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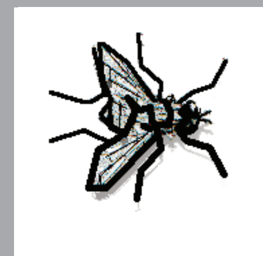
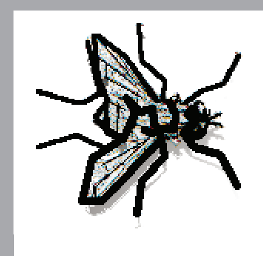
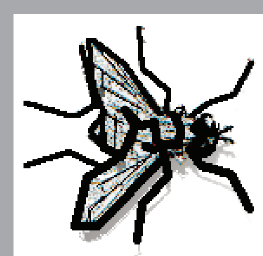
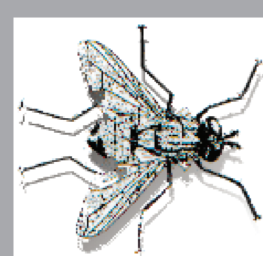


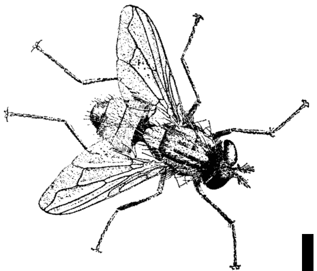
Integrated pest management of flies in Texas dairies







Contents



Integrated pest management of flies in Texas dairies

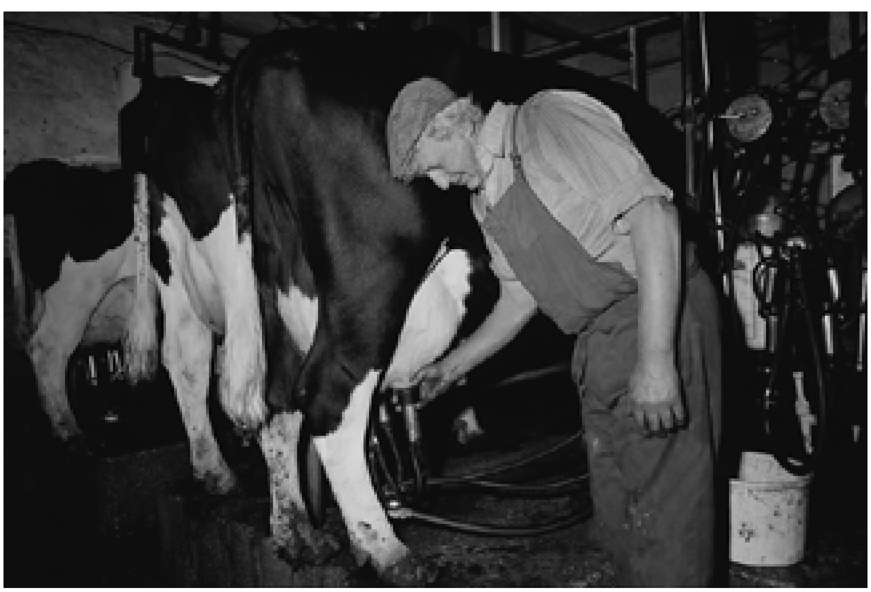
Douglass E. Stevenson and Jesse Cocke*

FLIES IN DAIRIES are managed best when producers coordinate several methods that together offer good control at low cost. Called integrated pest management (IPM), this approach reduces dependence on chemicals, instead combining sanitation practices, biological control and chemical agents to reduce fly populations.

The integrated approach to fly control is needed because:

- Fewer effective fly-control insecticides are available.
- Flies are becoming more resistant to insecticides.
- New regulations require reductions of insecticide residues in food.
- People need to reduce their exposure to insecticides.
- Dairy systems are expanding, producing more intense fly breeding.
- Concern is growing over the cost/benefits of fly control in dairies.
- Flies harm animals and lower milk production.
- The public is more aware of the health and annoyance problems flies cause.

Dairy producers need to understand the factors producing fly populations, including climate, regional terrain, management practices and production facility design. To keep fly populations the lowest at the least cost, producers should take action at decisive times in the pests' life cycle. Knowing the biology of the major fly pests — houseflies, stable flies, horn flies, garbage flies and blow flies — can help producers implement a successful dairy IPM program.



Dairies that control flies can increase production and reduce annoyance and disease spread.

* Extension associate; Extension entomologist; The Texas A&M University System

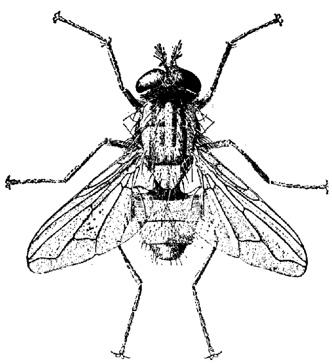


Fig. 1. Housefly adult

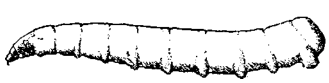


Fig. 2. Housefly maggot

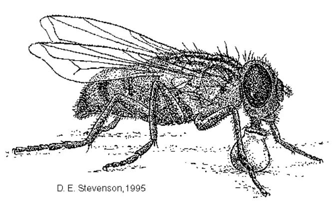


Fig. 3. Housefly regurgitating while feeding

Housefly *Musca domestica* L.

The most common, most prolific and most costly fly pest in dairies is the housefly (Figure 1). Besides annoying animals and people, houseflies spread diseases from animal to animal and to humans.

Life cycle

The housefly passes through four life stages: egg, larva (maggot), pupa and winged adult. Under ideal conditions, the life cycle may be as short as six days. In Texas, two to three generations may develop per month during warm months. Adult female flies have been known to lay more than 2,000 eggs, but normally produce about 500 to 600 eggs during their lifetime. Eggs are laid in clusters of 75 to 150 every three to four days during a 31-day period.

Flies usually deposit eggs in wet, decaying organic matter such as manure and spilled feed. After hatching, the cream-colored fly larva, or maggot (Figure 2), feeds from four to six days. The fly grows during the larval stage, the size of the adult being dependent on how big the larva grows during feeding.

After feeding, the maggots crawl away from moist feeding areas to a dry habitat to pupate. They may spend three to four days in this prepupal or migratory stage before pupating in dry feed or manure. Once at rest, the larva transforms into a brown, nonfeeding seed-like pupa. The pupa remains stationary until it emerges from the old larval and pupal skins as an adult fly.

Under ideal conditions, houseflies multiply quickly. Just one pound of wet manure can yield more than 1,500 maggots. It is possible for 1,000 pounds of wet manure to harbor 1.5 million larvae. This means that even small breeding areas can produce many flies.

Economic importance

Houseflies can spread diseases and parasites from one animal to another and to humans. Their feeding method and ability to carry diseases make them a constant threat to milk production and animal and human health (Table 1).

