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Filth Fly Control

First Edition

Edited By Dr. Stuart Mitchell

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Introduction

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The Order *Diptera* contains 122,000 species in 130 Families. Dipterans have one pair of wings, with reduced, club-shaped hind wings called halteres. A comparative few species are wingless.

Image Credit: CIEH

"Filth flies can carry over 100 human pathogens including *Salmonella, E. coli* O157, *Campylobacter,* and *Helicobacter*. House flies can maintain *E. coli* O157 for up to 30 days."

Public health significance of urban pests (CIEH).

Introduction

In the Family *Muscidae* there are approximately 3900 species of flies. Medically, the more significant are House flies and Stable flies. House flies vector viruses, fecal bacteria, flat worms and round worms, and protozoans. Enteric diseases like dysenty and typhoid result. Stable flies present a nuisance from biting.

Flies are an extremely mobile pest. Flies move from filth to food carrying disease-causing pathogens in their guts and on their bodies (flying infections).

Very few fly species interact with humans. Species that do are very destructive pests. Flies spread diseases to man and domesticated animals as well as contaminating food and packaging.

Increasing international travel means that there are very few barriers left to stop the global spread of insects. Flying insect mobility is a primary reason why they have significant pest status. Flies visit many diverse and contaminated habitats within the course of their relatively short life span.

A Nuisance

Filth flies are labeled such due to their association with carrion, feces, and waste. 122,000 species of flies reside within most all ecosystems. Flies pick-up pathogens as they walk and feed upon contaminated materials. House flies regurgitate digestive juices and defecate where they feed or rest.

Flies and Health

Filth flies carry over 100 human pathogens. House flies can maintain *E. coli* 0157 for up to 30 days. A single fly could transfer a lethal dose to a food portion. Flies associated with humans may carry bacteria resistant to antibiotics.

- Flies carry pathogens such as *Coxsackievirus, Enteroviruses, Poliovirus,* and *Cryptosporidium.*
- Eggs and cysts of various cestodes and nematodes can be transferred (particularly hookworms and ascarids).
- People sometimes have allergic reactions to the bite of the Stable fly (the primary biting fly within urban areas).

Myiasis

Over 50 fly species larvae can cause intestinal myiasis when ingested. This can lead to malaise, vomiting, pain, and bloody diarrhea.

Blow flies, Flesh flies, House flies, and Latrine flies can cause living human tissue myiasis. Beneficial medical maggots are used with difficult to heal wounds.

Climate Change

The average global temperature has increased approximately 0.6°C over the past 100 years. Warmer conditions could promote transmission of diseases and increase disease-vector populations. *A simulated climate change model predicted a potential increase in fly populations of 244 per cent by 2080.*

Image Credit: National Institutes of Health

Maggots used to clean a non-healing wound. Maggot Debridement Therapy (MDT)

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Biology

Flies undergo complete metamorphosis consisting of 4 stages (egg, larva, pupa, and adult). The duration of each developmental stage is dependent upon temperature, food, and moisture availability.

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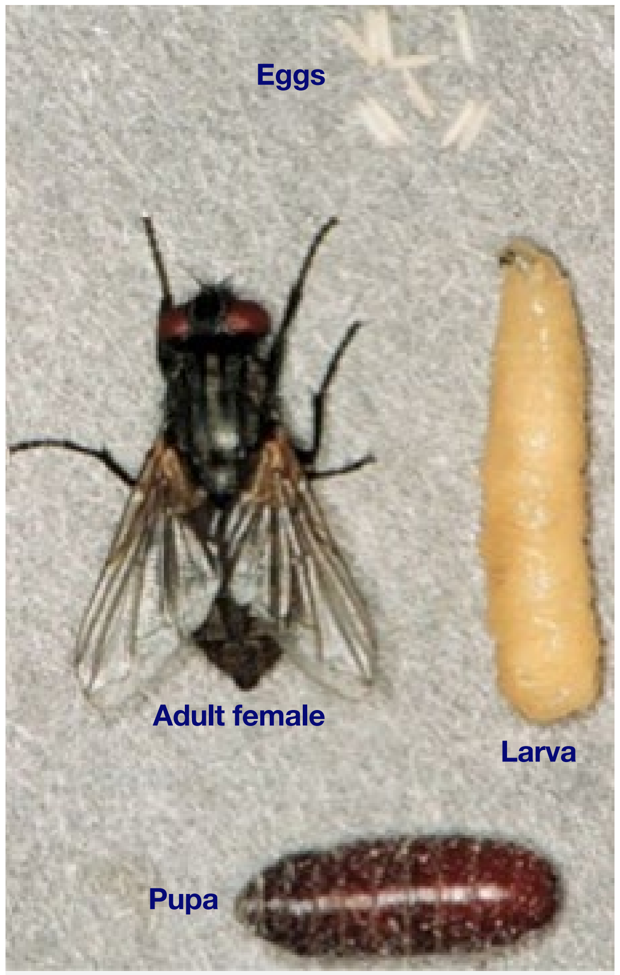


Image Credit: University of Nebraska Department of Entomology

The Life Cycle of the House Fly
The House fly *(Musca domestica)* can go through complete *metamorphosis* (egg to adult) in as few as 8 days. Other fly species have similar life cycles. The adult is 6 mm in length.

Synanthropic Flies

"Diptera" means two-wings. It is this characteristic that groups True fly species together. Flies have vibrating structures called halteres in place of a second pair of wings. Halteres aid in flying capabilities.

Synanthropic (attracted to human habitats) filth flies seek moist environments in which to place eggs. An adult female House fly can place up to 2,400 eggs in her lifetime. Flesh fly females place eggs whose larvae are ready to hatch immediately after deposition.

Adult flies determine larval development sites based upon environmental cues. Each species of fly prefers a specific microenvironment. Proper species identification is key to locating larval sources.

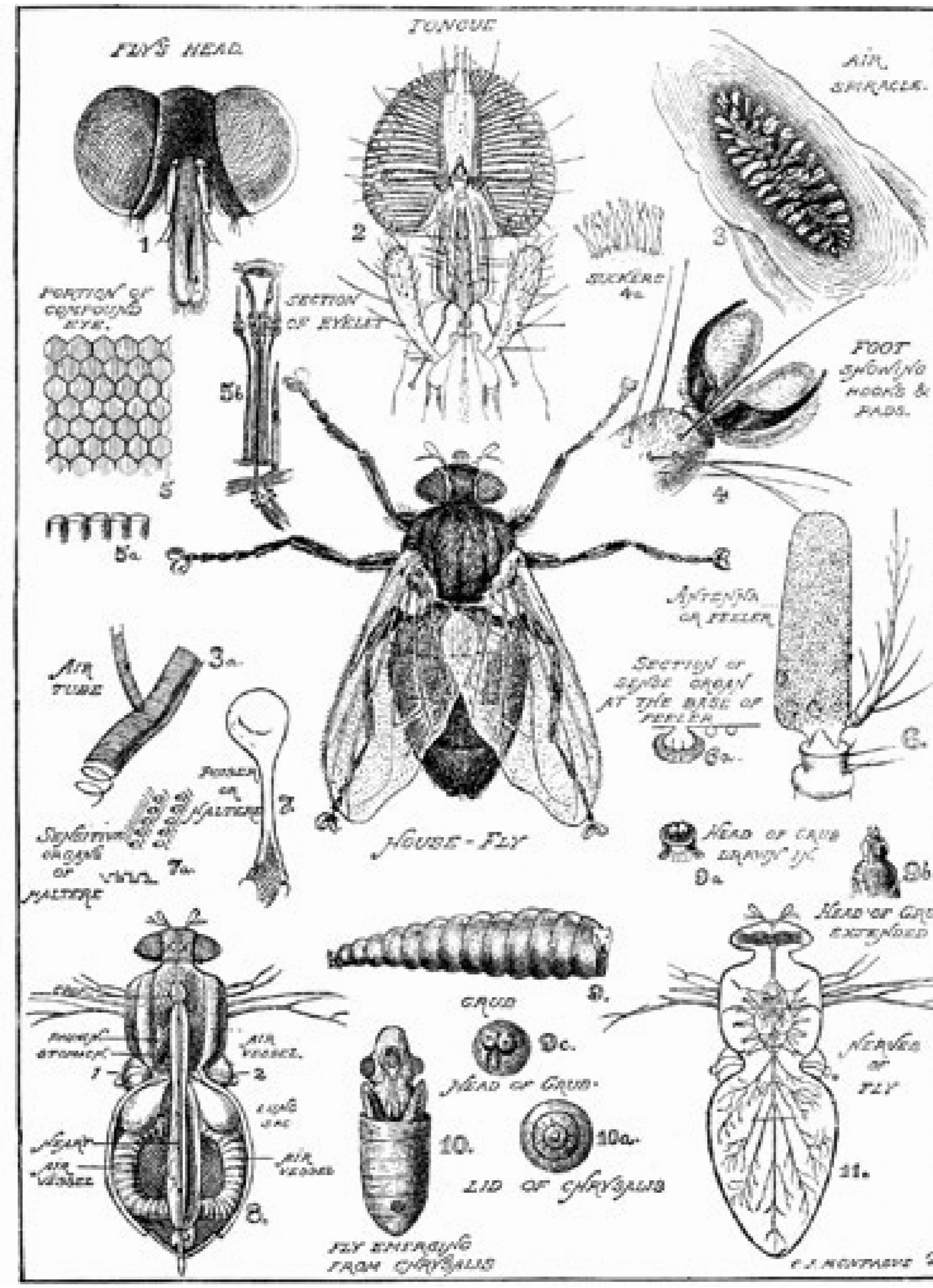
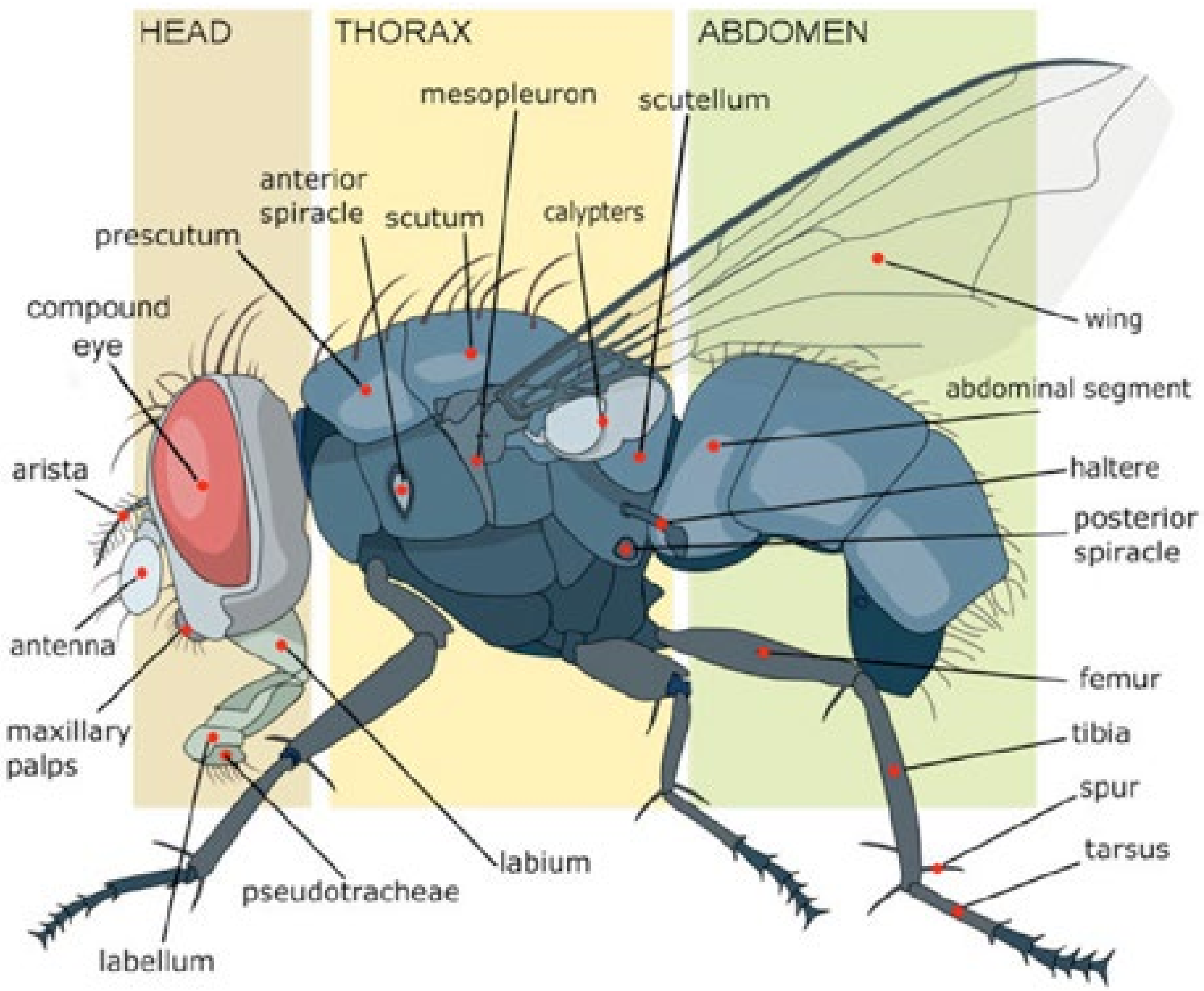
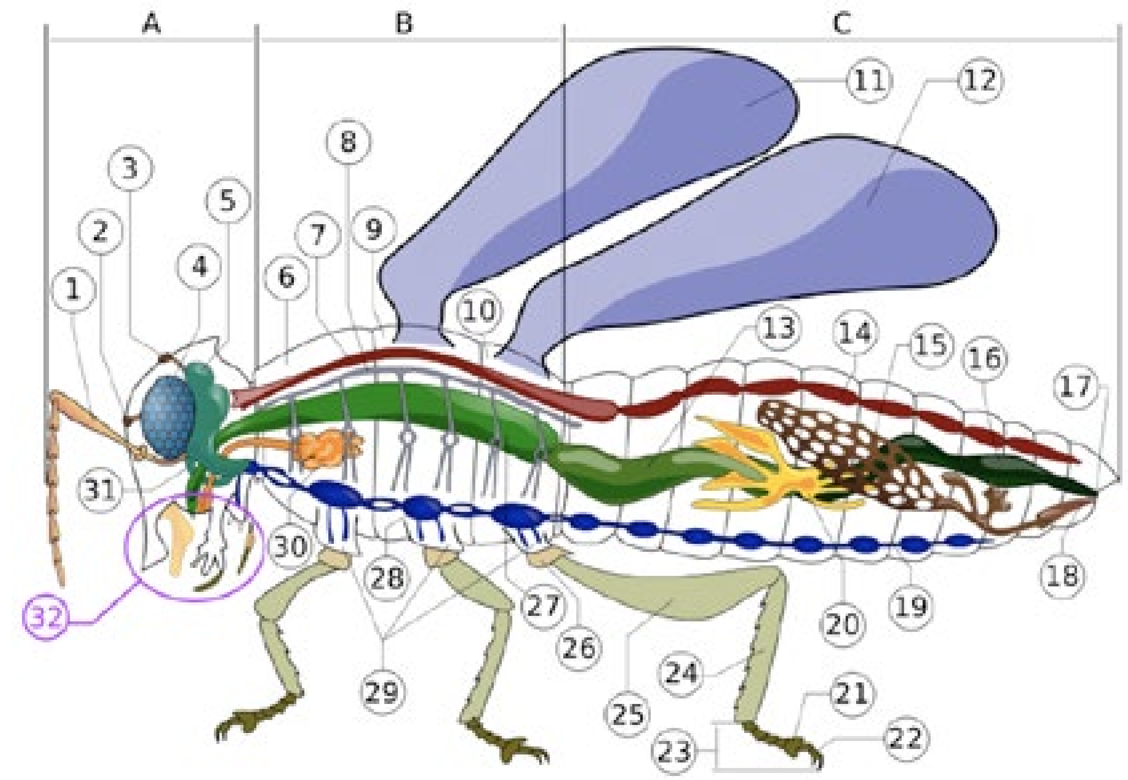


Image Credit: www.istockphoto.com



External anatomy of a House fly

Insect anatomy is mapped beginning with the head and extending to the end of the body.



