Chapter 42

FILTH FLIES AND MYIASIS-PRODUCING FLIES

Introduction. With few exceptions all of these species of flies have mouth parts which are not adapted for piercing and sucking blood. Although the adults have sucking mouth parts rather than a mandibulate chewing type, they are not able to pierce the skin and depend on lapping up dissolved substances or finely particulate organic debris for their food. Nevertheless, most of these flies are eager for blood (*i.e.*, hematophagous) when the opportunity is afforded, either in open wounds or at sites where blood-sucking flies have been feeding. Evans (1956) demonstrated experimentally that both the larval and adult blow fly, *Calliphora erythrocephala*, possess carbohydrases that hydrolyze several types of sugars. The filth-feeding habits of the adults, and particularly of the larvae of these species, bring them in contact with many types of bacteria and other pathogenic microorganisms, while some species in their larval stages invade human tissue, producing *myiasis*. A few of the more common and more important types will be considered and others will be referred to in diagrams or figures. The general characteristics of mature larvae (*i.e.*, so-called "maggots") are represented in Figure 42–1 and patterns of the posterior spiracles, which are particularly valuable in identifying the larva, are shown in Figure 42–2.

A number of the adults are illustrated in Figure 42–3.

THE HOUSE FLY, MUSCA DOMESTICA (Family MUSCIDAE)

Adult. The house fly, which has a cosmopolitan distribution, is a medium-sized fly (males 5.8 to 6.5 mm., females 6.5 to 7.5 mm. in length), of a general dusky-gray color (Fig. 42–3,*10*). The head is transversely compress-ovate, the frons straw-colored mixed with dark brown, the antennae brown and the maxillary palps black. The squarish-ovoidal thorax is patterned dorsally with 4 equally broad, dark, longitudinal stripes. The pyriform abdomen is generally yellowish, with a dorsal longitudinal, dark-brown stripe, while the terminal segment is dark brown. The legs are dark brown. The wings (Fig. 42–4) are transparent and nearly straw-colored at their base. The fourth longitudinal vein of the wing bends abruptly upwards, nearly meeting the third longitudinal vein. The squamae (*i.e.*, axillary basal lobes) are large and opaquely yellowish. The wing spread is 13 to 15 mm. The antennae (see Fig. 40–2,*B*), like those of *Stomoxys calcitrans* and *Glossina* spp., are more or less club-shaped (segments *i-iii*), with a lateral arista consisting of the 3 terminal segments. Segment *iii* is oval-elongated, bears 3 sensory pits and externally near its base supports the arista. The long, spinose, terminal sixth segment has spinose branches on both its anterior and posterior margins. The mouth parts have been previously considered (this section, Chapter 40, pp. 654 to 655). The salivary glands consist of a pair of long, glistening white tubules, with short ducts joining to form the common salivary duct, which dilates into a small chamber before emptying into the base of the proboscis.

The muscular esophageal diverticulum ("crop" or food reservoir) is filled with liquid food on which the fly has just been feeding. After a full feeding the fly can

dark brown oral hooks and by tufts of numerous brown hooks with spinose tips on the anterior margin of each body segment (Fig. 42–6). The posterior spiracles (see Fig. 42–2,*16*) are found on the eighth segment directed ventroposteriad. When these larvae have reached complete development (*ca.* 30 mm. long) they pass out of the tissues, drop to the ground and pupate. Larval development requires several months.

For Medical Importance and **Control** of *Oestrus* and *Rhinoestrus*, *vide* pages 727, 728 and 731.

EYE GNATS (Families CHLOROPIDAE and OSCINIDAE)

Morphology, Biology and Life Cycle. Members of these families are minute, acalyptrate forms (*i.e.*, without axillary basal lobes to the wings); with short antennae having an almost spheroidal third segment, an arista which is completely or essentially bare, and short, dark-colored, bare wings, a glistening dark thorax and pale legs. In species of medical interest the mouth parts are considerably modified, so that "when the fly is feeding the (spinose) tips of the 6 pseudo-tracheal rings (of each of the 2 labella) act as cutting or scarifying instruments, capable of cutting minute multiple incisions in granulation tissue or the delicate conjunctival epithelium, which are likely to assist pathogenic organisms carried by the fly in gaining a foothold" (Graham-Smith, 1930). These flies have a relatively huge esophageal diverticulum and commonly regurgitate droplets of blood or serous exudates, which appear as numerous vomit drops, deposited as "fly specks" within the first 2 or 3 hours following a meal (Kumm, 1935). The flies breed in, but the adults do not feed upon, decaying vegetable matter, feces and urine. The complete life cycle requires 6 to 14 days.

Medical Importance. Species of medical importance include *Hippelates pallipes* (Chloropidae) which feeds on conjunctival exudates (Egypt); *Siphunculina funicola* (Oscinidae), which feeds on lacrimal secretions, sweat, exudates of wounds and the conjunctiva (India, Ceylon, Java); *Hippelates collusor* (syn. *pusio*), which feeds on drops of blood on the skin, open wounds, sores and mucous membranes, including the conjunctiva (California); *H. flavipes* (Mexico, Central and South America, West Indies). In addition to man, these flies feed on chronic ulcers, mucopurulent secretions, sweat and hair oils of domestic mammals, especially dogs. They are strongly phototactic.

Davis and Pittman (1950) isolated two types of *Hemophilus* which are the causal agents of acute conjunctivitis in the United States and are frequently transmitted mechanically by *Hippelates collusor* in the Southern United States. The infection may be treated effectively with streptomycin.

The life history of *H. collusor* was described by Burgess (1951) in the Coachella Valley of California, which yearly had a scourge of this pest. Mulla *et al.* (1960) recommended soil treatment of infested areas to control this species. Kumm (1935) and Kumm and Turner (1936) associated this fly (*H. flavipes*) with the spread of yaws in Jamaica.