The housefly can consume food only in liquid form. When feeding, it frequently regurgitates droplets of food and saliva from its sponging mouthparts (Figure 3). Regurgitation helps the fly liquefy solid food. Then it can reconsume the mixture as it feeds on various food sources.

Male and female adult flies eat feed, excrement and other decaying organic matter. They usually pick up pathogens and parasites by walking over materials containing them, contaminating their wings and feet. When feeding, the flies' intestinal contents also become loaded with disease agents. The flies redeposit the disease agents each time they defecate, feed or vomit.

In a dairy, heavy housefly populations can cause serious economic problems (Table 2). Virus diseases carried by flies include bovine virus diarrhea (BVD), the bovine herpesvirus (BHV-1) causing infectious bovine rhinitis (IBR), and parainfluenza 3 (PI3). Fly-borne bacterial diseases include pink eye, mastitis, bacterial scours, typhoid, anthrax, vibriosis and several clostridial diseases.

Houseflies have harbored more than 100 different species of pathogenic organisms. Studies have incriminated them in more than 65 human and animal diseases. They also can transport eggs and infectious larvae of several important parasitic worms.

Economic thresholds have not been established for housefly populations in dairies. However, nuisance levels (Table 3) that annoy animals correlate closely with the incidence of such diseases as pink eye and mastitis. Tol-

HOUSEFLY PROBLEMS

Table 1. Economic problems from high housefly populations in dairy operations.

- Reduce milk production through annoyance
- Annoy humans and interfere with work such as milking and feeding
- Increase frequency of animal disease
- Raise disease medication costs
- Increase veterinary service costs
- Prompt complaints and legal action from the public
- Increase the potential for spread of contagious human diseases

erance levels often depend on the size of the area infested with flies.

Left unmanaged, houseflies can irritate cows, lowering feed conversion and milk production. Similarly pink eye, mastitis and other infectious diseases may spread more rapidly through the herd. Cow irritability and disease raise labor, medication and veterinary costs. Income also drops with production losses.

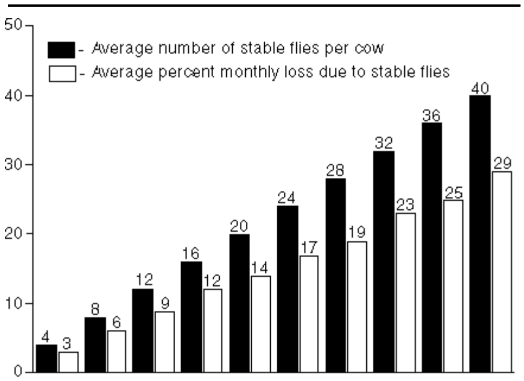
Stable fly *Stomoxys calcitrans* (L.)

The stable fly (Figures 4 and 5) feeds on blood. Although it is in the same family as the housefly and resembles it slightly, the stable fly bites aggressively. It is easily distinguished from the housefly by its piercing-sucking mouthparts, which it carries in a sheath projecting forward from under the head. When feeding, the stable fly inserts its mouthparts into the host to withdraw blood. Both males and females feed on blood, frequently changing position on the animal or moving to other hosts until they have engorged themselves with blood.

Stable flies also differ from houseflies in that they require a looser, drier environment and a superior diet. Stable flies prefer an undigested food supply higher in protein. They breed in decaying hay, straw, grain and mixtures of grain, manure and hay residue. Ideal breeding sites are manure piles containing mixtures of manure, urine-soaked bedding, straw and undigested feed. Stable flies develop less well in manure than in manure mixed with undigested food.

Milk production loss

Table 2. Milk production loss related to stable flies.



Bruce & Decker, Illinois

Nuisance levels

Table 3. Nuisance or tolerance levels for houseflies

Dairy location	Mean no. flies
Milk holding room	50 total
Milking parlor (closed)	200 total
Milking parlor (open)	400 total
Building walls	100/100 sq. ft.
Feeding lanes (per side)	100/10 linear ft.
Commodity surfaces	200/100 sq. ft.
Commodity barn walls	100/100 sq. ft.
Open lot holding areas	200/100 sq. ft
Cows	20-40 per head
Calves	10-20 per calf

Life cycle

The female stable fly crawls into loose breeding material and deposits from 25 to 50 eggs at each egg-laying site. It may lay as many as 600 eggs during its lifetime. In about three days, the eggs hatch into larvae, which feed for about two weeks before transforming into the nonfeeding pupal stage. In about 10 days, the adult stable fly emerges. On average, the life cycle from egg to adult requires about 28 days.

After mating, female adults return to their breeding sites to lay eggs. Soggy, fermenting hay and manure residue left in piles or under feed bunks is an ideal habitat for larval development. Old straw piles that remain moist during spring, summer and fall can harbor large fly populations.

Economic importance

Stable flies irritate cattle during resting, feeding and milking. Research shows that high populations of stable flies can lower milk production by 15 to 30 percent.

Stable flies usually bite during daylight hours. They can irritate cows so severely during milking that some cows kick off their milkers. They also bite humans and can torment workers during milking and feeding. Stable flies may travel several miles to find blood meals and suitable breeding sites.

The stable fly also can carry several animal diseases, including anthrax and trypanosomiasis.

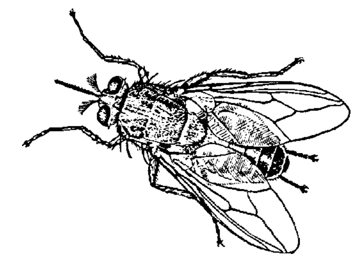


Fig. 4. Stable fly adult

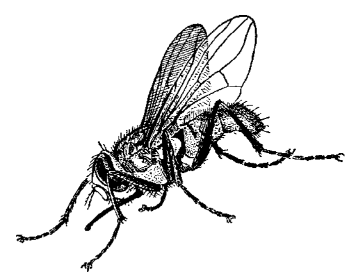


Fig. 5. Stable fly adult, side view

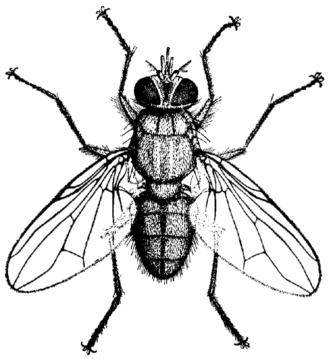


Fig. 6. Horn fly

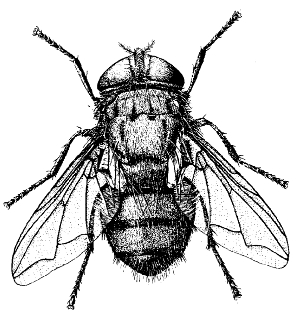


Fig. 7. Black garbage fly

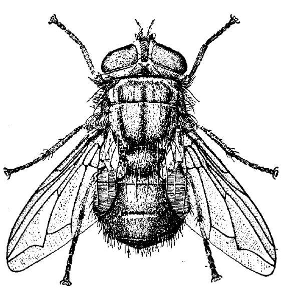


Fig. 8. Black blow fly

Horn fly *Haematobia irritans* (L.)