General Insect Anatomy

A - Head B - Thorax C - Abdomen

1. Antenna
2. Ocelli (lower)
3. Ocelli (upper)
4. Compound eye
5. Brain (cerebral ganglia)
6. Prothorax
7. Dorsal blood vessel
8. Tracheal tubes (trunk with spiracle)
9. Mesothorax
10. Metathorax
11. Forewing
12. Hindwing
13. Mid-gut (stomach)
14. Dorsal tube (heart)
15. Ovaries 16. Hind-gut (intestine, rectum & anus)
17. Anus
18. Oviduct
19. Nerve chord (abdominal ganglia)
20. Malpighian tubes
21. Tarsal pads
22. Claws
23. Tarsus
24. Tibia
25. Femur
26. Trochanter
27. Fore-gut (crop, gizzard)
28. Thoracic ganglion
29. Coxa
30. Salivary gland
31. Subesophageal ganglion
32. Mouthparts

Visual Perception

Insects (depending upon the stage) have many types of visual receptors (compound eyes, ocelli, and stemmata). Compound eyes are understood to be receptive to blue, green, and ultraviolet (UVA) light wavelengths. In addition, they form mosaic images.

Vitamin A is needed by several species for visual perception and normal compound eye structure. Many species use plane-polarized light.

Color vision perception has been behaviorally demonstrated in some insects. An experiment (generally using an electroretinogram or ERG) for color vision must yield demonstrative behavioral discriminated between two colors (wavelengths). Chromatic visual distinction has been demonstrated in *Dipterans* and *Hymenopterans.*

Chromatic perceptual process, and the resultant cascade within the compound eye, seems to be essentially the same as the vertebrate eye. One difference is that rhodopsin does not split away from 11-cis-retinal within insect eyes after receiving a photon of light leading to the metarhodopsin state.

Metarhodopsin can be transformed back into rhodopsin, upon absorption of another photon (ready to repeat the visual process).

Visual perception in yellow light (left) and visual perception of UVA light (right).

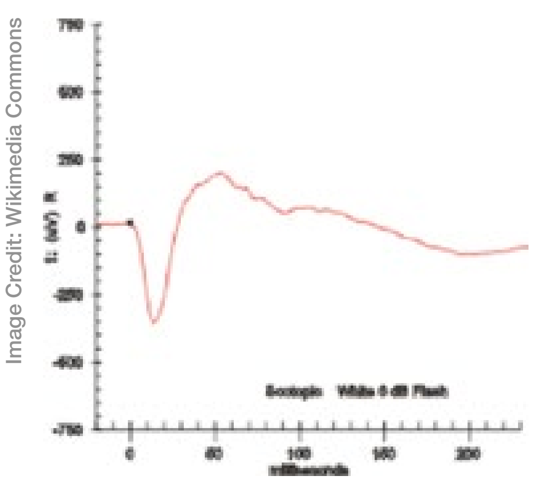
Image Credit: www.istockphoto.com

Each fly species has a different visual sensitivity that changes according to the sex of the fly, its age, its feeding status, its reproductive stage, etc.

Fifty percent of a fly's head is anatomous to visual perception. Seventy percent of a fly's brain is devoted to visual processing. Up to thirty percent of a fly's body mass can be eye anatomy.

Behavioral research using an (ERG) electroretinogram (measures the electrical responses of various cell types) allows for clues to what a fly can see.

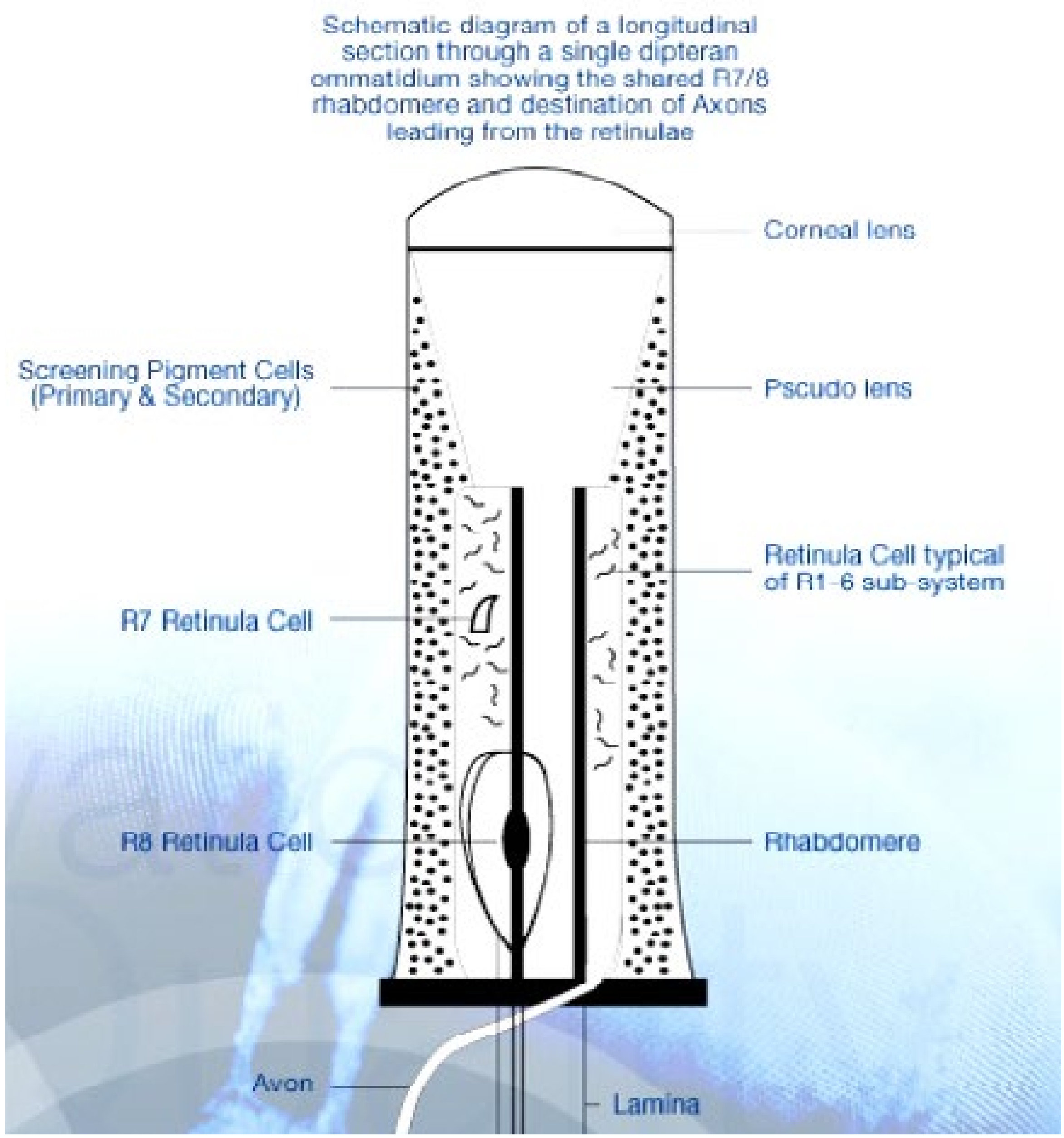
Image Credit: Wikimedia Commons



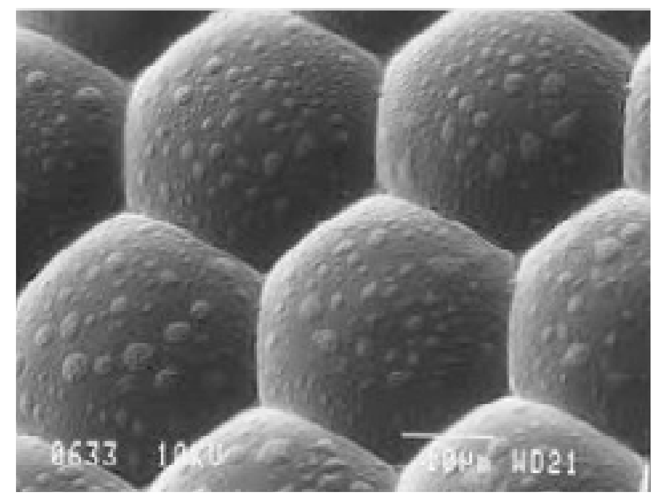
Example maximal response ERG waveform from a scotopic or dark adapted eye.

Such research shows the optimum range for attracting flying insects is 350 - 370 nm (specifically 365 nm) of UVA light. Species have priority of visual sensitivity that changes according to their sex, age, feeding status, and reproductive status.

Structure of a single ommatidium.



Insects have hemispherical eyes composed of thousands of hexagonal eye elements (ommatidia). They serve for orientation during flight. Multiple ommatidia enable the insect to see what is in front, behind, above, and below itself.



Six-sided ommatidia.

The spread and continuous outer layer of chitinous lenses shows the typical hexagonal pattern. Light is captured in the eyes of insects by structures called ommatidia. Each adult House fly has around 3000 ommatidia in each eye. Ommatidia are hexagonal patterns. Light from any point is collected by six different ommatidia.

Image Credit: PestWest USA

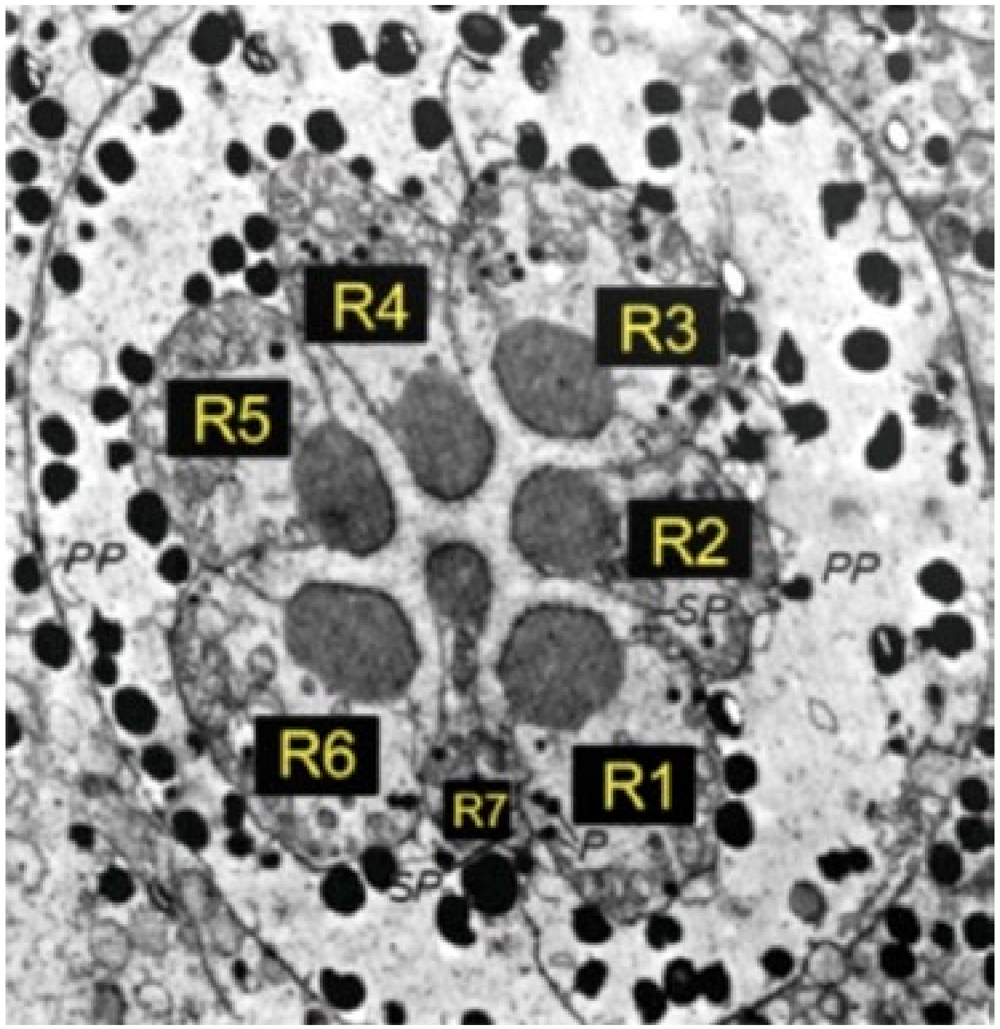
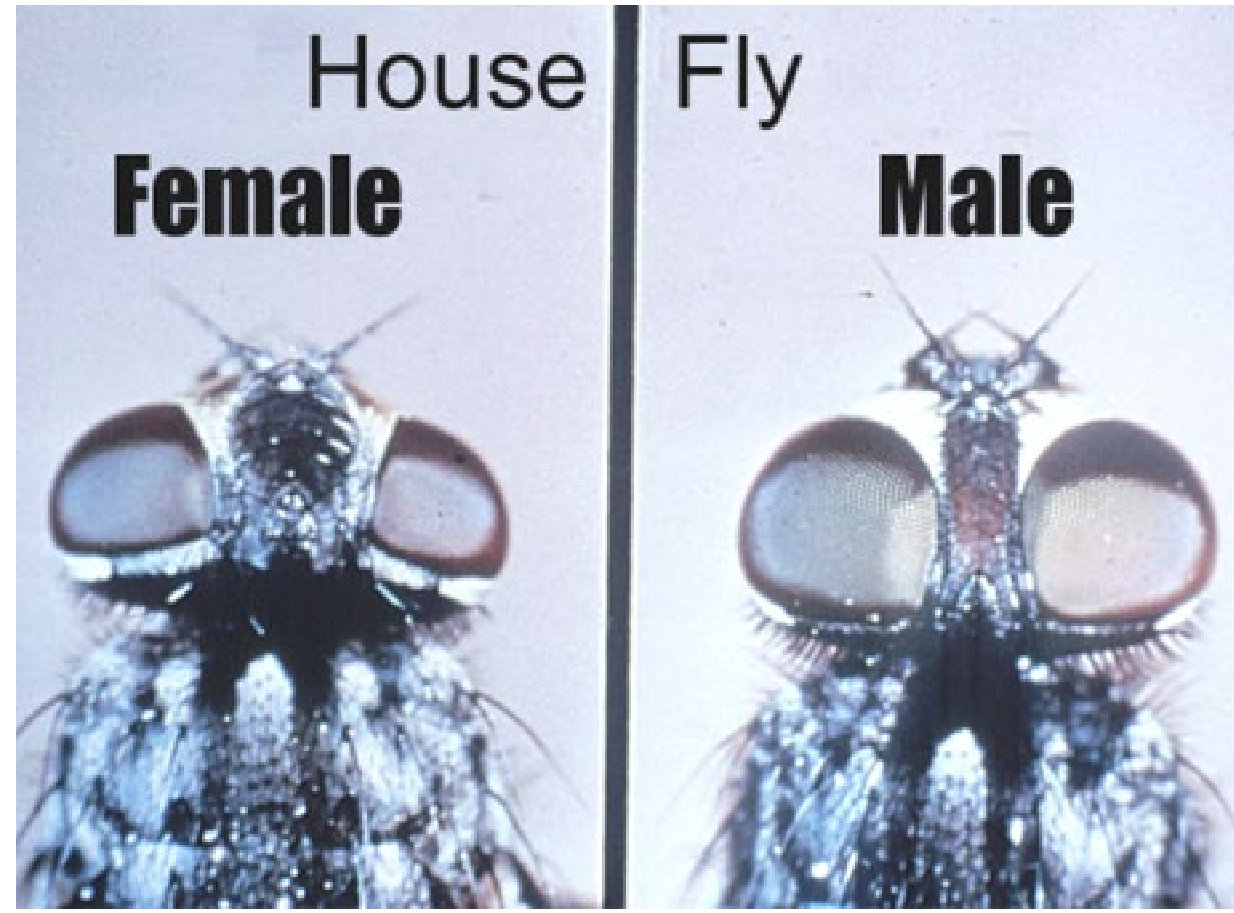


Image Credit: Van Waters & Rogers

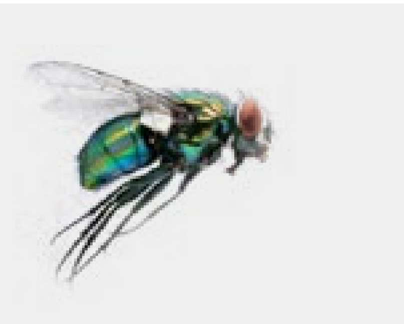


Arrangement of photoreceptors in one ommatidium of the House fly. In each of the ommatidia there are eight sensory cells (R1 to R8). Each contains a photo-pigment (opsin proteins) responding to a particular wavelength of light. The intensity of the image on the retina is greatly enhanced, making the vision of a fly much more sophisticated.

