Flies are insects in the order Diptera, meaning "two-winged." True flies have one pair of wings used for flying. Posterior to the wings is a pair of stalked knob-like structures (called halteres) which are organs of balance. Flies have complete metamorphosis, i.e., the life cycle consists of the following stages: egg, larva (called a maggot), pupa, and adult. The synanthropic flies associated with confined livestock production include species in the families Muscidae, Calliphoridae, Stratiomyidae, and Sypilidae. Most important are the species in the family Muscidae which includes the common house fly *Musca domestica* L. The house fly will be discussed in most detail since it is the major pest species and the primary target of fly control programs.

**HOUSE FLY** - *Musca domestica* L.,
Family Muscidae (Figure 1)

The stages in the life cycle (Figure 2) of the house fly are egg, larva, pupa, and adult. The larva molts twice so there are first, second, and third instar larvae with each being larger than the preceding instar.

**Egg.** The egg is white, ellipsoidal, about 1 mm long by 0.26 mm wide, with both ends bluntly rounded and the anterior slightly tapered (Figure 3). The chorion appears polished, but upon close examination a pattern of hexagonal
Figure 2. Lifecycle of the house fly showing stages: eggs, 1st instar larva, 2nd instar larva, 3rd instar larva, pupa, and adult.

Figure 3. Eggs of the house fly. They are laid during one day if the fly is not disturbed. A female typically deposits 4-6 batches of eggs in her lifetime.

Figure 4. First instar of the house fly hatching from an egg.

Figure 5. Eggs of the house fly. The posterior spiracles (on the broad, blunt end) are distinctive in form. The spiracles are the openings for air to enter the respiratory system of the larva.

Figure 6. First instar larva. The two posterior spiracles each consist of small slitslike apertures in a slight prominence. In the second instar larva the slits become larger and more conspicuous. The posterior spiracles of the third instar larva each have three distinctly sinusuous slits surrounded by a heavily sclerotized ring with a conspicuous perforated button that extends inward from the mesal side. The button is the site of extraction of the spiracle of the previous instar during the molting process. The second- and third instar larvae also have anterior spiracles on the third segment (apparent second segment). The anterior spiracles are tubular projections with 6-8 branches.

light is primarily due to photosensitive cells located in a cluster in a pocket internally and anteriorly between the dorsal and ventral cephalopharyngeal skeletons. The rate of larval development through the three instars depends on temperature within the range suitable for survival. Larvae can survive at 38°F (1°C) for several days. Below 50°F (10°C) the larvae will not pupate. Given a choice, young larvae seek areas with a temperature of 75°F (24°C) to 79°F (26°C) for pupation.

Figure 8. Anterior end of the house fly larva (third instar) showing sensory structures (dorsal organ, terminal organ and ventral organ). Also shown are the external cephalopharyngeal skeleton, terminal organ, and ventral organ. These organs provide the larva with sensory perceptions needed to survive by seeking the most suitable microhabitats based on odor, temperature, moisture, and chemical constituents.

The larvae respond to differences in light intensity. Young (first instar) larvae are negatively phototropic and move away from light and downward in the breeding site. Last (third) instar larvae react more positively to light and move upward to lighter and drier areas to begin pupation. The ability of larvae to detect light is primarily due to photosensitive cells located in a cluster in a pocket internally and anteriorly between the dorsal and ventral cephalopharyngeal skeletons. The rate of larval development through the three instars depends on temperature within the range suitable for survival. Larvae can survive at 38°F (1°C) for several days. Below 50°F (10°C) the larvae will not pupate. Given a choice, young larvae seek areas with a temperature of 75°F (24°C) to 79°F (26°C) for pupation.

Figure 9. Longitudinal section through the anterior sensory organs of the house fly larva showing sensory organs connecting to the dorsal (DO), terminal (TO), and ventral (VO) sensory organs. These organs provide the larva with sensory perceptions needed to survive by seeking the most suitable microhabitats based on odor, temperature, moisture, and chemical constituents.

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**Pupa.** In the process of pupation there is a general contraction of the larvae within its own integument so that the integument becomes a cylindrical puparium about 6.5 mm long (Figure 15). The puparium gradually darkens to a rich, dark brown color. Since the pupal case is formed by the larval skin, the pupa within is said to be exarate.

External features of the puparium include the posterior larval spiracles, represented by two flat, fan-like processes on the posterior end, and twelve segments. The pseudopodion is completely withdrawn, resulting in the anterior spiracular processes being very near the posterior end of the puparium. Locomotor pads on the ventral surface although the puparium is immobile. An opaque, pair of pupal spiracles are in the conjunctiva between the fifth and sixth segments of the dorsal side of the pupa.

Most of the basic features of an adult fly develop within the puparium in 18 hours. Full development requires 3–21 days depending upon temperature. The threshold for pupal development is about 52°F (11°C). Typical times for pupal development at different temperatures are as follows:

<table>
<thead>
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<th>°F</th>
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<tbody>
<tr>
<td>61</td>
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<tr>
<td>64</td>
<td>18</td>
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<td>68</td>
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<td>72</td>
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<td>76</td>
<td>30</td>
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<td>80</td>
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Upon completion of adult development, the adult pushes off the anterior end of the puparium. A circular slit appears in segment six (fifth visible segment) of the puparium and the detached cap splits into two parts. This is done with the pilum, an inflated sac that protrudes from the frontal region of the head just dorsal to the base of the antennae of the adult fly (Figure 14). Eversion of the pilum is by changes in blood pressure, and retraction is by muscles. Once its head is free, the fly crawls out of the puparium, it crawls about while the wings unfold and the cuticle hardens and dries. The pilum when last completely withdrawn leaves only the crescent-shaped sac (frontal lunule) above the antennae.

**Adult.** The adult house fly (about 6–7 mm long) is gray in general color (Figure 1). Like all flies, it has two wings and a body divided into three parts: head, thorax and abdomen (Figure 15). The thorax is gray equal broad dark longitudinal stripes on the dorsum. The abdomen has yellowish sides on the basal half, the posterior portion is brownish-black and a dark longitudinal line extends along the middle of the dorsum. The legs are black-brown. The wings are nearly clear and the venation is distinctive with the fourth longitudinal vein (**M** 3-4) bent sharply upwards near the end of the wing so as to nearly meet the vein (**R** 1-3) in front of it (Figure 16A).

In anterior view, the head is dominated by two large compound eyes, purple-brown in color, which occupy each side of the head (Figure 17). The.

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(Figure 16A) Diagrams of the wings of the house fly and other flies. 16A. Wing of the house fly. Musca domestica, showing the fourth longitudinal vein (**M** 3-4) curved forward to nearly meet the vein (**R** 1-3), at the wing margin. 16D. Wing of the little house fly. Fannia canicularia, showing the veins (**M** 1-2) curved forward towards the first anal vein. 16G. Wing of the stable fly. Stomoxys calcitrans, showing the veins (**M** 1-2) curved forward towards vein (**R** 1-3). 16D. Wing of the false stable fly. Muscina stabulans. 16E. Wing of the black garbage flies. Ophyra spp.
The head (Figure 17) is divided into about 4,000 facets, each an irregular hexagonal shape. Each facet is a visual unit so that the eye perceives a mosaic of a score. At the top of the head (vertex) between the compound eyes are three simple eyes (ocelli), arranged in a triangle. Lower on the head between the eyes is the one pair of antennae partially set in a depression. The area above the bases of the antennae and below the ocelli is very narrow in male flies and relatively wide in females. Therefore, in males the compound eyes appear to be set close together (biplicate, while in females they appear to be set far apart (dichoptic).

The antennae are important sensory structures used to detect air movement and odors (Figure 18). Among the olfactory receptors are sensilla located in several pits which lie ventrally on the basal one-third of the third segment of the antenna. The antenna is threeseptated with a branched arista projecting dorsally from the third segment. A U-shaped groove around the lateral and dorsal notch of the depression housing the pair of antennae is the frontal lobe (the surface through which the pituitary gland is set). The arista is set inward at the tip (emerges from the puparium).

Below the antennae are the proboscis or "mouthparts" (Figure 19). The proboscis is readily extended and retracted. Projecting from the basal portion of the proboscis is the pair of maxillary palp. At the end of the proboscis is a fleshy bilobed structure (labellum) or "oral sucker" with extensive ridges (pseudotrachea) which are food channels leading to the mouth opening. The fleshy labellum is pressed against any food. The pseudotrachea on each labellum are oriented towards the opening to the food channel (mouth) and are kept dilated by chitinous rings which thus determine the size of food particles that can be ingested (0.0004 to 0.001 mm diameter). Some larger particles may get ingested directly into the food channel without passing through the pseudotrachea. The fly can ingest food material by merely sucking up liquid foods or by using the distal segment of the pseudotrachea to scrape the surface of foods and maintaining the surface with regurgitated saliva liquid and liquid vomit so that a liquid material can be ingested (Figure 20). The regurgitation while feeding leaves light-colored spots that are dark on dark focal spots cause soiling of surfaces. The mouthparts of the house fly are called spurg-type sucking due to the fleshy structure and method of liquefying foods before ingestion. Muscular action of the pharynx is used to take up the food by suction.

