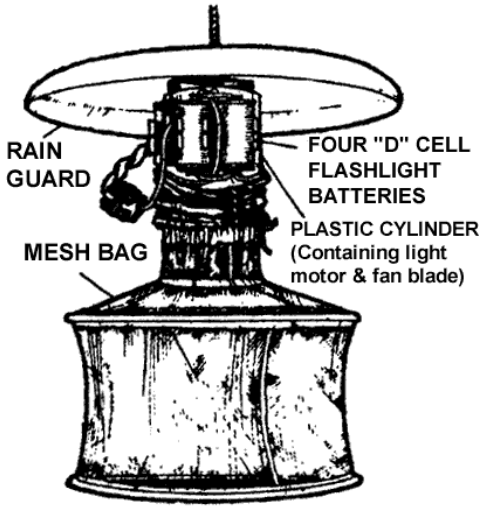

Figure 6.7

Larval sampling for black flies involves lifting and examining stones and other objects from the stream. Midge larvae are sampled by taking soil cores and recording subsequent emergence or forced migration of the **larvae** to the core surface. Inspection of prospective breeding sites is standard practice for detection of house fly and stable fly larvae. In these instances the samples are generally qualitative rather than quantitative.

IV. CONTROL

Filth fly problems represent excellent opportunities to apply sanitation and environmental tactics to manage the pest populations. Common pests, such as the house fly, have been exposed to so many pesticides over the years that many populations are highly resistant to most classes of **insecticides**. But, where they can be a problem, strict attention to management of breeding sites is highly effective. The need to control adult flies can be minimized through this mechanism.

For many other flies, especially the blood feeders, larval habitat can be large, diverse and ecologically sensitive. In many situations, control technology for adults is simply not available or is often uneconomical because of the dimension of the problem. However, in most cases there are ways to get relief and maintain activities in their presence.

Nonbiting Flies

Sanitation. Environmental control consists of cleaning garbage collection areas and the residues found at bottoms of trash cans, keeping loading docks clean and using other physical measures to prevent breeding. Twice-a-week garbage collection is the minimum recommended frequency for adequate fly prevention. In many communities open dumps have been replaced by sanitary landfills that compact the daily dumping and cover it with soil. This method reduces odors and fly breeding. Daily compaction and twice-a-week soil cover is the minimum frequency for adequate fly control.

The primary cause of excessive fly breeding at animal farms is often poor water management. Poorly constructed effluent ditches and leaking watering systems account for much of the wetting of manure that causes fly breeding. Any recommendations for fly control should give water management first priority for the permanent reduction of fly breeding. Proper grading of the land to ensure rapid drainage during the rainy season is an important feature.

Regular removal of accumulated manure from outdoor animal pens should be practiced as a routine management feature, with particular emphasis on removal of dung under fence lines. Often the work involved would seem to be considerable, but during dry periods the specific areas that are responsible for the bulk of the fly breeding usually turn out to be in small, isolated sections. Collected manure should be stored in cone-shaped piles; these piles reduce the surface area for breeding while the heat from fermentation makes the interior unsuitable for the flies. The outer surfaces of these piles dry rapidly and tend to narrow the zone in which the larvae can develop. Wetting of old manure piles usually does not cause house fly breeding since they prefer fresh manure. The fact that the dog dung fly and the face fly breed exclusively in fresh dung pats makes their control more difficult.

Dry manure is also the key to fly control at poultry farms. Leaking watering systems should be repaired and manure cones under cages not removed unless absolutely necessary since they act as a sponge to rapidly dry the fresh manure. House fly breeding occurs under cages in which manure cones have been removed because of the slower drying of the fresh droppings.

Daily washing of hog pens and adequate wash water lagoons greatly minimize fly breeding at hog farms. Breeding along effluent ditches can be eliminated by construction of concrete-lined ditches, an expensive action often rejected by farmers. But with the rapid suburbanization of rural areas, and the ensuing complaints of fly nuisance, it may turn out to be the cheapest and most effective method of control.

Indoor pests, such as the phorids, filter flies, fungus gnats and fruit flies, also can be controlled by sanitation measures, repair and cleaning of pipes and drains, and reduction of moisture levels in potted plants and other breeding sites.

Screening and caulking. Window and door screens are the most effective fly exclusion method, although occasionally tiny flies, such as fungus gnats, will pass through 16-mesh window screens. While these tiny flies can be prevented from entering by painting the window screens with varnish to reduce the mesh size to 23-mesh equivalent, that also reduces movement of air through screens. Paying special attention to gaps, tears and failure to close by sealing, caulking, repairing and installing automatic door closers can be highly effective at reducing entry. These measures may be particularly effective in preventing access of cluster flies and face flies that are seeking overwintering sites, when combined with fly proofing of access routes, such as ventilators, louvers, clapboard siding, etc.

Commercial establishments successfully use air curtains that are created by specially manufactured fans placed above doorways to produce a draft that is strong enough to prevent flies from entering. Air conditioning has significantly reduced the presence of flies in stores and homes.

Electrocution devices. Electric zappers are effective only in the context of the overall program. By themselves, they cannot control a fly population. Often such devices are used in conjunction with a black light attractant. This ultraviolet light may be harmful to eyes under prolonged exposure, so they should be placed with care, beyond the range of other lights. Because zappers cause insects to explode and fragment and thereby contaminate nearby objects and space, their use indoors has been replaced in

commercial establishments with glue boards. Attraction of flies to buildings can be reduced by replacing white security bulbs with yellow bulbs.