About half the size of the housefly or stable fly, the horn fly (Figure 6) is similar in color to the stable fly and also feeds on blood. Horn flies remain on the cow all the times. Females leave the animal only to deposit eggs on fresh manure.

Life cycle

A horn fly lays eggs in groups of three to seven on the manure surface, rarely depositing more than 20 eggs. Larvae hatch within 24 hours. They develop rapidly, reaching complete growth in three to five days. Then they crawl to drier parts of the manure to pupate, and remain in the pupal stage six to eight days before emerging as adults.

Under ideal conditions, the entire life cycle from egg to adult takes from 10 to 14 days. After emerging, adults fly to animals where they remain.

Economic importance

Constant feeding by heavy horn fly populations annoy, irritate and take blood from cattle, causing them to lose weight and eat much more feed than necessary. Cows heavily attacked by horn flies may lose half a pound of body weight per day. Milk production may drop as much as 10 to 20 percent.

Garbage and blow flies

Black garbage flies (*Ophyra spp.*)

Sometimes called "dump flies," garbage flies (Figure 7) are shiny black and about two-thirds the size of houseflies, with a similar life cycle. Garbage flies breed in the same habitat as houseflies and may become very abundant. Two species, *Ophyra ignava* (Harris) and *Ophyra aenescens* (Wiedemann), inhabit confined animal facilities in the United States.

Garbage fly larvae feed on housefly larvae and may reduce housefly numbers while increasing their own. They may become almost as annoying as houseflies when the two occur together.

Blow flies (*Family Calliphoridae*)

Several species of blow flies, including the black blow fly (Figure 8), *Phormia regina* (Meigen), inhabit confined animal production facilities. They are robust flies with a metallic sheen to the body. Species vary in color, ranging from green and blue to bronze-black and the color of a new penny. Ordinarily larger than houseflies, green blowflies and blue blowflies have stout bristles but no stripes on the back or thorax (Figures 9 and 10).

The blow fly life cycle is similar to the housefly's. It passes from white eggs through three larval (maggot) stages (Figure 11), a pupal and an adult stage. To develop, however, blow flies require a wet medium and a diet rich in animal protein. They prefer to breed in decomposing animal carcasses, afterbirth and areas contaminated with spilled milk. Though less well, they can develop in decaying manure and spilled feed when other food sources are unavailable.

Good sanitation can prevent major problems with garbage and blow flies.

Integrated pest management - IPM

Dairy flies can be managed effectively and economically using integrated pest management. IPM is not a way to control pests, but a way of thinking about pest control. It links many control methods into one system, excluding any that disrupt or diminish the effectiveness of the others. In IPM, all control methods must support each other.

Figure 12 shows a decision-making flow chart that includes four courses of action: chemical; larvacide-supplemented; IPM; and spray-as-needed, late-season suppression. All but the IPM program depend almost exclusively on chemical control methods. Larvicide-supplemented control is simply a variation of chemical control.

The spray-as-needed plan to defer any action until flies reach problem levels carries the highest risk. Putting off a decision until later in the season or adopting a "wait-and-see" attitude allows fly populations to explode. Sometime in mid or late summer, fly populations will multiply out of control. No amount of late-season spraying will bring an exploding population under control. The flies will have the day.

The IPM strategy uses as many nontoxic or nonlethal methods as possible to suppress fly population growth. It unites sanitation, biological control and chemical agents to manage flies effectively and economically. Compared to other approaches, the IPM method usually presents the lowest expenses and risks.

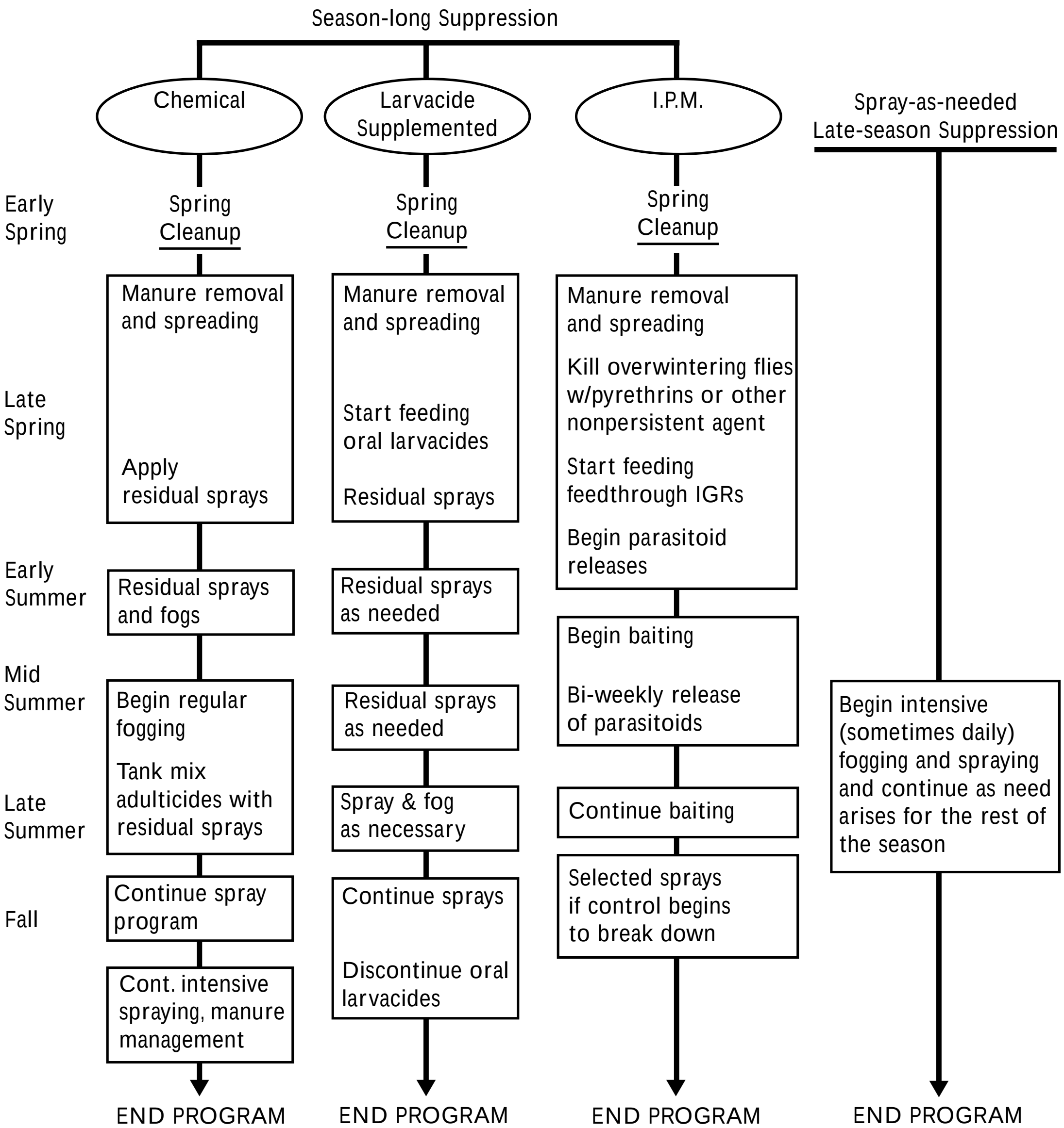
Dairy fly IPM activities should begin in winter or spring before flies are active and continue until fly activity shuts down at the end of the season. A good fly-control plan includes sanitation, biological control and chemical agents.