The thorax (Figure 21) is enlarged and contains the extensive musculature required for the wing movement. The two wings are characteristic of Diptera and are attached to the mesothorax. Below and behind the place of attachment of each wing is a haltere-shaped stalked structure called a haltere. The haltere is richly innervated and is a balance organ which aids in maintaining equilibrium during flight. The wing possesses a system of ridges or veins which provide support and also served as pathways for air and blood circulation during the development of the wing before the fly emerged from the puparium. The wing veins are assigned names and numbers for use in describing and identifying different species of flies. The area between adjacent veins is called a cell. The house fly is elongated and fairly distinctive and an important character to use in recognizing the species.

Also attached to the thorax are the three pairs of legs each made up of five segments (coxa, trochanter, femur, tibia, and tarsus) with the last portion (tarsus) divided into five parts (Figure 22). At the tip of the tarsus is a pair of claws with a fleshy pad (palpelli) by each. The palpelli are slender-like with tiny glandular hairs causing a sticky surface which enables the fly to cling to surfaces, even upside down.

The abdomen is divided into three parts when the fly is engorged with food. At the posterior end the female has a segmented ovipositor which can be retracted and extended to facilitate egg laying. The ovipositor has sensory structures which aid the female in selecting suitable oviposition sites. The male has posterior genitalia which are only withdrawn when the fly is not mating. During mating the complex lobes of the male genitalia clasp the ovipositor of the female and inseminate the female. The sperm move to a storage area (spermatheca) in the female reproductive system and remain available to fertilize eggs as they pass down the oviduct. Therefore, a female can lay several batches of fertilized eggs after only one successful copulation. Female house flies are monogamous, i.e., they normally mate only once. A volatile sex pheromone (muscate, (E)-9-tricosene, is produced by the female and attracts the male.
males. In the mating process, the male grasps the female in the air sometimes, but actual copulation takes place while resting on a surface, rather than in flight. The female mates and begins laying eggs 3–4 days after emergence (preoviposition period). The threshold for preovipositional development is about 57°F (14°C).

**LIFE CYCLE.** The overall life cycle of the house fly (from egg to adult) is about 7–10 days in the summer in warm temperate areas. As stated in the previous section, rates of development of each stage are dependent upon temperature. Often the temperature of the decaying and fermenting larval medium is considerably higher than the prevailing air temperature, however, so that development occurs much faster than anticipated by the climatic conditions. The times required for completion of development may be expressed as degree-hours or degree-days which are the product of time (hours or days) and number of degrees of temperature (°F or °C).

![Diagram of the house fly showing its various parts](image)

**Figure 21.** Lateral and dorsal views of the thorax of the house fly.

**Figure 22.** Leg of a house fly showing femur, tibia, and five-segmented tarsi with an enlargement of the tip of the tarsus showing claws and sticky pads (tarsilli).

Above the threshold temperature for development, typical values for the life stages of the house fly are:

- **Egg:** 13.3 hours (74-hour °C)
- **Larva:** 23 days (72-day °C)
- **Pupa:** 156 hours (60-day °C)
- **Preoviposition:** 81 days (45-day °C)

Typical days required for the total life cycle at various temperatures are:

<table>
<thead>
<tr>
<th>°F</th>
<th>Avg. No. Days (range)</th>
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<tbody>
<tr>
<td>61</td>
<td>16 (6–9)</td>
</tr>
<tr>
<td>64</td>
<td>18 (6–9)</td>
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<tr>
<td>68</td>
<td>20 (6–9)</td>
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<td>77</td>
<td>25 (14–18)</td>
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<tr>
<td>86</td>
<td>30 (6–9)</td>
</tr>
<tr>
<td>95</td>
<td>35 (6–9)</td>
</tr>
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</table>

![Image of Fannia canicularis](image)

**Figure 23.** Adult little house fly: Fannia canicularis (L.).

**LITTLE HOUSE FLY – Fannia canicularis** (L.), Family Muscidae (Figure 25)

A few species of the genus Fannia are commonly found breeding in animal manure and confined livestock facilities. The most common is the little house fly, Fannia canicularis (L.). It is smaller than the house fly being about 5–6 mm long. The adult is blackish-grey with three inconstant black dorsal longitudinal stripes. The sides of the thorax are lighter color; the legs are black, the halteres yellow. The head is gray with black frontal stripes and gray sides. Like the house fly, the male eyes are nearly together (holoptic) while the female eyes are further apart (dichoptic). The antennae are like those of the house fly but the stipes on each is slender and covered with a fine pubescence. The wing has the second anal vein strongly curved towards the first anal vein (Figure 168). The fourth longitudinal vein (M₁₄) is straight (not bent as in the house fly). The abdomen in the basal portion is yellowish. The adults of the closely related species Fannia scalaris (Fabricius) resemble the little house fly but can be distinguished by the possession of a definite crest on the apical part of the mid leg tibia. Fannia canicularis has no such crest. Fannia scalaris is known as the latrine fly because of its occurrence in human privies. It is less common in animal manure but on occasions may be found in this material.

The larvae of the little house fly are distinctly different from the white-tapered cylindrical larvae of the house fly. The Fannia larva is rough, brown, flattened dorsoventrally, abruptly narrowed anteriorly, and has many well-developed plumose lateral and dorsal processes on each segment after the first (Figure 24). There is one pair of anterior prothoracic spiracles each with 3–12 short processes arranged in a radial fashion. The posterior spiracles are raised on short, stout stalks. There are well-developed mouth hooks. The larvae develop through three instars. The larva of species of Fannia which may occur as much manure are all conform to this general description. To distinguish among the species it is necessary to examine closely the lateral processes and other characteristics especially in the posterior region (Figures 25 A–H). Larvae of F. scalaris resemble the larva of F. canicularis but the lateral processes of scalaris are more plumose and have a shorter terminal portion than canicularis. Another species, F. emoraius (Sabin) is frequently encountered in animal manure, and the larvae resemble those of scalaris and canicularis. However, the larvae of F. emoraius have lateral posterior processes which are intermediate in branching and length of the terminal portion in comparison to scalaris and canicularis. To further
Once a pheromone, (Z)-9-pentacosene which is slightly attractive to the males. A weaker sex pheromone, in F. femorialis and F. pusio is present and has been identified as (Z)-11-hentriacontene.

Adults of the little house fly can be recognized by their behavior in animal facilities. The adults fly slowly in circles and tend to hover periodically. They are often seen circling above animal pens and walkways. Since the little house fly does not tolerate high temperatures as well as the house fly does, in temperate regions the number of adults will often decline in midsummer after an early summer peak of abundance.

Figure 24. Larva of Fannia canicularis, the little house fly.

Complicate larval identification, it is extremely difficult to distinguish F. femorialis from F. pusio (Weidenmann) which occurs but fortimately is less common in animal facilities. The adults of F. femorialis and F. pusio are mostly black and much smaller than F. canicularis and F. scalaris and therefore are easily distinguished in the adult stage. Although F. canicularis is overall the most common Fannia in confined animal operations, caution is divided to sure that it is the species present in the manner in a particular situation.

The eggs of F. canicularis are white and have a pair of dorsal longitudinal flanges of wings. They hatch in 20-48 hours at 75-80°F (24-27°C) and the larva reach 6 or more days to reach pupation which lasts 7 or more days. The total life cycle (egg to adult) is 15-30 days depending upon temperature. At any given temperature the life cycle is slightly longer than for the house fly.

Fannia canicularis females produce numbers of larvae in and around confined animal production facilities. In addition to the distinctive mouthparts, the stable fly has a broader abdomen than the house fly and there is a checkerboard of dark spots on the dorsum of the abdomen. The fourth vein (4′.) of the wing is only slightly curved upward, much less than the fourth vein in the house fly wing (Figure 16C). The stable fly has four longitudinal stripes on the thorax similar to those on the house fly.

The larvae of the stable fly are white, cylindrical, tapered anteriorly and very similar to house fly larvae. However, the posterior spiracles differ greatly. In the stable fly larva the posterior spiracles are roughly triangular, widely separated.

Figure 26. Adult stable fly: Stomoxys calcitrans (L.), Family Muscidae (Figure 26).

The adult stable fly is about the same size as the house fly but can be readily distinguished by the mouthparts (Figures 27, 28). The stable fly has a stout, black proboscis which is used to pierce the skin and imbibe blood. Both the males and the females are bloodsuckers. The stable fly is usually the only biting, blood-sucking fly breeding in any appreciable numbers in and around confined animal production facilities. In addition to the distinctive mouthparts, the stable fly has a broader abdomen than the house fly and there is a checkerboard of dark spots on the dorsum of the abdomen. The fourth vein (4′.) of the wing is only slightly curved upward, much less than the fourth vein in the house fly wing (Figure 16C). The stable fly has four longitudinal stripes on the thorax similar to those on the house fly.

Figure 27. Heads of adult house fly (A) and stable fly (B) showing differences in the mouthparts (proboscis) (Figure 28). Diagram of the parts of the proboscis of the stable fly and each has three sinus spiracles set in a thick dark peritreme with the button in the center (Figure 6B). The house fly posterior spiracles are set close together and are nearly D-shaped with...
A much thinner peritreme than in the stable fly. The cephalopharyngeal skeleton differs in shape from that of the house fly larva (Figure 7b).

Stable fly eggs are white, very similar in size to house fly eggs and laid in small groups. A female fly will lay up to 800 eggs usually in groups of 25-50 after a bloodmeal. Repeated bloodmeals are needed for continued egg production. Eggs are laid in media that contains a large amount of decomposing matter. Favorable habitats for oviposition and larval development are silage, bedding mixed with urine and feces, rotting hay, fermenting feed, piles of grass clippings or other decomposing plant materials.