NON-BLOOD-SUCKING FLIES AS MECHANICAL VECTORS OF DISEASE

Conditions Under Which Flies Serve as Vectors. Flies which mechanically transmit pathogens to man are domesticated species which, as adults, feed indiscriminately on human feces and human food. While microorganisms, ingested by fly larvae about to pupate, may at times be retained through the pupal stage to the emerging adults, this occurs commonly only in the spore stage of the bacteria of tetanus, anthrax, etc. Most microorganisms are carried either (1) on soiled external hairs, bristles, foot pads and external mouth parts, or (2) in the digestive canal of the fly, later to be deposited in vomit drops or fecal drops. Flies which conform to these conditions include *Musca domestica* and related species of this genus, *Fannia canicularis, F. scalaris, Muscina stabulans, Phaenicia caesar, P. sericata, Callitroga macellaria, Chrysomyia bezziana,*

Sarcophaga haemorrhoidalis, Drosophila spp., *Tubifera tenax* and *Pollenia rudis*. Furthermore, flies like *Hippelates collusor*, which feed on human serous and purulent exudates, serve as vectors of microorganisms causing cutaneous infections and those of the mucous membranes.

Diseases Mechanically Transmitted. The diseases which flies mechanically transmit mostly belong to the enteric group. Experimental and epidemiologic evidence has incriminated *Musca domestica*, the most serious offender, in the following important enteric infections: *Salmonella typhosa, S. paratyphi, S. enteritidis, Shigella dysenteriae* complex, *Vibrio comma* and *Entamoeba histolytica*. Control of house flies and other domestic flies not only has brought typhoid epidemics under control, but in other instances has prevented their outbreak. Bacillary dysentery and salmonellosis have been similarly shown to be spread by flies; the causative organisms survive in the fly's gut for at least 4 or 5 days. Cholera vibrios remain viable on the legs of flies for 30 hours; they survive in the intestine of the fly from 24 to 120 hours, and may contaminate food or water by vomit drops up to 24 hours. The incrimination of flies in amebiasis was considered in Section II (p. 148). Larvae of *Musca domestica* and *Phaenicia cuprina* will ingest *Ascaris* eggs, which survive metamorphosis through the pupal stage and are passed in fecal droppings of adult flies. Experimental studies of Pipkin (1949), on the external and internal carriage of *Entamoeba histolytica* and the eggs of nematode parasites of man, are corroborative. On the other hand, Greenberg (1959) demonstrated that pathogenic bacteria ingested by fly larvae rarely survive through the pupal stage to the adult.

Poliomyelitis. Filth flies probably play an important role in the transmission of this disease in rural and other fly-infested areas. Melnick (1949), during an epidemic of poliomyelitis in Rockford, Illinois, isolated the virus from *Phormia regina* and *Phaenicia sericata* at the peak, from *P. regina, Musca domestica* and *Sarcophaga* spp. 2 weeks later, from no flies during the subsequent 2 weeks, and from *Cynomyopsis cadaverina* during the final 2 weeks of the epidemic. Melnick and Penner (1952) isolated the virus from excreta of flies 2 to 20 days after they had ingested the virus. The blow flies (*Phormia regina* and *Phaenicia sericata*), which ingested more virus menstruum than *Musca domestica*, were positive for a longer time than the house fly.

Non-enteric Diseases. In non-enteric infections domestic flies have been associated with spread of *Mycobacterium tuberculosis, Pasteurella pestis, P. tularensis, Bacillus anthracis, Brucella abortus* likewise trypanosomes, leishmanias and *Treponema pertenue* by interrupted feedings of *Musca spectanda*. The incidence of trachoma falls sharply when house flies are under control and rises again when such control is lost.

FLIES AND HUMAN MYIASIS

Types of Myiasis. Myiasis is "the infestation of live human and vertebrate animals with *dipterous* larvae which, at least for a certain period, feed on the host's dead or living tissue, liquid body-substances, or ingested food" (Zumpt, 1965). Myiasis-producing flies have been classified in three categories: (1) specific, (2) semi-specific, and (3) accidental. The first group includes species of flies having larvae which are obligatory tissue parasites *viz.*, a majority of the warble flies and several of the calliphorine muscids. The second group contains species which usually deposit their eggs or larvae in decaying flesh or vegetable matter, but also at times on morbid tissues. The third group consists of those which usually deposit their eggs in excrement or decaying organic matter, but at times lay them in foodstuffs. The various types of myiasis are classified anatomically by the locations of infected tissues, *e.g.*, intestinal, cutaneous (including subcutaneous), nasal ophthalmic, aural, etc.

Pseudomyiasis refers to accidentally ingested dead or living fly larvae without

necessarily associated pathology or symptomatology, while *sanguinivorous myiasis* denotes superficial attachment during blood sucking (Zumpt, *l.c.*).

The more important myiasis-producing flies will be briefly considered in relation to the types of lesions which they produce.

Cutaneous, Ophthalmic, Nasal and Aural Myiasis. Dermatobia hominis. (Tropical Warble Fly, producing Cutaneous Myiasis.) The manner in which the eggs of this fly are carried to man or other warm-blooded vertebrates, hatch and invade the skin, has been described. (*Vide supra*, p. 721.) Lesions produced by the larvae are commonly on unprotected skin (hands and wrists, ankles, neck and face). In Venezuela, Dao (1954) reported 104 cases of human infestation, most frequent on scalp, legs, forearms, and face, including eyelids, of children and adults. Dalmat (1955), in describing scalp infestation of a Mayan in Guatemala, referred to published accounts of palpebral involvement in Brazil and Panama, and cerebral infestation in Panama, in which larvae had migrated from the scalp through the anterior fontanelle and entered the left hemisphere of a 1½ year old child.

The tunnel produced is more or less perpendicular to the surface and is occupied by a single larva (see Fig. 42–5). At the time the skin has just been invaded there may be observed a small, slightly elevated somewhat itchy pimple, that can rarely be distinguished from a mosquito bite. Soon, however, the growth and movements of the larva, destruction of local tissue and toxic by-products of the larva produce throbbing pain and an almost insufferable pruritus, which invariably provokes scratching. From time to time, the posterior end of the larva protrudes a short distance through the mouth of the tunnel, at which time it can be definitely diagnosed. Usually the mouth of the lesion is patent and exudes seropurulent fluid. The lesion frequently resembles a local streptococcal infection and may cause an associated lymphangitis or lymphadenitis, particularly if it is situated on the ankle. The larva remains in the skin throughout its development of 6 weeks or more, after which it crawls out and drops on the ground to pupate.

The only known therapeutic procedure, other than applying local palliatives, is surgical removal (Harrell and Moseley, 1942). see 722.

