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TECHNICAL INFORMATION MEMORANDUM NO. 30

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Filth Flies

Significance, Surveillance and Control in Contingency Operations

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Filth Flies

Significance, Surveillance and Control in Contingency Operations

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TABLE OF CONTENTS

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Disclaimer

This TIM does not serve as the official authority for procuring or using the pesticides or equipment described herein. Use of trade names is solely for the purpose of providing information and does not imply an endorsement of the products named or criticism of similar ones not mentioned. Mention of trade names does not constitute a guarantee or warranty of the product by the Armed Forces Pest Management Board or the Department of Defense.

SECTION 1. INTRODUCTION

Filth flies have been, and will continue to be, a major preventive medicine issue during military exercises and operations conducted in warm weather. Filth flies have been implicated as disease vectors, especially in refugee and prisoner of war camps. They can also be a tremendous nuisance when they interfere with and degrade mission performance. Field messing facilities with inadequate screening often develop fly problems that make eating safely very difficult and unsanitary. Likewise, field latrines constructed without adequate fly exclusion are virtually unusable. In mass casualty situations, such as battlefields and natural disasters, flies will breed in corpses and wounds if they are not controlled or excluded. For these reasons, fly control is often a major responsibility for preventive medicine personnel.

This TIM provides basic information about the biology of several species of fly collectively known as filth flies. It discusses their medical importance and nuisance impacts within the context of military operations and exercises. In accordance with Department of Defense policy on pesticide use, it also provides guidance on preventing fly problems, and implementing control strategies using pesticides and traps.

SECTION 2. SIGNIFICANCE OF FILTH FLIES TO MILITARY OPERATIONS

2-1. Historical Examples of the Medical Impact of Filth Flies

Filth flies have historically had and continue to have an impact on combat, peacetime contingency operations, disaster relief operations, and refugee health support operations.

Filth flies may interfere with military operations through transmission of disease, contamination of food, myiasis (larval infestation of human and animal tissue), and annoyance or distraction from the job at hand. An increasingly persuasive body of evidence, described in detail below, suggests that flies play a major role in the spread of enteric disease agents. These pathogens have impacted military operations throughout history, underscoring the need for fly control.

Many reports of concurrent increases in fly populations and diarrheal rates come from military campaigns in North Africa and the Middle East during World Wars I and II (Levine and Levine 1991). Colonel J.C.G. Ledingham (1920), Royal Army Medical Corps, was assigned to the Mesopotamian Expeditionary Force in WW I and plotted fly density in relation to dysentery, showing a strong correlation. In World War II, at the battle of El Alamein in North Africa, Axis forces suffered severe losses to combat troops due to dysentery. On Pacific Islands during World War II, dead men on battlefields and excrement in latrines produced flies beyond modern comprehension. On Saipan in 1944, it was necessary to apply DDT from a C-47 type aircraft at 7 day intervals to bring blowflies under control (Hall 1948). In 1958, a United States Marine Corps (USMC) force sent to Lebanon was incapacitated by dysentery within two weeks. USMC forces deployed to Lebanon in 1982 and 1983 relied heavily upon preventive medicine for protection. This commitment to preventive medicine, which included extensive fly control efforts, resulted in very low diarrheal incidence (Daniell et al. 1985).

Flies were a monumental nuisance during the Vietnam War. It was reported that in one mess hall the fly infestation was so heavy that it was difficult to eat without ingesting one or two. It is impossible to estimate the disease transmission that may have been caused by flies in Vietnam, but it was undoubtedly significant. Several factors combined to make flies such a large problem. Many of the flies were breeding in villages near military camps, where they had easy access to animal feces, garbage, and poorly maintained dumps. Garbage collection and land filling, especially at smaller bases, were often inadequate. Human feces in burn barrels were sometimes not completely incinerated, and grease traps were overused or used incorrectly. Heavy rains often interfered with the correct functioning of grease traps and soakage pits. The hot and humid climate was conducive to rapid buildups in fly populations. Also, corpses that had been exposed in the field for several days were heavily infested with maggots, which necessitated application of pesticides inside body bags.

Similar problems were encountered in the Persian Gulf War of 1991 and subsequent humanitarian relief operations. In 1992-93, relief forces in Somalia faced persistently inadequate sanitation in local villages and cities, resulting in huge fly problems in U.S. military camps. A combination of poor sanitation in Mogadishu and numerous livestock yielded large populations of *Musca* species. The situation was compounded by varying levels of sanitation (particularly in food service programs) between different contingents of the international relief force.

A Korean Airlines jet crashed on the island of Guam in 1997, resulting in over 200 deaths. Victims were being recovered 10 days after the crash. Preventive medicine personnel from the U.S. Naval Hospital, Guam, used Fly-Tek in an attempt to protect corpses. Still, maggot masses had nearly consumed many bodies before recovery.

2-2. Current Literature on Disease Transmission by Filth Flies

Filth flies have been implicated in the direct and indirect mechanical transmission of a number of human diseases, especially diarrheal illness. This mechanical transmission of disease is facilitated by adult filth flies' habit of feeding on contaminated materials, as well as human food, and by their habit of vomiting and defecating while feeding.

The common factor in the ecology of several species of filth flies is the need for decomposing waste as a food source for adults and their maggots (larvae). Considering that these materials are often carrion, feces and food wastes (with associated pathogens), the potential for picking up microorganisms is quite high. Filth flies have numerous hair-like structures on their exteriors that dramatically increase their bodies' surface area and aid in harboring pathogens. Their deeply channeled mouthparts and hairy feet, each with sticky pads, are easily contaminated as they walk, probe, and feed across filth. Filth flies are potential mechanical vectors of disease because they can pass pathogens from their contaminated bodies to our food, eyes, noses, mouths, and open wounds.

While filth flies favor a variety of rotting materials and feces, they are also attracted to human foods. In addition to the great volume of pathogens filth flies carry on the outside of their bodies, they may transmit disease to our food in their vomit and feces. Almost all filth flies have sponging-sucking mouthparts and are incapable of chewing solid foods. They are, however, able to consume solid foods by regurgitating their stomach contents (along with any pathogens) onto the material, allowing the vomit to liquefy the solid food, then sucking the "soup" back into their mouths. Food is further contaminated as flies defecate while they feed. Kobayashi et al. (1999) showed that *Escherichia coli* O157:H7, a potentially deadly serotype of this common bacterium, actively proliferates in the minute spaces of the house fly mouthparts, and that this proliferation leads to persistence of the bacteria in fly feces. Based on DNA evidence, they further implicated house flies as the source of *E. coli* in an outbreak in a daycare center in Kyushu in western Japan.

Over one hundred pathogens that cause human disease are known to contaminate filth flies; the most significant are listed in Table 1. There is debate as to how great a role filth flies play in actually transmitting pathogens to humans and to what extent this transmission leads to disease. Depending on the pathogen and environmental factors, the role filth flies play in disease transmission may be significant, minor or nonexistent. There is strong evidence that flies play an important part in human illness due to certain enteric bacterial infections.

Table 1. Significant Pathogens of Human Diseases Known to Contaminate Filth Flies

amebic dysentery	hepatitis	*Shigella*
anthrax	intestinal worms	*Streptococcus*
cholera	leprosy	trachoma
diphtheria	polio	tuberculosis
Escherichia coli	rotavirus	typhoid fever
eyeworms	*Salmonella*	yaws

a. *Shigella* and Other Enteric Bacterial Infections

Shigellosis is a diarrheal disease caused by *Shigella* spp. bacteria that include over 40 serotypes. Symptoms include fever, vomiting and cramps, nausea, and sometimes toxemia. The illness is usually self-limited and lasts 4-7 days. Outbreaks commonly occur in crowded, unsanitary conditions, such as poorly maintained prisons, hospitals, day care centers, and refugee camps. Shigellosis is endemic in both temperate and tropical environments.

Transmission is mainly through direct or indirect fecal-oral routes. The prime route of transmission is thought to be between individuals who fail to wash their hands after defecation. Bacteria are then transmitted to the human or food that they contact. It takes the introduction of only a few *Shigella* bacteria (as few as 10) to cause illness. While shigellosis transmission is felt to be primarily a disease of unwashed hands, Watt and Lindsay (text box) (1948) showed a strong correlation between filth fly populations and *Shigella* rates in humans. In later work, Cohen et al. (1991) found similar results, including reduced sero-conversion in Israeli military camps with intense fly control. Recently, Chavasse et al. (1999) described dramatic reductions in diarrheal rates associated with fly control in rural Pakistani villages.

Relationships between Filth Flies and *Shigella* (from Watt and Lindsay, (1948)

In 1948 in South Texas, near the mouth of the Rio Grande, five of nine towns were selected for fly control using DDT. Towns with control had reduced shigellosis rates. After 20 months, the fly control regime was swapped, with control implemented in the towns that had none and ceasing in the towns that initially had it. The resulting shigellosis, reported diarrhea, and infant mortality trends reversed accordingly.

A similar study supporting this work was conducted among military personnel in Israel (Cohen, et al. 1991). Two self-contained military field units located several kilometers apart were subjected to two different filth fly control regimes. Both sites had field kitchens and chlorinated water sources with sanitation and hygiene rules enforced. Both camps had slit-trench latrines with wooden superstructures and hand washing was "encouraged." Cultures from both latrines were positive for *Shigella* sp. The house fly, *Musca domestica*, was the predominant filth fly (88-98%). Of the house flies, 6% were positive for *Shigella*. Both camps had fly control measures that included exclusion and pyrethroid spot spraying. For the study, intensive control measures (baiting and trapping) were implemented at one camp for eleven weeks. The other camp continued its routine control efforts. After eleven weeks, fly control regimes were swapped. The base with intensive fly control had 64% fewer flies than the base with routine controls. Fly control correlated with 42% fewer diarrhea cases, 85% fewer cases of shigellosis and 76% fewer personnel with antibodies to *Shigella*. In analyses, 19 of 20 fly count/diarrhea and shigellosis comparisons showed lower values with whichever base had intensive fly control. Fifteen of the 20 comparisons were statistically significant.

There are strong associations between filth flies and several other diseases (yaws, eye disease, polio, tuberculosis, and various parasites). However, the importance of filth flies in causing human illness through transmission of these pathogens is undetermined.

b. Myiasis

While we are presently uncertain about the degree to which filth flies cause human illness through pathogen transmission, there is no argument concerning the potential for human morbidity and mortality due to larval fly infestation of human tissues.

Myiasis is the infestation of living human or animal tissue with fly larvae. The larvae may feed on the host's living or dead tissue (gangrenous or necrotic). This review will concentrate on human myiasis in which almost any exposed part of the body is at risk. Forms of myiasis include: enteric (digestive), rectal, urogenital, auricular (ear), cutaneous and nasopharyngeal. When associated with wounds, myiasis is said to be traumatic. Myiasis may also result in boil-like lesions.

(1) Accidental Myiasis

Accidental myiasis is most often the result of ingesting maggot-contaminated food. Flies in this group don't require or seek a living body to invade. In fact, most ingested fly larvae are unable to complete their life cycles in the human digestive system. However, enteric myiasis can cause malaise, nausea, vomiting, pain in the abdomen, and bloody diarrhea. Living and dead larvae may pass in the stool. Over 50 species of fly larvae are known to cause enteric myiasis. The most common are the house fly (*Musca domestica*), the lesser house fly (*Fannia canicularis*), the latrine fly (*Fannia scalaris*), and the false stable fly (*Muscina stabulans*). One of the most problematic fly species associated with enteric myiasis is the cheese skipper (*Piophila casei*). Cheese skipper females lay eggs on cured meats, old cheese, smoked fish and other materials. The larvae often penetrate the surface fairly deeply, particularly in meat, and go unseen. When humans unintentionally consume cheese skipper larvae, the maggots pass through the digestive system alive, resulting in serious intestinal lesions. Other fly larvae that can survive the human digestive system include the black soldier fly (*Hermetia illucens*) and the drone fly (*Eristalis tenax*). Both species are documented to cause severe gastrointestinal disturbances.

Another form of accidental myiasis is rectal, in which flies that normally breed in feces lay eggs in fecal material around the anus. Rectal myiasis usually occurs in humans living under filthy conditions, especially infants and sick adults who are unable to care for themselves. Species of excrement feeders, such as the drone fly, lesser house fly, latrine fly, false stable fly, and certain flesh flies (Sarcophagidae), are known to inhabit the rectum or terminal part of the intestine.

(2) Facultative Myiasis

Facultative myiasis occurs when fly species that normally feed on feces or carrion adapt to life as parasites. Maggots of these flies can develop quite well in a living host but are not dependent upon other living animals for food. Urogenital and traumatic facultative myiasis occur most frequently. Vaginal myiasis is a concern of increased importance with the increasing number of women serving in deployed units.

Urogenital myiasis usually occurs at night in warm weather when people sleep uncovered. Egg laying may be stimulated by discharges from diseased genitals. The result is obstruction, pain, pus, mucus, bleeding, and a frequent desire to urinate. Larvae are expelled with urine. Flies most commonly associated with urogenital myiasis are the house fly, lesser house fly, latrine fly, and false stable fly.

Flies associated with facultative traumatic myiasis are usually carrion breeders. The blow flies (Calliphoridae) are most commonly involved, but flesh flies (Sarcophagidae) and the house fly are also known to infest wounds. Normally attracted to the rotting flesh of carrion, these flies are also drawn to foul-smelling, neglected wounds, especially if patients are helpless. Infestations can be quite painful. The maggots feed primarily on necrotic tissue, but they may also invade living tissue. Flies documented to cause facultative traumatic myiasis include the black blow fly (*Phormia regina*), a green bottle fly (*Phaenicia sericata*), the secondary screwworm (*Cochliomyia macellaria*) and certain calliphorids in the genus *Chrysomya*.

(3) Obligatory Myiasis

Flies involved in obligatory myiasis are incapable of reproducing without a living host for larvae to feed upon. These flies include blow flies (Calliphoridae), flesh flies (Sarcophagidae), and bot flies (Oestridae & Gasterophilidae).

The primary screwworm (*Cochliomyia hominivorax*) is a true parasite that feeds only on living animal flesh. Adult females do not lay eggs on cold-blooded animals like reptiles and amphibians, nor in carrion or decaying meat or vegetables. The primary screwworm is notorious for decimating livestock. Modern control measures have nearly eradicated this fly from the United States, with only sporadic re-infestations through importation of infested livestock. However, *C. hominivorax* still occurs from Mexico to northern Argentina and Chile. Human cases are often associated with livestock infestations. Egg-laying females are strongly attracted to open wounds, sores, and even tick bites, where individual females lay up to 2,800 eggs in batches of 10 to 400. Adults are deep greenish-blue metallic, with yellow, orange or red faces. It is often difficult to separate this species from the secondary screwworm (*Cochliomyia macellaria*), a blow fly causing facultative myiasis in wounds and abrasions.

The bot and warble flies (Oestridae) are obligate parasites of animals that often infest livestock and pets. However, they can infest humans who work with or live near infested animals. Adult bot flies are distinguished from other flies by their large, hairy, bumblebee-like bodies. Larvae are large and often armored with spines that make removal from flesh difficult. In humans, the horse bot maggot (*Gasterophilus intestinalis*) penetrates unbroken skin and burrows freely through flesh causing itching, ”creeping“ myiasis. Since humans aren't the horse bot's normal host, the maggots are unable to survive. However, the maggots of the ox warble or cattle grub (*Hypoderma bovis*) survive quite well in humans, often with serious consequences. Cattle grub larvae penetrate unbroken skin and wander in the arms and legs, causing dermal, creeping myiasis with severe pain. Local paralysis may occur due to invasion of the spinal cord. Sheep bots (*Oestris ovis*) do not survive in humans, although they cause pain and irritation, most commonly in the eyes.