Sanitation

To implement a successful IPM program, begin with sanitation and manure management. Spring is a good time to remove and spread manure and to suppress overwintering flies. At lower temperatures, flies are frequently more

INTEGRATED PEST MANAGEMENT - IPM

Fig. 12. Dairy fly pest management decision making flow chart for planning IPM actions for season-long fly control



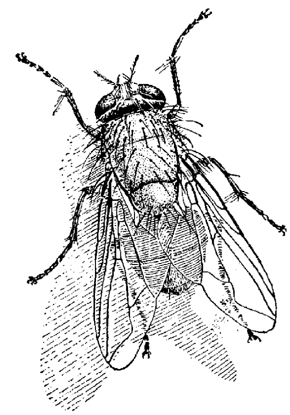


Fig. 9. Green blow fly adult (top view)

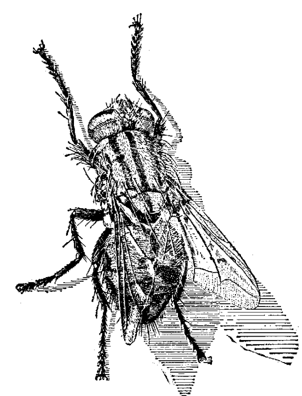


Fig. 10. Blue blow fly

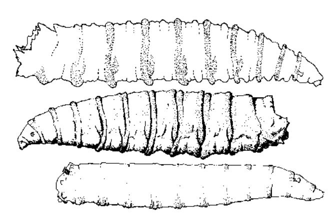


Fig. 11. Blow fly maggots (side view)

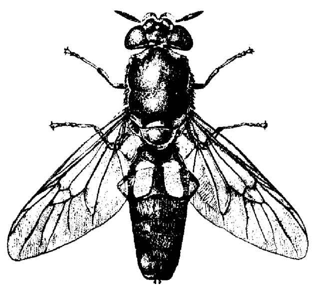


Fig. 13. Black soldier fly

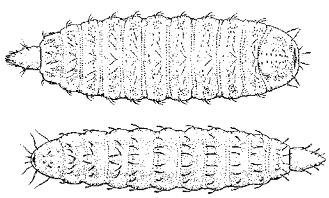


Fig. 14. Black soldier fly larvae

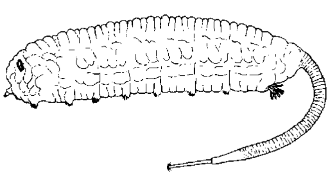


Fig. 15. Rat-tailed maggot (syrphid fly larvae)

active than their natural enemies. This offers an opportunity to use short-term, nonresidual pesticides to reduce fly numbers.

Adopt these sanitation practices in early spring to prevent heavy housefly and stable fly populations from developing:

- Clean and move calf hutches regularly. Elevate one side of the hutch to allow air circulation or provide ventilation in construction. Clean calf holding pens weekly if possible. Calf manure attracts flies rapidly.
- At least weekly, clean open feeding lanes and concrete corners where the feed stall(s) curb meets the drive-through feeding lane slab.
- Completely clean entrance and exit lanes (alleyways) to and from the milking area daily or after each milking.
- To prevent floating mats on the edges of lagoons where anaerobic respiration has declined, collect debris from runoff collection channels, sediment basins and retention ponds regularly.
- Keep the outside corners next to exit walkways from barns weed-free. Clean them at least weekly. In these areas, manure may wash over the curb to the outside of walkways.
- Remove and spread straw and manure piles frequently to eliminate stable fly breeding sites. Immediately dispose of dead calves, cows and afterbirth to prevent disease spread and blow-fly breeding.
- Never allow silage residue to accumulate at openings to pits on bagged silage.
- **Scrape pens** at least weekly to clean out manure. Remove manure piles within five days. Maintain at least a **3 to 4 percent pen slope**; avoid creating potholes during pen scraping. Maintain broad, shallow sediment basins to keep solids uphill away from runoff holding ponds. Use a **separate drainage** system from each pen. Keep the drain system at a uniform slope of 3 to 4 percent from feed bunks to the back of the pen. Maintain this slope through alleyways into main drainage channels.
- To move manure from pen to pen for complete manure collection and piling, clean under **fence lines** using a tractor front-end mounted push bar or other methods.
- Clean **manure spreaders** regularly to prevent fly breeding.
- Prevent moisture from accumulating at the entrances of feed holding facilities (commodity barns) and feed mixing areas.
- Use vertical-sided feed bunks and water troughs. Prevent manure from building up in these areas for more than seven days. Use overflow drains on water troughs to prevent water from overflowing into pens and feeding areas; fix water leaks.
- Move round bale feeders regularly to prevent manure, urine and hay buildup that can breed stable flies. To prevent housefly and stable fly breeding, scrape, pile, remove and spread manure-straw mixtures and clean under elevated feed bunks in pens.

Biological control

In IPM, lethal methods target the pests and avoid injuring helpful insects. To suppress fly populations, dairy producers can use such natural enemies as black soldier flies, rat-tailed maggots, beetles, mites and wasps.

Beneficial insects and arthropods

Black soldier fly [*Hermetia illucens* (L.)]

The black soldier fly (Figure 13) is a large (2 cm long) blue-black fly with black legs, white-yellow tarsi (feet) and two clear or translucent areas on the dorsal part of its abdomen. Females prefer to lay eggs in drier areas of manure, where they produce about 900 eggs in several batches, which hatch in about four days. Larvae pass through five instars over two or more weeks. During feeding, the large larvae (Figure 14) churn and liquefy the manure, making it less suitable for house fly development.

Large populations of soldier fly larvae not only reduce housefly larvae, but also discourage houseflies from laying eggs in the same habitat, such as in areas along drainage canals and around settling basins and lagoons.

Rat-tailed maggot [*Eristalis tenax* (L.)]

The rat-tailed maggot (Figure 15) is the larval stage of the syrphid fly (Figure 16). Large and cylindrical, the larva has a long filament-like tail projecting from the posterior end of the body, as the name implies. The tail is actually a breathing tube with two openings, or spiracles, at its tip. Surrounding the breathing tube are tiny hairs that allow the tip to take in air at the water surface. Larvae develop through three stages, each having a caudal projection or tail. When fully mature, the third stage is about 1 inch long.

Rat-tailed maggots gather in polluted liquid habitats such as run-off ditches, pools, settling basins and waste lagoons. They are important because they aid in decomposition and reduce other fly breeding in these habitats.