Gasterophilus spp. (Horse Bots or Warble Flies.) The three most common species are *G. intestinalis*, *G. nasalis* and *G. haemorrhoidalis*. Human infestation with these larvae (Fig. 42–1,*13*) is relatively uncommon compared with that of horses. Rarely, the larvae in man reach the stomach and develop in this location, causing gastric irritation, with nausea and vomiting. Usually the lesion in man is cutaneous, originating as a swelling at the site where the newly hatched larva enters the skin of face, trunk or limbs, and takes the form of a serpiginous tunnel, in which the larva is situated in the lower layers of the epidermis, with the stratum germinativum or corium at its base (Fig. 42–7). In this tunnel the larva may advance several millimeters in 24 hours, over a period of several months. Grossly the lesion bears a striking resemblance to that produced by *Ancylostoma braziliense* (Section III, p. 309), and similarly produces an aggravating pruritus, but it has no discharge unless secondarily infected. Differential diagnosis

Fig. 42-7. Larva of *Gasterophilus* in section of human skin. (After Montgomery, Arch. Dermatol. and Syph.)

may be made by massaging a small amount of a clear mineral oil over the infested skin, so that the larva may be located and identified by the black transverse bands of spines on its body segments. It may then be removed by using a sharp needle, without a local anesthetic. Specific identification can then be made by studying the detailed structure of the larva under a dissecting microscope. In the Western Hemisphere "creeping eruption" due to species of *Gasterophilus* is practically co-extensive with that of *A. braziliense*. Although cases are usually isolated, they appear at times in epidemic proportions. Ophthalmomyiasis interna due to *G. intestinalis* has once been reported. An unusual case in which an infarcted pulmonary granuloma was attributed to a horse bot (probably a second stage larva of *G. intestinalis*) has recently been recorded (Ahmed and Miller, 1969).

Hypoderma bovis and **H. lineatum.** (Cattle Bots or Warble Flies.) In these infestations of man the lesion is less serpiginous, since the larvae (Fig. 42-1,*12*) bore down more deeply into the subcutaneous tissues and produce an inflamed swelling more resembling a furuncle. More pain and less pruritus attend the lesion. Nevertheless, the "worm" migrates through the tissues and in the course of a month may be found many centimeters distant from a previous site. Beesley and Davies (1958) found that *H. lineatum*, when transplanted from the gullet of cattle to experimental calves, migrated through the subcutaneous fascia to all parts of the body; in rabbits even the thoracic cavity, cranium and deep layers of the back became infested. Thus, while the original site of invasion is usually an exposed part, the lesion noted later may be on any part of the body. The indicated therapeutic procedure is a cruciform incision through the lesion, removal of the larva, cleaning and dressing the wound. It is important to extract the larva before it dies and causes a suppurative process of greater magnitude.

Ophthalmomyiasis interna has been reported on several occasions as caused by larvae of *H. bovis* and *H. lineatum*. The two species may be differentiated, after surgical removal from the lesion, by clearing the larvae in a 10% caustic potash solution for several hours and studying the oral hooks, which in *H. bovis* are bifurcated at the tip, while those of *H. lineatum* have a single terminal point and a toothed process somewhat back from the tip. *H. bovis* is the common species in the North Temperate Zone and *H. lineatum* somewhat farther south, but the distribution of the two species is partly co-extensive. Persons most usually infested reside near cattle where flies are prevalent.

See 723

Oestrus ovis. (Sheep Bot or Gad Fly.) Gravid females of this species dart into the conjunctiva (usually the inner canthus), the outer nares, onto the lips or into the buccal cavity, and deposit their first-stage larvae which, by means of large, claw-like oral hooks and spines, rapidly bore into the mucous membrane. In the vicinity of the eye the larvae may burrow into the eyelid, conjunctival sac or lacrimal duct (external ophthalmomyiasis), rarely into the eyeball (internal ophthalmomyiasis). The former causes great irritation; the latter may lead to optic atrophy and require enucleation of the organ. From the nares the larvae may reach the nasopharynx. Although ophthalmomyiasis is quite common in U.S.S.R., as well as northern Africa and Israel, it is rare in western Europe and the United States. Infestation of the nasal sinuses in Algerian shepherds with *Oe. ovis* larvae (Fig. 42-1,*14*) results in congestion of the passages, with continuous secretion, accompanied by pruritus of the parasitized region and distressing frontal headache. In the pharynx, there is considerable inflammation, difficulty in swallowing, and, at times, vomiting. Larvae in the external membranes of the eye may be removed aseptically with a needle or scalpel; those in the nares will probably respond to chloretone or ephedrine drops. Gargles with strong salt solutions will probably cause pharyngeal forms to be discharged. Except

in cases of ophthalmomyiasis interna, larvae spontaneously leave the tissues after a few days. Nasopharyngeal myiasis requires differentiation from internal hirudiniasis (*vide* p. 568).

Rhinoestrus purpureus. (Russian Gad Fly.) This fly, which has an extensive distribution throughout southern and eastern Europe, northern Africa and Asia Minor, commonly deposits its larvae in nares of horses and cattle. Cases of human ophthalmomyiasis due to this fly have been reported from U.S.S.R., together with similar infestation with *Oestrus ovis*. The larvae of these two species are not readily differentiated.

Cordylobia anthropophaga. (Tumbu Fly.) This calliphorine species of tropical Africa lays its eggs on dry sand polluted with the excrement of animals, or on clothing. In about 3 days the larvae hatch and invade unbroken skin (usually the feet) of man and animals which come in contact with the larvae, producing a furuncular swelling at the site of invasion. The larvae (Fig. 42–1,*8*) mature rapidly and usually leave the human host in 8 or 9 days unless previously extracted. They may be identified by their pair of toothed, spade-like, oral hooklets and by several pairs of posteriorly directed fleshy processes arising from the eighth abdominal segment as well as by the character of the posterior spiracles, which lack a distinct chitinous rim (see Fig. 42–2,*4*). Introduction of a small amount of mineral oil into the lesion will hasten spontaneous exit of the larvae.

Lavoipierre and Beesley (1957) reported three cases of human myiasis in West Africa due to infestation with *Stasisia rodhaini*, a calliphorine fly probably often diagnosed in its larval stage as *Cordylobia anthropophaga*, and only reported once previously from man.