The human bot fly (*Dermatobia hominis*) is common in parts of Mexico and southward into South America. It resembles a blue bottle fly and parasitizes a very wide range of animals, including humans. The adult female captures a blood-sucking insect, such as a mosquito, black fly, horse fly or stable fly, and deposits an egg on its body. When the mosquito feeds on a human, the bot fly larva crawls off the mosquito and enters the human through the mosquito bite wound. The human bot fly larva doesn't wander in the flesh but produces a boil-like lesion (furuncular myiasis). The larva lives in the host for about six weeks, then exits the wound and drops to the soil to pupate. When the larva enters the bite wound, it only causes an itching sensation; however, intense pain will follow within three weeks.

2-3. Filth Flies As Nuisance Pests

The great amounts of filth and carrion encountered by military personnel during war, peace keeping, and humanitarian operations usually produce huge numbers of filth flies. These flies not only disrupt military operations by affecting human health, but in large numbers they can distract personnel from their work and can significantly degrade morale.

The house fly female is capable of producing about 120 eggs 4 to 6 times in her lifetime. Larvae that hatch from these eggs will develop into adults in about 10 days. The potential for a house fly population explosion in warm conditions during contingencies (poor sanitation, large numbers of refugees or prisoners of war, and/or numerous exposed cadavers) is quite high. Stable flies, *Stomoxys* spp., are among the few filth flies that bite. Although they are not associated with disease transmission, they can be a formidable nuisance.

Numerous anecdotal accounts exist of huge filth fly populations in all wars and several operations and exercises in which the U.S. military has been involved. As recently as 1999, entomologists encountered large filth fly populations (calliphorids) at certain U.S. air bases in Kuwait, where these flies were a severe annoyance to day workers and were present en masse in dining facilities.

It is difficult to quantify the emotional effects of large numbers of flies on personnel in an already stressful environment. However, large populations of filth flies certainly distract personnel from their duties. Proper management of latrine wastes, garbage, and dining facilities will significantly reduce fly numbers. This, in turn, will result in more attentive and effective personnel, greatly improving the chances for successful operations in garrison, onboard ship, and in the field.

SECTION 3. IMPORTANT FILTH FLY SPECIES, BIOLOGY AND BEHAVIOR

3-1. General

Generalized life cycle: The term “filth fly” refers to several species of true flies that belong primarily to the families Muscidae, Calliphoridae and Sarcophagidae. All flies have a complete life cycle, with egg, larval, pupal and adult stages (Figure 1). Larvae (maggots) complete 3 instars before pupation. Keys for identifying flies are available in Appendix A, which includes a simplified key to common house flies of the United States and a key to common filth fly genera. The generic key should be used outside the United States. The reader is also referred to Pont and Patterson (1971), which provides a key to species of the genus *Musca* worldwide and is broken down by geographic regions.

Fly development is temperature and humidity dependent; variations in developmental time within a species are usually related to these two factors. Changes in climate, such as the onset of the rainy season, can have a dramatic effect on fly populations, largely on the rate of development. Filth flies are very strong fliers. Developmental sites are often quite distant from areas where adults cause problems.

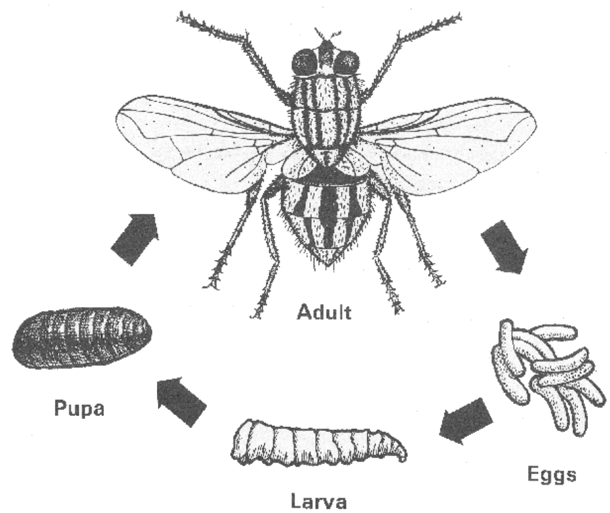


Figure 1. Generalized filth fly life cycle

3-2. *Musca domestica*, the house fly

a. Importance: Usually the most common filth fly invading homes. House flies mechanically transmit several pathogens, especially diarrheal agents.

b. Distribution: Worldwide.

c. Life Cycle: Female *M. domestica* lay eggs in a variety of decaying materials, including manure, carrion, decaying fruits and vegetables, kitchen refuse, garbage-pile drainage and cesspool material or other fermenting substances. Moisture content is critical for development. Substrates that have completed the fermentation process are not suitable media for reproduction. Females lay from 100 to 150 eggs at a time and can lay 4 to 6 batches in a lifetime. A female will scatter her eggs in a number of locations. Eggs hatch within 24 hours, unless temperatures are below 20^{o} C.

Larval development is temperature dependent. The first and second instars each last from one to several days; the third instar feeds from 3 to 9 days before pupating. Third instar maggots migrate away from food sources in search of suitable sites for pupation. Adults emerge from pupal cases in five days under optimal conditions. Under adverse conditions several weeks may be required for completion of the pupal stage. Egg laying (oviposition) begins four to eight days after copulation. Adults feed on a wide range of materials, including feces, garbage, fresh and decaying fruit, and most human food. Adult *M. domestica* are very strong fliers.

3-3. *Musca sorbens*, the eye fly

a. Importance: Adults are attracted to humans, especially unsanitary and malnourished persons. This fly is often associated with refugee camps established after natural and manmade disasters, such as flooding, earthquakes, war, and other situations in which sanitation levels in large populations are substandard. Adult *M. sorbens* feed on mucous secretions around the faces and eyes of humans. They are also attracted to wounds and ulcers. They are particularly troubling to famine victims, who often lack the energy to keep adult flies from feeding on secretions from their eyes and noses. Adults also feed on carrion and garbage. *Musca sorbens* adults vector epidemic conjunctivitis and mechanically vector several enteric pathogens. This species is often the most common filth fly species present in the field, especially in hot, dry regions.

b. Distribution: Old World tropics and subtropics, Australia and Pacific Islands.

c. Life Cycle: In certain areas, adult *M. sorbens* are found almost exclusively outdoors, but they are found both indoors and outdoors in other regions. Females generally show a strong ovipositional preference for human feces. Other types of excrement are used less frequently. Although *M. sorbens* is reported as a common species around privies, it apparently does not breed in them as it prefers to oviposit in more open, drier spaces. Females lay up to 80 eggs in 3 or 4 batches. Complete time of development is 8 to 9 days at 30^{o} C and 15 to 16 days at 23-26^{o} C. Pupation takes place in the drier soil beneath the stool. On average, adult males and females live 18.5 and 21 days, respectively.

3-4. *Musca autumnalis*, the face fly

a. Importance: Important pest of cattle; however, they can be a significant nuisance to humans when in close proximity to pasture and barnyard areas.

b. Distribution: Originally found in all regions of the Old World. Introduced into North America in 1952, and now present throughout the Western Hemisphere.

c. Life Cycle: Adult face flies feed on animal secretions. Large numbers cluster around the face and nostrils of cattle and feed on mucous and watery secretions. Face flies also feed on blood exuding from wounds made by biting flies. Face flies found on cattle are predominantly female. Dung and/or blood seem to be necessary for ovarian development. Males feed primarily on nectar.

In temperate climates, highest populations are seen in late summer. Adults are active during the day only, resting on vegetation at night. *Musca autumnalis* pester cattle and humans standing in the shade. Mating occurs 4 to 5 days after emergence and eggs are laid 2 to 5 days after mating. Over much of its range, the face fly breeds almost exclusively in fresh cattle dung, though bison or pig dung is occasionally used. Eggs hatch within a day and larval development takes 3 to 4 days. Third instar larvae migrate away from fecal breeding material to pupate. The pupal period is 7 to 10 days. The total life cycle from egg to adult requires about two weeks. Adults live 4 to 8 weeks. Face flies overwinter as adults in protected areas.

3-5. *Fannia canicularis*, lesser house fly; *F. scalaris*, latrine fly; other *Fannia* spp.

a. Importance: *Fannia canicularis* often vies with *M. domestica* as the most important pest fly in households. In cooler seasons, this species is often more common than *M. domestica*. In warmer seasons, *Fannia* spp. decrease in number. *Fannia canicularis* and *F. scalaris* breed commonly in latrines and cesspools. Both species have been associated with intestinal myiasis.

b. Distribution: Great Britain, North America, and Central Asia.

c. Life Cycle: Female *F. canicularis* and *F. scalaris* prefer to breed in excrement, but also lay eggs in decaying animal and plant matter. *Fannia scalaris* breeds in deep semifluid latrine material. Larvae are laterally compressed, with a feather-like process that acts as a flotation device. Female *F. canicularis* prefer to lay eggs in drier media.

Eggs hatch after 1 to 4 days. Each larval instar lasts 3 to 5 days. Pupae leave the semi-liquid or liquid substrate for somewhat drier places to pupate. Mating and oviposition take place 48 and 96 hours after emergence. The period from egg to egg is from 22 to 27 days. Breeding is continuous in warm climates. *Fannia* spp. overwinter as pupae, usually 5 to 8 cm below the soil surface.

3-6. *Stomoxys calcitrans*, the stable fly

a. Importance: This species is well known for tormenting cattle and humans. It is a vicious biter causing a sharp pain.

b. Distribution: Worldwide, both temperate and tropical. The habits of this species vary with climate and locality, making it difficult to generalize about breeding and larval development.

c. Life cycle: Both sexes feed on blood. Females lay 40 to 80 eggs per batch and 10 to 12 batches in a lifetime. The stable fly breeds in fermenting vegetation. Animal bedding with high dung and urine content is a primary breeding site. Aquatic grasses that have washed ashore and other well-moistened decaying vegetation can be a breeding source. Eggs are laid in a medium that is loose and porous, with high moisture content and moderate temperature.

Adult females do not lay eggs until 8 to 10 days after emergence. Maggots burrow into the breeding material, following moisture inward as the substrate dries. Under favorable conditions, the entire egg to adult life cycle is from 21 to 25 days. This can be as long as 78 days in unfavorable conditions or in cool climates. Before pupation the third instar larva crawls to drier parts of the medium. Stable flies overwinter as larvae or pupae. Adults are strong fliers and can travel many miles. Adults do not feed at night.

3-7. *Chrysomya bezziana*, the Old World screwworm

a. Importance: Larvae are obligate parasites of living flesh (human and domestic or wild animals). Cases of human myiasis associated with the Old World screwworm are common in East Asia but relatively rare in Africa.

b. Distribution: Afrotropical and Oriental regions extending south into Indonesia, the Philippines and New Guinea.

c. Life cycle: Females oviposit in the daytime, usually on or near a wound, but occasionally just inside the nostril. Eggs are deposited in batches of 150 to 500 and hatch 15 hours later. Larvae invade healthy tissue. A breathing tube is visible protruding from the host skin. Larvae emerge from the host as prepupae 4 to 7 days later and fall to the ground where they pupate for a week or more.

3-8. *Cochliomyia hominivorax*, the New World screwworm, primary screwworm

a. Importance: Larvae are obligate parasites of living flesh (human and domestic and wild animals). Human cases of myiasis associated with this species are uncommon, but a traumatic case was reported in a soldier wounded in Panama in 1988.

b. Distribution: South and Central America.

c. Life cycle: Similar to *C. bezziana.*

3-9. *Phormia regina*, the black blow fly

a. Importance: One of the most common flies associated with wound myiasis, especially in livestock. Larvae are also common in garbage cans and animal waste.

b. Distribution: Northern latitudes worldwide; at high elevations, as far south as Mexico and in Hawaii on Oahu.

c. Life cycle: Larvae normally feed in dead tissue, breeding in carcasses and wounds. They are commonly found in castration and dehorning wounds in livestock. In cases of myiasis, larvae sometimes cause a bloody discharge, indicating a certain amount of destruction of living tissue. They also breed in garbage cans and animal waste. The larval stage takes 4 to 15 days. Growth from egg to adult takes 10 to 15 days. Adult life span can range from 45 to 68 days.

Phormia regina is more common in the spring and fall and scarce in the summer. Cool weather favors development. These flies overwinter as adults. Adults emerge for brief periods throughout the winter. In warmer climates breeding is continuous.

3-10. *Calliphora* spp.

a. Importance: These are the familiar blue bottle flies. Forensically, they are the most important flies involved in cadaver succession in temperate regions.

b. Distribution: Best represented in the northern parts of the Old and New Worlds and in the Australian region, although two species, *C. croceipalpis* and *C. vicina*, occur in the Afrotropics.

c. Life cycle: Adult *Calliphora* emerge from overwintering as soon as the ground temperature reaches 5^{o} C and oviposit 4-5 days thereafter. Eggs are deposited on carrion. Depending on the species of fly and the season and situation, oviposition can occur immediately after death of the host, or up to 2 days after death. A female will lay up to 300 eggs. Upon hatching, larvae penetrate the skin or hide via natural or unnatural openings (i.e., wounds). Development takes from 15 to 27 days, depending on species and temperature. Larvae leave the corpse in large numbers and pupate in the top 5 to 8 cm of soil, and up to 6 m from a corpse. These flies overwinter as prepupae.

SECTION 4. SURVEILLANCE AND EVALUATION OF CONTROL EFFORTS[1]

4-1. Necessity of Fly Surveys.

Filth fly surveys help determine the effectiveness of sanitation practices, identify filth fly breeding sites and determine the need for control measures, such as improved exclusion in mess facilities or pesticide application. Filth fly surveys are also necessary to determine baseline fly populations, track the trends in populations, and measure the effectiveness of control measures. Sanitation is the cornerstone of a sound filth fly control program. Unfortunately, breeding areas may be off-post, placing sanitation beyond the charge of preventive medicine, and making it necessary to concentrate on adult surveillance and control.

[1] Information extracted from TB MED 561, Occupational and Environmental Health Pest Surveillance, Headquarters, Department of the Army, June 1992.

4-2. Five Elements of Effective Filth Fly Surveillance

a. Surveillance to identify the presence, species, and size of fly populations and conditions that favor breeding.

b. Sustained monitoring of fly populations and conditions that favor breeding.

c. Evaluation of survey results.

d. Initiation of control measures when established thresholds have been passed and notification of appropriate units responsible for conducting control measures.

e. Continued surveillance to determine the success of control measures.

4-3. Surveillance Program SOPs

Surveillance programs should be documented in Standard Operating Procedures (SOPs) or protocols. Information should include:

a. Who will do the surveillance? Specify the responsible units.

b. How will the surveillance be conducted? List the techniques and procedures that will be used.

c. Where are the surveillance locations? Clearly identify all locations on a map.

d. When will the surveillance be conducted? Include the rationale for the frequency of surveillance and when complaints are evaluated.

e. What are the criteria for initiating control measures? Identify the thresholds to be used and the recommended control measures.