The fly's functional separation of the eyes. Within the eyes of male flies there is a specialized zone in the front. Eyes have their greatest area of binocular overlap. These spots are especially developed so that the males can detect female flies in flight vicinity.

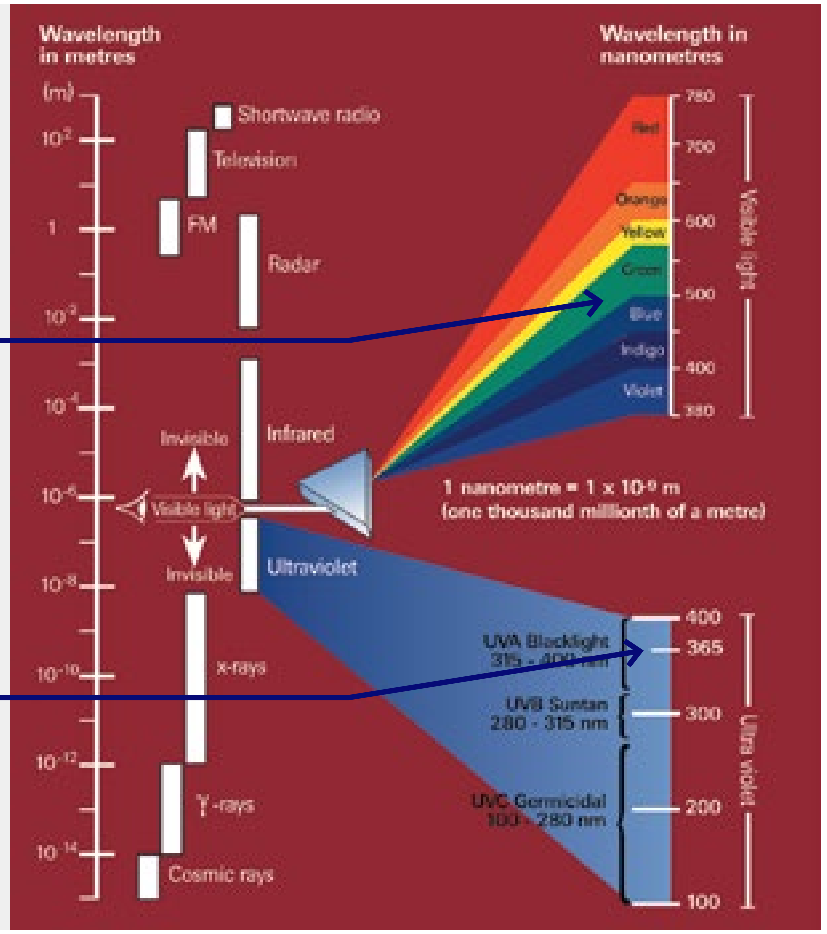
Electromagnetic Radiation Spectrum

Image Credit: PestWest USA



Human eyesight is most sensitive to light with a wavelength of 540nm or slightly lime green

The electromagnetic spectrum, highlighting the range of UVA light used in electrical fly control units



"In an enclosed environment, House flies will go the the easiest accessible attractant, no matter what the height."

"The Sky's the Limit" by Dr. Joseph Diclaro, Dr. Phil Koehler, and Dr. Roberto Pereira, University of Florida Entomology.

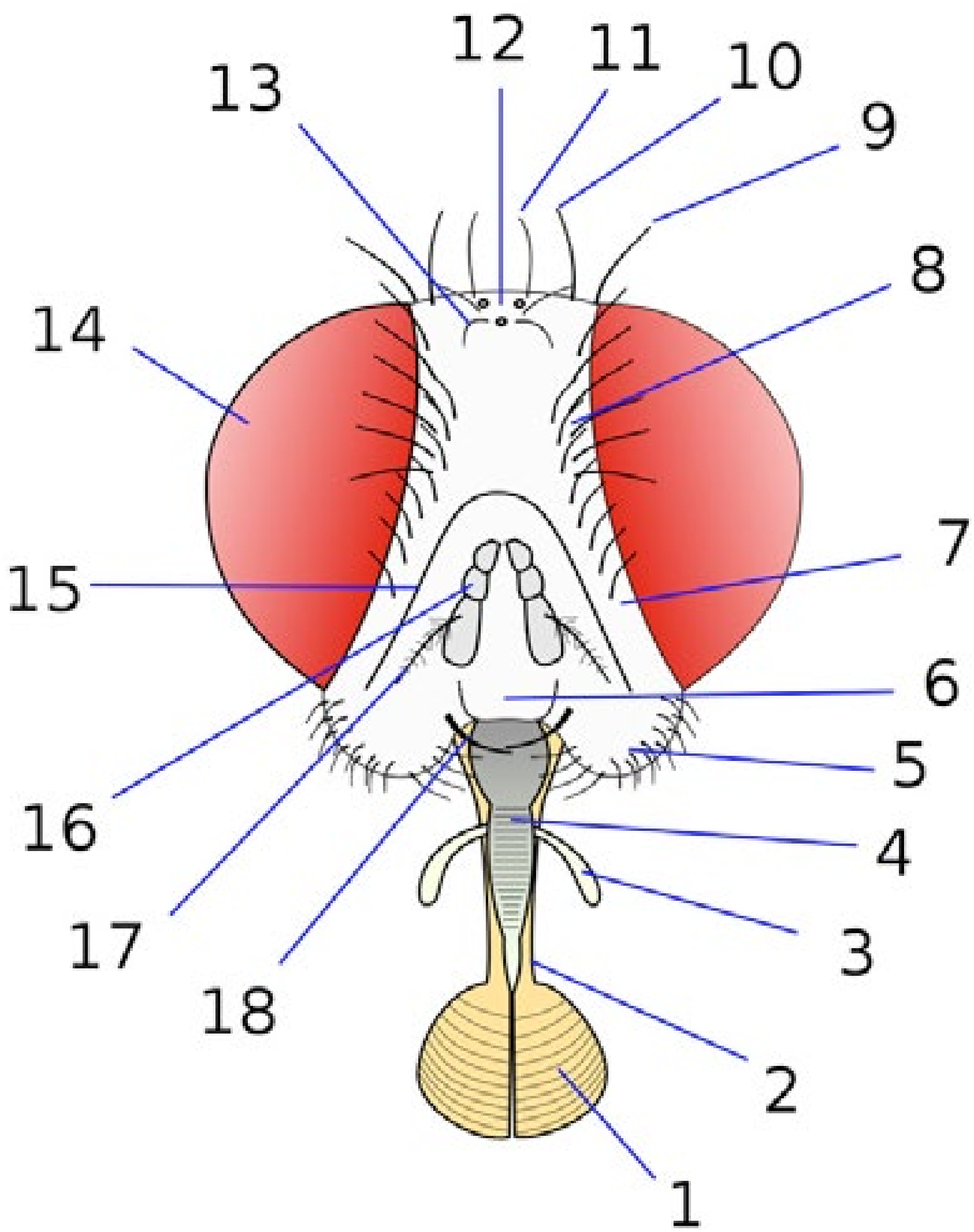
Many insects use ultraviolet wavelength emissions from celestial objects as references for flight navigation. The visual acuity and nature of the specific insect response varies (opsin pigment proteins).

A local ultraviolet emission from an insect light trap (ILT) or electronic fly killer (EFK) will disrupt the navigation process and will eventually attract flying insects. Insects do not respond to ILTs more than one hundred feet away (attraction zone). House flies respond at twenty to twenty-five ft., with a significant increase at twelve feet (capture zone). At twelve feet, it will take up to seven hours for ninety percent of the flies to respond. Thirty-six hours for a ninety-nine percent response.

Image Credit: PestWest USA

ON-TOP PRO2

Image Credit: PestWest USA



Anatomy of a fly's head

1. Labellum
2. Labium
3. Maxillar palp
4. Labrum
5. Subgenal area
6. Clypeus
7. Fronto-orbital area
8. Front-orbital bristles
9. External vertical bristle
10. Internal vertical bristle
11. Postocellar bristles
12. Ocelli
13. Ocellar bristles
14. Compound eye
15. Frontal suture
16. Antenna
17. Arista
18. Vibrissa

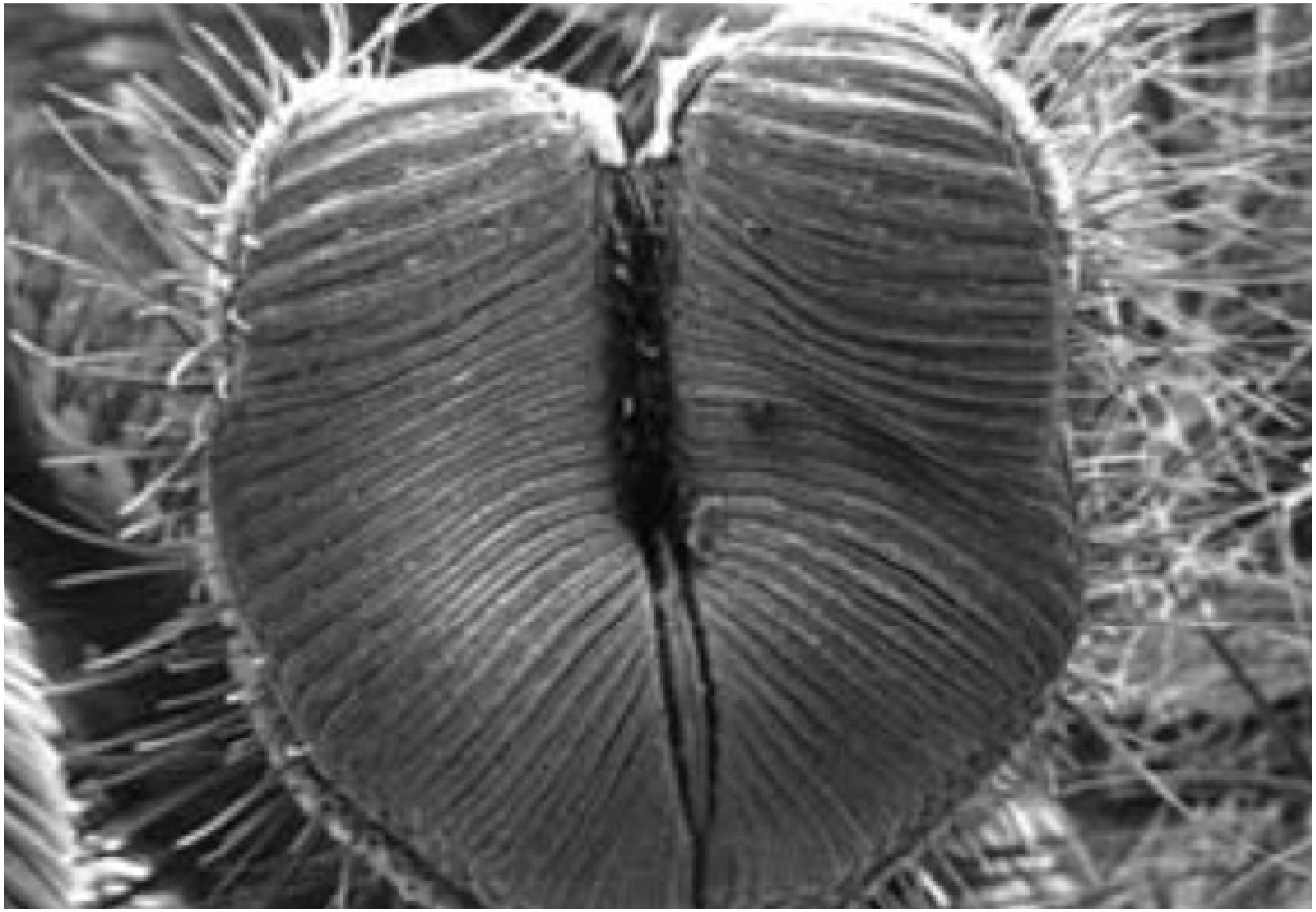


Image Credit: PestWest USA

Numerous pseudotracheal channels of the sucking tube. House flies are “flying infections” and can harbor up to 6 million external bacteria and up to 25 million internal bacteria. Fecal spots are darker than saliva spots. A House fly can deposit 16 to 31 spots in 24 hours (mostly saliva).

Image Credit: PestWest USA

A Fly Eating

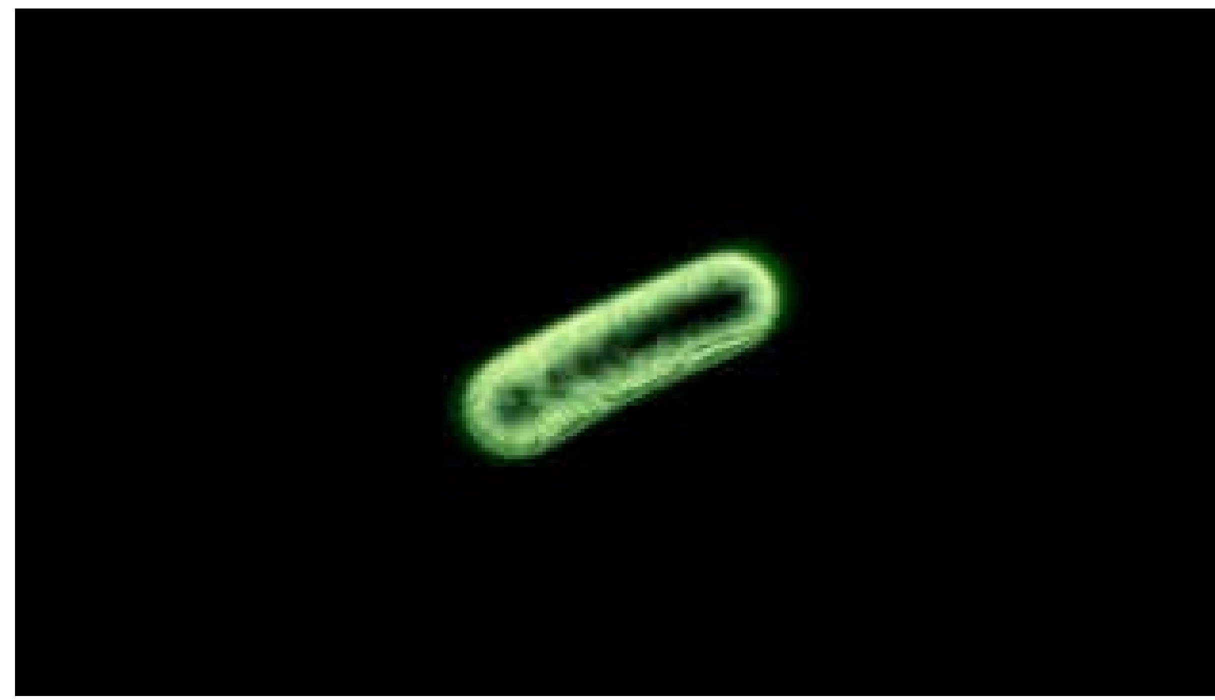
A Green Bottle fly eating and contaminating food.