Stable flies often become abundant around feedlots, dairy cattle feeding areas, and horse stables. The flies prefer sunny, outdoor conditions although a few will enter buildings and breed there. It is often found breeding in outdoor silage, decayed hay and piled manure mixed with bedding. The flies will be found breeding indoors in dairy calf pens and outside in calf hutsches where straw bedding is used. Sometimes, stable flies are found inside poultry houses containing spilled feed. Primarily, however, the fly is a pest on livestock and is a significant problem on livestock farms. The flies can be found on animals, especially on the lower half of the body. The flies will attack humans as readily as livestock.

Stable flies have the same life cycle as house flies, but develop more rapidly. At summer temperatures in temperate areas, the eggs hatch in 1-2 days and larval development requires 6-8 days. The pupal stage lasts 6-8 days. The entire life cycle (egg to adult) requires 13-18 days at temperatures of 75-85°F (24-30°C). Pupation period (during which bloodmeals are necessary) is about 6-8 days. Like the house fly, the development of the stable fly is slowed at lower temperatures and can require several weeks. For example, development from egg to adult at 50°F (10°C) requires 3-5 months.

**FALSE STABLE FLY** - *Musca stabulans* (Fallén), Family Muscidae (Figure 29)

The false stable fly is not a blood-sucking and harspsponging sucking mouthparts like the house fly. It is larger and more robust than the house fly. Overall color is dark gray with the head a lighter whitish gray. The gray thorax has four longitudinal stripes and the posterior tip of the scutellum (dorsal part of the thorax) is pale yellow. The abdomen is gray and black with a bloomed appearance. The fourth longitudinal vein (M. 4) of the wings is not bent and converges only slightly towards the vein in front of it. This is similar to the arrangement in the stable fly and quite different from the sharply bent vein in the house fly (Figure 16b). The legs of the false stable fly are purplish red or cinnamon.

A closely related species *Musca assimilis* (Fallén) = *Musca levicula* (Harrington) may be encountered in and around animal production facilities, but it has legs which are entirely black. The white eggs of the false stable fly are similar to house fly eggs and are laid in small batches. The larva resemble those of the house fly but differ in the characteristics of the posterior spiracles with each having three curved slits and a thick peritreme (Figures 6c). The shape of the cephalopharyngeal skeleton differs from that of the house fly larva (Figure 5c). Larval development is slower than the house fly and the life cycle (egg to adult) in temperate summer conditions is about 2 weeks.

The false stable fly sometimes is fairly abundant in animal facilities, especially in poultry houses where it breeds in accumulated manure. Overall, it is seldom as abundant as other flies, however. The larva of *Musca stabulans* will prey on other fly larvae, including those of the house fly. However, this predation is limited, and although the few experimental results conflict, it appears not to be a significant factor in controlling house fly or other pest species of flies breeding in animal facilities.

**BLACK GARBAGE FLIES** - *Ophyra* spp., Family Muscidae (Figure 30)

Members of the genus *Ophyra* are shining black and about two-thirds the size of a house fly. Unlike the house fly, the vein M. 4 of *Ophyra* does not bend near the tip of the wing (Figure 16e). They are sometimes called dump flies. Their larval stages and life cycle are very much like the house fly. The white egg resembles that of the house fly and is deposited in similar situations. The larva is cylindrical, tapering anteriorly and resembles closely the larvae of the house fly. The *Ophyra* larva, however, have a slightly tinge of yellow and tend to be more slender and more active than the house fly larvae. The posterior spiracle is distinctive with each composed of three nearly parallel straight slits (Figure 6d). The cephalopharyngeal skeleton differs from that of the house fly larva, including the presence of slender dorsal wings of the pharyngeal sclerite and two slender mouthparts (Figure 7d). The pupa has a pair of tympanal prominent respiratory horns.

The life cycle of *Ophyra* is about the same duration as for the house fly. At 80°F (27°C) the period from egg to adult requires 14 days with egg hatch in 12 hours, larval development in 5 days, pupal development in 4 days and a 4-day prepupal period. Typically about 300 eggs are laid by a female in her lifetime. The two major species associated with confined-animal facilities in the United States are *Ophyra leucostoma* (Wiedemana) = *Ophyra massarum* (Harrington) and *Ophyra arenosomast* (Wiedemana). *Ophyra arenosomast* has yellow or reddish-yellow palps while *Ophyra leucostoma* has black palps. The males of *leucostoma*
The most common species of Calliphoridae likely to be encountered in and around animal production facilities are as follows:

*Phormia regina* (Meigen) — A species commonly called the black blow fly because of the black body and the body is olive to blackish-green color. The legs are black. The mesothoracic spiracles are fringed with an orange pubescence that is readily seen in fresh specimens. 8–12 mm long.

*Phaonia sericata* (Meigen) — A bright coppery green with yellowish-pale and a faint line longitudinally on the dorsum of the abdomen. 6–9 mm long.

*Phaonia caprina* (Wiedemann) — A dull coppery color with a median longitudinal line on the dorsum of the abdomen. 6–8 mm long.

*Calliphora vicina* (Robineau-Desvoidy) — A blue color. Abdomen distinctly blue and the head blackish with lower part reddish-yellow. 9–11 mm long.

*Protophormia terraenovae* (Robineau-Desvoidy) — A robust bright dark greenish blue to deep blue with black legs and dark pubescence around the mesothoracic spiracles. 8–12 mm long.

**BLACK SOLDIER FLY** — *Hermetia illucens* (L.), Family Stratiomyidae (Figure 32)

The adults and larvae of the soldier fly are distinctive and easily recognized. Their occurrence around animal production facilities is erratic but sometimes they are present in tremendous numbers, especially in poultry and swine houses. Since it is in the family Stratiomyidae, the antennae and wing venation differ considerably from the Muscidae and the Calliphoridae. The soldier fly antennae are long, project directly forward from the head, and the last (third) segment is tapering with no aristae. The wings have a central enclosed cell and are partially shaded with brown. The adults are blue-black, 2 cm long, and the legs are black with white-yellow tarsus. The upper part of the hind tarsi is white. The abdomen has two clear or translucent areas dorsally near the base (second segment).

The larvae of the black soldier fly become up to 2 cm long and are

blowing flies are vigilant and prey on other fly larvae, including those of the house fly. The *Opilinae* larvae apparently inject a toxin into the prey because often the prey appear to become paralyzed quietly after being attacked. Because of this behavior, *Opilinae* have some role in reducing the numbers of house flies. However, both flies occur together in livestock facilities and excessive numbers of *Opilinae* may be nearly as annoying as equivalent numbers of house flies. *Opilinae* have a preference for sunny sites and often are found resting (along with house flies) on vegetation around animal facilities.

**BLOW FLIES** — Family Calliphoridae (Figures 31A–D)

Several species of blow flies of different genera may be found around animal production facilities. Although these breed in animal manure and decaying feed, they are more likely to be developing in decomposing animal carcasses and sites contaminated with milk or broken eggs. Blow flies are robust, with a metallic sheen to the body and variously colored (bright green, blue, bronze-black, copper). The thorax has no stripes and the bristles are stout. The calliphorids have hypopleural bristles and two notopleural bristles on the thorax. The wing venation is similar to the house fly but vein M2+3 curves sharply forward towards vein R2+3 (Figure 31F).

Blow flies have the same basic life cycle as the house fly with white eggs, three larval instars, pupae, and adults. The times of development are poorly documented, but most develop through a complete life cycle in 10–20 days at various temperatures. Usually the larvae will be found in clusters in a suitable microhabitat. The larva is shaped roughly like the house fly larva, but the cephalopharyngeal skeleton has stouter, wider mandibular sclerites and mouthhooks; the posterior spiracles are distinctive and there are small flabby prominences posteriorly around the area of the spiracles (Figures 6E–G and 7E–F).
The adult soldier flies are weak fliers and spend considerable time resting in and around the animal production facility. They are often found in the bright sunlight areas resting on the structure and on nearby vegetation.

The larvae of a few species of Syrphidae are encountered around animal production facilities and are readily recognized. As the name naiad or naiad implies, the larvae are large, cylindrical, with a long narrow caudal projection at the end of which is the pair of posterior spiracles surrounded by a rosette of hairs (Figure 36). The larvae are found in liquid habitats heavily polluted with manure. They are often encountered in run-off ditches and pools around dairy operations as well as in waste lagoons for dairy, swine, and poultry.

The most common species is Eristalis tenax although others may be encountered, including some species in the closely related genus Eristalinae (the adults of which are darker colored than those of Eristalis). The adults of E. tenax, known as drone flies, are clothed in dense short yellow hairs giving the appearance of a large honeybee. The antennae are short with the third segment rounded or oval with a non-plumose arista. The eyes are pilose (hairy). The wing venation is the typical form for the family Syrphidae with the most distinctive characteristic being a longitudinal vein (false vein) through the middle of the wing.