Excessive pesticide run-off may kill rat-tailed maggots. Feed-through larvicides also may destroy these good fly larvae or impair their development. Premise sprays may kill adults.

Predators (Beetles and mites)

Predatory beetles in the families Staphylinidae and Histeridae feed on fly eggs and larvae. Both larval and adult stages of these beetles are efficient fly predators. A small black beetle, the histerid, *arcinops pumilo* (Erichson), may consume 13 to 24 house fly eggs per day. Its larva eats two to three eggs per day. Dung beetles bury manure, aid in its decomposition and make it unsuitable for fly larval development (Figure 17).

Mite predators belonging to the families Parasitidae, Macrochelidae and Uropodidae feed on housefly eggs and first instar larvae.

Parasites (Wasps)

The fly parasites most commonly associated with dairy operations are small wasps (Figure 18). Three genera in the wasp family Pteromaldae are effective fly parasites: *Muscidifurax*, *Spalangia* and *Pachycrepoideus*. The most common species in confined animal operations are *Muscidifurax raptor* Gerault and Sanders; *S. nigroaenea* Walker, *S. cameroni* Perkins, *S. nigroaenea* Curtis; and *Pachycrepoideus vendemiae* Rondani.

Female wasps of these species actively search for fly pupae. The female wasp pierces the pupal skin and inserts a single egg into each fly pupa. Once the egg hatches, the parasite develops through three larval instars while feeding on and killing the fly pupa. After feeding, the larva pupates inside fly pupal skin. Later, the mature wasp cuts a hole in the fly puparium and escapes as an adult parasite. The parasitic wasp completes its entire life cycle in about three weeks.

Some adult parasites probe pupae and feed on the pupal exudate, killing the pupa without laying eggs in it. As a result, many damaged fly pupae fail to develop into adult flies. Parasitism of fly pupae on some dairies can reach 4 percent, but 5 to 15 percent is much more common.

Another parasite species, *Nasonia vitripennis* Walker, lays many eggs per fly pupa, producing as many as seven to 10 adult parasites from a single fly pupa. However, it is scarce, both naturally and where augmentive releases have occurred.

Under certain conditions, augmentive releases of fly parasites may increase parasitism rates and reduce fly populations. However, little is known about augmentive parasite releases, including guidelines on the species, numbers, times and conditions of parasite releases. When considering parasite augmentation, first use cultural and management techniques to increase the parasite populations occurring naturally.

Parasite species differ in their response to climate, weather and micro-habitat. The substrate and its condition also affect certain parasite species' ability to establish themselves.

Spalangia usually parasitize fly pupae buried 3/8 inch or less deep in manure or substrate. Researchers found that *Spalangia cameroni* Perkins occurs more often in loose substrates regardless of moisture. However, studies show that *Spalangia nigroaenea* Curtis prefers pupae in sheltered moist feed and wet straw.

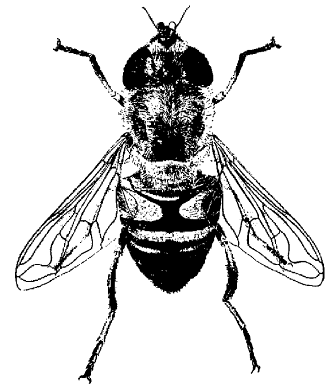


Fig. 16. Syrphid fly

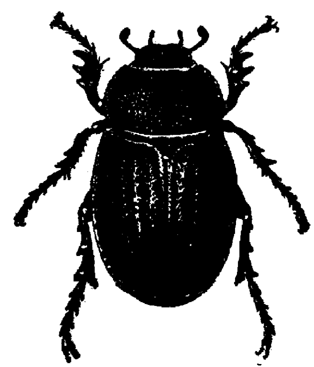


Fig. 17. Dung beetles

Fig. 18. Parasitic wasp on fly pupa

A drought-resistant strain of *Spalangia endius* is active at lower temperatures and hybridizes with other strains of *S. endius*. The offspring of these crosses are stronger and live longer.

Muscidifurax attack fly pupae 3/16 inch deep or less in dry or moist manure under feed bunks, fence lines and manure piles. These species occupy the broadest niches on the dairy, reproducing in older pupae and in those parasitized earlier by other parasites. They also survive longer when hosts are not immediately present.

Muscidifurax raptor and *M. zaraptor* are apparently less effective in hot, dry climates. However, a strain of *M. zaraptor* occurring in Colorado and New Mexico can better resist climate extremes and can forage better than those in California and the Midwest.

Dairies should release only those parasites that can effectively establish themselves. To establish itself, a parasite must find a suitable host and reproduce on the host in sufficient numbers to sustain population growth. A recent study of parasites released in Texas dairies showed that less than 15 percent of fly pupae contained parasites. Most of the parasites were species of *Spalangia* and *Muscidifurax*. The most efficient parasite was *Spalangia cameroni*, which accounted for about 41 percent of the parasites recovered. *S. nigroaena* accounted for another 17 percent; *S. endius*, 14 percent; and *Muscidifurax raptor* and *M. zaraptor*, only about 5 percent. Various other parasites accounted for the rest of the species recovered from parasitized pupae.

Another two-year study rated commercial parasite release material from two companies. This study showed that the commercial material contained mainly *M. zaraptor*, *M. raptor* and *S. endius* in various frequencies during the spring and summer. No shipments contained *S. cameroni* nor *S. nigroaenea*, even though these parasites establish most frequently on Texas dairies and feedlots.

The level of fly control to expect from adult parasites feeding or foraging on fly pupae is still unknown.

Parasites

Table 4. Pteromalid parasitoids that have established more and less frequently in Texas dairies and feedlots.

Established most frequently
Muscidifurax zaraptor Kogan and Legner
Muscidifurax raptor Gerault and Legner
Spalangia nigroaenea curtis
Spalangia endius Walker
Spalangia cameroni Perkins
Established less frequently
Nasonia vitripennis
Urolepis rufipes (Ashmead)
Spalangia nigra Latrielle
Spalangia drosophililae (Ashmead)
Pachycrepoideus vindemiae (Rodani)

Suggestions for using parasites

- Release only species that have shown ability to establish themselves (Table 4). Ask dealers the composition of their release material.
- To promote establishment, release parasites in early spring.
- Practice maximum sanitation in early spring to reduce breeding sites and adult populations.
- Place parasites directly on specific remaining fly breeding sites in early morning or late afternoon.
- Use at least 100 to 200 parasitized pupae per square foot of breeding media saturated with maggots and pupae.

Chemical control

Chemicals used for fly control must be applied to specific areas. Where proper sanitation occurs, it is seldom justifiable to use premise sprays or pesticide applications to entire dairies. Most insecticides are broad-spectrum, killing pests as well as fly predators and parasites. To preserve such natural enemies as mites, beetles and wasp parasites, spray insecticides only where flies and larvae are abundant. Such spot larvicide applications reduce overall populations of parasites and predators only slightly.