CLICK ON BOX FOR VIDEO >

Bacteria

Animation of bacterial replication or binary fission (occurring about every 20 minutes).

CLICK ON BOX FOR VIDEO >



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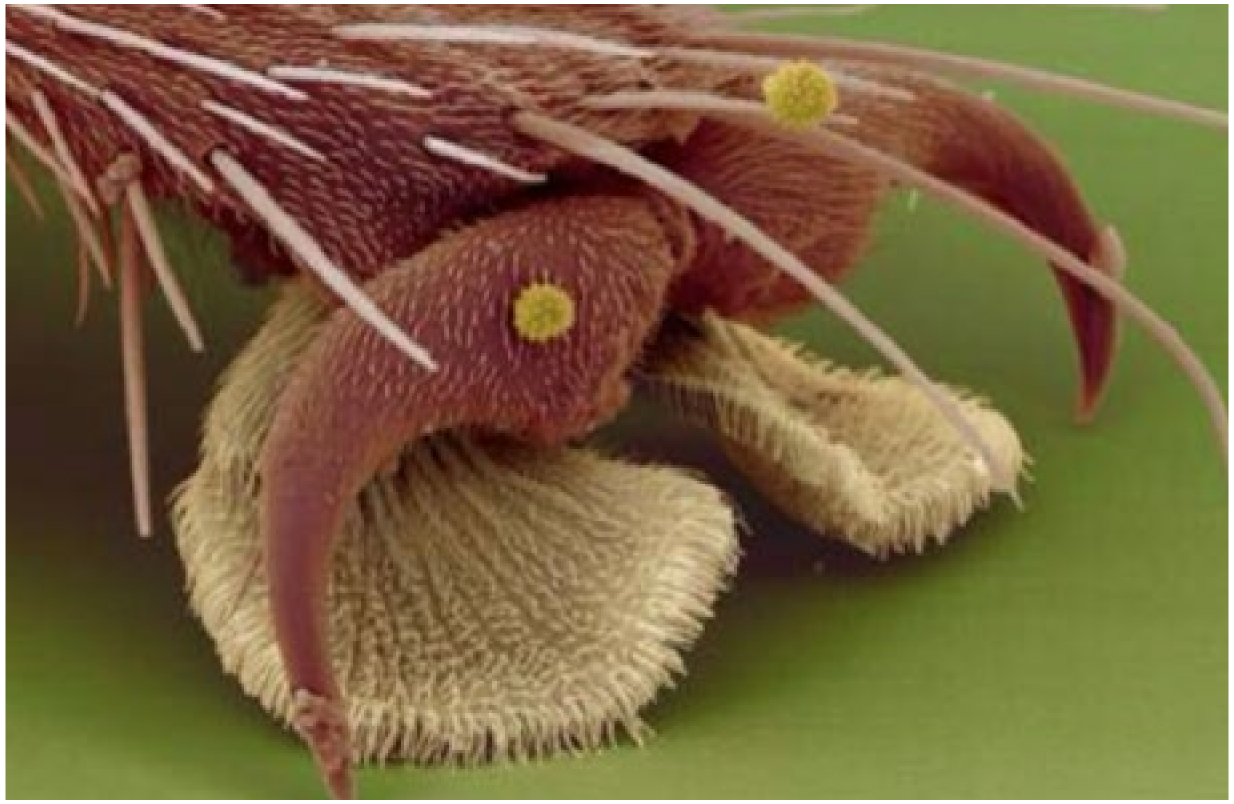

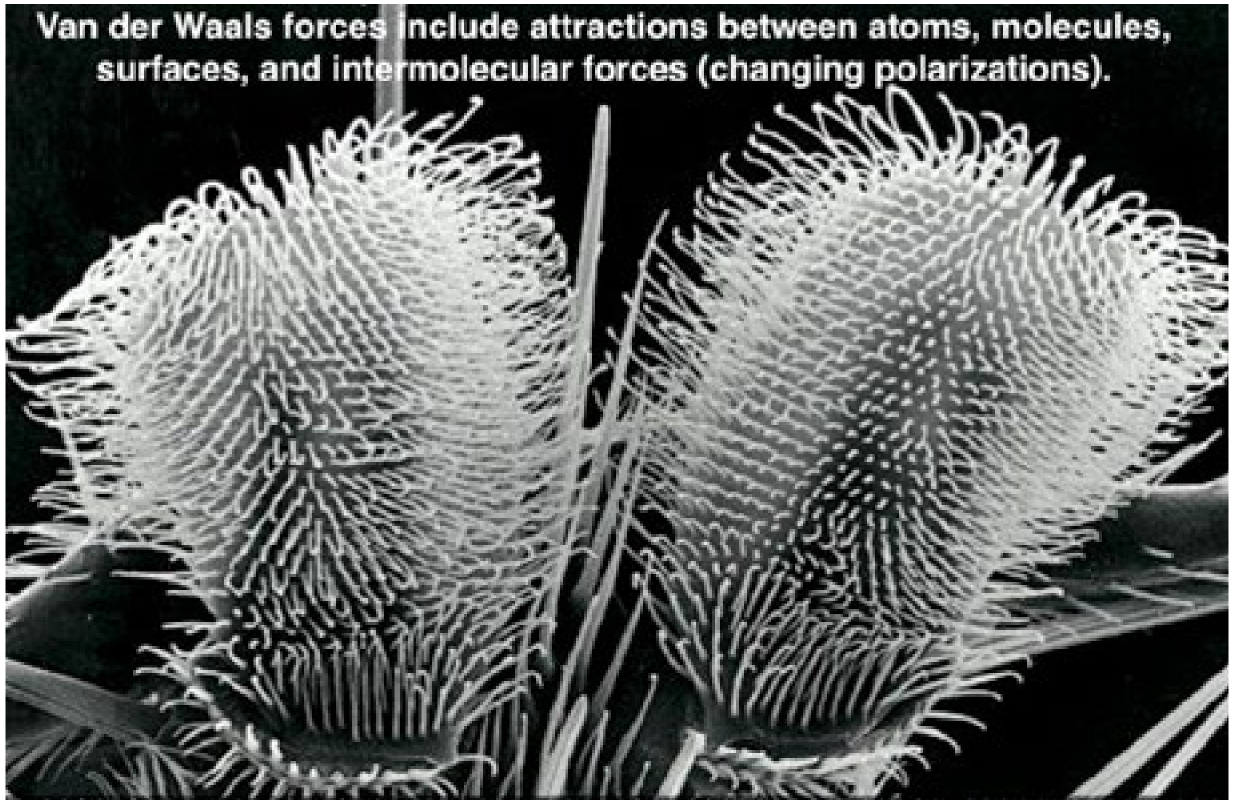

Image Credit: Science Photo Library

Pulvilli are membraneous, pad-like structures between the tarsal claws or cushions of short, stiff setae on the underside of tarsal joints. These are unique to Dipterans.

House flies are able to run around on both window-panes and the ceilings of rooms without falling. Pulvilli at the end of the last segment of their feet allow these acrobatics. Pulvilli are paired soft patches containing numerous glandular hairs which secrete a sticky substance. They contain hair-shaped chemical sensillae which enable the fly to recognize food substances when walking on them. The proboscis is then extended. House flies taste with their feet.

Image Credit: www.istockphoto.com

The wings of insects are lateral folds of the thoracic body wall. They consist of two chitinous membranes closely attached to each other. They are supported by veins which also contain nerves and spaces for air and blood transport. The venation is typical of the species. The wings of the House fly and of other Dipterans are transparent.

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Species

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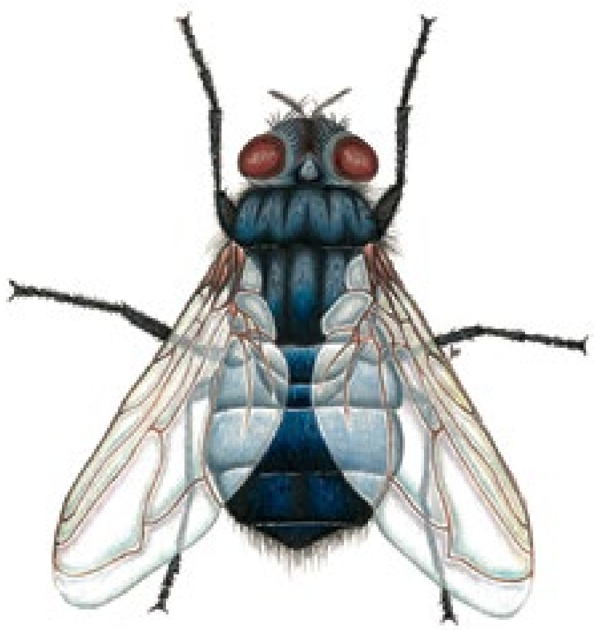
Proper species identification is the key to any successful filth fly control program.

Blow fly

Calliphora vomitoria adult.



Courtesy: Killgerm Group

Distribution
Worldwide - always closely associated with man and his dwellings.

Significance
Blow flies are attracted to rotting animal remains on which to place eggs. In their search they can mistake stored meat as a suitable "host." The possibility of disease spread is similar to the House fly.

Control
Treatment consists of finding the source of the infestation and, where possible, removing it. Insect light traps and electronic fly killers can be quite useful. The application of a residual insecticide may also be indicated, however attention to hygiene is the key to controlling this pest.

Calliphora spp.

Adult flies are generally 9-13 mm long with a wingspan of 18-20 mm. The adults are large robust flies, with a stout abdomen. The thorax is black-blue and dusky, and the abdomen is likewise colored.

Blow flies are primarily scavengers, placing their eggs on meat, decaying matter of animal origin, and wounds of animals and man. In the absence of more favorable sites, they will place their eggs on animal feces and decaying vegetable matter.

Females place around 600 eggs (each egg being 1.0-1.5 mm long, and creamy white in color). Eggs hatch within 18-48 hours. The egg period varies according to the age of the egg when placed as well as temperature and humidity. When gravid females cannot find suitable nutrient sites, they retain eggs for as long as possible. In such circumstances, eggs hatch in a very short time. *Calliphora* spp. have been seen to deposit living hatched larvae rather than eggs. *Calliphora* spp. usually oviposit at night. At temperatures below 4°C eggs will not hatch.

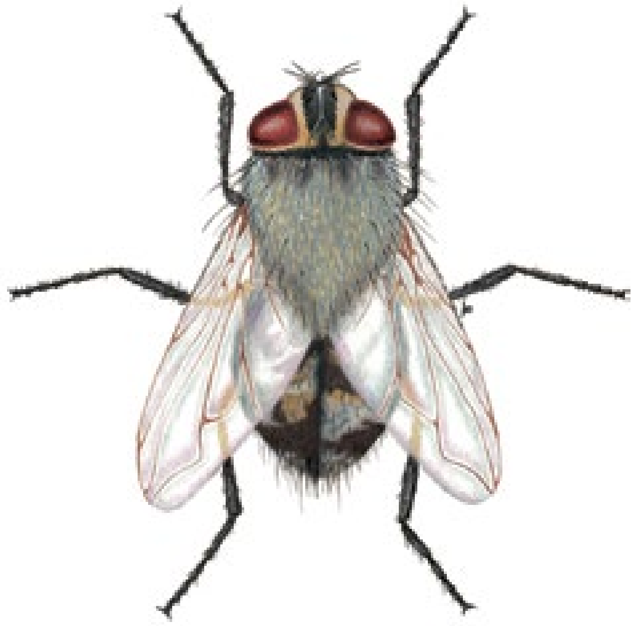
Larvae emerge and feed upon the nutrient substrate. Larvae grow rapidly, molting three times. Within 14 days, larvae have developed fully. Before pupation, larvae cease feeding and tend to migrate from the feeding medium. Pupation takes place in loose soil. If this is not available, then cracks in walls, under sacks, etc. will suffice. The length of time spent in each larval stage is variable (dependent on temperature, humidity, and nutrients).

Tolerance of low temperatures by eggs, larvae, and pupae is exhibited (development periods are extended).

Speed of development.
(27°C on liver-times in hours)
Egg 20-28
1st stage larva 18-34
2nd stage larva 16-28
3rd stage larva 30-68
Pre-pupa 72-290
Pupa 9-15

Cluster fly

Pollenia rudis adult.



Courtesy: Killgerm Group

Distribution
Northern countries - Northern Europe, North America, and Canada.

Significance
Ability to build-up large numbers during winter months when they "hibernate" within buildings.

Control
Voids should be investigated and may need to be treated with a properly labeled insecticide. Insect light traps and electronic fly killers can be quite useful. ULV treatment may be effective. ULV treatments are best carried out in late autumn or early winter when the majority of flies will have entered the property. A repeat treatment may be necessary in early spring, as temperatures rise and the flies begin to emerge from their overwintering sites. Insecticide baits are ineffective at controlling Cluster flies due to the fact that adult flies do not actively feed.

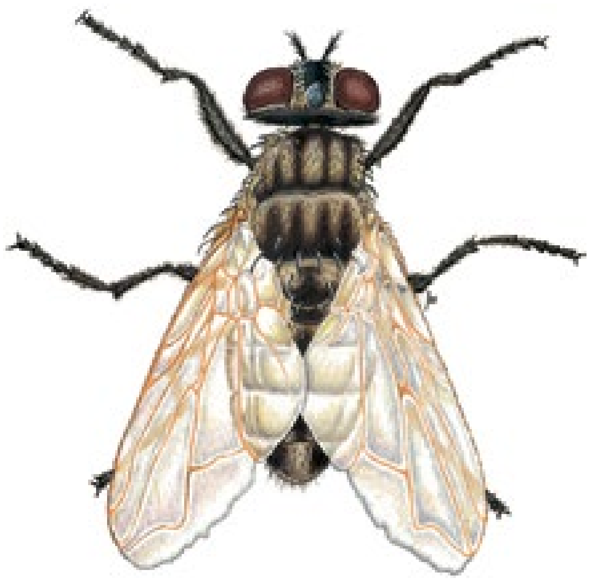
Pollenia rudis

The adult is a large fly up to 10 mm in length with a wingspan of up to 20 mm. The thorax has a distinctive dark greyish-olive color and is covered in golden hairs. The abdomen has a checkered pattern. The wings are held at rest, folded tightly on top of the abdomen.

Little is known in detail of the life cycle. The adult female places eggs at entries to earthworm burrows. Larvae hatch and find the earthworm. They enter the body of the earthworm and develop within it. They leave the earthworm to pupate, and after pupation, the adult flies emerge.

Common House fly

Musca domestica adult.



Courtesy: Killgerm Group

Distribution
Worldwide

Significance
House flies are vectors (flying infections) of a wide range of diseases such as dysentery, gastroenteritis, and tuberculosis. They move from filth to food indiscriminately translocating pathogens from dirty to clean areas. Fly spotting is produced when feeding and defecating.