The larvae develop through three stages all of which have the caudal projection with a small pair of spiracles at the tip. The third stage larva is about 23 mm long and 15 mm wide with eight pairs of ventral swellings (pseudopods). There is a pair of short, dark anterior spiracles. The maggot moves to drier areas to pupate. The pupae are grey-brown and have a pair of horn-like anterior spiracles as well as the caudal projection. The life cycle from egg to adult is about 30 days in the summer with the larval stages lasting about 18 days and the pupal stage about 10 days.
Factors Affecting Fly Abundance

The number of flies is determined by abiotic factors (environmental factors such as temperature, moisture of breeding habitat, humidity) and biotic factors (natural enemies including parasites, predators and pathogens). The climate of an area is an overall indicator of the potential level that fly populations may reach. However, facilities for confined-animal production greatly alter the environment. Natural enemies have a significant role in regulating fly population levels in nature, but the concentrations of animals and their manure in confined-animal production facilities create an unnatural situation.

The times required at different temperatures for fly development have been mentioned in the discussion of fly identification and biology. The overall temperature range and prevailing summer temperatures in an area are crude indicators of how fast flies will develop and how many generations per year there will be. The length of the fly season generally increases from north to south in the United States corresponding to the climatic zones. The higher the temperature and the longer the season of high temperatures, the more rapid is fly development and the number of fly generations per year. Because of overlapping of the generations and the rapid development, large fly populations develop quickly and are sustained as long as temperatures are high. However, confined animal housing alters the situation substantially since an artificial protected environment is created. Therefore, even more flies and generations per year are likely to occur in and around confined-animal housing than the climatic zones would suggest. The temperature maintained in the housing system will determine the fly population level more than the climate of the area.

In addition to the overall climate and the climate within the housing system, the microclimate of the breeding medium is of major importance in determining rate of fly development and fly abundance. Accumulated manure and other fly-breeding media (silage, hay, feed) generate considerable heat due to fermentation, and therefore, the temperature in the breeding medium is usually higher than the surrounding air (whether indoors or outdoors). The more the accumulation, the more the heating and the greater the range of temperatures that occur so, consequently, the fly larvae have greater opportunities to find suitable habitats for development. In the winter in cold northern areas, slow development of fly larvae and long-time survival of pupae routinely occur indoors in confined-animal facilities. The same occurs outdoors in piles of manure, silage and hay.

In the summer, the rate of fly development in accumulated manure or other breeding medium is often faster than expected from the weather data. The confined-animal housing systems and the concentration of manure and feeds constitute an artificial environment protected from the extremes of weather and conducive to fly breeding. Since the confined-animal production system is an artificial creation of humans, it can be manipulated to either encourage or discourage fly breeding. The covering and protecting of feeds (silage, hay, bales, grain) from moisture and minimizing their fermentation decreases the desirable habitats for fly breeding. The management practices in this regard are major factors in determining fly abundance.

Likewise, the system of manure management is a major factor in determining fly abundance. Two extremes exist: frequent manure removal and prolonged manure accumulation. When the manure is frequently and regularly removed completely, there is no medium for fly breeding in the animal facilities. This is done with flushing and/or scraping systems. If the systems are properly designed and function properly, most fly breeding will be eliminated by this frequent (each day or two) cleaning. However, it is common for these systems to leave pockets of manure which
support fly breeding. Corners, edges, and areas under railings and fences are missed by the equipment. Broken scraper cables or low water pressure causes these automatic systems to fail or do an incomplete job of manure removal. Crossing and caking of manure causes accumulations that cannot be removed by the equipment.

With daily or very frequent manure removal, there is a problem of manure disposal. If the manure is spread immediately on fields and in a very uniform thin layer, there will be no fly breeding. However, if the manure spreads, large clumps then breeding may occur. Adding water to produce a slurry of manure facilitates spreading although this may increase odor problems. Other options for disposal are to pile the manure or flush it into a deep lagoon for anaerobic decomposition. Files of manure will breed flies unless compacted and covered (such as with plastic sheeting) to cause the temperature in the pile to become too high for fly survival. A properly designed and managed lagoon will not breed flies. However, the lagoon is overloaded with too much manure for its size, there may be floating mats of manure and debris which will support fly breeding.

An alternative to disposal by flushing into an outbuilding lagoon is flushing into a pit containing water beneath the floor of the animal housing. This is a method commonly used in slotted-floor swine houses. Periodically the pit has to be flushed or pumped out into an outbuilding lagoon or spread on the fields.

The other extreme is to allow the manure to accumulate for long periods of time. If the manure is regularly compacted and trampled by large livestock (such as in feedlots) the medium will be unsuitable for fly breeding. In poultry production (caged layers and breeders) accumulation of manure for a year or more is often the system used. In that situation, if the manure does sufficiently fly breeding will be minimal. Accumulated manure is a habitat for many species of predators and parasites which attack the eggs, larvae, or pupae of flies and significantly aid in reducing fly numbers. With accumulations of manure, the degree of airflow and protection from moisture (rain, drainage, and leaking animal waterers) become of major importance because the drier the manure, the less the fly breeding.

Between these two extremes of manure handling are many intermediate procedures. These involve periodic and often erratic manure removal. The handling and feeder design dictate how well the manure removal can be accomplished and how often it is practical. When automatic equipment is not involved, removal has to be by hand tools and manual means. Monitoring flies and scours. Maintaining and controlling manure removal by these methods is important in an integrated fly management program. It is difficult, if not impossible, to execute a successful fly control program if the manure management program is erratic and unplanned.

Manure is allowed to accumulate for long periods or for periods of irregular length, the manure-inhabiting populations of predators and parasites build up. Total removal of all manure in one short period of time will remove most of that population of beneficial insects and mites. Therefore, staggered partial removal over a period of time (2-4 weeks) is preferable to total removal within a short period of time.

Competition among and between species of flies is another factor affecting the size and composition of the fly population. The most notable case is the black soldier fly, Hermetia illucens. Its large larva can harm the manure and render it physically unsuitable for the survival of other species of fly larvae and for egg-laying by the house fly and other muscid flies. The slow development of the soldier fly larvae results in large numbers accumulating in the manure. The black soldier fly may become extremely abundant in poultry manure, especially in high-rise or deep pit houses and in swine manure pits. In those types of confined-animal housing it may become the major fly species.

Other fly species important in competed with the house fly are the black garbage or dump flies (Ophyra spp.) whose larvae prey upon other fly larvae. The Ophyra, like the soldier fly, sometimes become very abundant in poultry and swine housing. Except for these cases of Hermetia and Ophyra flies, the other species of flies seldom compete with each other enough to be a major factor in determining the levels of fly abundance in and around confined-animal facilities. Even a small amount of manure or other breeding material can support large numbers of muscid fly larvae, and there are usually ample amounts available.

Theoretically, the house fly population would grow to astronomical numbers if there were no factors limiting production. However, the abiotic and biotic factors prevent this from happening. Fly populations reach unacceptably high levels in and around confined-animal production facilities when the livestock management system includes practices which cancel out the abiotic and biotic factors.
Fly control is made more difficult by the changing animal production systems which offer environments that favor fly production. This is accidental, of course, and an unplanned result of not considering the problem of fly production when designing facilities to enhance the efficiency of livestock and poultry production. Fly control measures must evolve to accommodate the evolving animal production and housing practices. The species of flies, their relative abundance and the success of fly control measures are affected by the animal husbandry practices, especially the housing and manure-handling systems. A multimethod management approach to fly control, using a mixture of cultural, biological and chemical control measures adapted to the production system, provides a rational approach to fly control. To use this approach, a knowledge is required of the fly species, including their biology and behavior, parasites and predators of flies (biological control agents), manure management techniques, insecticides and insecticide application techniques.

Reliance on only the use of insecticides for fly control seldom provides a satisfactory answer. The fly suppression effects of insecticides are best realized when the fly population level is already suppressed by proper manure management methods which minimize fly breeding and encourage populations of predators and parasites which attack various stages in the life cycle of the flies. Another factor is the resistance by flies to insecticides. Insecticide resistance among flies, especially the house fly, has developed rapidly to new insecticides after their widespread use. Chemicals such as malathion, diazinon and DDT, when first introduced were highly effective for fly control but rapidly became ineffective due to resistance development. Many chlorinated hydrocarbon and organophosphate insecticides which were formerly used for fly control are no longer effective. Resistance to one chemical is often accompanied by cross resistance to other related chemicals even if they have not been used for fly control. The search for new, effective fly control chemicals is a continuous and expensive proposition with only occasional success.

Although synthetic pyrethroids have been introduced recently for fly control, some cases of resistance are already developing. To help delay or avoid resistance development, the use of insecticides should be in conjunction with maximizing the cultural and biological measures. All insect pests, including flies, have fluctuating populations under natural conditions. Their numbers will rise and fall above and below a mean level. The concept of management encompasses using a combination of insect control methods to reduce that mean level to an acceptable level. It is recognized that the pest cannot be eliminated, but its numbers can be kept at a tolerable level. In the case of the house fly and other flies in confined animal production facilities, the precise mean level (that is acceptable) depends upon the circumstances. In any event, the management program for fly control is based on an integration of cultural, biological and chemical methods of fly suppression.