4-4. Threshold Values

An effective surveillance program must have a way to determine the need for control measures. The presence of flies does not automatically initiate a recommendation for control. Thresholds are established to help predict when control measures are needed. The threshold value itself is an index calculated from surveillance data. Continuous surveillance over an extended period of time may be required to establish reliable threshold values. Long-term surveillance data may also reveal identifiable trends that will protect personnel by allowing control measures to be initiated just before a serious fly problem occurs. Threshold values will vary at different geographical locations depending on such factors as species, area involved, habitat, collection technique, number of complaints, and disease potential. In certain regions, such as developing nations in the tropics, fly problems may be abundantly apparent even without surveillance. Still, fly surveillance is necessary to determine effectiveness of control measures and to identify seasonal fluctuations and temporal population trends. Thresholds are only indicators and therefore should not be the only factor used in the decision to recommend control measures.

4-5. Initiating Filth Fly Surveillance

a. Develop lists of all sites where adult flies could potentially feed and where flies could breed. A listing of facilities that receive sanitation inspections, including mess halls, latrines, dishwashing areas and soakage pits, is a good place to begin. In addition, include landfills, stables, kennels, and garbage handling areas. Surveillance and control at off-post facilities, such as landfills and sewage treatment facilities, may be necessary, especially to protect facilities that are occupied for several months or more.

b. Conduct a preliminary survey at all potential filth fly infestation sites listed. The purpose of this survey is to identify existing filth fly infestations.

c. Contact units or activities that are (or should be) concerned with fly control. Because sanitation is so important, successful filth fly control efforts require close coordination with all personnel involved. All personnel must be aware of the objectives of the surveillance program and their role in it. Meet with the appropriate units/activities to discuss:

(1) what is being done for filth fly control.

(2) how to integrate efforts.

(3) what criteria are used to initiate control measures such as:
- surveillance data.
- schedules.
- service orders.
- complaints.

(4) what facilities are or have been particular problems for filth fly control.

(5) meeting with managers of food handling facilities and personnel from other activities that generate infestible waste. Cooperation of these personnel is necessary for a successful filth fly control effort.

d. Select methods, as described later, and frequency for sampling fly populations. Fly collections are necessary to determine the species present and fluctuations in fly populations within a given area.

e. Initiate filth fly surveillance that consists of routine surveys for:

(1) the presence and number of flies.

(2) favorable breeding conditions.

(3) adequate exclusion at food handling facilities and other potential filth fly breeding sites.

Survey personnel should be alert for such conditions as properly bagged infestible refuse, closed dumpsters or trash container lids, clean dumpsters/trash containers, and properly screened windows and doors. Contractors, especially in foreign countries, must be monitored to ensure that food wastes are disposed of properly and that garbage bags and dumpsters are collected frequently. The effectiveness of sanitary practices may be determined by these surveys.

f. Develop thresholds and control options (do not forget non-chemical measures) and a policy for dealing with complaints. Write an SOP. Document all aspects of filth fly surveillance. Include maps to show fly sampling sites (consider using GPS to accurately identify sampling site locations).

g. Sampling Methods and Surveillance Data

(1) There are many techniques for sampling adult filth flies. For our purposes, the most appropriate are based on counting the number of flies on resting sites or those caught by sticky traps. Sampling should be conducted at a standardized time and at the same locations. The number of flies caught strongly depends on the location of the trap. Locations must be accurately identified so the trap will be placed in the same location for each subsequent survey. Weekly fly surveys should be conducted throughout the fly breeding season.

(a) Fly Grill. The fly grill technique (Scudder 1947 & 1949) is the most versatile and widely used of the counting techniques. The grill (Figure C-3, Appendix C), often referred to as a Scudder grill, consists of 16-24 wooden slats, fastened at equal intervals to cover areas of from 0.8 m^2 (big grill) down to 0.2 m^2 (small grill). The big grill is for outdoor use but is impractical for indoor use. For general use, a small or medium-sized grill is suitable. Place the grill where there are natural fly concentrations and count the number of flies landing on the grill for a given period of time (usually 30 seconds or l minute). In each locality, counts are made on 3 to 5 or more of the highest fly concentrations found and the results averaged. With practice it is possible to sight identify the fly species that land on the grill.

(b) Fly Bait Technique. Use this technique to determine fly densities indoors. A square card 30 cm on a side that has been painted with a mixture of molasses and vinegar (1:2) should be placed near a location frequented by flies. The number of flies attracted to the card over a specified time (e.g., five minutes) is recorded. Other baits, such as syrup, molasses or milk may be used, but in order for fly counts to be meaningful, uniformity of bait and technique is necessary.

(c) Sticky Traps. Sticky tapes or strips are used for assessing fly densities, particularly indoors. They may be exposed to flies from 2 hours to 2 days (one day is recommended). In order for data to be meaningful, the length of time and time of day must be uniform from observation to observation. Sticky traps should be located near doorways or trash receptacles. They should not be placed over food preparation or serving areas.

(d) Live Traps. These are recommended only when live specimens are required for identification or resistance testing. They provide quantitative data for fly surveillance but are not as convenient as sticky traps and Scudder grills for routine surveillance because of the problem of disposing of the live flies. However, these traps may also be baited with poison bait to serve as effective local devices (e.g., Figure C-1, Appendix C).

(e) Sweep Nets. Catching flies with a sweep net yields samples for identification, but this technique does not provide reliable quantitative estimates of the fly population.

(f) Field-Expedient Methods. These include visual counts of flies landing on a given surface, such as a table top, tent pole, appliance, or even a person in the area. Empty plastic water or soft drink bottles may also be modified for use as traps (Figure C-2, Appendix C). However, it can be difficult to replicate this method at different sites, so data obtained this way may not be statistically comparable.

(2) Recording surveillance data. A permanent record should be kept of all filth fly surveillance data. Maintain files of such data on a form such as the Filth Fly Survey Form shown in Figure C-4.a, Appendix C, or an equivalent that provides a record of the number of filth flies counted or trapped, the species observed, and sanitation and exclusion conditions in each facility surveyed. A blank form is provided in Figure C-4.b, Appendix C.

(a) Records of filth flies trapped and counted are useful indices for showing fluctuations in fly populations. The surveyor should use a graph that plots changes in the population level and dates of pesticide applications.

(b) A composite index for a particular area or installation is calculated by averaging data from several collection sites. The composite indices should be plotted in graph form. After some experience, a threshold may be established. For example, in residential areas, a grill index of 25 flies may be unacceptable.

SECTION 5. FIELD SANITATION

The predominant concern with filth flies is sanitation. Fly problems will most readily be recognized in field messes and latrine facilities. The presence of flies in otherwise clean facilities indicates an unsanitary condition. Further, declining food service sanitation leads to greater fly problems.

Protocols for sanitation will depend on the infrastructure available to handle wastes. If trash and waste removal is provided by contracted services, pertinent collection and storage guidelines must be strictly enforced. Garbage should be stored in fly-proof containers until removal. Portable toilets and garbage should be serviced often enough to prevent fly attraction and breeding. Fly and other sanitation issues that are related to contract services should be addressed through contract adjustments. Fly exclusion and abatement of breeding in situations with and without infrastructure are discussed here. Much of this discussion is drawn from the U.S. Navy Manual of Preventive Medicine, NAVMED P5010, Chapter 9. Detailed instructions on design of all waste disposal units noted in this section are available in Appendix B and NAVMED P5010.

5-1. Food Preparation Area Sanitation

a. Flies must be excluded from food service areas to prevent spread of enteric diseases and to ensure that messing facilities are as comfortable as possible. Adult flies feed on most human foodstuffs. Fly exclusion and proper food handling are always necessary in areas where flies are abundant. Exclusion is especially urgent when refugee and prisoner of war camps are in close proximity to mess areas because enteric pathogens are likely to be at elevated levels in refugee and prisoner populations. Additional control methods, such as pesticide application and trapping, may be necessary. These methods are discussed in Section 6. However, it cannot be overemphasized that fly control will be unsuccessful in the absence of adequate exclusion. Similarly, fly control measures will fail if garbage and latrine management, as discussed later in this section, are inadequate.

b. Food Preparation. In all cases, proper food handling is necessary to control flies and prevent fly-borne disease.

c. Fly Exclusion: The nature of food service facilities will have a profound effect on the likelihood of successful fly exclusion. Occasionally, messing facilities are established in permanent buildings with doors and windows that can be easily fitted with screening. More frequently, field messing facilities range from very primitive (where personnel sit on the ground) to semi-permanent tents with piped water. If exclusion is even moderately successful, indoor trapping and/or space sprays with d-phenothrin, as discussed in Section 6, may improve fly control from barely adequate to comfortable.

Flies can be excluded from mess tents by placing a small tent with double-doors at all entrances. The smaller tent serves as a buffer. If at least one door is closed at all times, flies will be impeded from passing directly from the outside into the food service spaces. In hot climates, this system is impractical because it would affect ventilation, making the mess tent unbearably hot. Attempts should be made to screen at least the food preparation and serving areas, or to keep food covered as much as possible, in mess tents that do not adequately exclude flies.

5-2. Garbage, Rubbish and Carrion Disposal

a. Garbage is solid or semi-solid waste generated through production and handling of food. Rubbish is dry disposable waste.

b. Disposal infrastructure unavailable. When in a camp 2 to 6 days, garbage and rubbish should be disposed of by burial in a continuous trench. The trench should be 0.5 m wide, 1.5 m deep and long enough to accommodate the next day's garbage. When a section is full, it is covered and mounded, and a new section is dug to accommodate the next day's garbage. In camps that will be used for one week or more, and where the tactical situation allows, incineration is the most common garbage and rubbish disposal method. Wet materials will not burn easily. It is necessary to separate liquids from solids. Separation is accomplished by straining garbage through a coarse strainer, such as a 55-gallon drum with holes punched in the bottom. The liquid is run through a grease trap and into a soakage pit (Figures B-1, B-2 and B-3; Appendix B). Dry garbage and rubbish are incinerated (Figures B-4 and B-5; Appendix B). Ash and non-combustibles are buried.

c. Liquid Waste Disposal. Liquid waste generated at food service facilities is attractive to flies as a food source. Every attempt should be made to keep liquid wastes separate from garbage and rubbish. Liquid wastes drained from garbage should be run through a grease trap (Figures B-1 and B-2; Appendix B) and disposed of in soakage pits (Figure B-3; Appendix B) or evaporation beds (Figure B-6; Appendix B). These facilities may attract flies unless they are well irrigated, but breeding should not occur. Disposal sites should be at least 30 m from dining facilities.

d. Cleaning garbage cans and dumpsters. Thoroughly washing containers after each emptying will prevent the buildup of encrusted liquid and solid food materials on surfaces. Garbage cans should be washed after each garbage collection. Wash water must be directed into a sanitary sewer or away from the bivouac area. Wash water allowed to run on the ground will attract flies. Dirty dumpsters indicate that food waste is not being handled properly. Plastic bags that contain food waste must be secured to prevent leakage. Empty food containers must be rinsed before being deposited in the dumpster/garbage can. Dumpsters that are found encrusted with liquid and solid food should be steam cleaned to prevent filth fly breeding.

5-3. Human Waste Disposal

a. Distance. All latrine facilities should be placed at least 30 m from natural bodies of water, 100 m from messing facilities, and 15 m from berthing.

b. Portable Toilets. Portable toilets are available in many training situations, particularly in CONUS where state laws may require their availability. Flies will be unable to breed in portable toilets that are cleaned frequently. Cleaning is usually a contracting issue that is best approached during pre-deployment planning. Portable toilets are attractive to flies and must be adequately screened. Placement of these facilities must be in accordance with paragraph 5-3.a above.

c. Urine Troughs and Urinals. In temporary and semi-permanent camps where permanent facilities and chemical toilets are not available, personnel should be encouraged to use separate, specifically designed facilities for urination and defecation. Urine troughs (Figure B-7; Appendix B), urine soakage pits (Figure B-8; Appendix B), and urinoil toilets (Figure B-9 Appendix B) should not present fly breeding problems. Flies will be attracted to urine troughs and soakage pits unless they are well irrigated.

d. Straddle Trenches. Straddle trenches (Figure B-10; Appendix B) are used in temporary bivouacs (1 to 3 days) and less often in semi-permanent camps. Waste is buried daily under 0.3 m of dirt that prevents fly breeding. Flies will be attracted to these facilities. Pathogen transmission and urinary and rectal myiasis may be a concern. Some manuals suggest treating latrine materials with pesticides before burial.

e. Deep Pit and Burn Barrel Latrines. Several types of latrines can be constructed in camps active for more than 3 days. Factors independent of fly control often dictate which type is most appropriate. Design and maintenance standards will greatly affect a latrine's attractiveness to flies and the extent to which flies can breed.

Deep pit and burn barrel latrines should be designed to exclude flies from potential breeding sites. Figures B-11 and B-12, in Appendix B, show proper construction, with adequate fly exclusion, of the two latrines. Seats should be covered with fly-proof, self-closing lids. Any other areas where flies may have access to latrine materials should also be sealed. It is necessary to exclude adult flies from latrine materials, even if breeding is successfully abated through burial or burning. This will prevent adult flies from carrying disease agents from latrines to other parts of the camp and will lower the threat of urinary and rectal myiasis.

SECTION 6. FILTH FLY CONTROL

6-1. Introduction

Integration of control methods is essential in filth fly suppression programs. In many instances, exclusion is the key to long-term control. Pesticide application alone is not sustainable, being limited by both time and money. However, pesticides constitute the most effective immediate solution for controlling filth fly populations and must be considered when a disease threat exists.

The bodies of DoD personnel killed during contingencies should not be treated with pesticides to control insect infestations. It is standard DoD Mortuary Affairs procedure that the bodies of dead DoD personnel not be treated to remove insect infestations in the field. Bodies are typically bagged and shipped to an embalming point in hermetically sealed transfer cases. Upon arrival at the embalming point, any infestations are removed using standard mortuary procedures for processing decedent remains. Further, application of pesticides to bodies may interfere with chemical analyses conducted on the remains.

Pesticide application must always be done according to label guidelines. Pesticide labels are legal documents. Failure to follow label instructions is a violation of Federal law. Also, a memorandum from the Joint Chiefs of Staff dated 1 February 1999 mandates that, except in an emergency as determined by the Joint Task Force Surgeon, only pesticides on the DoD Approved Pesticides List can be used by U.S. military personnel, whether in CONUS and on deployment. All pesticides noted in this manual are authorized for use by DoD certified pesticide applicators.

Pesticides should only be used as a backup to sanitation and exclusion. Several methods of pesticide application can be used in filth fly control. Often one or two methods, such as baits and space sprays, will adequately augment sanitation and exclusion. The choice of application method is dependent upon several factors. In deployed situations, the type and amount of application equipment are often deciding factors. Good planning is necessary to ensure pesticide formulations match application equipment, and that the planned method of application is adequate to accomplish the task. Ordering information for pesticides and pesticide dispersal equipment is available in Armed Forces Pest Management Board Technical Information Memorandum (TIM) Number 24, Contingency Pest Management Guide, available on the AFPMB web site located at http://www.afpmb.org/coweb/guidance.htm.

6-2. Insecticide Baits

a. Active Ingredients and Trade Names:

(1) Granular Baits (see TIM 24). If used correctly, these can effectively reduce adult fly populations. Application: For outdoor use only. Bait should be applied following label specifications, scattered over specified fly feeding areas daily or as needed. These baits are also effective in and around dumpsters and garbage cans. Distribute bait directly from the container; specialized equipment is not required. Avoid contact with skin.