Chrysomyia bezziana. This calliphorine fly of the Oriental and Ethiopian regions is bluish-green, with dark thoracic stripes and dark transverse abdominal bands. The female lays her eggs in one batch in a cutaneous ulcer or cut on any exposed part of the body, or on the gums, in the nares, nasal sinuses, conjunctiva, ear or vagina. The larvae hatch in 8 to 10 hours, and burrow into the tissues, moult in 12 to 18 hours, burrow more deeply, reach the third instar (Fig. 42–1,*7*) on the second or third day and usually leave the wound on the sixth or seventh day, occasionally as late as the tenth to fourteenth day. In the sinuses they may erode the bone and produce a hideously disfiguring lesion. These lesions are foul-smelling, frequently secondarily infected, and have a mucopurulent discharge. Human cases have been encountered frequently in India, and more recently in the Congo (Fain *et al.*, 1959).

Callitroga hominivorax. (Primary Screw worm Fly.) This greenish-blue calliphorine species of tropical and sub-tropical regions of the Western Hemisphere is an obligatory parasite of warm-blooded animals. The eggs are deposited in small batches on injured or unbroken skin. The larvae (Fig. 42–1,*10*) hatch in less than a day and invade the skin, producing festering, frequently deep, disfiguring wounds. Several persons in the southern United States, usually those in contact with infested cattle, have become infested, and some have died as a result of the lesions.

Callitroga macellaria. (Common American Screw worm Fly.) This species, which requires specific differentiation from *C. hominivorax*, commonly deposits its eggs in decaying or moribund flesh of cattle, horses and sheep, rarely in exposed wounds of human beings (*i.e.*, it is saprozoic rather than parasitic). It is probable that most human infestations referred to this species were due to *C. hominivorax*.

Auchmeromyia luteola. (Congo Floor Maggot.) This calliphorine species of tropical Africa tolerates a wide range of temperature, humidity and altitude. Garrett-Jones (1951) referred to this maggot as the only ectoparasitic fly specific to man and the only blood-sucking fly larva that parasitizes man. It lays small batches of eggs on the floor of native huts or on dry sand. The larvae hatch within 2 days, and await an

opportunity to infest the skin of persons, particularly those asleep on the bare infested earth, from whom they suck blood. They are distinguished by having 5 pairs of fleshy posterior processes and characteristic posterior spiracles (see Figs. 42–1, *9*; 42–2, *5*). They feed on blood which exudes from the wounds produced by their oral hooklets and body spines, so that the fed larvae have a reddish-black gut. The habits of this fly are nocturnal.

Species of **Calliphora (C. vomitoria, C. vicina)**, of **Phaenicia (P. sericata, P. cuprina)**, **Phormia regina**, and rarely other less common calliphorine species, have been found in human wounds, feeding primarily on moribund flesh and bones, but at times attacking adjacent healthy tissues, and even penetrating unbroken skin. *Phaenicia sericata* has also been obtained in large numbers incubating in human nares (Ryckman and Halstead, 1952).

Wohlfahrtia magnifica. (Old World Flesh Fly.) This flesh fly is a large grayish species, with large black spots on the dorsal surface of the abdomen. It occurs in the Mediterranean region, in the Near East, Iran, Arabia, Iraq and throughout U.S.S.R., depositing its young in lesions of the skin, in the nasal sinuses, on the papillae of the tongue, in the external auditory meatus, in sore eyes, and in the vagina. As many as 70 larvae have been found in the human eye. The larvae are large and produce serious disfigurement, unless promptly removed. Related species are recorded from the same territory in which *W. magnifica* occurs.

Wohlfahrtia vigil. (Nearctic Flesh Fly.) This fly is usually larviparous, depositing its larvae in decaying animal matter, in skin lesions, those of the mucous membrane, or on uninjured skin. It is attracted particularly by foul odors from secretions of the eye or nares, and possibly from soiled diapers of infants. In children in the northern United States and Canada, clinicians have reported larvae of this species in superficial swellings of the head and neck (Fig. 42–8). Permanent disfigurement was prevented by surgical removal of the larvae. The characteristic posterior spiracles of the mature larvae are illustrated in Figure 42–2,*12*. Females are photophobic, preferring sugar solutions to fresh, stale or decomposed flesh, but are particularly attracted to young children and young animals for larviposition, although they do not enter homes.

Fig. 42-8. Lesions produced by *Wohlfahrtia vigil* larvae in a 5-month-old child. (From Faust, in Brennemann, after Walker, Jour. Parasitol.; courtesy of W. F. Prior Company.)

Wohlfahrtia meigeni, a closely related species, with a distribution in the western United States, was once observed as the agent of cutaneous myiasis in a young child in Utah, while still another species, *W. opaca*, has been identified as the cause of myiasis in 2 children and one young mature male in Colorado (Stabler *et al.*, 1962).

Sarcophaga haemorrhoidalis, S. fuscicauda and **S. carnaria** are flesh flies which larviposit on decaying flesh and human excrement, but also utilize ulcerated human tissues (*S. fuscicauda*), including the orbit, the face and neck. At times they larviposit on food consumed by human beings (*S. haemorrhoidalis*) and become temporary parasites in the human bowel.

Accidentally eggs of other flies may be deposited in exposed lesions of the skin, hatch and develop in these situations.

Intestinal Myiasis. Not uncommonly gravid female flies (Families MUSCIDAE, CALLIPHORIDAE, ANTHOMYIDAE, SYRPHIDAE, PSYCHODIDAE, PHORIDAE, SEPSIDAE, TRYPETIDAE, ORTALIDAE, STRATIOMYIDAE, etc.) deposit eggs on food consumed by man, or larviposit (Family SARCOPHAGIDAE) on stale food. Although the eggs frequently are digested or fail to hatch, or the larvae are killed *en transit* down the intestinal tract, at times they survive, may become temporarily lodged in the crypts and folds, and may develop through part or all of their larval period before being evacuated.

Urinary Myiasis. While most reports of fly larvae in the urine are probably referable to a contaminated container for the specimen, several cases, in which physicians vouch for the passage of these larvae from the urethra, apparently constitute true accidental myiasis. In female subjects, in whom either the bladder or vagina has become infested with fly larvae, the opportunity for the organisms to enter the lumens of these organs from the external meatus is appreciable.