Reduce drift by applying surface sprays for adult flies as coarse droplets. Direct any residual surface treatments to structures where flies rest, such as upper partitions and the upper parts of buildings that show fly spotting.

Houseflies develop resistance to insecticide rapidly. To avoid resistance, follow resistance management practices strictly, alternating or rotating classes of insecticides. Do not use pyrethroids consecutively. Alternate them with organophosphates or carbamates, but not with methoxychlor or other DDT-related compounds, because both classes of insecticide affect the same target site. This means they both produce the same type of resistance. Pyrethroid-resistant flies also resist methoxychlor.

Also, DDT- and methoxychlor-resistant flies probably will resist pyrethroids. When using pyrethroid surface sprays, use organophosphate dust bags or self-treatment devices. For organophosphate surface or premise sprays, use pyrethroid or methoxychlor dust bags or self-treatment devices.

For adult flies, chemicals are used in sprays, mists, self-application devices, baits and traps (Table 5). Surface applications of pesticides are effective where adult flies gather or rest. Larvae are suppressed with sprays and feed-through or oral larvacides (Table 6). Larvicidal pesticide applications work where maggots are abundant and biological control has failed.

Adulticides

Sprays

Surface sprays are dilutions of pesticide formulations applied as coarse droplets. Applied to walls, posts, ceilings and other structures, formulations used as surface sprays include wettable powders (WP) or emulsifiable concentrates (EC). Surface sprays create a long-lasting toxic surface to control flies where they rest. To wet surfaces completely, apply these sprays at pressures of about 40 psi, but not to the point of run-off. For small areas, hand-pumped compressed air sprayers may be the most economical.

Larger operations may require low-pressure roller or piston pumps driven by motors. Small gasoline engines or power-takeoff equipment serve this purpose well. Wettable powders or soluble powders usually control flies longer. However, wettable powders require constant agitation to keep them from settling to the bottom of the tank. When applying wettable powders as residual sprays for fly control, be sure the spray tank has bypass or mechanical mixing to keep chemicals suspended.

Mists

Mists are sprays with very small droplets used exclusively to control adults. Mist droplets are so small that they float freely in the air and take a long time to settle, directly exposing adult flies to the insecticide as they fly through the air. Insecticides used in mist sprays produce quick knock-down and are useful as short-term space sprays. Mists have little or no long-term residual effect. They are most effective when used to reduce quickly the number of flies in and around facilities.

Tractor- and R.V.-mounted equipment is available for larger facilities. Small hand-carried or backpack equipment may be useful for localized applications. Hand-carried mist generators are available in both gasoline- and electric-powered versions. Misting equipment breaks insecticides into fine droplets either by mechanical means (rotating plates or vanes) or by shearing with high volume air or a combination action.

Various concentrations of mists may be produced by mixing active ingredients with either water or oil solvents. Oil solvents include refined kerosene, mineral oil or other organic solvents. Oil controls flies more rapidly. However, petroleum products may irritate animals or present a fire hazard. Ultra low volume (ULV) application equipment produces mists with undiluted high concentration formulations, with particle sizes around 15 to 30 microns in diameter.

Automatic misting systems installed with timers are also available. They use “piped-in” insecticide mixes through nozzles at exit walkways and lanes. Connecting pressurized cylinders directly to the system avoids the need for electric power. Although convenient, automatic misting have several disadvantages: They are expensive to install, maintain and operate; air currents may move insecticide away from animals, wasting it; and drift may kill parasites far from the source.

ADULTICIDES

Table 5. Adulticides for use on dairy flies.

Horn flies: (on animal)

Pyrethrins + Synergist—use as needed (aerosol)

Permethrin:

Atroban 11% E.C.—use per label directions

Ectiban 5.7% E.C. - use per label directions

Insectiban 5.7% E.C. - use per label directions

Permectrin II 10% E.C. - use per label directions

LiquiDuster 1% - Rope wick in exit walkway self-treatment

Synergized DeLice 1% - 0.5 oz/100 lbs. up to 5 oz/animal

Permectrin 25% WP - 1 lb/50 gal. water (wet animals)

Permectrin 0.25% dust - 2 oz/animal or dust bag

Rabon (tetrachlorvinphos) 3% dust - 2 oz/animal or Dust Bag

Marlate (methoxychlor) 50 WP - 1 Tablespoon/animal or Dust Bag

Ear tags (two/cow)

Ectrin (8.0% fenvalerate)

Atroban (10% permethrin)

Expar (10% permethrin)

Ear Force (10% permethrin

Gardstar Plus (10% permethrin)

Deckem (10% permethrin)

Perma-Tect (10% permethrin)

Perma-Tech II (10% permethrin + chlorpyrifos 6.6%)

Ear Force Ranger (10% permethrin + 4.2% pbc)

MaxCon (7% cypermethrin + 5% chlorpyrifos 13% p.b.o.)

PYthon (10% zetamethrin + 10% p.b.o.)

Dusts

Co-Ral (coumaphos 1% dust) - follow label directions

Marlate (methoxychlor 50% WP) - follow label directions

Rabon (tetrachlorvinphos) - follow label directions

Houseflies and stable flies

Pyrethrins + Synergists - aerosol spray formulations

Permethrin (on animal)

Atroban 11% E.C. - spray as label

Ectiban 5.7% E.C. - spray as per label

Insectiban 5.7% E.C. - spray as per label

Permectrin II 10% E.C. - spray as per label

LiquiDuster 1% - rope wick self treatment

Synergized DeLice 1% - 0.5 oz/100 lb or up to 5 oz max

Permectrin 25% WP - 1 lb/50 gal water (wet animals)

Permectrin 0.25% dust - 2 oz/animal or dust bag

Rabon 3% dust - 2 oz/animal or dust bag

Ear tags - provide only limited control of these flies

Premises:

Dairy barns

Dimethoate (cygon 23% E.C.) - 1 qt/6 gal water; use 1 gal mix/500 sq. ft.

Rabon 50 WP - 4 lbs/25 gal water; use 1 gal per 500 sq. ft.

Permethrin - both WP ad EX formulations

Pyrethrins + Synergists - aerosol sprays

UV light + sticky board - change sticky boards regularly

Other buildings

Diazinon 50 WP - restricted use (certified applicators only)

Naled (Dibrom 60% E.C.) - 3 pts/25 gal. water; use 1 gal. spray/500 sq. ft.

Dimethoate (Cygon 23% E.C.) - 1 qt/6 gal water; use 1 gal spray/500 sq. ft.

Rabon 50% W.P. - 4 lbs/25 gal water; use 1 gal/500 sq. ft.

Permethrin - WP and EC formulations as for adult fly applications (follow label)

Space sprays (blowers, foggers, mist systems)

Dibrom (36% E.C.) - 1 qt/40 gal water

Dibrom (1 % Ready-to-use) - 1 oz/3,000 cu. ft.