(2) Fly Abatement Strips (e.g., Quickstrike®). These products are more than the simple sticky tape strips of old. They are marketed specifically for control of house flies and lesser house flies, but they also kill other flies such as blowflies. These devices contain a plastic strip that is impregnated with pesticide. Ampoules containing house fly sex pheromone and other attractants are attached to the strip. The strips are often enclosed in a plastic frame and contain a bittering agent to discourage accidental ingestion.

These devices work best in areas with medium to high fly populations. Each station can cover from 9 to 30 m^2. Stations should be placed at about shoulder height, or lower, and should be protected from moisture and direct sunlight. They should not be used indoors because the attractant odor may be considered unpleasant.

6-3. Space Sprays

a. Outdoor Application

(1) Ultra low volume (ULV) application, is the most rapid method of outdoor adult insect control. In situations where fly populations must be brought under control immediately, e.g., to reduce the incidence of diarrheal diseases in a refugee camp, ULV pesticide application is the only assured means of immediate control. Space sprays are effective at killing flying insects over large areas, but results are often short-lived, as insects move in from unsprayed areas. More long-term control strategies should be implemented as soon as possible to reduce reliance on space sprays, which are expensive and labor intensive.

(2) Application: ULV application utilizes specially formulated pesticides for application through thermal and cold foggers. The theory of application is to fill the air with a cloud of small droplets. Droplets in the cloud are so dense that a lethal dose will impinge on all target insects within the treated area. Space sprays are carried through the target area by wind. Shortly after treatment, all pesticides either move or settle out of the treated area. Because pesticides do not remain in the treated area, fly populations may begin to rebuild immediately after treatment.

If the treatment area is too small, re-invasion can be almost immediate. Regardless, frequent reapplication is often necessary unless more sustainable methods are implemented.

b. Indoor Application.

(1) d-phenothrin aerosol can be almost 100% effective indoors when used to augment effective exclusion measures. In the absence of exclusion, indoor treatments may be of little value. d-phenothrin can be used for disinsection of aircraft, ships and vans. Aircraft disinsection with d-phenothrin is no longer permitted when passengers and crew are aboard.

Dichlorvos pest strips should be used indoors and in garbage cans. They must not be used in food preparation or serving areas. Pest strips may be ineffective inside screened structures, as opposed to buildings with solid windows and doors, because air exchange will prevent adequate buildup of pesticides in the air. Further, pure pesticide has been observed dripping from resin strips in the hot, humid climate of Vietnam, making this an unacceptable control strategy in such conditions.

(2) Application: Buildings and tenting can be disinsected by spraying d-phenothrin for 10 seconds per 1,000 ft^3 (30 m^3), per label instructions. Tents will require repeated spraying if attempts are not made to exclude flies. One pest strip should be used every 1,000 ft^3 (30 m^3).

6-4. Residual Insecticides

a. Residual sprays can be used to control adult or larval flies. In both cases, efficacy is often poor, but this approach can be useful in certain situations. Residual pesticides are usually ineffective against larvae. Pesticides do not penetrate into materials where maggots live. Also, breeding material is often widely dispersed, making it difficult to locate and treat. Further, flies disperse great distances, so it is unlikely that most of their breeding areas will be located. Still, applying residuals to inside surfaces of garbage cans, and other areas where maggots are seen, should be included in control programs.

Residuals can be applied in strategic areas to control adult flies. Certain surfaces attract flies, especially indoors. Flies are attracted to narrow vertical surfaces, such as strings hanging from ceilings, hence the utility of fly paper. Hanging strings or paper strips treated with residual pesticides from the ceiling can effectively augment screening for indoor fly control. Surfaces around garbage handling areas are attractive to adult flies. Applying residuals in these areas is useful.

b. Application: Residual sprays are applied with hand can and backpack sprayers. Hand cans are well suited for small jobs, where all areas to be treated are easily accessible. Backpack sprayers are necessary where pesticides must be dispersed over large areas.

6-5. Traps

a. Light traps are available to augment exclusion and sanitation inside buildings. These traps are effective at removing small numbers of flies that enter well-screened buildings and should be used on deployments of extended duration in permanent and semi-permanent facilities. They work by attracting flies to an ultra-violet light, requiring 120V electricity. These wall- and ceiling-mounted units are designed to blend with restaurant decor. They are not disposable and should not be used where screening is inadequate, as they are likely to attract far more flies than they kill. Outdoor insect electrocution devices are not authorized for use on U.S. military installations.

b. Physical traps are available for purchase or can be constructed from local materials at deployment sites. These basically consist of a cone and chamber into which flies are attracted by bait and from which they cannot easily escape. These traps are inexpensive, dependable, easy to transport and use, and are effective as a supplementary means of fly control, or as the primary if no other means is available under field conditions. See Appendix C for details.

6-6. Physical Control

Fly swatters are always good for supplemental fly control, and are morale boosters for troops who are being pestered or sickened by large numbers of flies. They are a "force multiplier" for preventive medicine troops responsible for pest control. If fly swatters are not available, field expedient swatters can be constructed out of coat hangers and tape. Encourage creativity on the part of troops in custom-designing their own devices. Swatters may range from lightweight "stealth" to heavyweight "anvil" models, depending on the materials available. Design, construction, testing, and redesign offer hours of entertainment for bored troops, and can bring about a detectable decrease in fly populations.

6-7. Aerial Spray

a. Aerial spray is necessary when large areas, up to several hundred thousand acres, must be treated in a short period of time. Aerial pesticide application for fly control almost always uses space sprays or ULV application. Because of problems with re-infestation from unsprayed areas, large-scale application is often the only feasible method of immediate control.

Specially trained personnel must authorize and manage aerial spray operations. Treatment of large areas in short periods of time increases the potential for large-scale accidents, which may endanger human and environmental health. Moreover, extensive documentation of environmental compliance is necessary for approval of all such missions, except in public health emergencies. During large-scale disease outbreaks, medical entomologists must be consulted. The Air Force’s Modular Aerial Spray System is the largest aerial spray platform. It is mounted in a C-130 aircraft and can dispense up to 2,000 gallons (7,500 liters). The Army and the Navy both maintain helicopter-mounted spray systems, capable of treating tens of thousands of acres.

APPENDIX A - Taxonomic Keys

Key to Adults of the Non-biting Muscoid Fly Genera

1. Small, usually dark flies; hind tibiae with distinct, curved, shining black, apical or sub-apical spur; third antennal segment globular; arista bare .... *Hippelates*

   Medium-sized or large flies 2

2. Gray, yellowish, or dull-colored flies 3

   Blue, metallic green, or blue-green flies 5

3. Bend of fourth vein absent, reaching wing margin far below third vein; arista bare; anal vein characteristically strongly curved forward as if to intersect the sixth vein ....*Fannia*

   Bend of fourth vein acute, joining margin of the wing close to the third vein; arista with hairs ... 4

4. Frequently large, gray or yellowish colored flies; abdomen with a "checkerboard" appearance; thorax marked with three dark, longitudinal stripes .... *Sarcophaga*

   Medium-sized grayish-black flies; abdomen without "checkerboard" appearance; thorax marked with two or four dark longitudinal stripes ....*Musca*

5. Face yellow with soft yellow pile 6

   Face without yellow pile 7

6. Thorax marked with three longitudinal stripes; lower squama without long hairs above; genus of Western Hemisphere...*Cochliomyia*

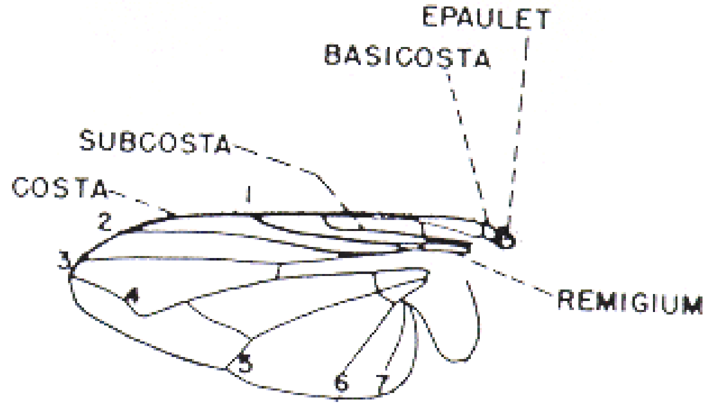
   Thorax without distinct longitudinal stripes; lower squama with long hairs above; confined to Africa and islands of the Pacific, including the Philippines, Australia, and certain sections of Asia .... C*hrysomya*

7. Base of first vein with a row of long, distinct hairs on its upper surface; anterior spiracle with bright orange hairs; dark, metallic blue-black in color. .... *Phormia*

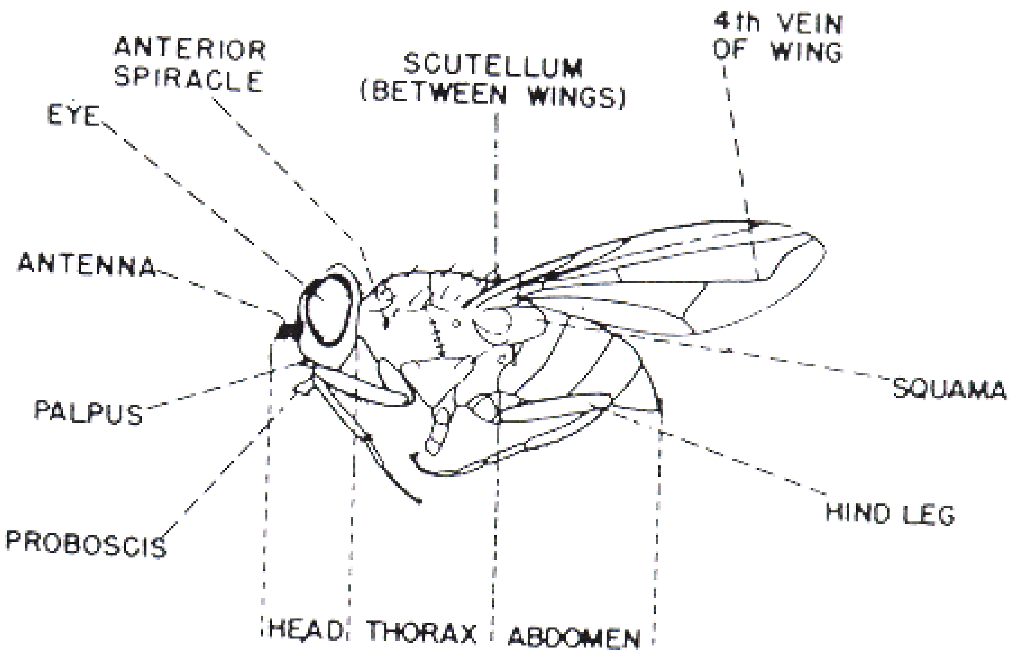
   Base of the first vein lacking, or with poorly developed, hairs on its upper surface; anterior spiracle with dark hairs; blue or green in color.. 8

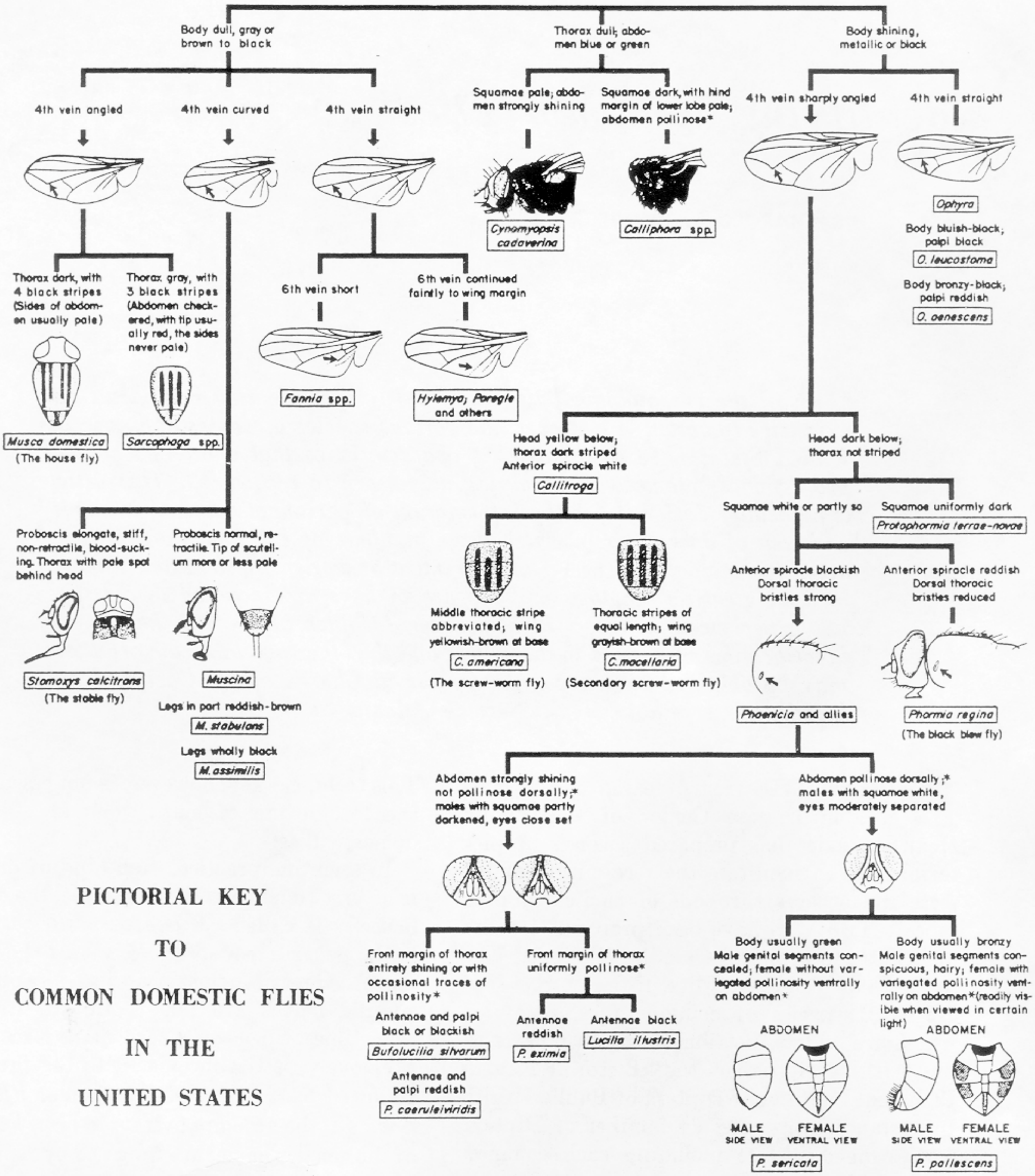
8. Usually large flies with a whitish sheen over abdomen; lower squama with long hair above; bluebottle flies ....*Calliphora*

   Usually flies of moderate size; lower squama without long hair above; greenbottle flies. .... *Phaenicia* and *Lucilia*



No'S 1-7 ARE THE "LONGITUDINAL WING VEINS" USUALLY REFERRED TO AS "VEINS"