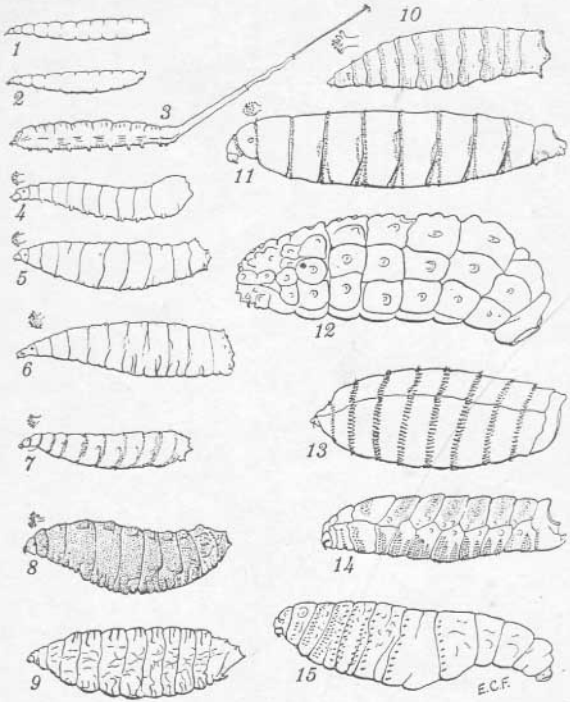

Fig. 42-1. Macroscopic appearance of some of the more common and more important fly larvae (mature stage), lateral view. *1, Sepsis* sp.; *2, Piophila* sp.; *3, Tubifera tenax; 4, Musca domestica; 5, Phaenicia* (*vel Lucilia*) *sericata; 6, Calliphora vicina; 7, Chrysomyia bezziana; 8, Cordylobia anthropophaga; 9, Auchmeromyia luteola; 10, Callitroga hominivorax; 11, Wohlfahrtia magnifica; 12, Hypoderma bovis; 13, Gasterophilus intestinalis; 14, Oestrus ovis; 15, Dermatobia hominis.* × 3½. Anterior spiracle at upper left of *4, 5, 6, 7, 8, 10* and *11*. (Compiled and adapted by Faust from various sources.)

wing its way to a more comfortable site and at its leisure regurgitate the meal into the proventriculus and mid-gut. Frequently some of this ingested food is allowed to flow back to the outer end of the proboscis, where it is known as a "vomit drop." This habit is of importance in the mechanical transfer of pathogenic microorganisms from a dirty feeding site to human food. The foot at the end of each leg of the house fly is provided with a pair of horny claws, a pair of ventral cushions or pulvilli, each with many glandular hairs (which enable the fly to walk on smooth surfaces and up-side-down on ceilings), and a single, median ventral, feathered spine, the empodium.

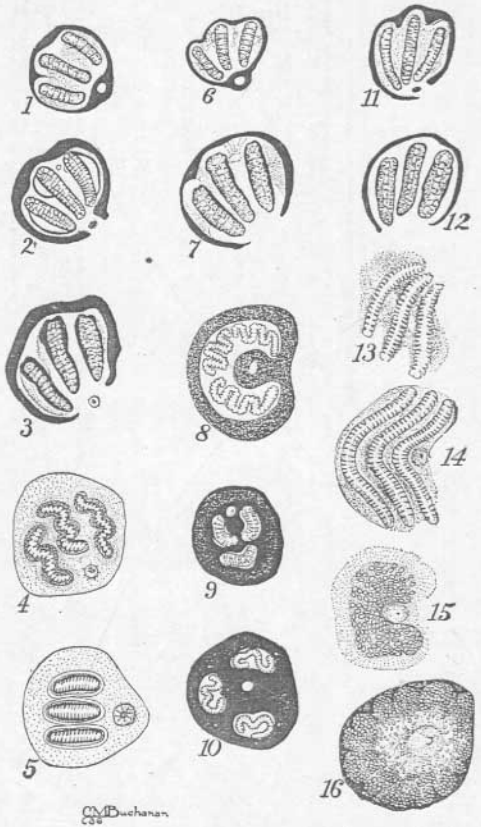

Fig. 42-2. The posterior spiracular pattern of representative fly larvae (left spiracular plate only). *1, Calliphora vomitoria; 2, Chrysomyia bezziana; 3, Callitroga macellaria; 4, Cordylobia anthropophaga; 5, Auchmeromyia luteola; 6, Phaenicia (vel Lucilia) sericata; 7, Phormia regina; 8, Musca domestica; 9, Muscina stabulans; 10, Stomoxys calcitrans; 11, Sarcophaga fuscicauda; 12, Wohlfahrtia vigil; 13, Dermatobia hominis; 14, Gasterophilus intestinalis; 15, Hypoderma bovis; 16, Oestrus ovis.* (Partly original and partly adapted by E. C. Faust from various sources.)

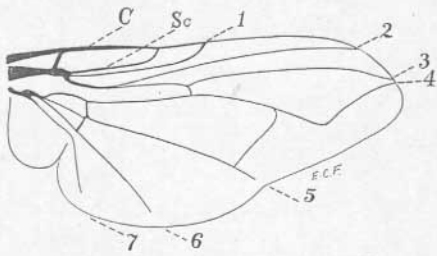

Fig. 42-4. Wing of *Musca domestica*. *C*, costal vein; *Sc*, subcostal vein; *1, 2, 3, 4, 5, 6, 7* longitudinal veins. (Original adaptation, Faust.)

The posterior 5 abdominal segments of the female are telescoped into the end of the abdomen and are modified into a tubular ovipositor. At the time of oviposition this structure, which is as long as the abdomen when it is extended, is exserted and is introduced into hidden sites, preferably horse manure, where the elongate pearly-white *eggs* (1 mm. in length) are deposited in batches of 100 to 150. Several such batches are laid by each female during her lifetime. Favorable sites include dung of domestic animals, human feces, garbage and other decaying animal and vegetable matter, and at times clean food prepared for human consumption.