Control
Good hygiene is essential. Refuse should be stored in well-sealed containers. Fly screens and other proofing methods should be utilized. Insect light traps and electronic fly killers can be quite useful. Traps with a bait attractant may prove useful in dealing with localized problems. The program of fly control should be based on a combination of bait products and space sprays. The use of a larvicide may be appropriate. It is recommended that baiting be carried out using an approved paint-on bait or granular bait.

Musca domestica

Adults are 6-8 mm long. Wing span is 13-15 mm. The thorax is grey with four longitudinal stripes. The fourth vein on the wing bends sharply forward (almost reaching the third vein). The sides of the abdomen are yellowish and may be transparent. A central dark band broadens at the back to cover the final abdominal segments. The pupa is about 6 mm long and may be yellow, brown, or black. Larvae molt, gradually increasing in size, and change color from white to cream.

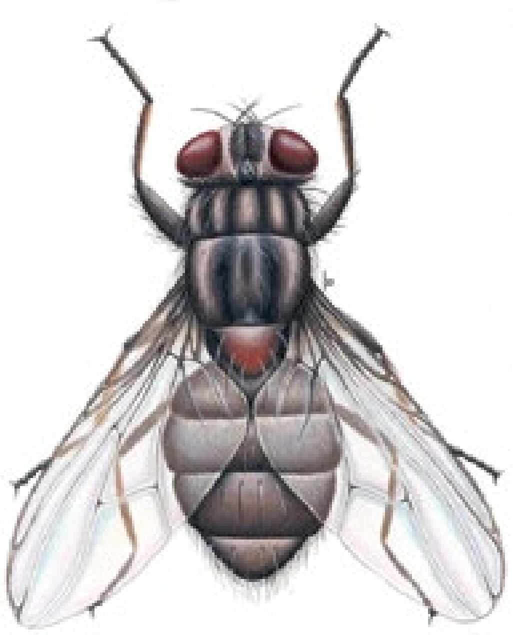
A female fly becomes sexually mature one to two days after emergence. Eggs are placed a few days after copulation. Adult flies live 1-3 months depending on temperature.The female will produce 400-750 eggs in her life. Eggs are placed in moist, fermenting, or putrefying material such as excrement or rotting vegetable matter. Newly hatched larvae shun the light and tend to burrow into the food material. In fermenting materials, larvae often seek zones of high temperature (as high as 45°C - 50°C). When mature, larvae leave the breeding site and seek a cooler environment. Wandering larvae may travel considerable distances and may become an accidental inclusion within commodities. The adult fly may travel up to 5 miles in search of suitable development sites. It is attracted by odors. The food requirements of adult flies are mainly carbohydrates which are taken in liquid form having been dissolved by saliva type digestive juices.

In common with other insects, development times are influenced by temperature, relative humidity, moisture content, and quantity and quality of food. The following figures are a guide, showing the hours spent at each life stage.

Egg 0.3-2
Larva 3.5-30+
Pupa 3-30+
Adult 30-90

False Stable fly

Muscina stabulans adult.



Courtesy: Killgerm Group

Distribution
Worldwide.

Significance
False Stable flies readily place their eggs upon human food and open wounds. Their larvae are often responsible for invasion of living tissue (myiasis). Their association with unhygienic areas gives them the potential to spread disease.

Control
Treatment consists largely of identifying and removing the development sites if possible. Attention to hygiene and the removal of food residues is important. Proofing measures such as fly screens and strip curtains may be indicated as well as the use of UVA light traps.

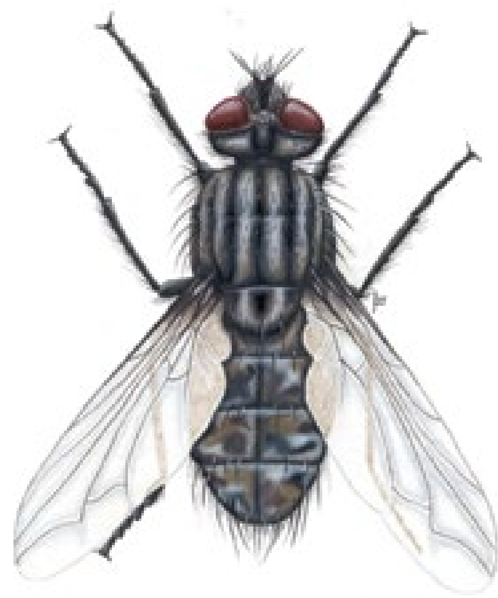
Muscina stabulans

The adult fly is 7-9 mm long. This fly has a grey thorax with four lighter-dark longitudinal stripes, and an orange posterior tip. The legs have a characteristic orange tibia. The wings have a yellowish base, and the mid-veins curve towards each other, but remain widely separated.

Female flies place small eggs (1-1.5 mm) in batches of around 10 at a time. Each female produces between 50 and 200 eggs and places them in good medium for larval growth such as feces or rotting plant material. The larvae emerge from the eggs in around 1-3 days and feed on organic matter. Later in the larval stage, they become predatory, frequently feeding on House fly larvae as well as being cannibalistic. The larval life is 1-2 weeks, and pupation lasts for the same amount of time.

Flesh fly

Sarcophaga carnaria adult.



Courtesy: Killgerm Group

Distribution
Worldwide

Significance
Flesh flies are associated with rotten meat for the larval diet. They can utilize stored meat as a larviposition site. Bird and rodent carrion are used by these flies as food sources for their larvae. Adults may be encountered as a nuisance within structures (adults are rarely found indoors).

Control
Treatment consists of locating the source of the infestation and removing it. Large numbers of flies may emerge from relatively small quantities of decaying matter (a dead rat will provide enough nutrients to rear 4,000 flies). Attention to hygiene is very important. The use of fly screens and UVA light traps prove useful.

Sarcophaga carnaria

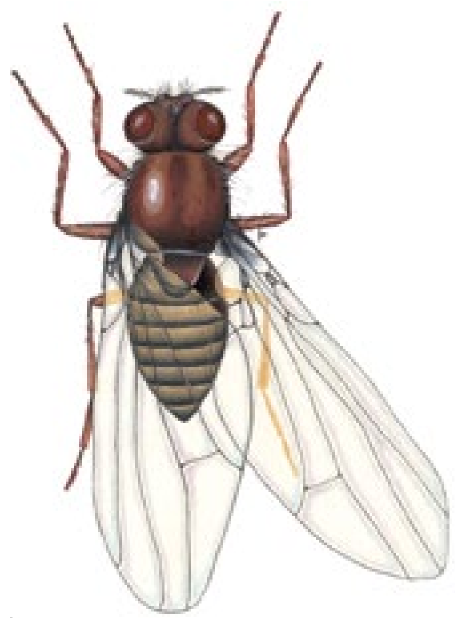
Adult flies are around 10-18 mm in body length with a wingspan of about 22 mm. They are bristly grey flies with three distinct black stripes on the thorax. The abdomen has checkered patterning, which changes according to the angle of view.

Larvae are typical, but the hind end is rounded, and the posterior spiracles (breathing tubes) are sunk into a deep pit surrounded by fleshy lobes which prevents water from entering the spiracles if submerged. Flesh flies exploit decaying organic matter for their larval feeding sites, for example, open wounds, dung, and carrion. They will also parasitize insect larvae and mollusks.

The adult females, after mating, are larviparous (deposit larvae rather than eggs). The larvae feed immediately on the food source and rapidly grow to maturity (around 15-18 mm in length). Pupation occurs away from the food source (frequently in soil or debris). The total development time for *Sarcophaga* spp. is approximately 25 to 30 days at 21°C. Adults are found from March to October.

Fruit fly

Drosophila spp. adult.



Courtesy: Killgerm Group

Distribution
Worldwide and associated with human food preparation and storage areas.

Significance
These flies are an annoyance in many kitchens, restaurants, etc. Attraction to alcohol (glycerol) and waste fruit means they can build up to very large numbers. These flies are harmless to man. Infestations are often indicative of inadequate hygiene or drainage problems.

Control
Treatment consists of locating the source of the infestation and removing it. Insect light traps and electronic fly killers can be quite useful. Residual synthetic pyrethroids should prove effective in controlling emergent flies. A concurrent resource cleaning (RC) program to maintain consistent environmental hygiene is essential. Such a program can benefit from the use of Biogel products.

Drosophila spp.

Fruit fly adults are 3 to 4 mm long. They are small yellowish-brown flies with a darkly striped abdomen. The prominent compound eyes are generally red in color, although darker variants occur. The wings have two clear notches in the front border (clearly seen with a hand-lens).

The eggs are white and 0.5-1 mm long. Each female places between 400 and 900 eggs in batches of 15-25. Eggs hatch within 24-30 hours. The larvae that emerge feed upon decaying organic material, and the larval life is between 5 and 6 days. Pupation occurs out of the feeding medium and lasts 2-5 days. The life cycle is rapid in warm conditions with development from egg to adult taking less than two weeks.

Fungus gnat

Sciara spp. adult.

Courtesy: Killgerm Group

Sciara spp.

These flies are small insects, with a body length of 5-6 mm and a wingspan of 14-15 mm. They have a black head, thorax, and abdomen. The thorax has a humped appearance. The wings have few veins, but have a characteristic Y-shaped cell in the central portion of the wing. Little detail is known of their life cycle. The eggs are placed in soil and rotting vegetation from which larvae emerge to feed on fungal material within the soil.

Distribution

These flies are found in many places throughout the world, particularly where potted plants are used. Fungus gnats can result from flat-roofs that leak and perpetuate fungal growth.

Significance

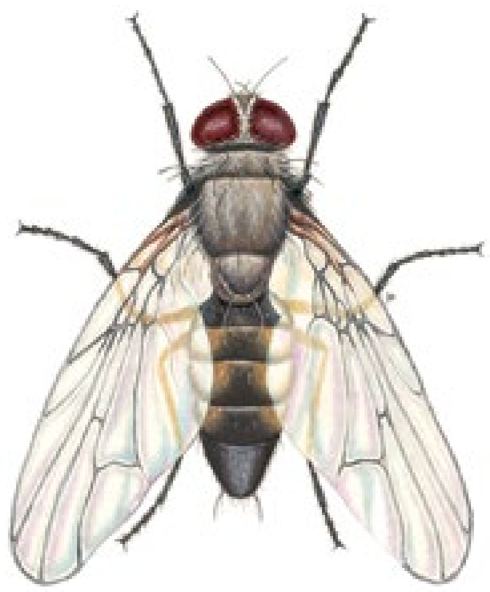
They are nuisance pests and large numbers can develop in both domestic and office areas. Greenhouses can become severely infested.

Control

These flies are harmless to man and treatment is rarely necessary. If remedial treatment is required, then it is necessary to find the source of the infestation and remove it. Insect light traps and electronic fly killers can be quite useful. The use of an insecticide such as a residual synthetic pyrethroid may prove suitable. ULV space spray treatments can eliminate heavy adult populations.

Lesser House fly

Fannia canicularis adult.



Distribution
Worldwide, particularly in association with poultry houses.

Significance
Lesser House flies are potential vectors of a wide range of diseases such as dysentery, gastroenteritis, and tuberculosis. They can also transmit intestinal worms. They move from filth to food indiscriminately and may therefore move pathogens from dirty to clean areas. Fly spotting is produced when feeding and defecating.

Control
Treatment consists of eliminating the source where possible. Fly screening to windows would prove to be beneficial. Insect light traps and electronic fly killers can be quite useful. Low volume application of a mist of insecticide would be appropriate to control swarms of adult flies. It is recommended that baiting be carried out using an approved paint-on bait or granular bait.

Courtesy: Killgerm Group

Fannia canicularis

Adults are 5-6 mm long. They have a grey thorax which has three indistinct longitudinal stripes on it. The abdomen has an extensive area of yellow at its base. The wingspan is 10-12 mm and venation is characteristic with the 4th longitudinal vein extending to the wing margin in a relatively straight line.

The egg produced by the females is 1 mm in length with float-like ridges for survival in liquid. There are approximately 50 eggs per batch and 4 or 5 batches per year per female. The eggs hatch within 24-48 hours and the larvae emerge to feed on rotting vegetation. Larval development takes 7-10 days. Pupation follows and lasts 1-9 weeks.

Moth fly

Psychoda alternata adult.

Courtesy: Killgerm Group

Distribution
Worldwide

Significance
Moth flies are found breeding in areas of rotting organic matter, so there is always the chance that they are carrying bacteria. Moth flies are only a nuisance pest and not of any great public health significance.

Control
Treatment consists of finding the source of the infestation and removing it. The application of a residual synthetic pyrethroid would be effective in controlling adult flies (as would a ULV application of insecticide).

Family *Psychodidae*

The adults are 3-4 mm in length with a wingspan of 10-12 mm. They are greyish-brown in color with the wings and body covered in scales. This fly has the appearance of a small moth. The venation of the wings has no cross veins and only around 8 veins (two of which are forked) running almost parallel to the front edge of the wing. Moth fly antennae are hairy in appearance with large hairs emanating from the intersegmental junctions.

Adult flies are frequently abundant in sewage facilities. Females find a suitable medium in which to place their eggs (typically the wet organic matter found in drains).

The larvae hatch from the eggs, normally within 48 hours. They feed in the rotting organic matter for around 14-15 days. Pupation is short (a few days and then the adults emerge). The adults only live for 2-5 days.

Phorid fly

Megaselia pleuralis adult.

Courtesy: Killgerm Group

Distribution
Worldwide

Significance
Phorid flies are found in association with moist decaying organic matter. They are often indicative of broken sewer systems. Adult flies have a characteristic habit of immediately taking flight when disturbed and scuttling in a fast run (representative of their name "Scuttle flies"). Because they frequent insanitary sites there is always the potential of these insects carrying disease-causing bacteria.

Control
Identify the source of the infestation and remove it. Attention to hygiene is important in cases of Phorid infestation. When the flies occur indoors, the most usual source of infestation is blocked or broken sewers. Insect light traps and electronic fly killers can be quite useful. A residual insecticide applied to cracks, crevices, floor boards, pallets, etc. where flies are seen will aid control. A camera can be run to determine sewer breaks.

Family *Phoridae*

Adult flies are around 3-4 mm in length with a wingspan of 9-10 mm. The thorax of the Phorid fly is usually dark brown-tan in color with a distinctive humped appearance. Wings have no cross veins.

Each female fly places approximately 40 eggs, one at a time, over a period of around 12 hours upon decaying organic matter. The larvae will emerge from the egg after approximately 24 hrs and feed 8 to 16 days depending upon environmental factors.

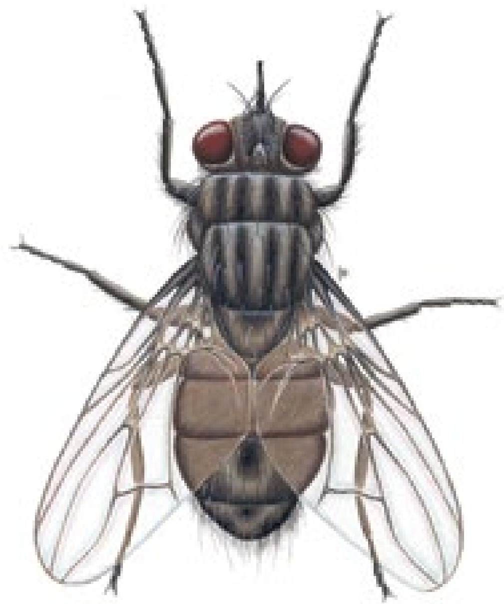
The larvae crawl to a drier spot to pupate and then adults emerge. Under ideal conditions, the life cycle is complete in approximately 14 days, but when conditions are not perfect, it may take closer to 40 days.

Stable fly

Stomoxys calcitrans adult.