**CULTURAL METHODS**: Cultural control of flies is basically manipulating, insofar as possible, the abiotic factors that suppress fly numbers. In essence this means proper management of the manure, feeds, and facilities. Either removing the manure frequently and thoroughly, or keeping it dry, reduces the habitat for fly larval development. Likewise, preventing feed spoilage and keeping the feed dry reduce habitats for fly breeding. Spillage around the bases of silos and feed bins, improperly covered slage, and unprotected hay bales are all prolific fly-breeding sites when there is sufficient moisture. Proper protection and covering of the stored feeds and the feed bunkers prevents moist conditions due to rainfall and thereby reduces fly breeding.
Preventing moisture in the potential fly breeding areas is the critical cultural factor in fly control. Watering systems for the animals are a potential source of moisture if those systems are poorly designed and/or maintained. Grading and site selection for the animal facilities determines how well rainwater is removed from the area to reduce moisture in the fly breeding media. Liberal use of properly sloped concrete floors with appropriate gutters and curbs facilitates drainage and makes manure removal easier. The basic design of the livestock and poultry production facility determines how easily and how well the system can be managed to keep it dry, and how effectively the manure can be removed. Areas that are hard to clean (such as under feeders and stalls, in corners, beneath feed bunkers and waterers) will allow the accumulation of manure and feed which will retain water and support the breeding of large numbers of flies. Concrete aprons around feed bunkers and waterers encourage runoff, simplify cleaning, and lessen fly breeding.

Ventilation and airflow in animal housing will affect the rate of evaporation and may be critical in producing sufficient drying to suppress fly breeding. Within the constraints of the animal needs, as much airflow as possible should be maintained to promote moisture removal from manure and other fly breeding media. Often insufficient airflow results in the unnecessary retention of moisture in houses to the point of condensation and runoff on the walls. The large number of animals in confined housing contribute substantial moisture to the air and proper ventilation and airflow are needed to remove this excess moisture. Otherwise, an ideal habitat for adult fly survival and for most fly breeding media are created. The outside temperature and relative humidity of the air will, of course, affect the efficiency of drying in different climates.

The compactness of manure will affect the amount of fly breeding. In the center of cattle feedlots, pens or indoor pens, the trapping and compacting of the manure, and bedding if present, will render the habitat poorly suited for fly breeding. This occurs with high densities of animals in the pen but the effect is lost with very low densities. Mechanically compacted pens and manure produces the same effect of reducing fly breeding. Therefore, manure and bedding removal from pens and stables and piled for storage should be compacted and covered. The cultural practice of adding large amounts of water to the manure creates a habitat unsuitable for the breeding of house flies and related muscid flies. However, it may create conditions for other species which tolerate or even prefer low liquid conditions, such as rat-tailed mites and soldier flies. Diluting the manure with water is used in manure pits in swine houses and in outdoor waste lagoons used for dairy cattle, swine and poultry in conjunction with flushing systems for manure removal in the housing.

BIOLOGICAL METHODS. In production systems having prolonged accumulations of manure, a diverse heterogenous fauna of arthropods develops in the manure. Among these are species of flies and mites which prey on fly eggs and larvae (the small flies). Also a number of species of hymenopterous parasites visit the manure and lay eggs in the fly pupari. The parasites develop in the fly pupari and as a result kill the flies.

The maximum benefit from predators and parasites is achieved with dry manure. In very wet manure, the predators cannot move about effectively to find and consume the fly eggs and larvae. Likewise, the parasites have to find the fly pupari and can move more easily. Proper manure management will render the habitat poorly suited for fly breeding. This occurs with high densities of animals in the pen but the effect is lost with very low densities. Mechanically compacted pens produce the same effect of reducing fly breeding. Therefore, manure and bedding removal from pens and stables and piled for storage should be compacted and covered. The cultural practice of adding large amounts of water to the manure creates a habitat unsuitable for the breeding of house flies and related muscid flies. However, it may create conditions for other species which tolerate or even prefer low liquid conditions, such as rat-tailed mites and soldier flies. Diluting the manure with water is used in manure pits in swine houses and in outdoor waste lagoons used for dairy cattle, swine and poultry in conjunction with flushing systems for manure removal in the housing.

Mite predators of fly eggs and first instar larvae are mainly species of the families Macrocroobidae, Uropodidae and Parasitidae. Typically, as mite accumulates and ages, the order of invasion by these mites is Parasitidae—Macrocroobidae—Uropodidae. The parasitoids are poorly known but have been observed feeding actively on fly eggs. The life stages of the parasitoids are egg, larva (6-legged), protonymph, deutonymph, and adult, with the last three stages having eight legs. The deutonymphs are usually most abundant. They move very rapidly in and out of the manure and can be identified by their light yellow-brown bodies with the dorsal aspect appearing to be divided into two parts with darker brown dorsal shields. The deutonymphs attach to beetles or flies and are thereby transported to new areas. Species of parasitoids in the genus Paecilomyrmex are frequently found in livestock and poultry manure.

The mite predators (Figures 37-41) are better known and are frequently extremely abundant in livestock and poultry manure. Most commonly encountered are Macrocroobidae: M. acuminatus (Scopoli) and G. confusa Forl. Another species, M. globus (Müller) is sometimes common. G. confusa is much larger than the others and often may be abundant in piled manure and bedding (such as from calf pens and horse stables). The species can be distinguished by the characteristics of the ventral plates.
Figures 42A-C. Ventral plates of female adults of common manure-inhabiting macrochelid mites. Shown are the external plate (top, anterolateral), genital plate (mid-lateral) and ventral anal (bottom, posterior) views.

42A. Macrocheles muscadelomesticus consumed per mite per day. Substantial reductions in fly numbers in livestock and poultry manure by these mites have been demonstrated. The life cycle from eggs to adult requires only 2–3 days under favorable conditions.

Among the Uropodidae, the most common species in livestock and poultry manure is Pseudotexochus vegetans (DeGeer). It is slightly oval, reddish-brown and highly sclerotized giving a beetle-like appearance. The legs can be pulled back into depressions on the ventral surface. Pseudotexochus vegetans is predaceous on first instar house fly larvae but is unable to subdue larger larvae. It is usually unable to pierce the abdomen and feed on fly eggs. In addition to fly larvae, it feeds on nematodes and organic matter in the manure. This mite is slow moving and often found in aggregations. It has a 20–40-day life cycle so populations build up slowly, but it often becomes the most abundant mite after 8–12 weeks of manure accumulation. A specialized deutonymph stage attaches to beetles or flies and is transported to new areas.

In accumulations of piled manure there is a distribution of macrochelid and uropodid mites, and Carcinocheles which makes them complimentary predators of flies. Macrochelids are mostly in the outermost layer of manure in areas likely to be used by the flies for oviposition. The uropodids are deeper in the manure. The macrochelids prefer the egg stage, move rapidly and have well-developed olfactory senses. Those fly eggs which escape predation by the macrochelids, hatch into first instar larvae which, being negatively phototactic, move deeper into the manure and then cut a hole and emerges. One parasite emerges from a parasitized pupa. In addition, many fly pupae are destroyed by the parasites probing through the pupal case and feeding on the exuviae. Consequently, many damaged pupae fail to develop into adult flies. A parasite generally requires about 3 weeks to complete its life cycle within the puparium (at 78°F, 26°C).

Figures 42C. Glyptophilus confusus, where the uropodid mites aggregate. The group attacks and gregarious feeding behavior of the uropodid tend to contain the fly larvae while they are being destroyed. The Carcinocheles beetle tend to be on and slightly beneath the manure surface where they can easily find fly eggs in a similar manner to the macrochelids. The beetles found deeper in the manure feed on the first instar larvae. The beetles, like the uropodids tend to aggregate and engage in group feeding.

The parasites of flies commonly associated with confined livestock and poultry systems are small wasps (Hymenoptera) primarily in the genera Muscardinidae, Spalangia, and Pachycrepoidea of the family Pernatidae (Figures 43A-B and 44A-D). These generally lay one egg on a fly pupa after piercing the pupal case (puparium) with the ovipositor. The parasite egg develops through three larval stages while feeding on the fly pupa and destroying it. The parasite pupates within the fly puparium and then emerges as an adult fly. One parasite emerges from a parasitized pupa. In many, fly pupae are destroyed by the parasites probing through the pupal case and feeding on the exuviae. Consequently, many damaged pupae fail to develop into adult flies. A parasite generally requires about 3 weeks to complete its life cycle within the puparium (at 78°F, 26°C).

Biological control methods consist of taking actions to enhance and preserve the naturally occurring populations of predators and parasites. This includes the cultural steps to make the manure as dry as possible. The predator and parasite populations are not decimated. Removing portions of the manure over a period of time and preferably in the cooler season when fly numbers are lowest, preserves a portion of the parasite and predator population to recolonize the new manure. Sometimes attempts are made to augment the naturally occurring parasite populations by release of additional individuals. Such augmentation can result in increased parasite population.
rate and reduced number of flies. However, at this time it is not possible to predict the quantitative guidelines as to when and where to use the method and what species and numbers of flies will be affected. If augmentation is attempted, it should only be after the chemical and biological methods have been evaluated and the use of chemical control is not adequate. The effective use of chemical control is an integrated control program in conjunction with biological methods.