Development. The eggs hatch in 8 to 24 hours at usual summer temperatures and the *larvae* feed ravenously on organic matter immediately around them. There are 3 larval instars; larval development requires 4 to 8 or more days. The last larval stage (Fig. 42-1,*4*) is about 12 mm. long, milky-white, of greatest diameter posteriorly and tapering to the head end. There are 13 body segments in addition to the "head" (*i.e., pseudocephalon*), which is usually retracted within the anterior end of the body. There are no legs. The "head" bears (1) a pair of dorsal lobes, each with a sensory papilla, (2) a pair of clawed mouth hooks (of which the left is much the smaller), used for boring into food, clinging to objects and for progression, and (3) a food channel, through which the food (liquid organic matter) is introduced into the pharynx within. The first thoracic segment bears a pair of small lateral papillae which contain the anterior spiracles. At the posterior end of the abdomen is a pair of D-shaped posterior spiracles with long sinuous slits and a central button (see Fig. 42-2,*8*).

After reaching its full larval development, the organism crawls into a drier location, draws in its anterior end, and from the third larval cuticle forms an elongate-ovoidal pupal case around itself, thus becoming the *pupa* or so-called "resting stage." Originally light yellow, the pupal case soon turns dark brown. In cold climates this is the overwintering stage, but in warm regions complete pupation requires only 4 or 5 days, after which the adult emerges through a circular seam on the head end of the puparium. Mating takes place within a few days after emergence (2 days in the male, 3 days in the female), and 2 or 3 days later the first batch of eggs is laid. Sperm from the first mating are stored in the seminal receptacle of the female, and are employed for the rest of its life; subsequent matings are ineffectual. Under optimal conditions a complete life cycle requires about 2 weeks.

M. domestica and several other species of the genus are omnivorous in their feeding habits, but *M. bezzii* and *M. autumnalis* are hematophagous, depending on blood oozing

out of wounds produced by true blood-sucking flies.

For **Medical Importance** and **Control** of *M. domestica*, *vide* pages 724, 725, 730.

CALLIPHORID FLIES (Family CALLIPHORIDAE)

Callitroga macellaria (Fabricius, 1775), *Common American Screw Worm Fly.* **Adult.** This fly is distributed throughout the Western Hemisphere. It is 10 to 13 mm. long, has a metallic blue-green color with a silvery sheen, and has 3 conspicuous longitudinal dark stripes on the dorsum of the thorax like the pattern of the primary screw worm, *C. hominivorax* (Fig. 42–3,*3*). The large eyes of the male are close together (*i.e.*, nearly holoptic), those of the female far apart. The antennae differ only in minor structural details from those of *M. domestica;* their third segment is dark on the frontal side, while the 2 basal segments are orange. The maxillary palps are small, slender, orange-colored. The squamae of the wings are dark and bear a few white hairs on the upper surface near the attachment end. The body is covered with numerous, stiff black hairs. Laake *et al.* (1936) found that this species is difficult to distinguish from *C. hominivorax;* however, in *C. macellaria* "the underside of the abdomen along the midline is covered by a dense whitish pruinosity which, on the last visible segment of the abdomen, appears as 2 lateral whitish spots when the specimen is viewed from above." This character is absent in *C. hominivorax.* Adults feed on semiliquid or liquid matter derived from wounds or from moribund or decaying flesh. Females lay their eggs (up to 1000 or more) in batches of a few hundred, at 2- or 3-day intervals, in flesh of dead animals.

Development. The *eggs* hatch in 6 to 10 hours and the *larvae* feed ravenously on liquid exudates of wounds or decaying flesh, which they penetrate by means of their powerful oral hooks (hence the name "screw worm"). There are 3 larval instars, requiring only 3 to 6 days for complete development. The third instar is 12 to 15 mm. long. The general shape and character of *Callitroga* larvae (Fig. 42–1,*10*, *C. hominivorax*) is similar to that of *M. domestica*, but it can readily be distinguished by bands of small spines, each with 1 to 3 points, usually 2, on the anterior border of the body segments. These spines are dorsally interrupted on segment 10, and on segments 11 and 12 are confined to the ventral and ventrolateral surfaces. The specific pattern of the posterior spiracles is shown in Figure 42–2,*3*. When mature, the larvae crawl out of the carcass, bury themselves in loose top soil and pupate in 2 or 3 days. The *pupa* is elongate-ovoidal, dark brown, and possesses the bands of spines of the third larval stage. The pupal period requires 3 days or longer (about one-half that of *C. hominivorax*). A day or two after emerging, the adults mate and oviposition soon takes place. Under optimal conditions a complete life cycle requires 12 days (that of *C. hominivorax*, 24 days).

C. macellaria requires specific differentiation from *C. hominivorax* (southern United States) and *Chrysomyia bezziana* (India, Africa, Philippines), both of which are more important medically, as well as from other species of this and related genera: *Cordylobia anthropophaga*, *Auchmeromyia luteola*, species of *Calliphora*, *Cynomyia*, *Phormia* and *Phaenicia*, and those of the true flesh flies (Family SARCOPHAGIDAE).

For **Medical Importance** and **Control** of these several species, *vide* pages 724, 728, 731.

THE LESSER HOUSE FLY, FANNIA CANICULARIS (Family ANTHOMYIDAE)

This common, grayish, non-metallic domestic fly, which measures 5 to 6 mm. in length, is narrow for its length, possesses 3 dark longitudinal stripes on the dorsum of the thorax, has a bare antennal arista and has a distinct venation of the wing (in contrast to *M. domestica* the fourth longitudinal vein does not approach vein 3 at an abrupt angle). It feeds and breeds in decaying vegetable and animal refuse. The *eggs* hatch

in about one day, under favorable conditions the larval period requires about one week and the pupal stage about one week. The *larvae* are characterized by a dorsoventral flattening and by branched fleshy processes extending out from the sides of the body. (In the related species, *F. scalaris*, the latrine fly, the fleshy processes of the larva are more "feathered" in appearance.)

For **Medical Importance** and **Control** of *F. canicularis*, *F. scalaris*, etc., *vide* pages 724, 730.