Image Credit: University of Florida

Biting mouthparts project forward



Courtesy: Killgerm Group

Distribution
Worldwide

Significance
Adult flies are blood feeders and can bite humans (their preferred hosts are cattle and horses). The bite can be painful and secondary infection can result from wound scratching. They generally bite around the legs and ankles, and because the mouthparts are robust, clothing is no barrier to the feeding. Bare skin is rarely attacked (flies prefer to stab through clothing). Dogs, cats, and poultry may be attacked. Stable flies have been implicated as a transmitter of poliomyelitis. In rare cases, larvae cause intestinal myiasis in man.

Control
Treatment consists of removing the larval development sites and the application of a properly labeled residual insecticide. If animal units, stables, etc. are to be treated, then a product with animal husbandry approval should be selected. UVA light traps should be installed where appropriate.

Stomoxys calcitrans

Adult flies are between 5.5 and 9 mm in length with a wingspan of 15 mm. The thorax has dark stripes on a grey background similar to the House fly. It is easily distinguished from the House fly by the fact that piercing mouthparts project outwards from the head and are kept permanently in that position.

The larva resembles the maggot of the House fly. It moves rapidly and fakes death if disturbed. Adults mate in flight. Female flies place eggs in batches of 30-40 in cool conditions, and up to 200 per batch in warmer conditions within animal manure (from horses, pigs and cattle). Rotting vegetation may also be used as an oviposition site. The eggs are around 1 mm in length and 0.2 mm across. Each female produces approximately 600 eggs. Larvae emerge from the eggs after approximately 3 days and feed upon organic matter. Upon maturity, larvae reach 10-12 mm long and pupate in drier parts of the habitat or in the ground.

Adults are found from May to October, and sun themselves on walls, vehicles, etc. In common with other insects, development times are influenced by temperature, relative humidity, moisture content, and quantity and quality of food. The shortest times are at 30°C, the longest at 16°C.

The following is a guide. Number of days for develpoment.

Egg 1-5
Larva 6-34
Pupa 5-19

PestWest® FLYING INSECT SCIENCE

Monitoring

4

Early detection and interception of pest activity are essential if the impact of corrective measures are to be optimized.

Monitoring

Early detection and interception of pest activity are essential if the impact of corrective measures are to be optimized. A combination of ongoing thorough inspections and monitoring using a variety of detectors will provide the information upon which to build control strategies.

The main benefit of monitoring devices is time management. Physical inspections are time-consuming, and rely upon the skill of the inspector. Monitors such as insect light traps (ILTs), electric fly killer (EFKs), pheromone traps, and adhesive detectors are able to collect information from a range of locations over a greater time scale.

Monitoring devices can be broken down into three main categories:

- Those using ultraviolet light (UVA) to attract flying insects onto an adhesive substrate or electrocuted on a live-grid.
- Those attracting insects with of a sex pheromone.
- Those attracting insects using a food attractant.

Adhesive detectors may be used without bait in order to pick up insects moving within the vicinity. These are sometimes referred to as “blunder traps.” The use of ILTs and EFKs are effective as pest monitoring tools. Adhesive film or catch tray analysis can provide information on the species of insect present, numbers (particularly increases which should trigger a change in control strategy), seasonal fluctuations, likely foci of infestations, and related hygiene or process shortcomings.

Trend analysis will depend upon the nature of the site, the potential risk of contamination, and the contract specifications. Monthly counts would be the norm, but the period between counts may possibly be extended during the winter months. In a high-risk operation, weekly counts may be required. Units should not be placed near open doors where they may attract insects into the premises.

All facilities must be continuously evaluated. Visual inspections, monitoring data, and feedback from facility staff are essential.

Visual inspections contrast observational changes in conditions favoring pest entry and development. Monitoring devices detect and identify pests occurring at low infestation levels (LIL).

A central pest-sighting log must be established (recording pest occurrence and location). The log encourages staff to maintain interest and involvement in reducing pest presence. A log helps the pest management professional (PMP) to quickly focus on any new problems.

All information must be shared (written service reports) for emphasis on good housekeeping, pest exclusion, and delivery inspections (interception). All incoming materials should be sampled for the presence of insects (Blue-Orange Shift, UVA, Infrared, Swab Reactive, Pheromonal, Organoleptic, etc.).

Organizational cleaning (rotation) must be implemented or lastin, first-out and first-in, first-out (LIFO & FIFO). Resource cleaning (RC) is required to prevent sanitation deficits.

Monitoring procedures should be in place to identify early signs of infestation. Staff must be aware of the high-risk areas. Correct species identification is essential in order to pinpoint a source of infestation.

Pest Sighting Log

Integrated Pest Management
Pest Sighting Log

Facility:

To Be Filled Out By School Official			To Be Filled Out By Pest Manager		
Location of Sighting Bldg. # / Specific Location	Type of Pest(s) Sighted	Date	Action Taken	Technician Name	Date

Courtesy: University of Florida

An example of a pest sighting log.

Trap-Line Audit

IPM is inspection and investigation, identification, establishing threshold levels, implementing two or more control measures (cultural, physical, mechanical, and chemical), and evaluation of effectiveness.

PestWest

Facility Trap-Line Audit

interior					exterior				
1	11	21	31	41	1	11	21	31	41
2	12	22	32	42	2	12	22	32	42
3	13	23	33	43	3	13	23	33	43
4	14	24	34	44	4	14	24	34	44
5	15	25	35	45	5	15	25	35	45
6	16	26	36	46	6	16	26	36	46
7	17	27	37	47	7	17	27	37	47
8	18	28	38	48	8	18	28	38	48
9	19	29	39	49	9	19	29	39	49
10	20	30	40	50	10	20	30	40	50

Key

ILT=insect light trap EFK=electronic fly killer MR=monitor PT=pheromone trap
BS=rodent bait station MT=mechanical trap ST=snap trap
I=insects S=spiders D=droppings M=mouse R=rat
B=broken station MS=missing station SB=station blocked

Facility:__________ Location:__________
Date:______ SPS Technician:__________ Certification No:______
Date:______ Facility Representative Signature & Title:__________

Comments:__________

Trap-Line Audit form available from PestWest USA.

Mantis® Uplight

"The key to pest prevention and management is early detection through the use of more insect light traps (ILTs) and electronic fly killers (EFKs)."

Dr. Ted Granovsky, BCE

PestWest®
FLYING INSECT SCIENCE

Control

Integrated pest management or IPM is a cyclical process.

5

Integrated Pest Management (IPM)
Integrated pest management is a programatic approach to pest control which embraces a cyclical process involving techniques that include cultural, physical, mechanical, biological, and chemical controls. Below is a mechanistic view of the five steps of IPM.

Five Steps of IPM

1. Inspection and investigation of the environment
2. Pest identification (down to species)
3. Two or more control measures (cultural or behavioral, physical, mechanical, bio-rational, biological, and chemical)
4. Determination of tolerance levels (aesthetic, legal, economic, and medical)
5. Evaluation of effectiveness

Once a survey has established how many ILT and/or EFK units are required to cover doors and critical areas, units at a much lower density should be placed in general areas. When using an insect light trap (ILT), a sticky trap with a grey-grid board should be installed (for census or species identification, species distribution, species density, and species flight direction). In large areas, choose a unit with an output of at least 40 watts (better at 80 watts). Where feasible, units that attract at 360 degrees (suspended units) should be used.

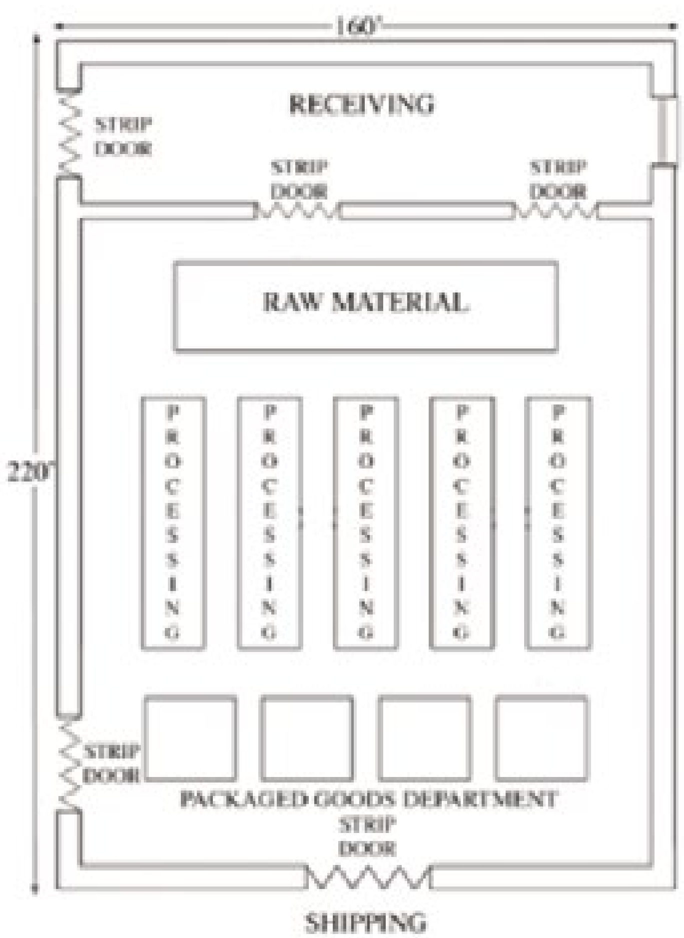
The client must be told, in writing, how many ITL and/or EFK units are needed, including the type and placement to do the job effectively. If the client states that the budget is not available to do the job properly, a choice has to be made to make best use of what the budget allows.

ILT and EFK maintenance are essential. The main reason quality machines need to be replaced within 7 or 8 years is that they are not kept clean. If the maintenance staff on-site cannot carry out regular cleaning and servicing, then the PMP must be responsible. All machines should be on the master cleaning schedule (MCS).

Nemesis® QUATTRO

An all-metal electronic fly killer blending robustness and power with energy-efficient, environmentally responsible technology. Ideal for large open industrial areas. Both higher energy efficient UVA tubes, and a state of the art electronic ballast allow optimum fly management. Performance with low running costs and reduced materials (glass & mercury). This unit allows for quick, tool-free maintenance. The front guard is lockable in open position, and the spring loaded killing grid can be removed for cleaning. ‘’Power-on” and ‘’grid-on” warning lights permit inspection at a distance.

Intuitive ILT and EFK deployments are dependent upon the assessment of both ambient and UVA light. A UV-AMeter allows one to conduct both an ambient and UVA light assessment survey. Pre-deployment assessment allows optimal placement of both new or inherited traps. Certainty is assured that trap deployments are not in competition with room or area lighting, and that a trap's UVA lamps are at maximum output as well as favorable condition (replace or not).



Accurate site plans are required when carrying out pest management surveys

PestWest UV-AMETER

The general principle of siting is to intercept flies before they enter critical areas, and those that do are attracted away from the products towards the fly management machines (push-pull).

It is essential to protect the doors, open windows, access points, etc. (interceprion zones). Sometimes use more than one machine at a particular opening, off-setting them slightly so that they do not attract flies from outside (especially at night).

To protect doors, it is preferable to use a machine with an electrical killing grid (EFK) since these sites are not critical contamination areas and this type of machine has an almost limitless capture capacity.

Place units both perpendicular to and above door openings. Air movement in this area will be high and therefore it is an advantage to use a machine with a draft deflector to avoid the catch being blown out of the tray.

An insect light trap system for open industrial areas which are not explosion-proof rated. This unit allows for over 926 square inches of capture surface.

American Institute of Baking Audit Requirements

Courtesy AIB www.aibonline.org

- ILTs assist in monitoring and identifying insects.
- ILTS are installed farther than 10 feet from food contact surfaces.
- ILTS are installed in a way as to not attract insects to the facility.
- ILT service checks are performed on all units weekly.
- Service checks include emptying, cleaning, repairing and checks for lamp breakage.
- Shatter-resistant lamps are used.
- All services are documented on a trap line audit form.
- Tubes are changed at least annually. Documentation is used for trend analysis.

PestWest recommends using Quantum BL, no Lead (Pb), low Mercury (Hg), shatter-resistant lamps.

100% more effective 40% more powerful than standard UV lamps

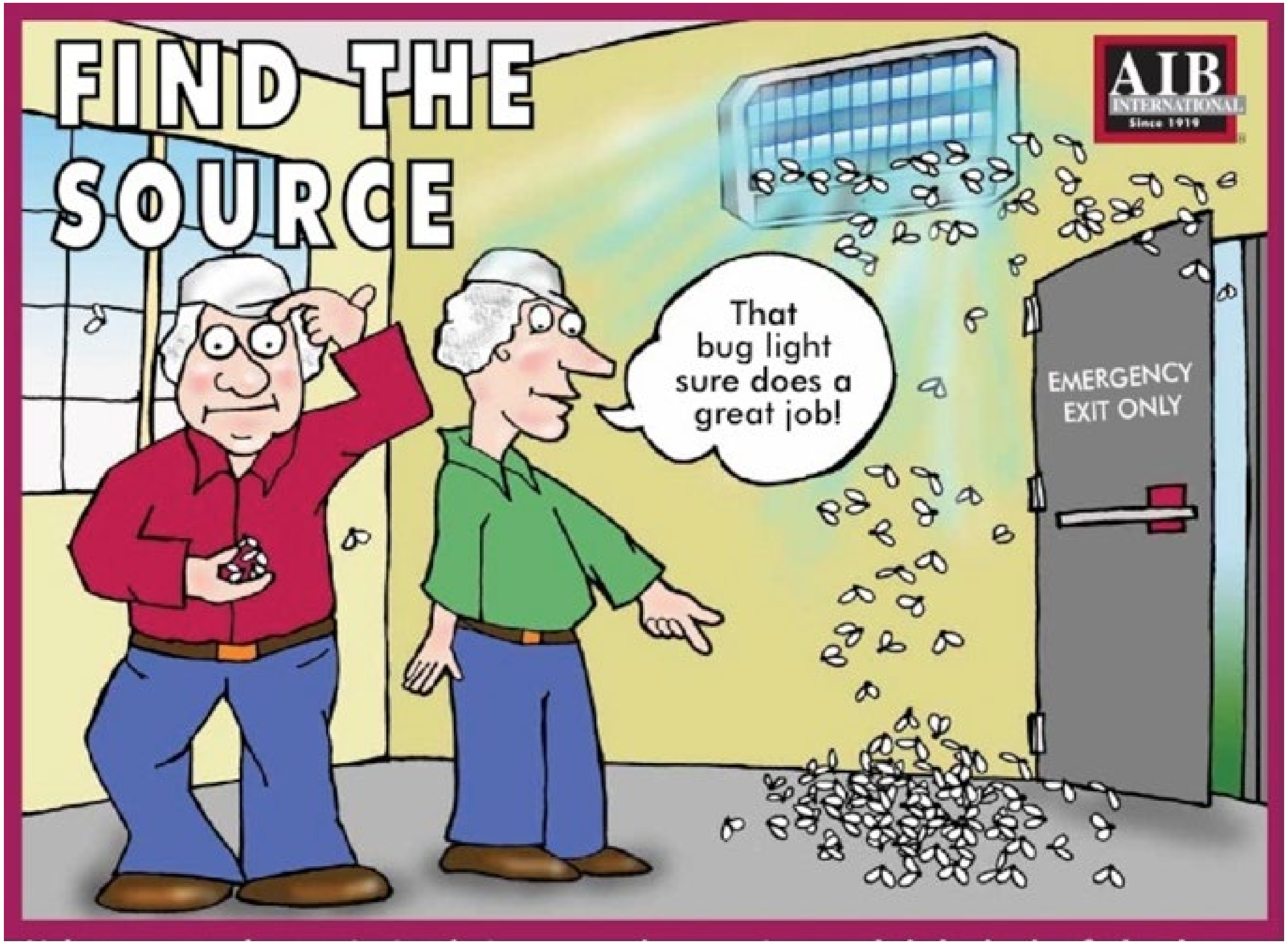


Image Credit: AIB

- Distances at which insects respond to an ILT or EFK is determined by lamp type and trap design.
- The visual acuity and nature of the specific insect varies responses (photopic or scotopic and opsin pigment proteins).
- Insects do not respond to ILTs more than 100 ft. away (attraction zone).
- House flies respond at 20 to 25 ft., with a significant increase at 12 ft (capture zone).
- At 12 feet, it will take up to 7 hours for 90 percent of the flies to respond.
- 36 hours for a 99 percent response.