Methods of using insects are as effective as the predators and parasites against the flies. An systemic insecticide is highly toxic to fly larvae but very low in toxicity to beetles and mites. Selective activity can be achieved by the use of insecticides that are specific to the flies. Routine spraying of all the manure and the manure with a high insecticide will kill all the predators and parasites. Selective activity can be achieved by spraying only where the flies are abundant. Spot treatment with insecticides will have a greater adverse effect on the predators and parasites. Further, treatments directed against the adults fly (adulticiding) should be applied to the surfaces of the building and the manure with a coarse spray to minimize the residual effect of the treatment and the manure. Residual treatments should be directed at those areas where the flies are observed. Those areas usually partitions and upper parts of the structure where flies rest for long periods at night. Spotting of the surfaces by regurgitation of flies indicates fly resting areas. After maximum effort to suppress flies, the use of insecticides is highly effective against the flies. The application of insecticides is directed to the surface areas where the flies rest. Consequently, it is necessary to be sure that the applications are directed to the surface areas where the flies rest. The use of insecticides is directed to the surface areas where the flies rest. The use of insecticides is directed to the surface areas where the flies rest. The use of insecticides is directed to the surface areas where the flies rest.
swine and calves) may be counted. With several areas or animals being examined, fairly reliable data can be obtained. However, the same limitations as with fly grids apply in that the observer has to be present, counts are for only a brief period and fly species cannot be accurately determined.

Sticky fly ribbons are commercially available and the flies catch on them give a useful index of fly population. Also the species of flies stuck on the ribbons can be positively identified. Several ribbons are placed in a facility. The positions in which the ribbons are placed and the number used are important variables. The ribbons should be replaced in the same locations in order to be able to compare fly counts from sample to sample. Usually the ribbons are left in place a few days, but if left more than 3 days or if there is a large population of flies, the ribbons will become filled with flies and the rate of catch will decrease drastically. In dusty situations, especially in poultry houses, the dust will render the ribbons ineffective in a day or two. Sticky ribbons are messy to handle but offer the advantages of being able to identify the fly species and providing a sample of flies over a period of a few days.

Baited jar traps are a simple, practical fly monitoring device and can be left in place for up to one week to give a continuous sampling of flies. The same trap can also be used for the purpose of fly control. The baited jar trap consists of a 1-gallon plastic milk jug with four holes (1 in. diameter) cut around the circumference in the lower third of the jug. About one tablespoon of fly bait containing insecticide is placed in the bottom. Flies enter, feed on the bait and die in the jug. The number of flies and the species caught can be easily determined. After one week the bait has reduced effectiveness so that flies and old bait should be dumped out at least once a week and fresh bait added. The placement of the traps is important and they should be in the same locations week to week throughout a monitoring period. The number of traps needed depends upon the precision desired and the level of fly numbers to be detected. At least six traps should be used per facility. In poultry houses, an index of 550 flies per trap per week has been used as the threshold for chemical treatment. However, lower thresholds may be desired when neighbors are close or animal facilities are exposed to visitors (such as horse stables).

Spot cards are simple devices for measuring fly activity. These are white 3 x 5 in. cards which are fastened to prechosen locations in a facility. They may be fastened to posts, rafters, partitions, feed troughs, etc., where the flies will not disturb or soil them.

Flies rest on the spot cards and eat the insecticide on the cards. The number of spots per card is easily counted after an interval of exposure which is usually 3-7 days. Exposure for longer than 7 days is not practical because the cards become too soiled. Cards may be labeled, counted, and kept for later reference if needed (such as in legal proceedings or fly control cases). Most spots are caused by the house fly. However, if other flies are present (especially Ophyra spp.) they will spot the cards. Therefore, spot card counts are an index of fly activity and the species of flies cannot be determined from only the spot card counts. Other observations should be made to verify whether or not the house fly is the most abundant species. The placement of the cards (like ribbons and jug-traps) is important and they should be placed where flies are observed to rest or fly species are present. Generally, locations in the upper parts of a person can reach are desirable. Several cards are necessary depending upon the level of fly activity to be measured and the precision desired. At least 10 cards should be used in a facility. In poultry houses, an index of 50 spots per card per week has been used as a threshold for chemical treatment. However, in different situations lower thresholds may be chosen.

Monitoring for fly larvae and pupae is important in order to determine specifically where the flies are developing (breeding) and to use cultural and chemical control (laricides) effectively. Locating fly larvae is laborious but must be done to know what changes in manure handling and facilities maintenance need to be made to reduce fly breeding. It is also necessary in order to know precisely where to apply insecticides as laricides. The only practical way to monitor for fly larvae is to examine likely places and remove portions of manure, sludge, bedding, etc., for closer examination. The large third-instar larvae and brown pupal cases can be readily seen (Figure 46). All possible breeding habitats should be inspected with particular attention to manure accumulations in places difficult to clean, as well as spilled feed, sludge, feed bunkers, around waterers, hay racks, under stables, etc. (Once the fly breeding spots (sites having fly larvae) are detected in a facility, they can be given special attention in routine monitoring. Breeding sites also can be laricided at the time of monitoring if necessary. Since the life cycle of the fly house and many other species is only about 7-10 days in hot summer weather, monitoring should be at least once a week and preferably twice a week. This can be meshed with a systematic overall inspection of the facilities and animals to detect any animal health or equipment problems. Such routine inspection is a sign of good herd and flock management.
Confined Animal Facilities And Fly Control Programs

The following descriptions of confined livestock and poultry production systems are generalized, and considerable local variations occur. The basic housing concepts are universal, however, and the descriptions serve to illustrate the significance of the production system to fly control. As noted in the introduction, this discussion concerns control of house flies and other flies in and around confined animal facilities, and those flies which are primarily pests of cattle on pastures and rangeland are not included.

**BEEF CATTLE**. The beef cow-calf operation provides the basis for beef cattle production. There are diverse methods used, with the cows and calves kept on pasture and rangeland in some cases, especially in large operations in the western United States. In other operations, the cows and their calves spend most of their time in a limited area for feeding and shelter while having access to limited pasture. The latter type of partially confined operation creates flies problems which are the subject of this presentation.

Categories of the cattle in a cow-calf operation are: (1) dry, mature pregnant cow, (2) cows nursing calves, (3) weaning replacement heifers, (4) bred yearling heifers, (5) growing steers and heifers, and (6) herd bulls. Stalls and areas for feed and water are sites for fly breeding. Feeding is often accomplished with hay racks which may be covered or open (Figures 47, 48). The racks may be fixed on a paved apron or movable. Rather than a hay rack, a solid-bottom bunk for hay andage may be used. Bunks are also needed to feed grain and minerals.

Since calves require a different nutrient composition in their diet, they are fed in a facility which excludes the brood cows. Such a facility is a creep (Figure 49). A creep in a fence line will restrict grazing. Movable grain creep feeders (usually on skids) may be used. Although arrangements vary, the creep feeder basically consists of some kind of fenced area or structure with openings about 3 feet high by 16 inches wide which allow access of only the calves. In the creep feeder, the calves have access to the high nutrient feeds including feed grain, molasses and protein supplements. Spillage from these feeders and wet feed in the feeders can
provide prolific fly breeding areas.

In addition to feed, there has to be
an ample supply of drinking water in a
cow-calf operation. In typical summer
weather, cows and heifers require 10–14
gallons of water per day, while nursing
calves require 16–17 gallons. Calves
drink about 8% of their body weight
per day in the winter and up to 15% in
the summer. The resulting urine mixed
with feces and spilled feed provides
ample substrate for fly breeding when
the animals are confined in high
densities.

Figure 49. Diagram of a creep for feeding calves and excluding cows.

The calves produced in the cow-calf
operation may be kept for various
lengths of time according to the needs
of the operation for replacements and
the market conditions. For a period suffi-
cient to add weight to bring the calves up
to 600–700 lb. each (about 6 months)
the calves are fed on either pasture and
hay, corn silage, or grain and pasture.
This is known as backgrounding or
growing, after which the calves are
assembled into reasonably uniform
groups and sold to feedlots. Calves may
be kept longer (1 year) and sold to feed-
lots at 700–800 lb. each. On the feedlots
the cattle are finished, i.e., brought up
to market weight on a diet of silage and
protein supplements. Alternatively,
finishing may be on grain and pasture.

The finishing of cattle on feedlots
is a very high-density confined-animal
system (Figure 50). Cattle are grouped
by type, age, sex, and weight in outdoor
pens and provided feed and water. Many
pens are grouped together into a single
feedlot operation. The conditions are
ideal for fly breeding. There are large
accumulations of manure, ample moisture
from urine, rain and watering devices, and nutrient-rich feed which

Figure 50. View of pens in a beef cattle
feedlot.

but often are only trenches in the
ground. The sludge is packed and cov-
ered with plastic sheeting. The margins
of improperly packed and covered sludge
provide conditions favorable for fly
breeding in horizontal storage systems.
Sludge around the base of tower stor-
age facilities likewise provides habitat
for fly breeding. Sometimes the sludge is
piled above ground without proper
compacting and covering to suppress
fly breeding.

The use of hay can contribute to
fly production. There has been increased
use of large round bales of hay which
may be moved by tractor-mounted
equipment. The margins of these bales
stored outdoors provide suitable habitat
for fly breeding after there is rain or
after the bales sit on moist ground for
long periods of time. The put of hay
which is often left on the ground after
moving the bales provides an excellent
habitat for fly breeding. To prevent
fly breeding, hay bales should be cov-
ered and stored on pallets to raise them
above the ground.

Cow-calf and cattle feedlot opera-
tions are extensive in the United States.