THE FLESH FLIES
(Family SARCOPHAGIDAE)

Sarcophaga haemorrhoidalis (Fallen, 1816–1817). **Adult.** This large, grayish fly has a nearly world-wide distribution. It has a length of 10 to 14 mm., 5 black longitudinal stripes on the dorsum of the thorax and a checkered light and dark upper abdominal surface (Fig. 42–3,2). The antennal arista is spinose on both anterior and posterior margins of its basal half, bare on its distal half. The fourth vein of the wing bends very sharply forward before proceeding to the margin of the wing, where it ends nearby the outer termination of the third vein. The hypopygia of the male are large, conspicuous, chitinized structures, somewhat reddish in color, and of diagnostic importance. These flies feed on feces or decaying meat or fish (cooked or uncooked). The females, which are *larviparous*, as are the other species of this genus and of *Wohlfahrtia* of this same family, deposit in these media (or possibly at times on the anus or nearby rectal mucosa of persons sitting on the seats of out-door latrines), 40 to 80 first-stage *larvae* which have hatched *in utero*.

Development. The larvae penetrate into decaying or decayed material (or possibly invade clean or injured mucosa), and develop to maturity, with 3 successive instars. These larvae (Fig. 42–1,*11*, *Wohlfahrtia magnifica*) resemble those of *Callitroga* and *Calliphora*, with an attenuated anterior end and wide abdominal segments, but may be distinguished by (1) more distinctly narrowed posterior end, (2) pit-like depression within which the posterior spiracles are located, (3) pattern of these spiracles (see Fig. 42–2, *11*), (4) in the third instar relatively large, fan-shaped anterior spiracles, with 15 to 18 very short, closely massed, finger-like processes arranged in 2 irregular rows, bearing the spiracular openings, and (5) delicate, finely pointed, dark spines, situated in bands at the anterior margin of each body segment. The *pupa* is dark brown, elongate-ovoid, and has a distinctive posterior pit at the base of which the spiracles are found. The life cycle of this species has been inadequately studied, although adults have been reared from larvae.

Other flesh flies of medical importance include *Sarcophaga fuscicauda* Böttcher, 1912, *S. carnaria* (Linnaeus, 1758), *Wohlfahrtia vigil* (Walker, 1849) and *W. magnifica* (Scheiner, 1862), *W. nuba* and *W. opaca*.

Differentiation of species of *Sarcophaga* is difficult. Adults of the related genus *Wohlfahrtia* may be readily distinguished from species of *Sarcophaga* by the spotted rather than checkered pattern of the dorsal surface of the abdomen. (See Fig. 42–3,*1* and *2*.)

For **Medical Importance** and **Control** of flesh flies, *vide* pages 724, 729, 730, 731.

THE WARBLE FLIES
(Families CUTEREBRIDAE, GASTEROPHILIDAE, HYPODERMATIDAE and OESTRIDAE)

Tropical Warble Fly, Dermatobia hominis (Modeer, 1786) Say, 1882. **Adult.** This fly, which has a Neotropical distribution from Central Mexico on the Gulf Coast to Argentina, is a member of the warble or bot fly group, which includes the sheep nasal bot (*Oestrus ovis*), the cattle bots (*Hypoderma* spp.), the horse bots (*Gasterophilus* spp.), the Russian gad fly (*Rhinoestrus nasalis*) and species of other genera less commonly parasitizing man. The adult *D. hominis* is a large, stout fly, measuring 15 to 18 mm. in length, with a yellowish face, black frons having a grayish pruinosity, a dark bluish-black thorax with a grayish pruinosity, and

a more or less diamond-shaped abdomen of metallic blue with a violet tinge (Fig. 42–3,*8*). Both males and females are dichoptic, with relatively small eyes. The third antennal segment is long, bright orange; the arista is spinose only on its anterior side. The legs are orange. The wings are dark brown and have a venation somewhat resembling that of *Sarcophaga*, except that the angle of the fourth longitudinal vein is not so conspicuous or abrupt. The mouth parts are vestigial, since the adults never feed; the female derives nourishment for her eggs from the food stored up during the larval stage. When she is ready to oviposit, the female captures a mosquito or other blood-sucking arthropod, and glues to its abdomen a batch of 14 to 25 small, elongate-ovoidal eggs.

In summarizing the characteristics of the adult female *D. hominis* Bates (1942) stated that it is diurnal in its flying and seeks out insects of moderate size and moderately active habits on which to deposit its eggs. "Both *Dermatobia* and its vectors seem to be forest insects, though *Dermatobia* will occasionally leave the forest accompanying a host. The *Dermatobia* abundance may differ from forest to forest with no obvious relation to the abundance of cattle (assumed to be the chief host) in the vicinity."

Development. When the vicarious vector of the *Dermatobia eggs* alights on a warm-blooded host, the young *larvae* (all ready to hatch) emerge from the egg membranes through a small opercular opening, and in less than an hour invade the skin, frequently through the puncture wound made by the vector. Each larva produces a separate lesion. Common vectors are several species of *Psorophora* (subgenus *Janthinosoma*), but species of *Culex* and *Trichoposopon* (Subgenus *Runchomyia*) *longipes* among the mosquitoes, *Stomoxys calcitrans* and *Neivamyia lutzi* of the blood-sucking muscoids, *Anthomyia*, *Synthesiomyia*, *Musca*, *Sarcopromusca*, *Sarcophaga* and *Pselaphephilia* of the non-blood-sucking muscoids, and the tick, *Amblyomma cajennense*, have all been incriminated. *D. hominis* may also deposit its eggs on damp laundry hung out in an exposed yard; the infested clothing may later produce infestation in small children.

Within the host's skin layers (Fig. 42–5) the larva feeds, grows and moults twice. The recently hatched first-stage larva is elongate-cylindroidal, tapering somewhat posteriorly. The mature third-stage larva (Fig. 42–1,*15*) measures from 18 to 24 mm. in length and is characteristically inverted flask-shaped. It has well-developed oral hooks and a dark brown anterior cuticle. The dark brown anterior spiracles each consist of 2 rows of 6 small, dark brown processes, located on the mesothorax. Near the anterior border of the second and third thoracic segments, and more conspicuously on the first 4 to 6 abdominal segments (and on some abdominal segments also near the middle), are short, stout, posteriorly-directed spines or hooklets which anchor the larva in the skin. The terminal 2 abdominal segments are covered with minute, inconspicuous, anteriorly-directed spines. The posterior spiracles lie in a small, deep cleft and are usually concealed in the shrunken specimen. Each spiracular plate has 3 somewhat curved slits (see Fig. 42–2,*13*), directed ventrad and somewhat mesad. Larval development requires from 46 days (Dunn, 1930) up to as long as 2½ or 3 months, after which the larva works its way out of the skin, falls to the ground and pupates in the soil. The *pupa* requires 14 to 24 days for metamorphosis, following which the adults emerge, copulate, females soon oviposit, apparently only once, and then die.