Truman's Scientific Guide

Intuitive ILT & EFK Deployment

- Avoid competing light (not near or facing bright windows).
- Intercept flight paths of insects.
- Height: draw away from sensitive areas.
- An appropriately designed system for wet or dry environments (food processing).
- A dedicated power source.
- No potential for cultural practice obstructions to trap line of sight (constructive v. deconstructive light projection).
- Placement security from damage, theft, or sabotage.
- Always hang units where they can be accessed for servicing.
- For example, it is undesirable to hang a unit over machinery that has to be switched off before servicing.
- Make sure units are not positioned where they might be damaged (by a fork lift truck).
- Avoid mounting units in areas where they may present a hazard to people.

Mantis® 4x4EX

GLUE BOARD SYSTEM

Meets all FDA, USDA, and Zone 22 (dustcloud unlikely to occur in normal operation) requirements.

Florida Fly Baiter

The “Florida” Fly Baiter (FFB) is a patented device that attracts target fly species onto a treated surface as an aid to their control. The FFB can be used by described assembly, or flattened and attached to tree trunks, appropriate sides of buildings, etc.

The FFB can be used most places flies congregate or are present in numbers that could be hazardous to health. Uses in food/feed handling establishments are permitted only in non-food/non-feed areas. Do not use where dead flies can contaminate food or food preparation surfaces (kitchens and food preparation areas).

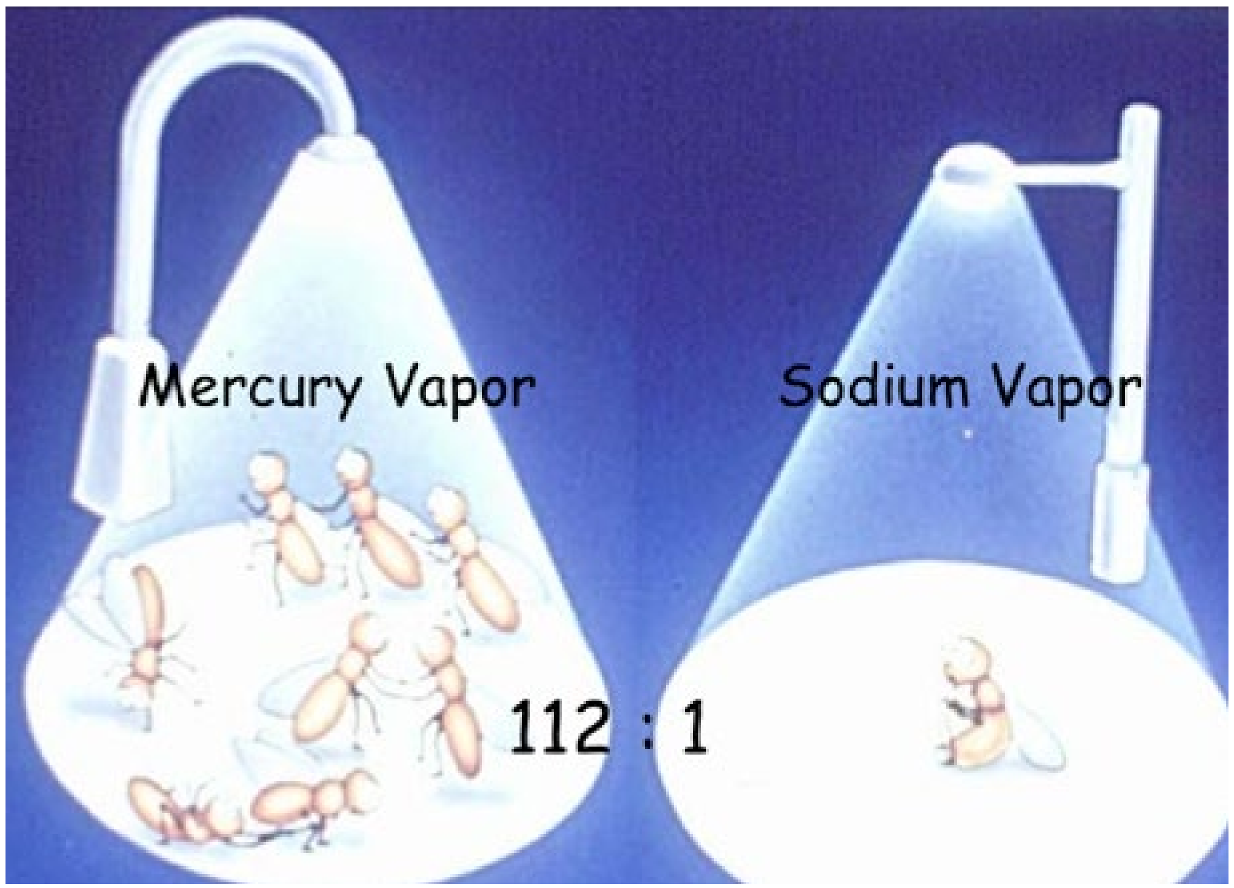
The general placement of the FFB should be as close to the fly breeding area as possible. Where flies are breeding on ground level organic matter, the FFB should be installed at an approximate height of 1m or 3.28 ft. If flies are breeding on organic matter in a dumpster then increase the height to approximately 1.5m or 4.92 ft. As a general guide, 1 to 1.5m or 3.28 to 4.92 ft. from the ground is ideal.

Seek areas where wind is not an issue. Creativity with the tie-line, weighting the FFB, securing a side to a surface, attaching flat onto a wall or tree, or coupling 2 FFB’s together, etc, will reduce the amount of swaying and spinning of the FFB.

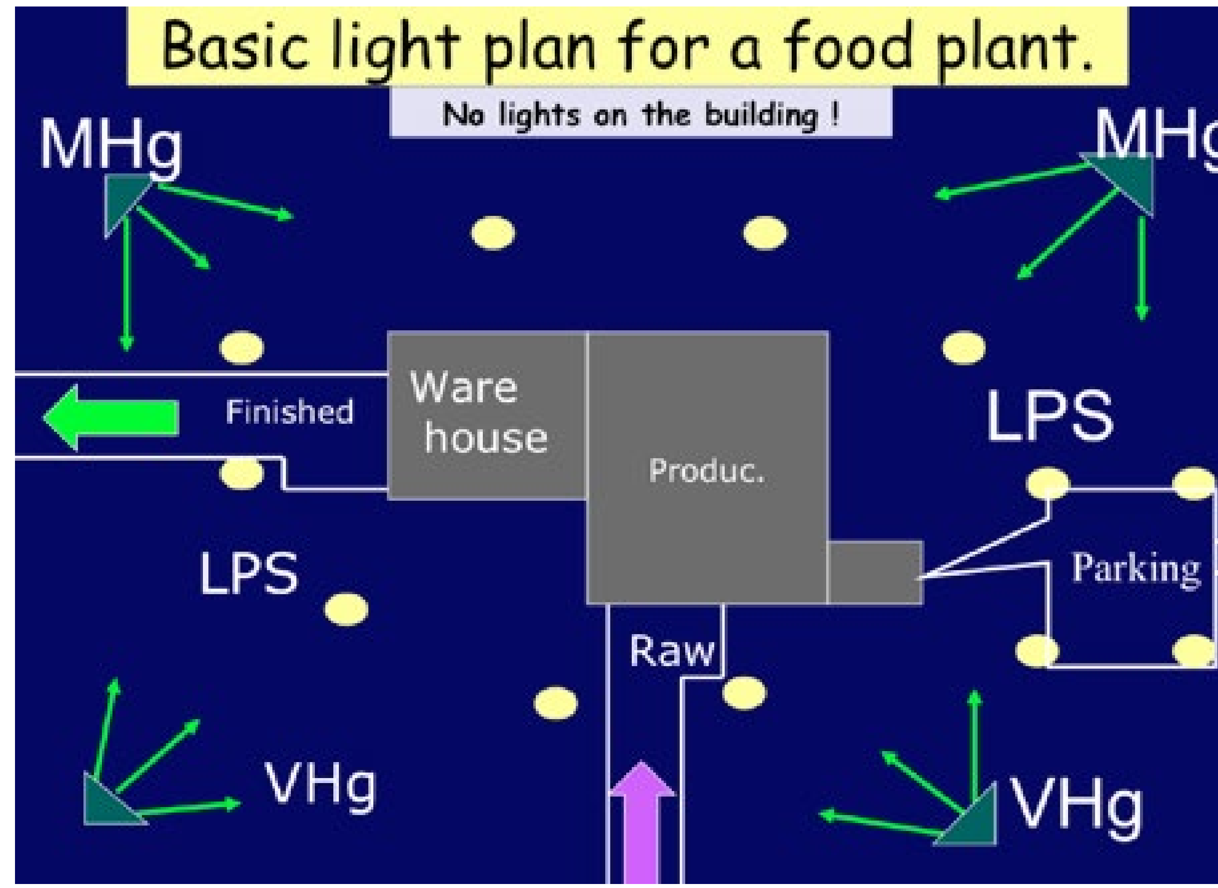
Florida Fly-Baiter

IMPORTANT: Before using any EPA Registered and appropriately labeled insecticide product with the FFB, read the entire insecticide label.

Lighting



Courtesy of Dr. Ted Granovsky



Courtesy of Dr. Ted Granovsky

Mercury vapor or blue light is 112 times more attractive to insects than Sodium vapor or yellow light

Project Mercury (Hg) vapor lighting onto the building to attract insects away from the building.

House flies undergo a complete life cycle of egg, larva, pupa, and adult. Female flies place egg batches upon, or adjacent to, appropriate nutritional sources based upon environmental cues. Within a short time, eggs hatch and and the larvae enter the food source and morph through three stages of growth before pupation. Upon larval maturity, a pupa is formed to allow further development to the adult stage. This growth period requires two days to three weeks, depending upon conditions. The House fly's life cycle is four to twelve weeks.

Adult flies become active immediately after emergence; seeking various environmental interactions based upon incoming stimuli. House flies are attracted to animal wastes, carrion, garbage, and food materials. Within the urban environment, companion animal wastes and garbage are potent attraction and breeding sites.

The most effective control for filth flies involves an integrated approach of proper sanitation (cultural control), physical control (exclusion), mechanical control (UVA traps or ILTs and EFKs), and judicious chemical control. Cultural control involves working closely with the client to ensure ongoing and effective sanitation practices. Physical and mechanical controls include fully serviceable architectural features, UV traps, and air curtains. Insecticidal treatments must be performed per the product label.

PestWest®
FLYING INSECT SCIENCE

Larvae Pictorial Key

Accurate fly species identification is essential to a successful IPM program.

6

FLY LARVAE: KEY TO SOME SPECIES OF PUBLIC HEALTH IMPORTANCE

Chester J. Stojanovich – Harry D. Pratt – Elwin E. Bennington

1. Larva with a definite, hard, sclerotized head capsule (Fig. 1 A)........................... 2

   Larva without a definite, hard, sclerotized head capsule (Fig. 1 B)....................... 3

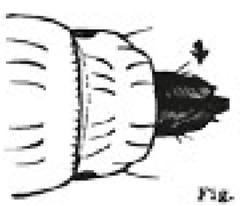


Fig. 1 A

Fig. 1 B

2. Body flattened, large larvae 12-20 mm. long (Fig. 2 A)... (Hermetia illucens) SOLDIER FLY

   Body cylindrical with spiracles opening in a tubular segment at posterior end of body, last segment modified into a sclerotized air tube (Fig. 2 B)... (Genus Psychoda & allies) FILTER FLIES

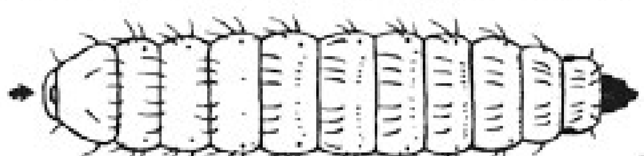


Fig. 2 A

Fig. 2 B

3. Body with spine-like dorsal and lateral processes on each segment; posterior spiracles on small elevations (Fig. 3 A).. (Genus Fannia)... 4

   Body smooth, or with short spines, but no long lateral processes (Fig. 3 B).............. 5

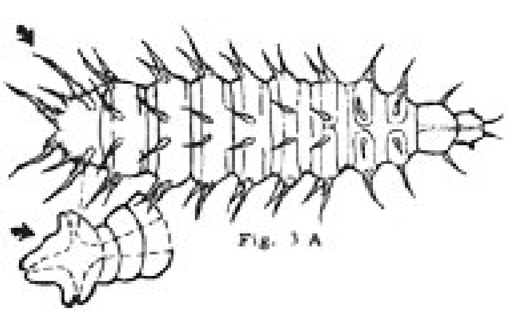


Fig. 3 A

Fig. 3 B

4. Processes branched or feathery (Fig. 4 A)............... (Fannia scalaris) LATRINE FLY

   Processes without branches, spiny (Fig. 4 B).. (Fannia canicularis) LESSER HOUSE FLY

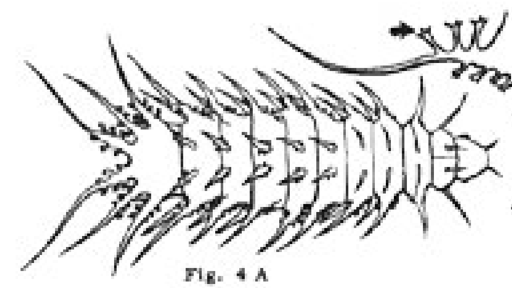


Fig. 4 A

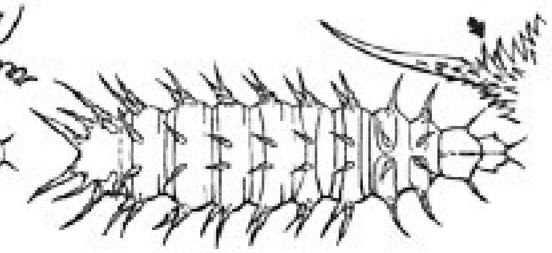


Fig. 4 B

5. Posterior spiracles on peg-like tubercles or cones; smaller larvae, usually 6-9 mm. long (Fig. 5 A).. 6

   Posterior spiracles not on peg-like tubercles; larger larvae, usually 9-18 mm. long (Fig. 5 B).. 7

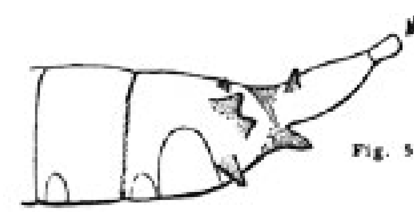


Fig. 5 A

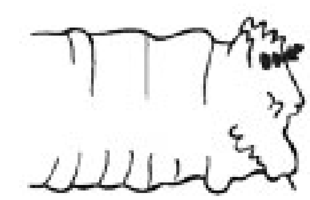


Fig. 5 B

6. Posterior spiracles at ends of long tubercles (Fig. 6 A)..................................... .... (Genus Drosophila) VINEGAR FLIES

   Posterior spiracles on short cones, last segment with short finger-like lateral process (Fig. 6 B).. (Piophila casei) CHEESE SKIPPER