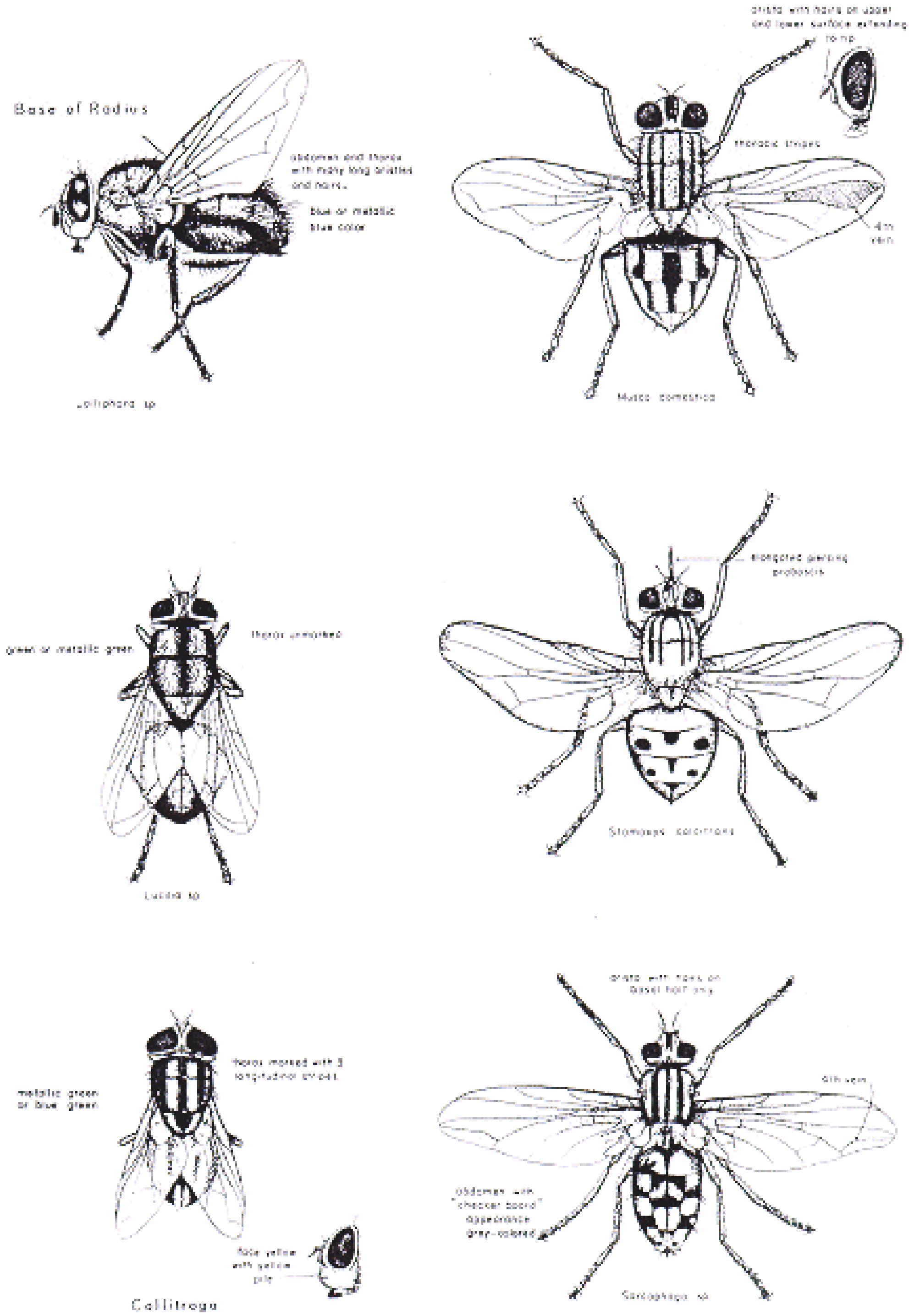




PICTORIAL KEY TO COMMON DOMESTIC FLIES IN THE UNITED STATES

*"Pollinose" refers to a whitish dusting of a surface caused by microscopic hairs.

MUSCOID FLIES



Key to the Important Myiasis-Producing Larvae

1. Body with spinous or fleshy processes laterally and dorsally or terminally................................ *Fannia*

Body smooth or with short spines, but never with long fleshy lateral processes...................................2

2. Body with a long slender tail or caudal process capable of a certain amount of extension and retraction .... *Eristalis*

Body sometimes narrowed posteriorly, but never with a long flexible caudal process capable of a certain amount of extension and retraction...3

3. Larvae more or less grub-like; most species slightly flattened dorsoventrally.....................................4

Larvae maggot-like, or typical "muscoid" shape, tapering anteriorly, broadly truncate at the posterior end; cross-section more or less circular at all points 5

4. Posterior spiracular plate with three distinct slits ....*Dermatobia*

Posterior spiracular plate with many fine openings... *Hypoderma*

5. Posterior spiracles within a well-chitinized and complete ring encircling the button area; spiracles never in a distinct depression 6

Posterior spiracles with the button very slightly chitinized or absent; chitinized ring incomplete; spiracles in a distinct depression or flush with surface...8

6. Button area with spiracular slits nearly straight...7

Bottom area with spiracular slits sinuous, with at least a double curve..9

7. Principal transverse subdivisions of spiracular slits well marked, usually not more than six in number; both ring and button heavily chitinized, the ring thickened into points at two places between the slits .... *Calliphora*

Transverse subdivisions of spiracular slits less distinctly marked, from 6 to 20 in number, ring and button less heavily chitinized, the ring thickened into point at only one place between the slits...*Phaenicia*

8. Posterior spiracles in a more or less distinct pit or depression, vestigial button usually present; integument rather smooth ....*Sarcophaga*

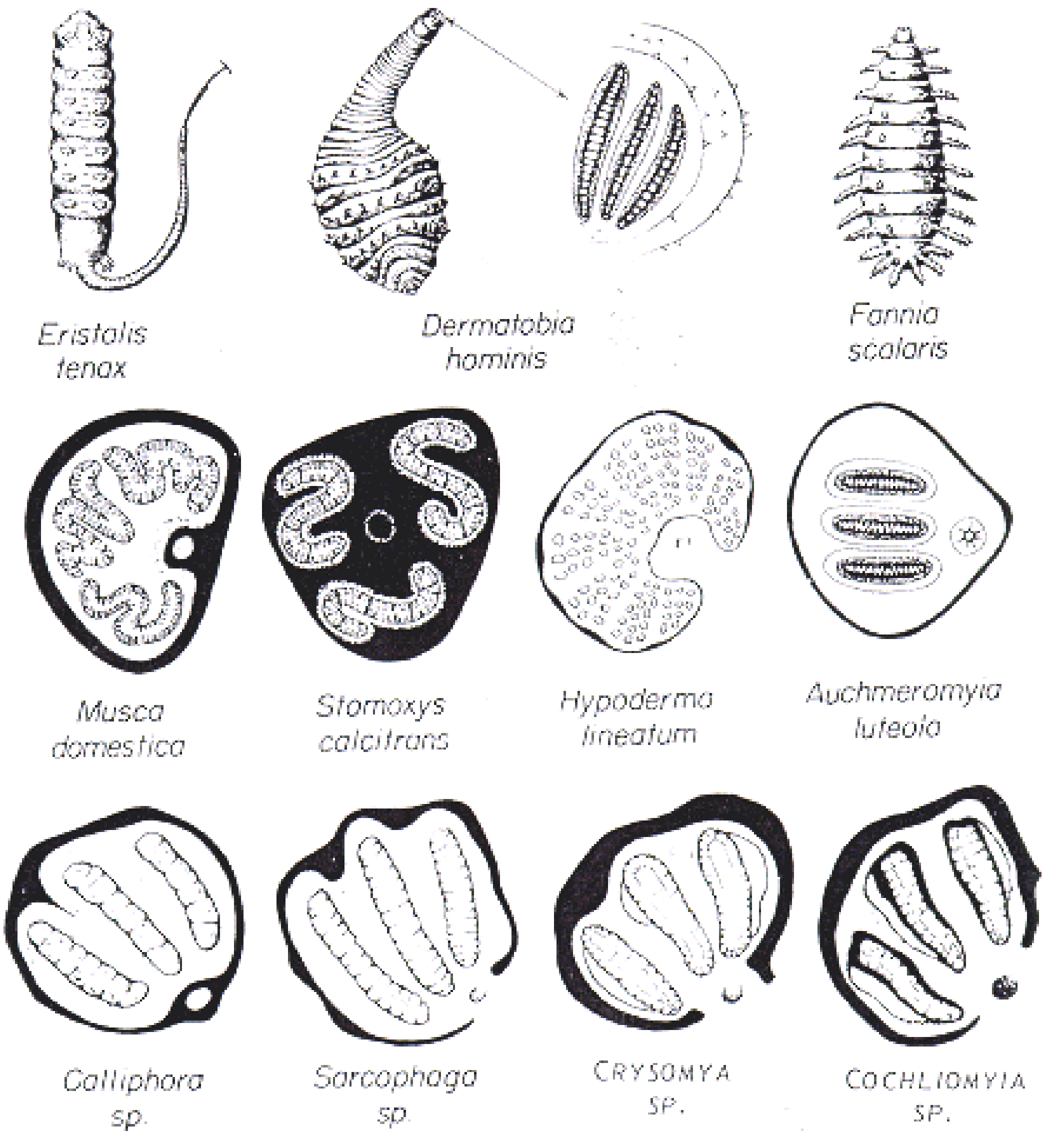
Posterior spiracles flush with surface; integument rather spiny (Western Hemisphere) ....*Cochliomyia*

9. Posterior spiracular plates D-shaped, each slit thrown into several loops .... *Musca*

Posterior spiracular plates triangular, with rounded corners; spiracular slits S-shaped; button indistinct, centrally placed..*Stomoxys*

BODY STRUCTURE AND STIGMAL PLATES OF SOME MYIASIS-PRODUCING FLY LARVAE

Above from R. Hegner, et al, © 1938 by D. Appleton-Century Co., Inc., New York. Used by permission.



APPENDIX B - Field Sanitation Device Specifications

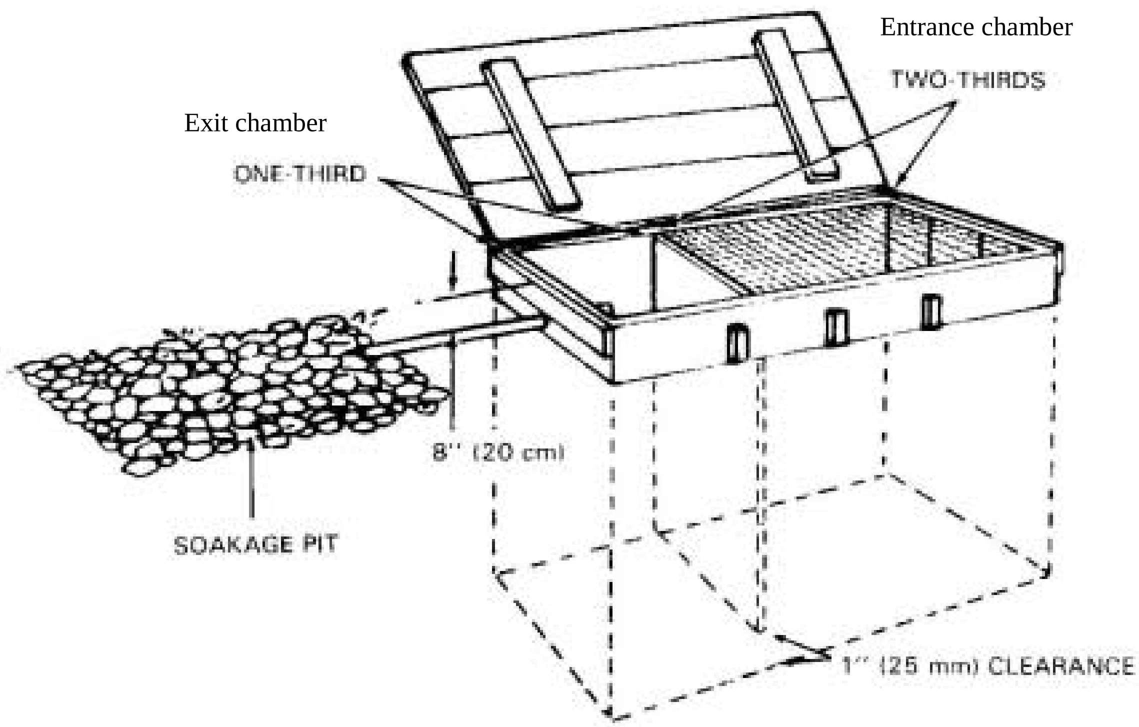


Figure B-1: BAFFLE GREASE TRAP

A baffle may be used in a watertight box, drum or barrel in the construction of a grease trap. Salvage boxes or barrels may be reinforced or treated to serve the purpose. The baffle separates the larger (2/3) entrance chamber from the smaller (1/3) exit chamber and extends to within 2.5 cm of the bottom of the box. Water is poured into the entrance chamber and the grease remains on the surface of that chamber. The pressure of the fluid forces the grease-free water under the baffle board and out of the exit pipe into the soakage pit. The exit pipe should be located about 20 cm from the upper edge of the exit chamber. Adding multiple baffles can increase the efficiency of the trap.

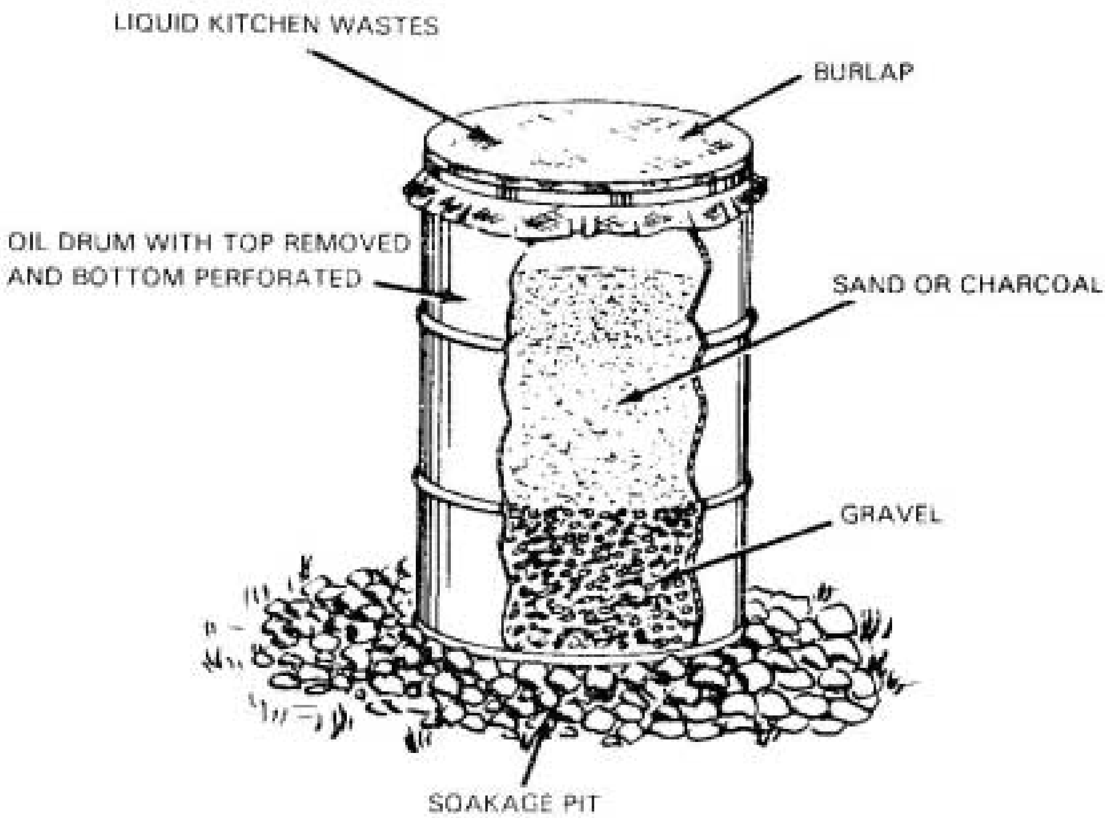


Figure B-2: **FILTER GREASE TRAP**

This grease trap may be used in place of the baffle trap though it is not as efficient in removing grease. Fill the lower 1/3 of the barrel with crushed rock or coarse gravel. Fill the middle 1/3 with coarse sand, finer gravel or charcoal. Finally, add a 15 cm layer of filtering material such as fine sand, ashes, charcoal or straw. This filter layer will need to be removed and buried frequently (once or twice a week) and replaced with fresh filter material. The burlap (or other fabric) filtering cover should be removed daily, buried or burned, and replaced with a clean fabric filter.