The flies breed in the coastal areas as well as on the inland plains and in the jungles of tropical America, frequently near forests. Domestic and wild mammals are most commonly parasitized by the larvae, although birds have at times been found infested. Man is usually infested when associated with domestic animals, although the South American Indian, who has no domestic animals, is frequently parasitized.

For **Medical Importance** and **Control** of *D. hominis*, *vide* pages 726, 731.

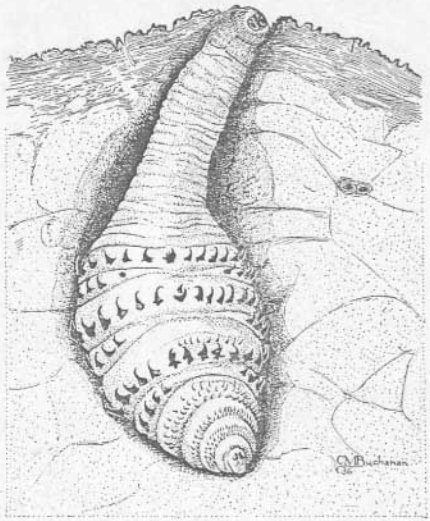

Fig. 42-5. Maturing larva of *Dermatobia hominis* in human skin. Note that the posterior end of the larva is at the outer end of the tunnel, so that breathing may occur through the posterior pair of spiracles. (Original, C. M. Buchanan for Faust.)

See 726.

Species of Gasterophilus. These horse warble flies, *Gasterophilus nasalis* (Linnaeus, 1758), *G. intestinalis* (de Geer, 1776), *G. haemorrhoidalis* (Linnaeus, 1758) and other less common species, are large, brown, hairy forms, with a naked antennal arista and with attenuated posterior abdominal segments (Fig. 42–3,6). *G. nasalis* females usually attach their eggs near the base of the hairs of the host; in other species of the genus eggs are cemented more distally on the hair shaft. In *G nasalis* and *G. haemorrhoidalis* the anatomical areas chosen are on the lower lip or between the mandibular branches of the lower jaw; in *G. intestinalis*, on the inner side of the legs and the sides of the abdomen. The eggs hatch, the spinose larvae are licked off by the host, and pass from the mouth through the tissues to the stomach, or may invade the perioral skin and migrate down through the tissues to the stomach or anterior levels of the small bowel, where they are attached to the wall while undergoing growth (Figs. 42–1,*13*, 42–2,*14*). Eventually they are passed *per anum* to pupate in the ground. Accidentally they get on exposed human skin and produce creeping myiasis.

For **Medical Importance** and **Control** of species of *Gasterophilus*, *vide* pages 726, 731.

Species of Hypoderma. Cattle bot flies, *Hypoderma bovis* (Linnaeus, 1758) and *H. lineatum* (Villers, 1789), are large, stout hairy, bee-like, usually tawny-colored forms, with functionless or rudimentary mouth parts, lacking maxillary palps (Fig. 42–3,7). The females usually alight on cattle, to whose hairs they attach one or more of their

eggs (up to 100 or more on one host). The larvae (Fig. 42–1,*12*), which bear numerous flat tubercles and spines, hatch, invade the skin, usually through a hair follicle, and migrate through somatic and visceral tissues. The left posterior spiracle of the second-stage larva is illustrated in Figure 42–2,*15*. After several moults (only three according to Knipling, 1935), requiring 6 months or more, the mature larvae (25 to 28 mm. long) congregate in subcutaneous tissues on the backs of cattle, where the "warbles" can be recognized by the presence of raised indurated lumps, due to their adventitious encapsulation. In a month or more they work their way out of the capsule and through the skin layers, drop to the ground, and pupate. The perforations produced in the skins of cattle at the time the larvae leave the host render their hides worthless commercially. These species infest many other herbivorous mammals and occasionally parasitize man.

For **Medical Importance** and **Control** of species of *Hypoderma*, *vide* pages 727, 731.

Species of Oestrus and Rhinoestrus. The sheep bot or gad fly, *Oestrus ovis* (Linnaeus, 1758), and the Russian gad fly, *Rhinoestrus purpureus* (Brauer, 1858), are large, dark-gray flies, with dark spots on the dorsum of the thorax and abdomen, and are covered with a moderate amount of light-brown hairs (Fig. 42–3,*9*). The females dash at their victims and deposit hatched larvae in the nares, on the conjunctiva, occasionally on the lips and in the mouth of sheep and other mammals, including man. These larvae crawl into the mucous membrane or up into the nasal sinuses, where they develop through 3 instars. They are characterized by having a pair of sharp, powerful,

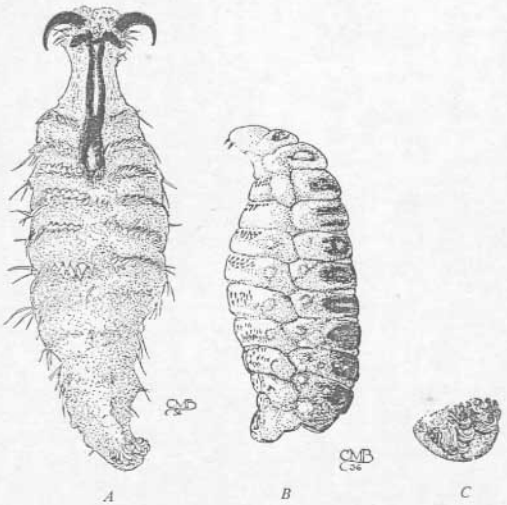

Fig. 42-6. Larvae of *Oestrus ovis*. *A*, First-stage larva removed from inner canthus of human eye, greatly enlarged; *B*, mature larva, × 4; *C*, enlarged detail of hooked caudal spines. (*A*, *C*, original, from specimen sent for diagnosis by Dr. Seab J. Lewis; *B*, from Castellani and Chalmers' *Manual of Tropical Medicine*, courtesy of Ballière, Tindall & Cox.)