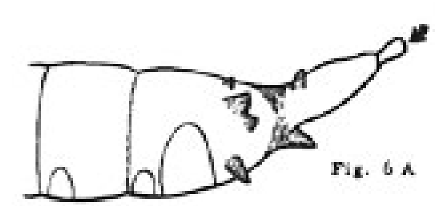


Fig. 6 A

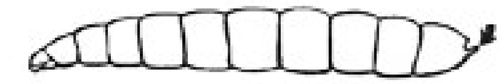


Fig. 6 B

Credit: Centers for Disease Control (CDC)

7. Posterior end of body extended to form a tail (Fig. 7 A)..(Eristalis tenax) RAT-TAILED MAGGOT

Body swollen or tapered posteriorly, but never extended into a tail like process (Fig. 7 B).. 8

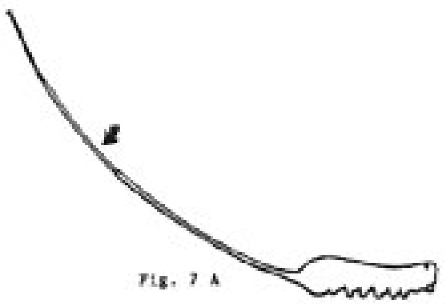


Fig. 7 A

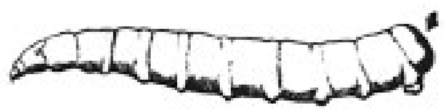


Fig. 7 B

8. Peritreme present, with 3 distinct slits (Fig. 8 A)..9

Peritreme absent; or if present without 3 distinct slits (Fig. 8 B & C).................... 23

Fig. 8 A

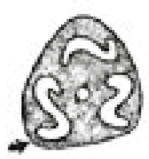


Fig. 8 B

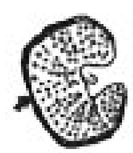


Fig. 8 C

9. Slits of posterior spiracles straight (Fig. 9 A)...10

Slits of posterior spiracles strongly sinuous (Fig. 9 B).................................22

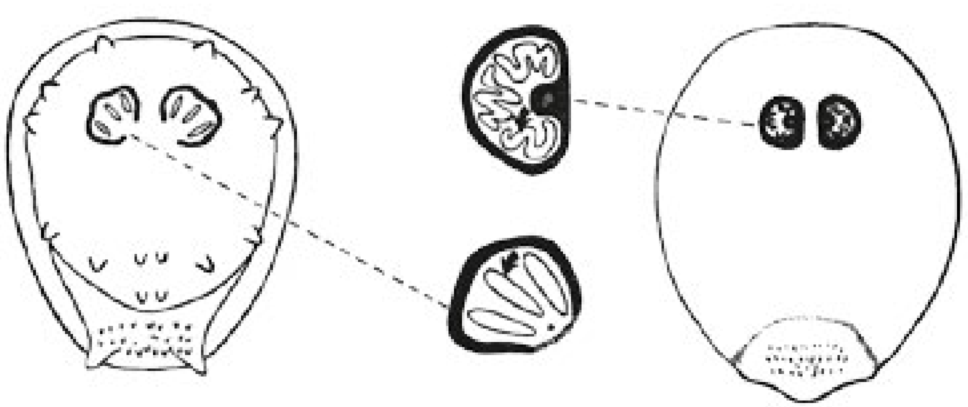


Fig. 9 A

Fig. 9 B

10. Dorsal and ventral arms of cephaloskeleton almost equal (Fig. 10 A); peritreme with two non-sclerotized areas away from the button (Fig. 10 B).. (Genus Ophyra) DUMP FLY

Dorsal arm of cephaloskeleton longer than ventral arm (Fig. 10 C); peritreme complete or with one weakly sclerotized area (Fig. 10 D & E).. 11

Fig. 10 A

Fig. 10 C

Fig. 10 B

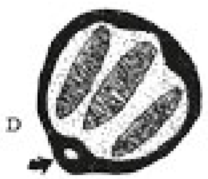


Fig. 10 D

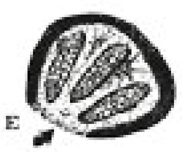
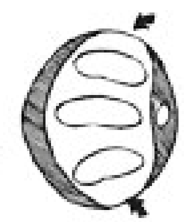


Fig. 10 E



11. Posterior spiracles with peritreme complete, sometimes weak in area of button (Fig. 11 A) 12

Posterior spiracles with peritreme incomplete, not enclosing a sometimes ill-defined button (Fig. 11 B).. 16

Fig. 11 A

Fig. 11 B

12. Spiracular plate and button heavily sclerotized; accessory oral sclerite present (Fig. 12 A & B)... 13

Spiracular plate and button not heavily sclerotized; accessory oral sclerite absent (Fig. 12 C & D).. 14

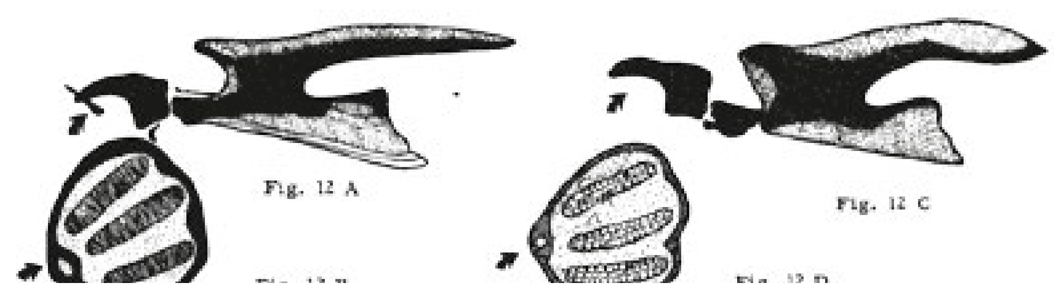


Fig. 12 A

Fig. 12 C

Credit: Centers for Disease Control (CDC)

13. Mandibular sclerite with tooth longer than greatest width of basal portion (Fig. 13 A)..... .... (Calliphora vicina) A BLUE BOTTLE FLY

Mandibular sclerite with tooth only as long as greatest width of basal portion (Fig. 13 B).. .... (Cynomyopsis cadaverina) A BLUE BOTTLE FLY

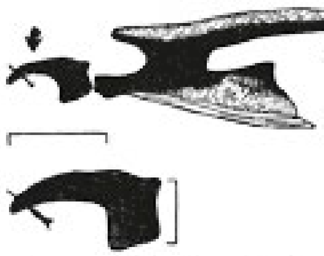


Fig. 13 A

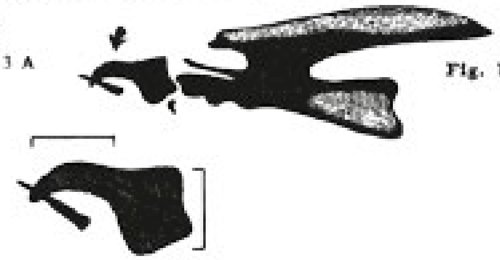


Fig. 13 B

14. Peritreme thick with rounded or sharp projections which extend inward toward spiracular slits (Fig. 14 A); cephaloskeleton as in figure 14 B.................................... .... (Phaenicia caeruleiviridis) A GREEN BOTTLE FLY

Peritreme thin, usually with no projections or if present only slightly sclerotized (Fig. 14 C)... 15

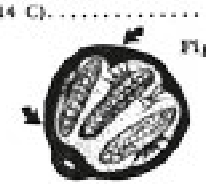


Fig. 14 A

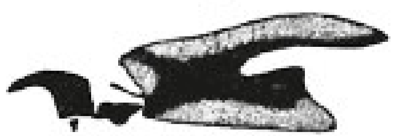


Fig. 14 B

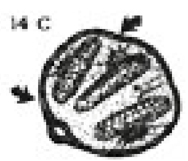


Fig. 14 C

15. At least one of the prothoracic spiracles with 8 or more openings (Fig. 15 A); peritreme and cephaloskeleton as in figures 15 B & C. . (Phaenicia sericata) A GREEN BOTTLE FLY

At least one of the prothoracic spiracles with 6 or less openings (Fig. 15 D); peritreme and cephaloskeleton as in figures 15 E & F.. (Syn. P. pallescens)...................... (Phaenicia cuprina) A BRONZE BOTTLE FLY

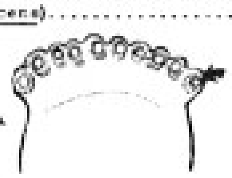


Fig. 15 A

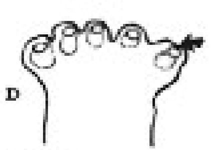


Fig. 15 D


Fig. 15 B

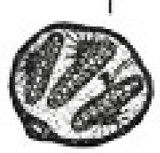


Fig. 15 E


Fig. 15 C

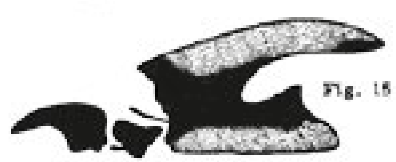


Fig. 15 F

16. Spiracular slits not pointing toward opening in peritreme (Fig. 16 A)................... 17

Spiracular slits pointing toward opening in peritreme (Fig. 16 B)...................... 18


Fig. 16 A


Fig. 16 B

17. Very large size, about 20 mm. long; mandibular sclerite as in figure 17 A............... .... (Sarcophaga citellivora or S. bullata) A FLESH FLY

Smaller size, about 10 mm. long; mandibular sclerite as in figure 17 B.................. .... (Sarcophaga haemorrhoidalis) A FLESH FLY

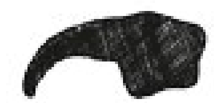


Fig. 17 A

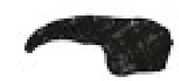


Fig. 17 B

18. At least one of the prothoracic spiracles with 9 or less openings (Fig. 18 A)............ 19

At least one of the prothoracic spiracles with 10 or more openings (Fig. 18 B)........... 20


Fig. 18 A


Fig. 18 B

19. Mandibular sclerite with tooth longer than width of basal portion (Fig. 19 A)............. .... (Wohlfahrtia opaca) A FLESH FLY

Mandibular sclerite with tooth only as long as greatest width of basal portion (Fig. 19 B).. .... (Wohlfahrtia vigil) A FLESH FLY


Fig. 19 A

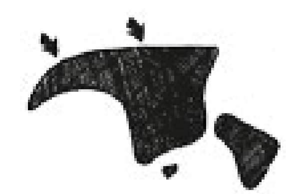


Fig. 19 B

Credit: Centers for Disease Control (CDC)

20. Button indistinct or absent; walls of slits with lateral swellings (Fig. 20 A)..............21

Button present; walls of slits without lateral swellings (Fig. 20 B)........................ ....(Phormia regina) BLACK BLOW FLY


Fig. 20 A


Fig. 20 B

21. Tracheal trunks pigmented (Fig. 21 A)... ....(Cochliomyia hominivorax) PRIMARY SCREW-WORM

Tracheal trunks not pigmented (Fig. 21 B)... ....(Cochliomyia macellaria) SECONDARY SCREW-WORM

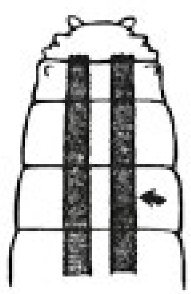


Fig. 21 A

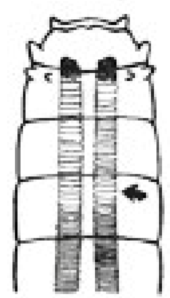


Fig. 21 B

22. Peritreme thick (Fig. 22 A)...............................(Musca domestica) HOUSE FLY

Peritreme thin (Fig. 22 B)...........................(Haematobia irritans) HORN FLY

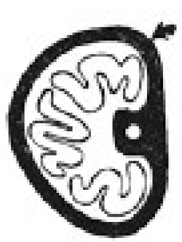


Fig. 22 A


Fig. 22 B

23. Small or slender, round larvae, usually less than 13 mm. long, tapering anteriorly (Fig. 23 A)...24

Large, robust larvae, over 15 mm long, with very stout spines (Fig. 23 B).............. 26

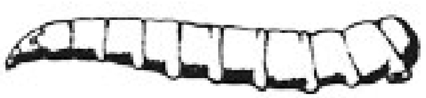


Fig. 23 A

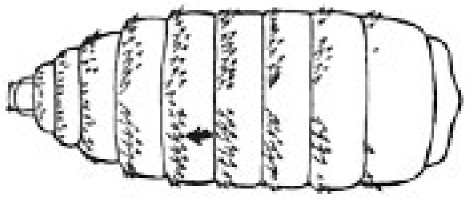


Fig. 23 B

24. Button centrally located (Fig. 24 A).................. (Stomoxys calcitrans) STABLE FLY

Button not centrally located (Fig. 24 B)..25


Fig. 24 A

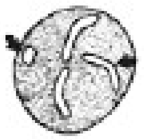


Fig. 24 B

25. Slits of posterior spiracles strongly sinuous (Fig. 25 A).....(Musca autumnalis) FACE FLY

Slits of posterior spiracles not strongly sinuous (Fig. 25 B).............................. ....(Genus Mucina) FALSE STABLE FLY

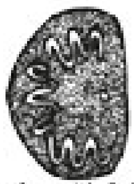


Fig. 25 A

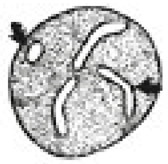


Fig. 25 B

26. Posterior spiracles with 3 distinct slits (Fig. 26 A)....................................27

Posterior spiracles without 3 distinct slits (Fig. 26 B)................................28


Fig. 26 A

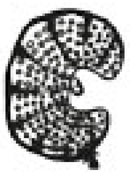


Fig. 26 B

Credit: Centers for Disease Control (CDC)

27. Spiracular slits straight and sunken in deep cavity (Fig. 27 A); body shape as in figure 27 B. ....(Genus Dermatobia) HUMAN BOT FLY

Spiracular slits curved and at most in shallow cavity (Fig. 27 C); body shape as in figure 27 D. ....(Genus Gasterophilus) HORSE BOT FLY

Fig. 27 A

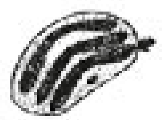


Fig. 27 C

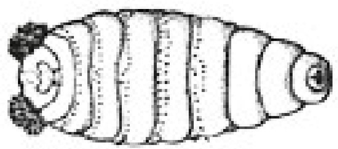


Fig. 27 B

Fig. 27 D

28. Each spiracle divided into several plates (Fig. 28 A)..(Genus Cuterebra) RABBIT AND RODENT BOT FLY

Each spiracle not divided into several plates (Fig. 28 B).................................29

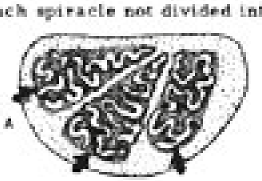


Fig. 28 A

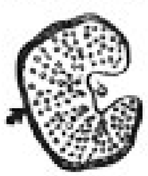


Fig. 28 B

29. Button centrally located (Fig. 29 A).......................(Oestrus ovis) SHEEP BOT FLY

Button not centrally located (Fig. 29 B)...30

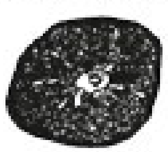


Fig. 29 A

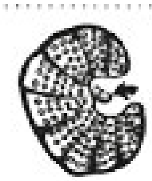


Fig. 29 B

30. Opening toward button narrow (Fig. 30 A).... (Hypoderma bovis) NORTHERN CATTLE GRUB

Opening toward button wide (Fig. 30 B)................(Hypoderma lineatum) CATTLE GRUB

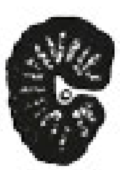


Fig. 30 A

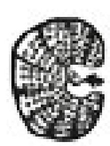


Fig. 30 B

Credit: Centers for Disease Control (CDC)

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