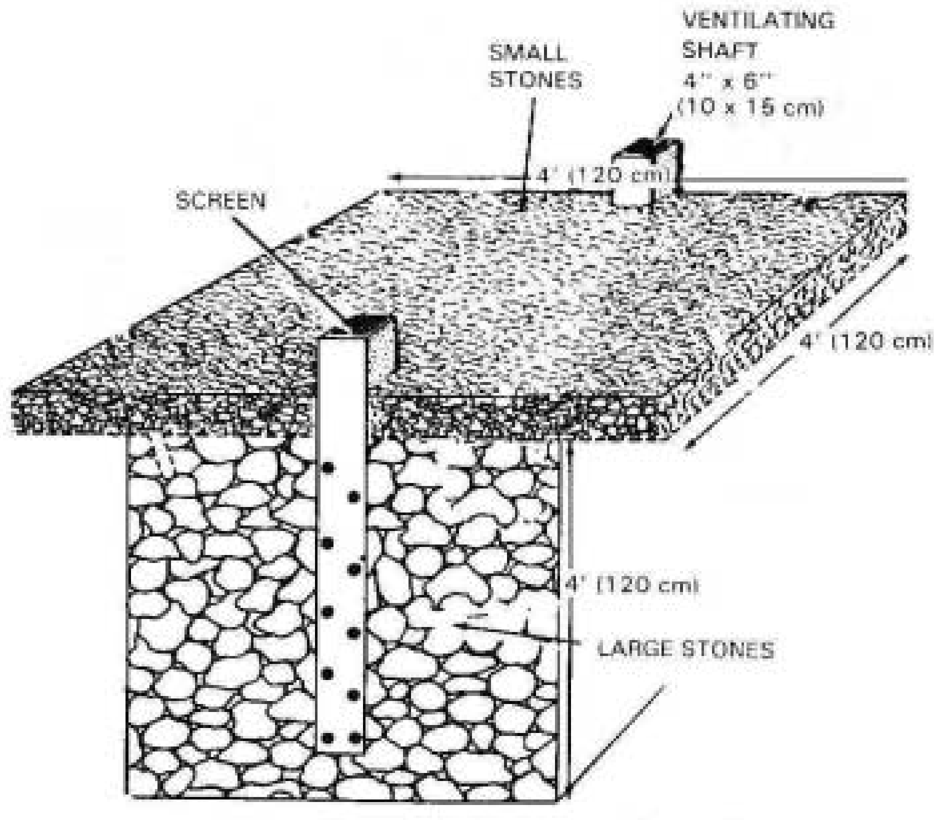


Figure B-3: SOAKAGE PIT

The soakage pit is used to dispose of all types of liquid wastes where the soil is capable of absorbing moisture. The pit is dug 0.5 m^2 and 1.5 m deep. The hole is filled with any of the following materials: rocks, flattened tin cans, rubble, bricks, broken bottles, or other suitable contact material. The liquid waste is held in void spaces until it seeps into the ground. A layer of small gravel or crushed stones may be placed on the surface of the stone filling the pit.

Ventilating shafts made of scrap materials 10 to 15 cm square may be used but are not essential to satisfactory operation of the soakage pit. When shafts are used to introduce air into the pit, they extend 15 to 30 cm above the surface and to within 15 cm of the bottom of the pit. Numerous holes are punched in the sides of the underground sections. The tops of these shafts are covered with screen, straw or grass.

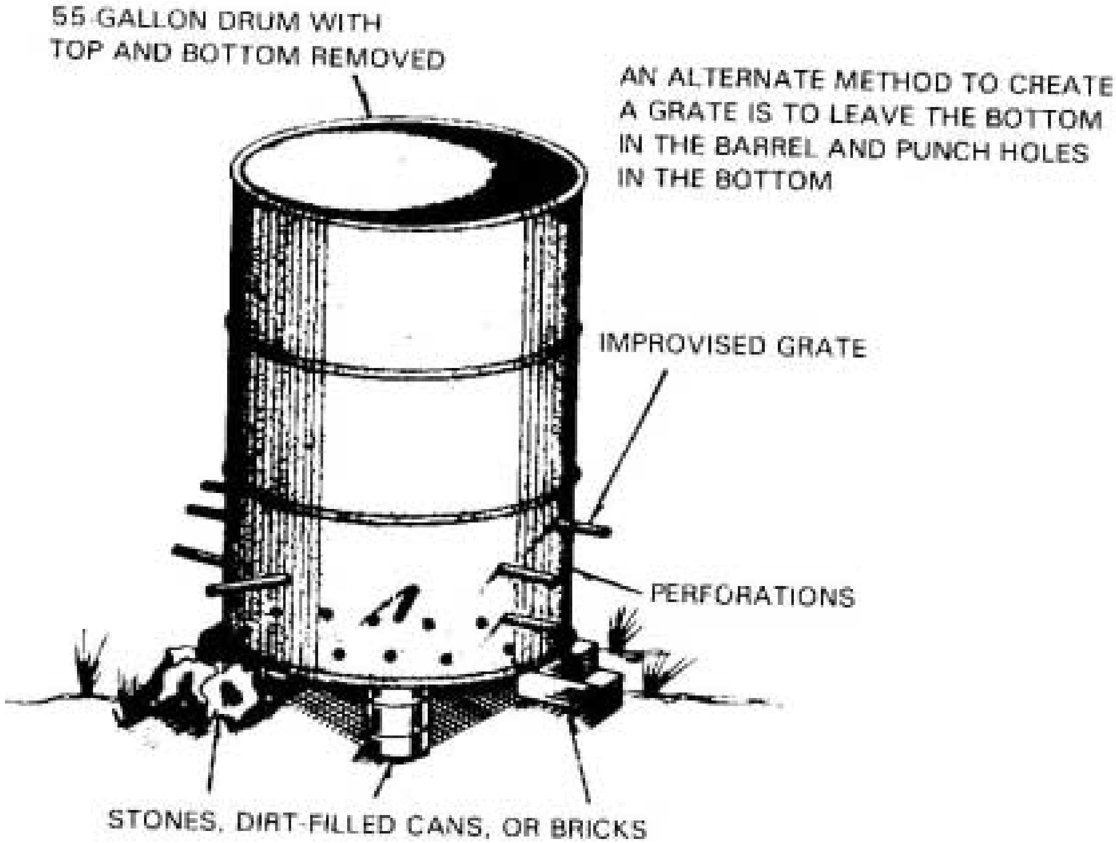


Figure B-4: BARREL INCINERATOR

This incinerator is easily improvised and will effectively consume small amounts of garbage and combustible refuse. A grate is made of scrap pipe inserted in the holes, as shown. An alternative method is to create a grate by simply punching holes in the bottom of the barrel. Instead of trenches to supply draft, the barrel could be elevated on supports of bricks or stones.

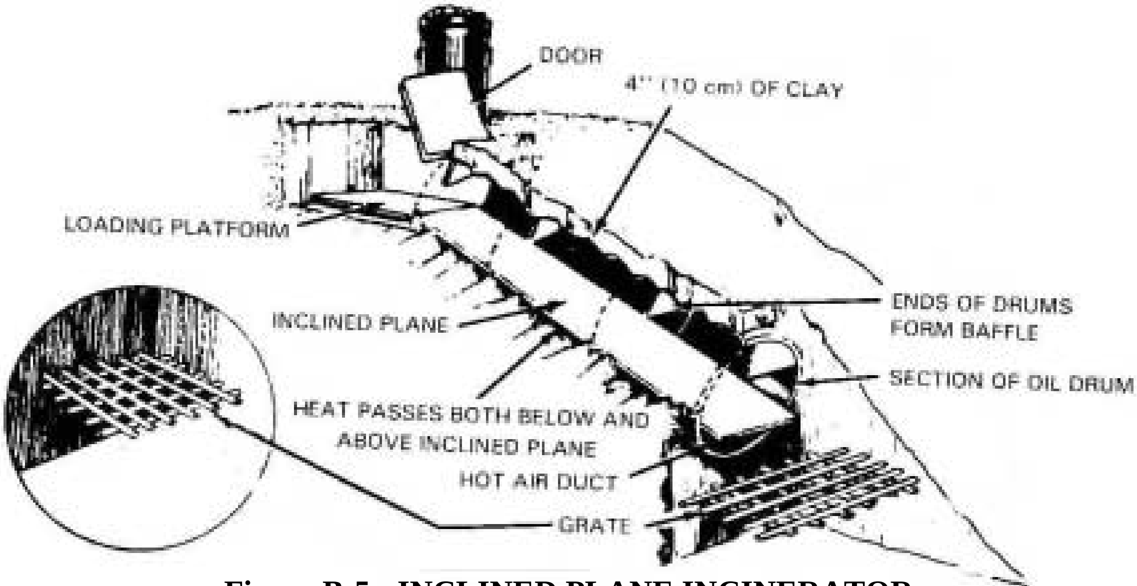


Figure B-5: INCLINED PLANE INCINERATOR

This incinerator can be very useful in temporary camps. Garbage is placed on the loading platform and fed continuously down the inclined plane toward the grate. This device is particularly useful for burning wet garbage in places where it cannot be buried.

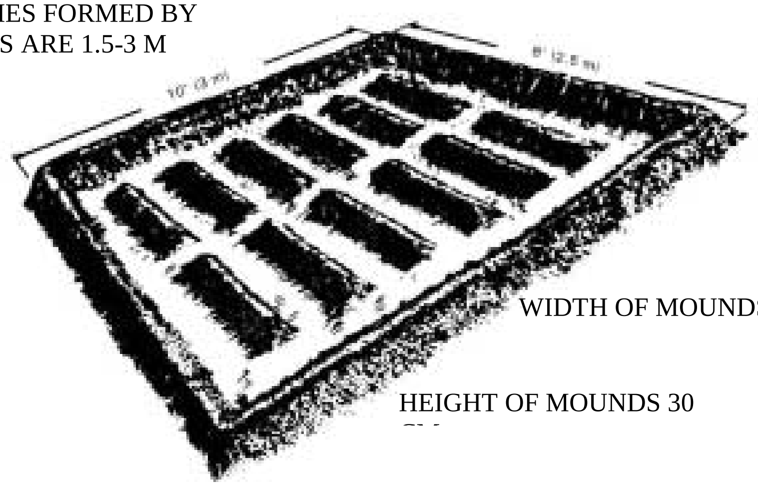


Figure B-6: EVAPORATION BED

This sanitary device is used to dispose of liquid kitchen waste in locations where soakage pits and grease traps are impractical. Evaporation beds are recommended for short stays in a hot, dry climate where soakage pits cannot be dug or where the soil is too hard (frozen or rocky) to absorb moisture.

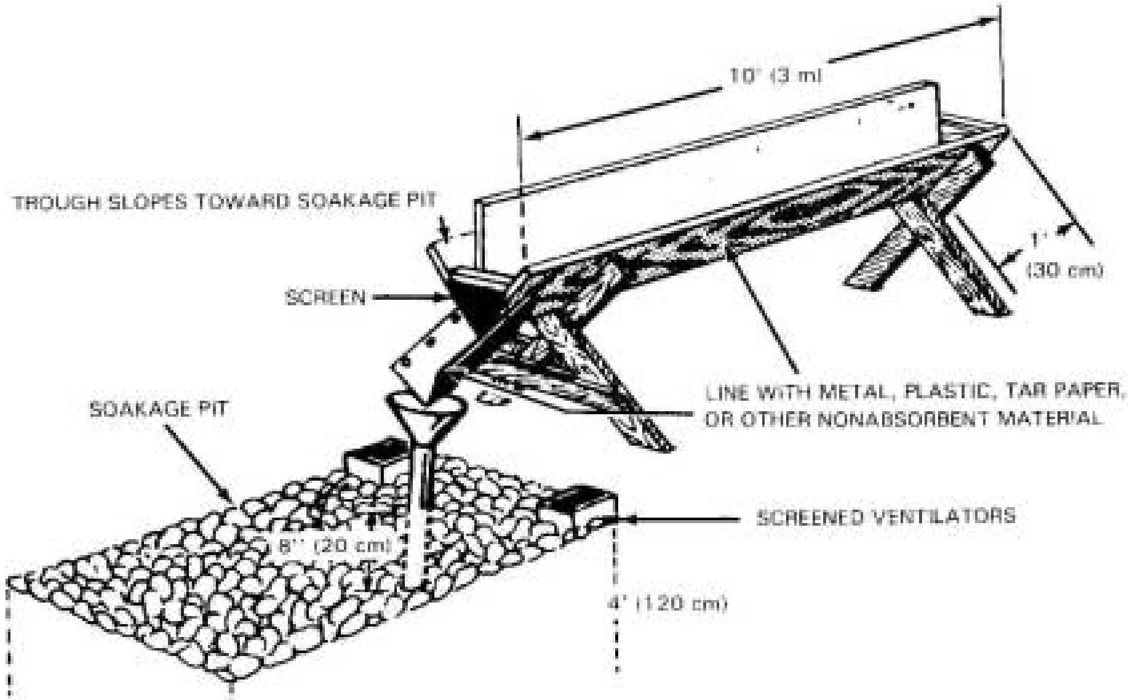


Figure B-7: TROUGH URINAL

This figure illustrates a trough urinal with splashboard and soakage pit. This urinal is made of wood and tarpaper, but equally effective troughs may be made of tin, galvanized iron, or any other suitable material.