Ectiban 5.7% - mist undiluted 4 fl oz. per 1,000 sq. ft. surface

Insectiban 5.7% - 1 qt/12.5 gal diesel or mineral oil; use 4 fl. oz spray/1,000 sq. ft. in overhead system.

Atroban 11% E.C. - pt/10 gal diesel or mineral oil; use 4 fl. oz/1,000 cu. ft. in overhead system.

Permectrin II 10% E.C. - mist undiluted at 4 oz spray/1,000 sq. ft.

Pyrethrins + Synergist - follow label directions for each product.

Use mists only when wet weather prevents proper sanitation, allowing adult fly populations to become unacceptable.

Aerosol sprays under high pressure containing natural pyrethrins, PBO, and synthetic pyrethroids are available for space sprays. Aerosol space sprays are most useful in milk holding rooms, milking parlors and other building spaces.

Self-application

A highly cost-effective way to control flies chemically is self-treatment. This method allows animals to treat themselves with insecticide using various devices that apply formulations directly to the animal. Self-application devices include dusters, dust bags, liqui-dusters, and back rubbers and oilers. Various pesticides are labeled for use in self-application systems, including synthetic pyrethroids, organophosphates, and methoxychlor, a biodegradable chlorinated hydrocarbon. When using self-application systems, use caution and follow label instructions.

Baits

Fly baits usually contain an insecticide such as propoxur mixed with an attractive substance such as sugar or molasses. The most effective attractant is a pheromone such as z-9-tricosene. Other baits may contain the insecticide trichlorfon. Users also can prepare their own mixtures, but results from homemade baits may be somewhat erratic.

Traps

Traps are mechanical devices that capture and kill flies. Although properly belonging in a section outside chemical control, most traps involve chemicals registered as pesticides either as attractants or killing agents. All traps use attractants to lure flies to destruction in a container, on a sticky surface or on an electric grid. Some also contain an insecticide.

Traps come in many shapes, as simple as paper with a sticky surface or as complex as an electronic fly "zapper." Among the simplest and oldest traps are fly strips or fly paper, which have been used for more than a hundred years.

Container traps, variations of the old-fashioned bottle trap, are almost as old. They use chemicals to lure flies into a container from which they cannot escape and where they are held until they die.

Some electronic traps use ultraviolet light as an attractant. The light lures flies to a charged grid where a powerful current electrocutes them. Several electronic traps use both light and chemical attractants; they also may use a combination of electric grid and sticky surface to destroy flies. These are among the most complicated of all traps.

Many chemical attractants exist. The older ones are usually foul-smelling substances that mimic the odor of fly food. Some newer attractants are odorless feeding or sex attractants. The most powerful is z-9-tricosene, a sex and aggregation pheromone of the housefly. Used in most modern traps, z-9-tricosene has the common name Muscamone®.

Traps are useful where chemical use is difficult or impossible, or where residual sprays or mists are ineffective or inconvenient. These areas include milk holding rooms, milking parlors and feed holding and mixing areas.

Larvicides

Direct larviciding applies insecticide mixes to manure or other fly breeding sites. Larviciding should be applied with high-volume, large-droplet equipment. Always use a coarse spray and high-volume mix. Consider this type of application only where fly larvae are abundant and sanitation difficult. Chemical larviciding also may be effective where biological control has failed. Larviciding the whole dairy is never justifiable, and may reduce natural control, increasing the need for continuous insecticide control.

Use larvicides carefully. Most kill beneficial insects as well as fly larvae. Apply them if you have a "hot spot" of heavy fly larvae, where they damage overall beneficial insect populations only slightly. Insect growth regulators such as methoprene (Altozid®) do not affect most beneficial insects, controlling fly larvae only. However, methoprene may damage black soldier fly and rat-tailed maggot populations. Methoprene is the only larvicide registered for use in dairies that does not injure predators and parasites.

Feed-through or oral larvicides

Also available are feed and mineral larvicides, which can reduce fly breeding in manure and feed waste. When fed, oral larvicides prevent flies from developing in manure and spilled feed. They are ineffective against existing adult flies.

For the feed additive to be effective, animals must consume the recommended dosage, and all animals and manure must be treated. In areas with many separate dairies located close to each other, all must use oral larvicides to control flies effectively. Flies may migrate from one herd to another within a few days, traveling across many miles to any of dozens of dairies.

Larvicides are more effective against horn flies than for other flies. They do not control house flies, stable flies, garbage flies or blow flies completely because the flies develop in many sites other than fresh manure, including feed mixing areas, silage holding areas and feeding lanes.

Fly control with oral larvicides also requires good manure sanitation. Supplemental fly control is always needed where flies breed in manure from such untreated animals as indoor penned calves.

The active ingredients in feed-through larvicides include tetrachlorvinphos (Rabon®), methoprene (Altozid®), and phenothiazine. Only tetrachlor-vinphos and methoprene have tolerances in lactating cattle. Rabon 7.76 percent oral larvicide is suggested to be fed at 70 mg/100 pounds body weight. It comes in premixes, mineral mixes or blocks, molasses blocks, or in custom feed blends.

Principles of fly control

Nine principles govern fly control in dairies. They also provide excellent guidelines in your IPM program.

1. Set a measurable and clearly defined goal. If progress is slower than expected, perhaps your goals are ill-defined. Planning is essential in any IPM fly-control program. For each goal, lay out a plan of action that:

- Includes a way to measure progress.
- Plans for prevention.
- Includes only mutually compatible methods, eliminating those that counteract each other.
- Is simple and flexible to allow changes.
- Plans for setbacks.

2. Gain and maintain the initiative. Take action before problems arise. Get ahead of the flies before they get ahead of you. Start control activities early, use multiple methods, and keep constant pressure on flies throughout the season:

- Begin control activities while flies are still dormant.
- Monitor fly populations and control results.
- Adjust fly-control practices to meet new situations.
- Avoid repeating actions that have failed.
- Add control practices to support previous actions.
- Continue control efforts until fly activity stops at the end of the season.

3. Use everything needed to get the job done. Apply decisive force at critical times and places to achieve your desired goal. Don't scrimp on resources. Reluctant half-measures work against you.

4. Attack weakness, not strength. Flies have three great strengths: a short generation time, a high reproductive rate and the ability to detoxify many poisons. It is almost useless to attack the strengths head-on. IPM uses roundabout methods to gnaw at the strengths that allow fly populations to build up to economically harmful levels.

To erode the flies' strengths, dairy producers can:

- **Increase generation time.** The length of time it takes to produce a new generation of flies depends on conditions of the physical environment. Changing the environment can double and even triple the time that flies complete a generation.
- **Reduce reproductive rate.** The physical environment and amount of food available affect the flies' reproductive rate. Limiting available habitats and food can severely cut the fly reproduction.
- **Manage resistance.** Although flies rapidly become resistant to chemical control agents, resistance can be limited through many management strategies, some of which do not kill flies or maggots. For instance, insect growth regulators (IGRs) affect larval development and alter generation time and the number of individuals passing into the adult stage. This strategy preserves a large proportion of insecticide-susceptible individuals in the population and reduces the number of resistant adults reproducing in a succeeding generation.