Biological control. Several natural parasites and predators forage on fly larvae and pupae. Fly programs based on sanitation, rather than pesticides, are more likely to benefit from these influences.

Poison baits. The poison bait station is an effective public relations tool on occasions when the inspector has difficulty in locating or eliminating the source of fly breeding. The sight of many dead flies surrounding a bait station visibly assures the public that some action is being taken while giving the inspector time to do the real job of permanently controlling the source of breeding.

A liquid bait trap works well for blow flies and house flies and is capable of eliminating temporary infestations in small areas and reducing fly populations in larger areas if many traps are used. Dry, commercially prepared, sugar-based baits are effective if properly used and become more effective when placed in plywood trays or other shallow containers that retain dead flies. The decaying odor of accumulated dead flies makes the trap even more effective. Dry sugar baits are generally unattractive in areas that are hot and dry; wet baits should be used in these dry areas. In Hawaii, dog owners can use fresh dog feces as a bait for the dog dung fly. Dry sugar bait or a mixture of water and sugar bait may be used on fresh dog feces.

Outside residual sprays. Flies alighting on surfaces treated with residual sprays either absorb the toxicant through the **tarsi** (feet) or ingest it with their mouthparts. Residual spraying may be enhanced by the addition of a pound of sugar to each gallon of spray to make it also act as a bait. However, because flies have become resistant to most insecticides, this method is now seldom practiced.

Larvicides. Larviciding with insecticides is not recommended unless judicious care is made in its application. Indiscriminate **larviciding** kills valuable parasites and predators of flies. The treatment of those breeding areas that contain only the nuisance species is made possible by the fact that most nuisance flies have specific preferred breeding sites. Long-lasting residual insecticides are unnecessary since the exact conditions that attract egg-laying last only for a short period and make continued breeding in the same spot unlikely. These spot treatments will not appreciably affect fly parasites because most usually attack the pupal stage. Predators are also not greatly affected since they do not congregate in large numbers at fly breeding sites. Larviciding should be used only when other measures are either not possible or are unsuccessful. Spot treatments with insect growth regulators are preferable and more beneficial than those made with other types of chemical larvicides.

Fly cords. Cotton fly cords impregnated with residual insecticides can be hung from ceilings of buildings. Cords are effective because they take advantage of the habit of the house fly to rest on vertical objects. These cords should be handled with care because they are usually formulated with high concentrations of relatively toxic insecticides. With the widespread incidence of insecticide resistance, the use of sticky paper fly strips where practical is recommended.

Space spraying. Space and area spraying with mist, fog or **ultra-low-volume** (ULV) spraying apparatus is used to eliminate adult fly infestation in large areas. To avoid aggravation to people with respiratory problems, residents should be warned before application. Bug bomb aerosols are usually recommended only for indoor use; the user should spray directly at the offending fly to conserve expensive aerosols.

Blood-feeding Flies

Only a few of these flies are routinely subject to control activities. Black fly, stable fly and tabanid populations can be managed to some extent. Some of the measures used for nonbiting flies are effective at reducing human exposure to biting flies, such as screens and other exclusion devices for most species and management of breeding habitat for stable flies. But for the most part, control of these pests is specialized and often economically restrictive.

Larval control. Black flies are highly susceptible to **biorational** formulations consisting of dead bacteria. When applied to the streams where black flies breed, their filter-feeding behavior effectively captures particles containing the bacterial spores that contain toxins specific for Diptera. Ingestion of these particles releases the toxins from the dead bacteria into the larval gut, thus killing the larvae. Treatments are conducted by air or by point application from bridges or other fixed locations on the river or stream. Bacteria remain suspended in the moving water for several miles downstream and are picked up by black fly larvae as they pass.

Stable flies can be controlled in the larval stage by application of insecticide to the breeding habitat (freshly cut and rotting plant materials) or by removal or covering (exclusion) of the breeding substrate.

Adult control. Stable fly adults frequent the beaches in the southern U.S., where they drive tourists and residents alike away from their vacation and entrepreneurial activities. The resulting impact on the local economy is such that aerial insecticide application is routinely called upon to provide relief. Application designed to drift the formulation onto the beaches provides temporary control of these vicious biters.

Most blood-feeding dipteran adults, including black flies, tabanids and biting midges, can be controlled by **ULV applications** of the appropriate pesticide. But these pests quickly reinfest the treated areas, and the relief is only temporary. Thus, while initially effective, this type of control is not commonly conducted. Homeowner outdoor **space spraying** using a power mister to clear a back yard for a few hours is a relatively common occurrence.

These same insects can be managed with residual applications of insecticides. For example, homeowners can apply insecticides to window screens to kill biting midges that are trying to access the interior of the house. These applications may persist and remain effective for several weeks. In similar fashion, insecticides can be applied to shrubbery and other resting sites of these biting flies to serve as an effective barrier to pest infiltration for a week or two.

Carbon dioxide trapping of biting midges has been shown to protect people within a perimeter of such traps. As long as the carbon dioxide is released, the midges are trapped and do not reach their normal hosts. Similar findings have been reported with mosquitoes.

Tabanid flies are fairly strongly attracted to movement and dark objects. Some species can be controlled on a back yard or community basis by hanging insecticide-treated black spheres 12 to 18 inches in diameter from branches and other suitable supports. In Florida, community-level homeowner protection from yellow flies has been accomplished with pyrethroid-treated or sticky-coated beach balls painted black and hung from branches near homes adjacent to marshy breeding sites.

Personal protection with repellents should not be underestimated. Several commercially available repellents are quite effective against biting flies.

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