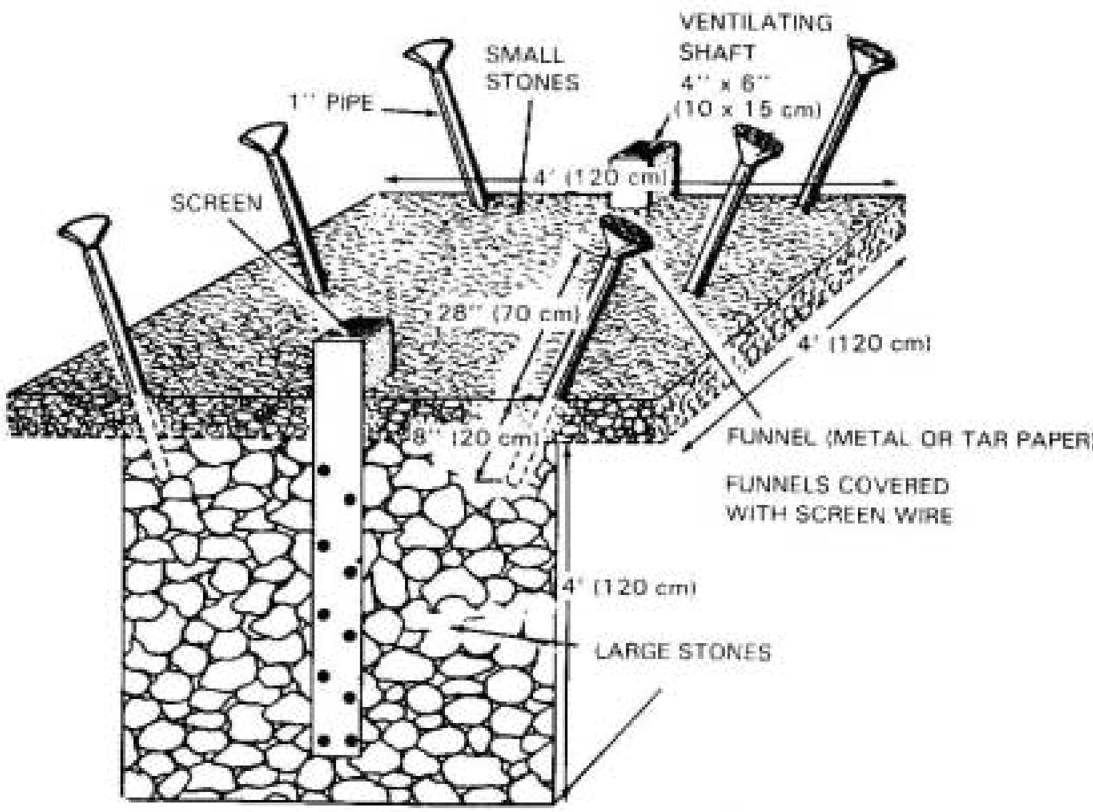


Figure B-8: URINE SOAKAGE PIT

This figure shows salvaged pipe and improvised funnels and depicts a soakage pit in cross section showing construction. The pit is filled with rocks, flattened cans, broken bottles, bricks and other material. The walls of the ventilation shafts that extend below ground level are perforated with 2.5 cm holes.

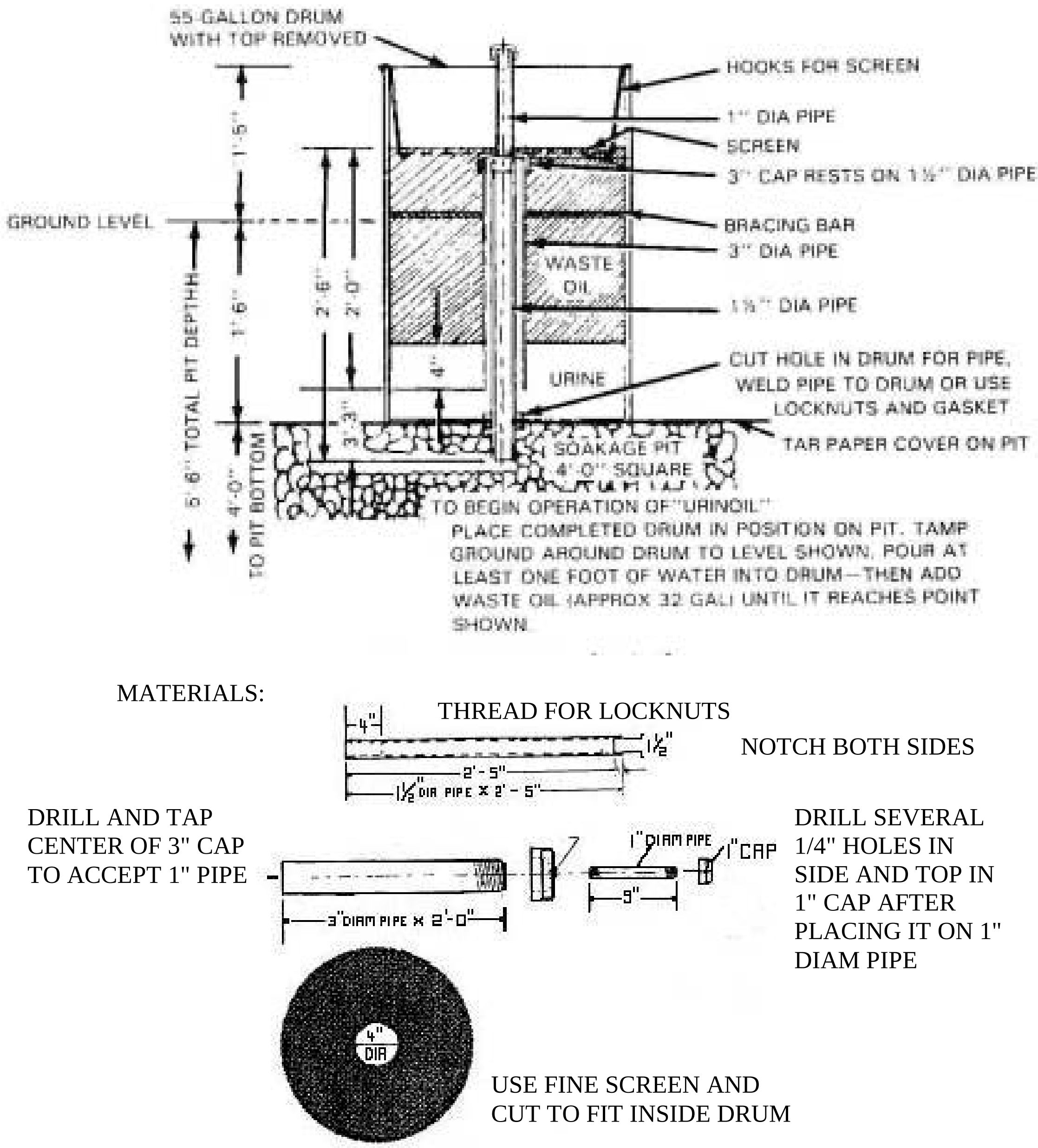


Figure B-9: URINOIL URINAL

This urinal may be improvised from a 55 gallon drum, as shown in the drawing. It should be placed on a soakage pit when possible, or installed with a French drain.

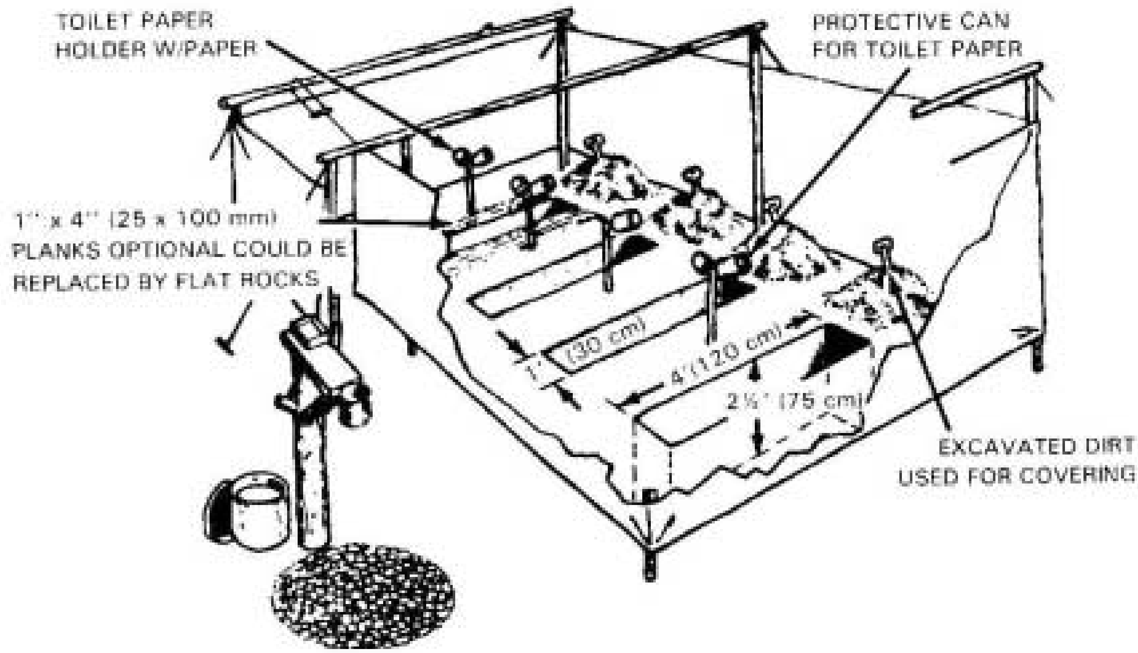


Figure B-10: STRADDLE TRENCH

Trenches are built 0.3 m wide, 1 m deep and 1.5 m long. Boards may be placed along both sides of the trench to provide footing.

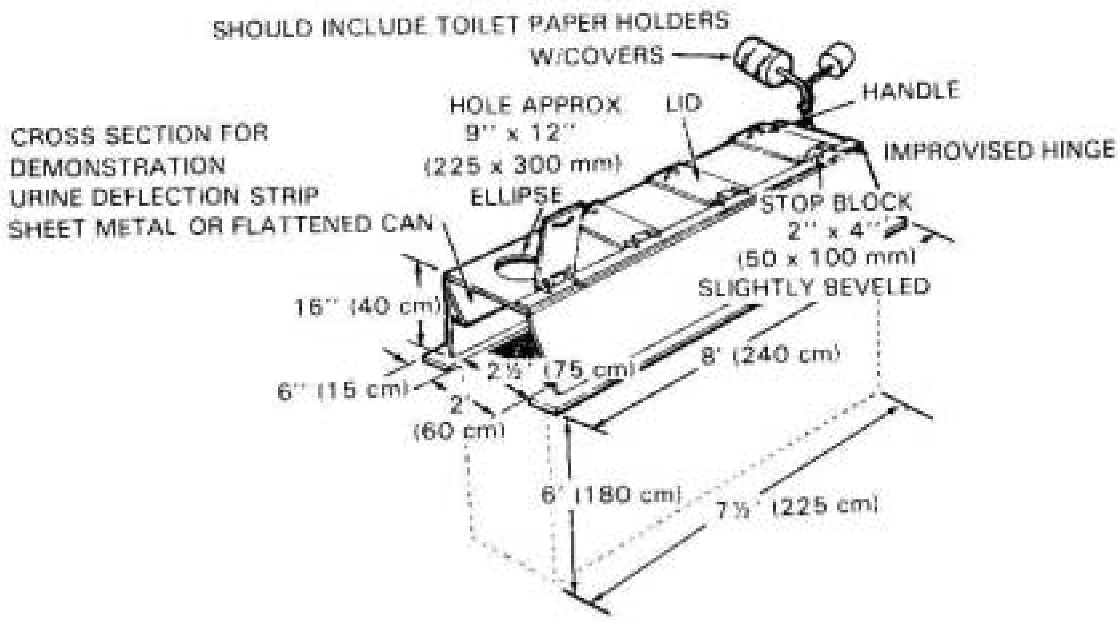
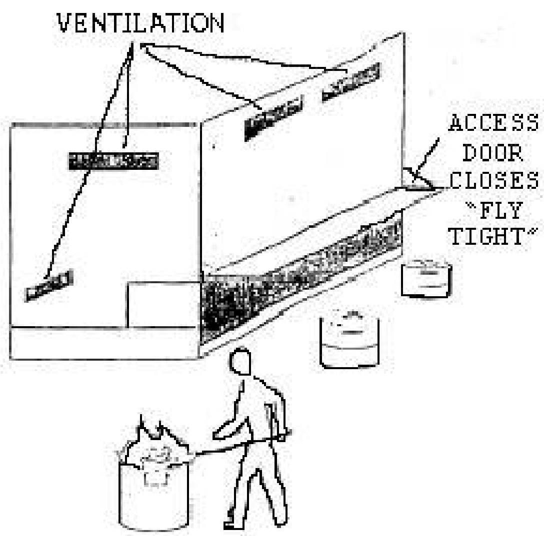
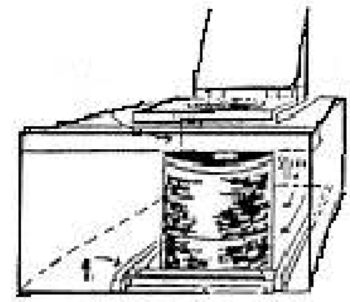


Figure B-11: DEEP PIT LATRINE

Dig a pit 2.5 m long and 0.6 m wide that conforms to the standard size latrine box, which is 2.5 m long and 0.75 m wide. The depth of the pit will depend on the length of stay. The illustration shows stop blocks to ensure self-closing lids, a metal urine deflector strip, and a method of keeping the toilet paper dry, such as tin can covers. Provide a separate urinal at each deep pit latrine.





1. FORWARD EDGE OF HOLE SHOULD BE WELL BACK FROM THE EDGE OF BENCH (6-15 CM).

2. TOP OF BARREL SHOULD BE NO MORE THAN 5 CM FROM UNDERSIDE OF SEAT (MORE THAN 5 CM WILL RESULT IN SPLASHING AND SPILLAGE INTO COMPARTMENT).

3. THE BARREL SHOULD BE PUSHED ALL THE WAY BACK AGAINST THE BACKSTOP, WHICH HELPS TO CENTER THE CAN UNDER HOLE.

4. RUNNERS HELP TO CENTER BARREL UNDER HOLE.

Figure B-12: BURN BARREL LATRINE

APPENDIX C - Fly Trap Specifications and Surveillance Forms

C-1: BAITED FLY TRAPS

Baited fly traps have been designed by preventive medicine personnel to help control fly populations in and around base camps and troop living areas in Saudi Arabia. The trap works by attracting flies to bait, which is placed in a tin in relative darkness. Flies that have entered the darkened tin feed and lay eggs on the bait and then are attracted to the light above. The flies follow the path of the wire gauze cone through a small opening at the top of the cone into a large cage trap where they die from starvation and exhaustion within a 24-hour period.