LARVICIDES

Table 6. Larvicides for use on dairy fly larvae.

Rabon® 50WP - 4 lbs in 25 gal. water applied at 1 gal. spray per 100 sq. ft. of manure. Repeat at 7-10 day intervals.

D.z.n.® diazinon 50W - 4 lbs. in 25 gal. water applied at 1 gal. spray per 350-750 sq. ft. manure or debris.

Baits

Methomyl + tricosene (Golden Malrin) - Place where flies congregate away from feed, water, milking area. Apply where children, birds or animals will not contact.

D.z.n. Diazinon 50 W.P./Sugar/Molasses - Mix 1/2 lb. 50% W.P. with 1.0 lb. sugar or 2 cups of syrup or molasses and dissolve in 2 1/2 gal. of water. Treat around cracks, crevices, doorways, windows and other areas where flies congregate; do not contaminate milk, feed, water or apply where animals may consume.

Ultra low volume (ULV) applications (nuisance flies)

Aerial: Dibrom® 14 concentrate (85% Naled)—Dilute 100-230 fl oz (3/4-1 3/4 gals) Dibrom concentrate in 100 gals. No. 2 fuel oil or diesel oil. This is equivalent to 0.1 to 0.2 lbs. actual Dibrom per acre at 100 m.p.h.

Ground (Thermal Fog): Dibrom® concentrate (85% Naled) I—Dilute 1 gal. Dibrom to 99 gals. No. 2 fuel oil or diesel oil or 13 oz. Dibrom to 10 gals. oil. Apply at 40 gal/hr. at ground speed of 5 m.p.h. with swath of 300-400 ft. wide.

Flies also have four great weaknesses: They are vulnerable to changes in habitat, changes in food supplies, competition from other species, and predators and parasites. These well-known weak points have been the foundation of fly control for centuries.

To attack weaknesses, dairy producers should:

- **Change, limit or destroy larval habitats.** Habitat changes severely restrict fly development. The key is sanitation. Take preventive actions to reduce the size of available habitats. Spread and dry manure or store it as liquid until spreading. Maggots develop much more slowly at very high or very low temperatures and when the growth medium is too dry or too wet. Slight changes can double and even triple generation times. As a result, far fewer individuals survive, and populations are more exposed to natural control factors.
- **Limit or destroy larval food supplies.** Here, sanitation and feed commodity management are crucial. Make sure that livestock — not flies — get the feed. Keep commodities, hay and bedding materials dry. Without food or water, maggots die. Limit fly access to spilled feed, hay, silage and mixtures of feed and manure. This cuts he number of flies that live to maturity.
- **Encourage fly competitors.** Adult soldier fly larvae, rat-tailed maggots and dung beetles never bother livestock or people. However, they alter the development medium to favor their own kind. Fly competitors squeeze out flies by destroying the fly habitat and consuming available food. To encourage fly competitors, avoid contaminating their environment. Prevent off-target pesticide drift or runoff that can kill these valuable allies.
- **Cultivate and conserve fly enemies.** Birds, predatory beetles, mites and other predators take an enormous toll on flies. Provide shelter and protection for predators. Conserve parasites. Artificially increase parasite numbers through release programs. Limit pesticide use to areas that do not shelter helpful animals. Avoid pesticide drift or runoff. When possible, use chemicals that do not harm natural enemies. Use fly control practices that take advantage of fly natural enemies.

5. **Use only the material and effort necessary to achieve the desired result.** Don't waste time, energy or resources on overkill.
6. **Make all methods and actions work together.** Remember that you are in charge of your fly-control operation. Don't let the flies or other factors distract you from your goal.
7. **Continue to monitor fly populations throughout the season.** Don't be surprised by a fly population explosion. Be flexible in your use of time and IPM methods. Give yourself some space to adjust to situations as they develop.
8. **Do the unexpected.** Take advantage of materials and practices that flies have not experienced before. When flies resist a control agent or adapt to overcome a control practice, use new materials or different practices the flies have not recently encountered.
9. **Keep control efforts simple.** The more complex the fly-control operation, the more there is to go wrong.

Certain states **do not** recommend the use of oral larvicides or insecticides given through the feed. Rabon® oral larvicide, methoprene (Moorman's IGR), and phenothiazine feed additives often do not control flies unless used extensively.

Resistance

A disadvantage of feeding tetrachlorvinphos is resistance. Tetrachlorvinphos (Rabon®) is an organophosphate insecticide. When feeding Rabon® oral larvicide, flies are likely to resist other organophosphates.

This means that other insecticides in this class will be ineffective, including naled (Dibrom®), dimethoate (Cygon®, Golden Malrin Liquid®), coumaphos (Co-Ral®), fenthion, diazinon, malathion and many others. Bear resistance in mind when planning to use tetrachlorvinphos oral larvicides.

Methoprene oral larvicides do not produce resistance. However, they injure several helpful insects, including black soldier flies and rat-tailed maggots. Take precautions to keep methoprene from destroying them. **When feeding oral larvicides, follow label directions and precautions.**

Scouting for breeding sites

Only certain areas on the dairy may exceed the nuisance or tolerance levels of flies. Scouting is essential to find breeding sites and to decide where to apply additional sanitation and larvicides and where to release parasites. Check breeding media for maggots and pupae in these locations:

- In poorly drained cattle guards where manure and feed accumulates.
- Inside calf hutches around bottom sides where manure and bedding remain wet.
- Outside the curbing of exit walkways and lanes where the curb meets the soil and where manure and feed wash over the curb.
- On feeding lanes where upright concrete stalls meet drive-through lanes.
- Under open elevated feed bunks in holding lots where undisturbed manure and feed collect.
- In manure wash or flush canals away from free stalls where manure gathers and remains wet.
- In settling basins collecting debris alongside; at entrances and exits from basins.
- On excess floating mats on edges of lagoons where anaerobic respiration has declined.
- Around solid separators where manure accumulates and remains undisturbed.
- Around the edges of manure piles that have remained unmoved for 10 days.
- In entrances to silage pits where water has collected.
- On unwashed mechanical manure spreaders.
- At entrances and areas next to feed-holding facilities where moisture and feed collect.
- Along milk parlor exit lanes that collect manure.
- Along water troughs where manure collects.
- Under fence lines where manure has not been removed by scraping.
- In sick-calf and -cow pens where manure builds up along sides of sheds or under fence lines.
- Around water leaks where feed and manure may accumulate.
- Around feed-mixing facilities where feed spillage and moisture occur.
- Around bale feeders where manure and straw accumulate.

For IPM to work effectively, each control method must be timely, decisive and compatible with present and evolving dairy production practices. Once you have decided on a strategy, it is best not to switch to another. Adopting a course of action usually locks you into a chain of related activities until the end of fly season. By following the decision maker in Figure 12, you can design your own individualized program and adopt a program that best fits your operation.

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