There are 30–40 million beef cows
producing about 15–17 million calves
per year of which about 3 million are
retained for herd replacement, and the
rest are finished, mostly in feedlots,
for slaughter. Economic and modern
large-scale production practices favor
more confined high density manage-
ment of these cattle, and as a result offer
more challenges in providing satisfac-
tory fly control. Feedlots are especially
troublesome because accumulations of
manure under fences, in corners,
and beneath bunkers cannot be easily
removed and consequently provide
ample fly breeding habitats. The areas of
pens with manure constantly being
tamped and compacted by the cattle
are usually not suitable for fly breeding.
If a pen is undersized with only a
few animals there may not be sufficient
tamping and compacting to prevent
fly breeding throughout the pen. The
feedlots require large quantities of
hay and silage and these feeds, when
improperly stored, become fly breeding
habitats (Figures 51–60).
Dairy cattle. Dairy cattle are grouped in larger and larger operations to provide more efficient and economical milk production. It is a highly organized operation with careful record-keeping and herd improvement through selective breeding and artificial insemination. Although dry cows (those not producing milk) are kept in pastures most of the time, the majority of a herd will be housed in a free stall or manure system with limited or no access to pasture. A shed or barn is provided for maternity stalls and calf pens. The urine- and manure-soluble bedding in these stalls and pens is provided as an excellent medium for fly breeding. There is increased use of calf hutches which are small shelters for each calf placed outdoors. Bedding, a manure, and urine in and around these hutch provide ample habitat for fly breeding. In addition to the calf and maternity barns and the calf hutch, other areas in a free stall dairy housing system are: (1) feeding area, (2) loafing area (with bunkers for hay, silage, and nearby waters), (3) milking area, and (4) paved or dirt lot. Some provision for a manure storage area is necessary also. An alternative to the free stall housing is the stanchion system in which cows spend most of their time confined in individual metal stalls. Stanchions are not in a barn rather than being free to move around. In a stanchion barn, feed and water are provided in front of each stanchion. A gutter and frequent scraping and/or flushing are used to remove the manure.

For fly breeding habitats to develop in the accumulated manure and spilled feed and water in the feeding areas. Tractor-mounted scrapers are usually used to clean the paved areas but accumulations of manure in corners and under fences, feeders, and partitions provide many opportunities for fly breeding. Cars should be provided under fences and railings to prevent accumulation of manure. In stall areas, automatic chain-pulled scrapers and gutters may be installed, but these systems will often leave some manure residue to support fly breeding. Stanchion housing is difficult to clean completely, and some fly breeding medium is frequently left around the stanchion supports and under the feeders, bunkers, and waterers.

Dairy production in the United States involves about 11 million cows concentrated in about 12,000 herds. Milk and milk products are important constituents of the human diet. High standards of dairy sanitation are required, milking parlors and manure handling procedures are subject to inspection by health officials. Inspectors evaluate the presence of flies with unsanitary operations so the need for a high degree of fly control in dairy operations is obvious.

Whatever the manure removal system in dairy operations, there is a problem of manure disposal. Ultimately it is spread on cropland and pastures, but intermediate storage is often necessary. Filling of the manure will produce more flies unless the manure is carefully compacted and covered with plastic sheeting to render conditions unfavorable for fly development. Equipment is available for extracting most of the water from manure and this is sometimes used in conjunction with automatic scraper systems. After water removal, the manure residue is easily stored or spread without significant fly breeding habitat development.
breeding problems. Another method of manure handling is to flush the manure into a deep rectangular lagoon. If properly designed and maintained, the lagoons are effective in preventing fly breeding. However, if the lagoon is overloaded with manure and mats of solid materials float on the surface, these may support fly breeding. Manure mixed with bedding from maternity stalls and calf pens cannot be placed in a lagoon and disposal has to be by piling and spreading.

Figures 73-74. 75. Moist hay around hay rack feeder. 76. Manure accumulation around waterer in dairy lot. 77. Accumulated manure in corner of dairy lot. 78. Edge of concrete apron with wet manure and runoff where flies may breed. 79. Accumulated manure along fence line. 82. Piled sludge and water waste adjacent to dairy lot. 83. Manure left piled on concrete apron. 84. Manure piled on ground.

Figures 75-78. 75. Runoff from a dairy lot. 76. Hay left on ground for feeding. 77. Freestall dairy housing. 78. Stanchion dairy housing.

CHECKLISTS FOR FLY CONTROL IN DAIRY CATTLE FACILITIES
Potential major fly breeding areas:
- maternity stalls
- calf pens and calf hutches
- under fences and corners of loafing area
- under and around feed bunkers and waterers outside
- under feed bunkers and waterers in stanchion barns
- in stanchion corners and gutters
- mangers of horizontal silage silos and silage piles
- base of tower silage silos
- manure and feed bales
- old feed in bunkers
- spilled feed around feed bins
- runoff areas
- around manure spreader loading area
- floating mats in lagoons

Control measures:
- clean maternity stalls and calf pens and hutches frequently
- move calf hutches frequently
- enclose under feed bunkers
- provide curbs and concrete surface in loafing area
- clean stanchions and gutters frequently
- scrape and clean loafing area frequently
- provide concrete apron around feed bunkers and waterers
- provide sloped and curbed concrete area for loading manure spreader
- cut adjacent vegetation
- provide concrete channels and settling basin for runoff
- keep lagoon free of debris and floating solids and do not overload
- clean up spilled feed weekly
- shelters over feed bunkers

SWINE. Swine production may be classified as (1) low-risk which includes feeder pig production and farrow to wean, and (2) feeder pig finishing. In either case, housing facilities vary from simple to specialized, high-density confinement. The simplest is a pasture system usually operating only to yield two litters per year from one group of sows in a farrow to finish system. Feeders and waterers are provided and fly breeding may occur around them. This type of production is rapidly disappearing. Most hog production occurs in either low-intensity or high-intensity confinement systems. Low intensity involves the use of simple buildings (sometimes converted from other uses) with concrete floors (with or without bedding) and partially open fronts. There may be an outside run or pen area with feeders and waterers. Manure is removed from the building and outside pens by scraper or occasionally by flushing. Runoff from the pens is collected in holding ponds after passing through a settling basin in the system is properly constructed. Sometimes, however, there is no provision for collecting runoff, and areas adjacent to the pens become saturated with manure and produce flies. This low-intensity housing may be used for sow herds or for feeder pig finishing. Separate buildings are usually used for growing-finishing and
for farrowing. Often the low-intensity system involves the use of large open or semi-open pens.

In the high-intensity confinement system, the buildings are designed and built specifically for hog production.

There are close scheduling and staggering of farrowing in a sow herd system to allow continuous year-round production. This continuous production involves a high investment of about $1500 per sow unit with each unit yielding about 15-18 market hogs per year. The sophisticated buildings and equipment may be used for feeder pig production, farrow-to-finish, or for feeder pig finishing only. In a sow herd system, a separate building or partitioned portions of a building are used for gestation and breeding, farrowing, nursery, and growing-finish. Growing-finishing is either to feeder pig selling weight (40-60 lb) or to market weight (about 220 lb). The buildings are either totally or partially enclosed and equipped with fans and heaters. In mild climates, partial curtain sides may be used. Feeders and waterers are automatic systems. The trend in hog production is to totally enclosed, environmentally controlled facilities. These allow the greatest production efficiency during all seasons of the year.

Manure removal and management with modern swine production facilities is accomplished by various arrangements of slotted floor made of wire mesh, concrete slats, or expanded metal. The floor may be totally or partially slotted. In the partial slotted arrangement, the pens are about one-half concrete floor and one-half slotted. Feeders and waterers usually are in the solid floor area which slopes toward the slotted portion. The manure falls through and is flushed through the slotted floor to a concrete pit area beneath. The supports along the margins of the slotted floor have no openings, however, and provide an area for manure accumulation and fly breeding. The concrete pit is relatively shallow (1-2 ft) if there is frequent flushing to an outside holding pond. An alternative is to use a deep pit (4-6 ft) beneath the slotted floor to allow long-term storage of the manure slurry. Periodically, the slurry is pumped out or allowed to flow by gravity, either to a lagoon or into a spreader for distribution on cropland. It is necessary to have ventilation (usually plenums and fans) of the manure pit to reduce problems from odors and the accumulation of gases which are detrimental to the swine and corrodible equipment.

The trend to larger swine production units and the use of specialized high-density confinement facilities has increased the problem of manure management and fly control. Pockets of manure may accumulate along the edges of pens and be forced through the slotted floors. Flushing out the manure from the slotted floor requires large volumes of water, and manure removal may not be complete. Due to insufficient water in the deep pit, there may develop crusts and piles of partially dry manure which allow fly breeding. Flushing manure into an anaerobic lagoon is a common method which is also used for dairy and poultry manure disposal. If the lagoon is too small, the accumulation of solids will provide sites habitat for fly breeding.

Partially slotted floors and manure flushing systems are used also in the less sophisticated partially open-front buildings with curtain sides in mild climates. In the simpler open-front buildings with outside pens, the floors and pens are solid and scrapers or flushing with hoses are used for manure removal. In both of these housing systems are areas along the pen walls, beneath railings and fences, and in corners where manure can accumulate and provide a habitat for fly breeding.

Swine production is increasing in the United States with about 60 million head per year. To meet the demand for production, swine operations are becoming larger. Many of the operations are under the contract system with integrators supplying feed, management advice and marketing channels. Whole herd and year-round continuous production in confined, high-density, controlled environment facilities are becoming more common production systems. Concurrently, fly control becomes more difficult. Each growing and finishing pig produces 18 tons (4,000 gallons) of feces and urine per year. This does not include the large amounts of water used in the flushing systems for manure removal. The large number of swine and the large amounts of manure in a limited area create the potential for large amounts of fly breeding.