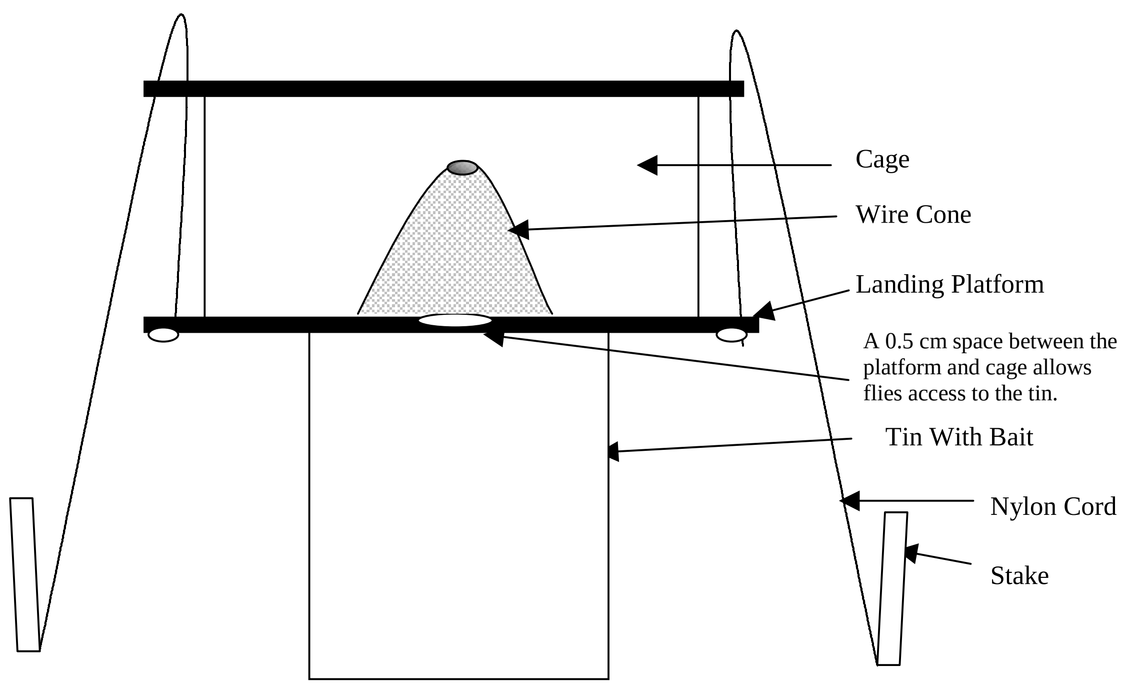


Figure C-1: Baited Fly Trap

OPERATION AND MAINTENANCE: The bait should be bulky and moist and fill the tin half-way. The bait is selected from the contents of a kitchen swill bin, with scraps chosen from items such as meat or fish. Raw chicken parts in water have been found to attract many flies. Attraction to chicken intestines, due to the fermentation of food in the intestines and the microorganisms they contain, is quite strong. Other baits include 1 kg of brown sugar in a gallon of water, fruit such as dates, grapes and bananas, or a combination of foodstuffs. The bait should be changed at regular weekly intervals. The old bait should not be buried but instead burned along with dead flies.

The trap is emptied when fly corpses reach the height of two thirds of the cone. Living flies may be killed by pouring boiling water over the trap or by using a reserve trap cage and waiting 24 hours for flies to die.

Fly traps should be positioned outdoors and given the maximum exposure to sunlight. Traps should not be sited closer than 300 meters from each other. Secure traps by running nylon cord through holes in the top and bottom platforms and then fastening the cords to a stake in the ground. Stabilize the bottom tin by shoveling sand or gravel along its basal perimeter. Traps will attract large numbers of flies and should therefore be positioned away from mess halls and living areas.

The platform will become fouled with fly vomit and excreta and should be cleaned at least once a month with soap and water. The wire gauze will become fouled as well and should be cleaned with an old toothbrush. The bait tin may be used repeatedly, provided it is cleaned out thoroughly each time. Remember that success of the fly trap depends on maintaining a high standard of sanitation in and around base camps.

C-2: FIELD-EXPEDIENT BOTTLE TRAPS

Fly traps can be fashioned from disposable plastic water bottles. The simplest of these is constructed by cutting off the top and inverting it to form a cone leading into the body of the bottle, where a bait is placed. Flies attracted to the bait are trapped inside the bottle and disposed of when the bottle becomes too full to be effective (see Figure C-2.a). Baits may consist of spoiling fruit or meat, food residue, and similar fragrant items. Once flies are attracted into the bottle, their natural pheromones increase attractiveness of the trap to other flies. These traps can be hung (no higher than 2.5-3 m) or placed on the ground out of traffic areas.

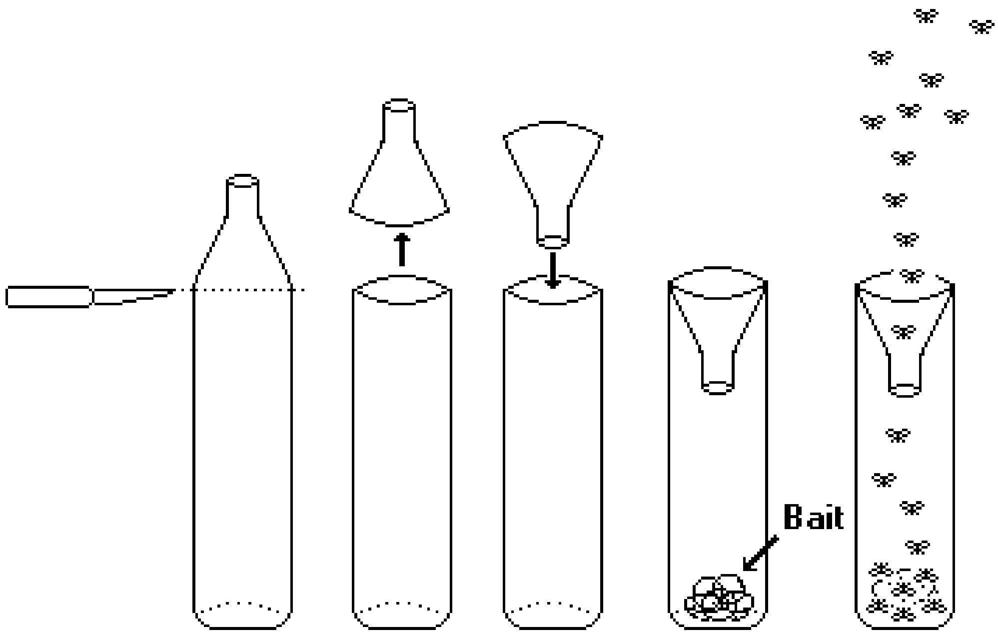


Figure C-2.a. Plastic water bottle fly trap (inverted cone model)

Under adverse environmental conditions, such as constant high wind, rain, or dust storms that prevent fly baits from being fully effective, it may become necessary to employ alternatives for dispensing baits. One such is to add poison bait to the trap illustrated above, or fashion a trap that is filled to a depth of 5 cm with poison fly bait and in which four 6 mm holes are cut near the top of the bottle to allow the flies access (see Figure C-2.b).

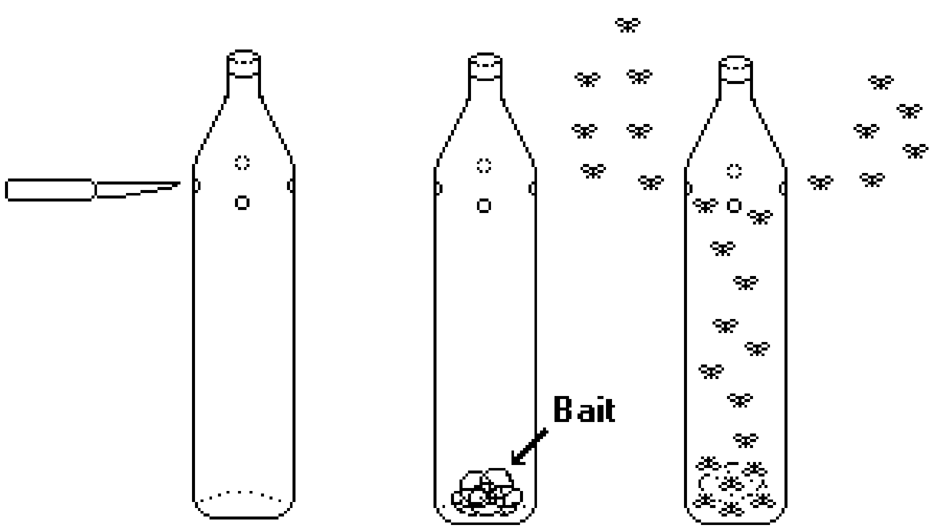


Figure C-2.b. Plastic water bottle fly trap (multi-hole model)

The trap should be hung between 1 and 3 m above the ground. These traps work well indoors. The contents must be shaken periodically so that dead flies do not accumulate on the surface of the bait, inhibiting contact between newly attracted flies and the poison. Another technique is to place the bait in a box to keep it from blowing away or becoming soaked or dust-coated. Simply put a granular fly bait in a flat box constructed from scrap wood, clearly labeled with the appropriate warning, and place the box on the ground where flies can access it. Such boxes should be checked periodically to dump dead flies and recharge them with bait. Dead flies should be disposed of with waste material, ideally with medical waste when possible. An added advantage to this method is that it prevents troops from collecting and misusing the bait. These bait stations work well when placed near latrines, showers, and waste disposal sites (burn locations, dump sites, etc.). Do not place them near dining facilities, even though flies attracted to the bait seldom leave it before dying.

C-3: THE SCUDDER FLY GRILL

The Scudder fly grill is used outdoors and is the most versatile of the counting techniques. The grill consists of 16-24 wooden slats, fastened at equal intervals to cover areas of from 0.8 m^2 (big grill) down to 0.2 m^2 (small grill) (see Figure C-3). The big grill is for outdoor use; it is impractical for indoor use. For general use, a small or medium-sized grill is recommended. Place the grill over natural fly concentrations and count the number of flies landing on the grill for a given period of time (usually 30 seconds or l minute). In each locality, counts are made on 3 to 5 or more of the highest fly concentrations found and the results averaged.

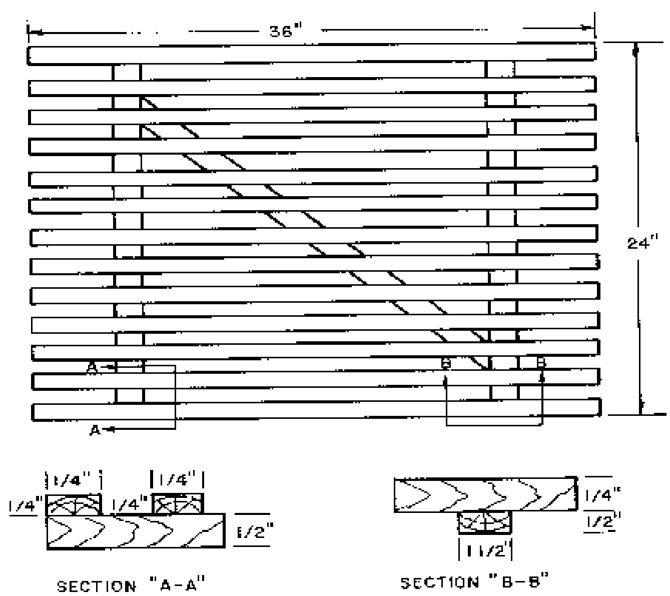


Figure C-3: Scudder Grill

C-4: FLY BAIT TECHNIQUE

Fly densities indoors can be determined using this technique. Place a square card 30 cm on a side that has been painted with a mixture of molasses and vinegar (1:2) near a location frequented by flies. Record the number of flies attracted to the card over a specified time (for example, 5 minutes). Other baits, such as syrup, molasses or milk, may be used, but in order for fly counts to be meaningful, uniformity of bait and technique is necessary.

C-5: TRAPPING

Sticky tapes or strips can be used for assessing fly densities, particularly indoors. These devices should be exposed to flies for a period of 2 hours to 2 days (1 day is recommended). Place them near doorways or trash receptacles, but not over food preparation or serving areas. In order for the data to be meaningful, the length of time and time of day must be uniform from observation to observation.

SAMPLE	**FILTH FLY SURVEY FORM**	**SAMPLE**

1. Building 5454	2. Organization 1st Bn / 1st Inf	
3. Date 6 July 2000	4. Time 0900	5. Person Contacted SGT Cook

6. Food Handling Facility		7. Quarters		
a. Meals/ Day	b. Days Open/Week	a. Single	b. Multiple Unit	C. Other
600	7			

8. Sanitary Conditions *(check one)*				9. Exclusion *(check one)*				10. Air Curtains Present (*circle one*)	
a. Very Good	b. Good	c. Fair	d. Poor	a. Very Good	b. Good	c. Fair	d. Poor	Yes	No
	X					X			X

11. Operational/Effective		12. Windows Screened		13. Fans Screened		14. Doors Screened	
Yes	No	Yes	No	Yes	No	Yes	No
		X			X	X	

15. Other

Doors propped open

16. Refuse Disposal {*Yes (Y) or No (N)*}				17. Sampling Method (*check one*)			
a. Container		b. Lids/Doors		a. Grill	b. Sticky Trap	c. Live Trap	d. Sweep Net
(1) Clean	(2) Rodent-Proof	(1) Closed	(2) In Good Repair	X			
N	Y	N	Y				

18. SURVEY DATA	
a. Location	b. Number of Flies Counted / Trapped / Caught
Next to dumpster	# per min. 4 / 15 / 3
Garbage can washing area	# per min. 10 / 15 / 13

Specimens Sent for Identification to:

19. Date	20. Species

21. Comments:

SAMPLE **SAMPLE**

Figure C-4.a: Sample Filth Fly Survey Form

FILTH FLY SURVEY FORM

1. Building	2. Organization	
3. Date	4. Time	5. Person Contacted

6. Food Handling Facility		7. Quarters		
a. Meals/ Day	b. Days Open/Week	a. Single	b. Multiple Unit	c. Other

8. Sanitary Conditions *(check one)*				9. Exclusion *(check one)*				10. Air Curtains Present (*circle one*)	
a. Very Good	b. Good	c. Fair	d. Poor	a. Very Good	b. Good	c. Fair	d. Poor	Yes	No

11. Operational/Effective		12. Windows Screened		13. Fans Screened		14. Doors Screened	
Yes	No	Yes	No	Yes	No	Yes	No

15. Other

16. Refuse Disposal {*Yes (Y) or No (N)*}				17. Sampling Method (*check one*)			
a. Container		b. Lids/Doors		a. Grill	b. Sticky Trap	c. Live Trap	d. Sweep Net
(1) Clean	(2) Rodent-Proof	(1) Closed	(2) In Good Repair				

18. SURVEY DATA	
a. Location	b. Number of Flies Counted / Trapped / Caught

Specimens Sent for Identification to:	
19. Date	20. Species
21. Comments:	

Figure C-4.b: Blank Filth Fly Survey Form

APPENDIX D - WHO Filth Fly Resistance Testing

There are several methods for assessing pesticide resistance in filth fly populations. Each method has its merits and shortcomings. In general, resistance testing is time consuming, labor intensive and best conducted in a laboratory environment. In order to obtain accurate test results, uniform fly populations (same sex, similar age distribution, reared on standard diet) and controlled environmental conditions (temperature and humidity) must be maintained during the test. It is hoped that a more field-expedient "screening method" will eventually be developed.

The standard method for detecting pesticide resistance in adult filth flies is the micro-applicator method published by the World Health Organization (WHO, 1981). In this method, batches of adult flies are treated topically with different concentrations of insecticides and the mortality at each level is determined. This test is conducted periodically, with two to five replicates each time. Resistance is determined by comparing the results to established baselines.

The micro-applicator test is conducted by anesthetizing adult flies by chilling them on ice or exposing them to CO_2 or ether vapors. Use a micro-capillary tube to apply a set quantity of pesticide to the dorsal surface of the thorax of each fly. Treated flies are then placed in a clean, well-ventilated holding cage. Results are obtained by counting mortality after 24 hours.

Other methods of determining resistance include the Sheppard and Hinkle (1986) test for pesticide resistance in horn flies, which involves anesthetizing flies with CO_2 and exposing them to various pesticide residues on the surfaces of glass petri dishes. This technique was compared to the topical application of pesticides by Hinkle et al. (1985) and resulted in similar findings. Sheppard and Hinkle (1987) later modified this technique with the use of pesticide-treated filter paper and disposable plastic petri dishes. Although not recommended by the WHO, this test appears to be more useful under field conditions.

APPENDIX E - References

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