**Figure 80. Sectional view of swine low-intensity housing with outside pen.**

**Figure 81. View of swine lot with adjacent waste lagoon.**

**Figure 82. Swine feeder on an unpartitioned lot.**

**Figure 83.**

**Figure 84.**

**Figure 85-87.**

**Figure 85-87. Sectional drawing of a partially slotted floor swine house.**

Manure slurry is pumped from the pit periodically. **84. View of multi pens in enclosed, environmentally controlled, high-intensity, partially slotted floor swine facility.**
Figure 86. Diagram of a section of a caged-layer poultry house showing stacked cages and manure accumulation on the flat floor. Houses are grouped together in an operation with feed stored in upright bins and conveyed by augers to each house. Laying hens for commercial egg production are housed in banks of cages in several different types of houses. In most cases there are three or four birds per cage (about 12 x 12 x 18 inches), although larger cages are occasionally used. The cages are stacked three or four high with each level set back to allow manure to drop beneath all the cages. If the stacked cages overlap, an angled dropping board (often heavy plastic) is located between the cage levels to divert the manure from the birds. The simplest arrangement is a narrow house (also called a California house) with a center walkway and one tier of four cages on each side of the walkway. The narrow house is about 10 ft wide and 200-300 ft long; several are usually grouped together next to a common service and egg storage building. In the narrow house, the manure accumulates beneath the cages on the dirt or concrete floor and is removed by hand or with a small tractor and scraper.

In larger houses there are back-to-back tiers of cages running the length of the house and two to five walkways per house. These houses may be the wide-span type or the high-rise type (also called deep-pit). The wide-span house is one-story, with the lowest cages about 3 ft above the floor where the manure accumulates. The floor is usually concrete and may be flat, in which case the manure is removed by tractor-mounted scraper. Often the floor is recessed beneath the cages (shallow pit), and the manure is removed frequently by a mechanical cable-operated scraper or by flushing with large quantities of water pressurized by electric pumps. With both the scraper and the flush systems, the manure is brought to one end of the house and then augered, or flushed, into a lagoon or transported for spreading upon the fields. The scraper and flush systems must be operated two or three times a week to prevent excessive accumulation of the manure, which the equipment cannot effectively move.

Figure 87. View of a scraper in a shallow-pit-type, caged-layer poultry house.

Figure 88. Diagram of a high-rise, deep-pit-type, caged-layer poultry house showing stacked cages on the top story and deep manure accumulation beneath the first story of the building.

Figure 89. Wet accumulated poultry manure in bottom story of a high-rise caged-layer poultry house.

The high-rise house is similar to the wide-span structure but is two-storied. The birds are on the top story with wooden walkways between the banks of tiered cages and no floor beneath the cages. The manure accumulates on the floor (usually dirt, occasionally concrete) of the first story. The first story is 8-9 ft high, and sometimes is set below ground level, although it should be slightly above the prevailing ground level to provide drainage away from the house. The manure is allowed to accumulate in this first story level for months or even a few years. Manure removal is by tractor-mounted front-end loaders. Both the wide-span and the high-rise housing may be openable, with movable curtains for ventilation control in warm climates or with fans for ventilation control in cool climates. A wide-span house will typically be about 55-60 ft wide by 300-400 ft long and hold 20,000 to 35,000 birds. A high-rise house will be typically 40 ft by 400-600 ft, long and hold 50-60,000 birds. In both types of houses, egg collection and feed delivery are handled by automatic conveyor belt systems. These may be used also in narrow houses, although sometimes the feeding and egg collection are done by hand.

Figure 90. Dry accumulated poultry manure in bottom story of a high-rise caged-layer poultry house.

The cages in commercial egg houses provide an ideal habitat for fly breeding. Leakage from the waster and poor drainage contribute to keeping the manure moist and suitable for fly breeding. Often it is difficult or impossible to achieve sufficient air flow over the manure in the houses to dry the manure. Poultry production is increasing and the units of production are becoming larger. There are about 300 million laying hens in the United States. With an average weight of 4 lb and the fact that laying hens excrete about 5% of their body weight per day, the laying hen population produces about 30,000 tons of manure per day in the United States. Even with the best of manure handling

Figure 85A. B. 85A. Drawing of a section of a poultry breeder house showing raised slotted floor with manure accumulation beneath 85B. View of slotted-floor area of a poultry breeder house.
procedures, this presents an enormous potential for fly development. Frequent flushing and scraping, and disposal of the manure into a lagoon, similar to the systems used for dairy and swine operations, is effective provided lagoon design and maintenance is satisfactory. Often, however, flushing or scraping is incomplete and pockets of manure are left for fly breeding in the houses.

Floating mats of solid matter in the lagoons occur with overloading and support fly breeding. In the housing systems where the manure is allowed to accumulate for longer periods, inadequate drying of the manure is common and, consequently, fly breeding is frequent a problem. When the manure is removed from the houses, disposal often becomes a problem.

Sorting the manure in piles is seldom done due to the odors and fly breeding. Distribution of the manure on cropland and pastures in a thin layer will not support fly breeding, however, improper spreading leaving deep clumps can result in some fly production in those fields. Often there is insufficient land on which the manure can be spread due to the small acreage of many poultry farms and the limits to the amount of manure that can be used on cropland within any period of time.

**CHECKLISTS FOR FLY CONTROL IN POULTRY FACILITIES**

-accumulated manure under caged laying hens
-accumulated manure under slats in breeder laying-hen houses
-residues of manure left by scrapers and flushing systems
-water under waterers in broiler and turkey houses
-wet manure under waterers in caged layer and breeder houses
-wet areas due to surface runoff into the houses

- moist spilled feed
- dead birds
- broken eggs on floor and in manure
- debris and floating solids in lagoon

**CONTROL MEASURES:**
- Proper ventilation and airflow to dry manure
- Prevent leaking waters
- In scraper and flush systems, remove manure frequently
- In systems with accumulated manure, remove only once or twice per year during the cool season
- When removing accumulated manure, leave some of absorptive old manure
- Remove only a portion of accumulated manure at a time
- Grade and provide drainage around houses to divert surface water
- Cut vegetation around houses
- Prevent feed spillage
- Incinerate dead birds immediately
- Remove broken eggs
- Provide proper size lagoon and prevent floating debris and solids
- Residual insecticide spray on surfaces of house and surrounding vegetation
- Fly bait stations
- Larvicide
- Misting if needed
- Feed additive

**HOSES AND OTHERS.** Horses are important for pleasure riding, breeding and racing in the United States with the horse population about 10 million. These are about 3.2 million horse owners. Horses are an expensive investment for the owners and there is usually a great concern for proper housing and environment. Included is a desire for few or no flies.

**Housting facilities for horses:** There are dispersed and often have small capacity. Housing basically consists of: (1) tie stalls, (2) box stalls, or (3) free choice open sheds. Usually the system is too small to allow sophisticated cleaning and manure handling systems. Large amounts of bedding are used. In tie and box stalls the flooring is packed clay, wood or concrete or concrete (although the hard surface of concrete makes it undesirable). Stalls have stout partitions reaching to the floor to prevent accidental foot injury. The many edges and corners in the stalls and the large amounts of bedding soaked with urine and feces provide a ideal fly breeding habitat. Cleaning with hand tools is time consuming and difficult to accomplish completely. Water and feed and grain and hay must be provided to the stalls or in the free choice sheds and spillage from these contributes to fly breeding in the bedding. Each horse produces about 40 lb. of manure per day and in combination with bedding, spilled feed and water, this provides ample oppor-

![Figure 91. Diagram of typical arrangements for feed and water in box stalls for housing horses. 92. Diagram of typical arrangements for feed and water in tie stalls for housing horses.](image)

- Figure 91. Spilled hay and wet manure around feed bunkers in horse or other similar housing.
- Figure 92. Diagram of typical arrangements for feed and water in tie stalls for housing horses.
- Figure 93. Diagram of typical arrangements for feed and water in box stalls for housing horses.

- Figure 94. Digested bedding from horse stalls or similar animal housing and feed providing suitable media for fly production. The frequent removal of contaminated bedding in horse stables presents a disposal problem. If the manure is piled, the piles can support large amounts of fly breeding (unless the piles are compacted and covered with plastic sheeting).

- Other livestock, such as sheep and goats, present similar problems of fly control as horses because housing is similar (but usually cleaned much less often). Sheep and goats are usually housed in open feed choice sheds or indoor pens with ample bedding, spilled feed, and water, and accumulated urine that will prevent fly breeding. This housing should be located on well-drained sites and graded so that surface water does not enter the sheds. Improper drainage and leaking waterers are the major contibutors to wet bedding which encourages fly breeding.

**CHECKLISTS FOR FLY CONTROL IN HORSE AND SIMILAR FACILITIES**

- Corners and edges of stalls
- Under feed mangers
- Under waterers
- Margins and stored hay and grain
- Old feed in bunkers
- Wet spilled feed
- Piles of manure and bedding
- Wet bedding due to entrance of surface water

**Control measures:**
- Clean stalls frequently
- Ventilate well to dry bedding
- Compact and cover piles of removed manure and bedding
- Clean up spilled feed frequently
- Grade to prevent invasion by surface water
- Residual insecticide spray on surfaces and adjacent vegetation
- Misting for adult fly control as needed
- Fly bait stations
- Larvicide
Sources Of Further Information

GENERAL REFERENCES


55
SELECTED REFERENCES


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