CHAPTER 27

The Insects

The class Insecta (Hexapoda) is the largest and most important group in the phylum Arthropoda and probably represents the dominant form of animal life upon the face of the earth. The insects comprise about 70 per cent of the known species of animals; over 600,000 having already been described.

As might be inferred from their enormous representation among living things, insects are probably more beneficial and, at the same time, are more injurious to man than any other group of animals. From a medical standpoint, their primary importance is due to the fact that they are either directly injurious to man or are the vectors of some of the most dangerous pathogenic organisms.

CLASSIFICATION AND MORPHOLOGY. Most adult insects may be readily distinguished from other arthropods by the separation of the body into three distinct regions—head, thorax, and abdomen. The head bears eyes, mouth parts, and a pair of antennae. One pair of legs is found on each of the three segments of the thorax. Wings, when present, occur on the second (meso) and third (meta) thoracic segments; when there is but a single pair they are attached to the mesothorax. The abdomen is made up of a series of segments, varying in number and bearing no appendages except the terminalia; each abdominal segment consists of a dorsal plate (tergite) and a ventral plate (sternite) connected by membranes to permit expansion and contraction of the body. Most insects undergo marked changes in form during the course of their development from egg to adult, a feature of major importance when control measures are considered. Two types of metamorphosis are recognized; these depend upon the degree of change which takes place during growth to maturity. Lice are common examples of insects with an *incomplete* metamorphosis; here immature stages resemble the adults very closely except for size. The bedbug and cockroach have an incomplete metamorphosis, but the young, or nymphs, exhibit a greater change in growth of the body, development of wings, and genital appendages. Control measures do not vary greatly for the different stages of such insects, since the environment, anatomy, and food habits of both young and adult are very much alike.

Other insects, such as flies, fleas, and mosquitoes, undergo a *complete* change in appearance, and usually a different ecologic habitat is evident in their development from egg to adult. In many of these insects the mouth parts of the immature and adult forms are of totally different types, involving entirely distinct feeding habits; thus, control measures will differ greatly, depending upon the stage to be destroyed.

Species from nine orders are known to affect the health of man to a greater lesser degree, and these orders will be discussed in detail:

Order Orthoptera (cockroaches)
Order Coleoptera (beetles)
Order Lepidoptera (butterflies)
Order Hymenoptera (bees, ants)
Order Ephemeroptera (mayflies)
Order Hemiptera (true bugs)
Order Anoplura (lice)
Order Siphonaptera (fleas)
Order Diptera (flies)

Cockroaches (Order Orthoptera)

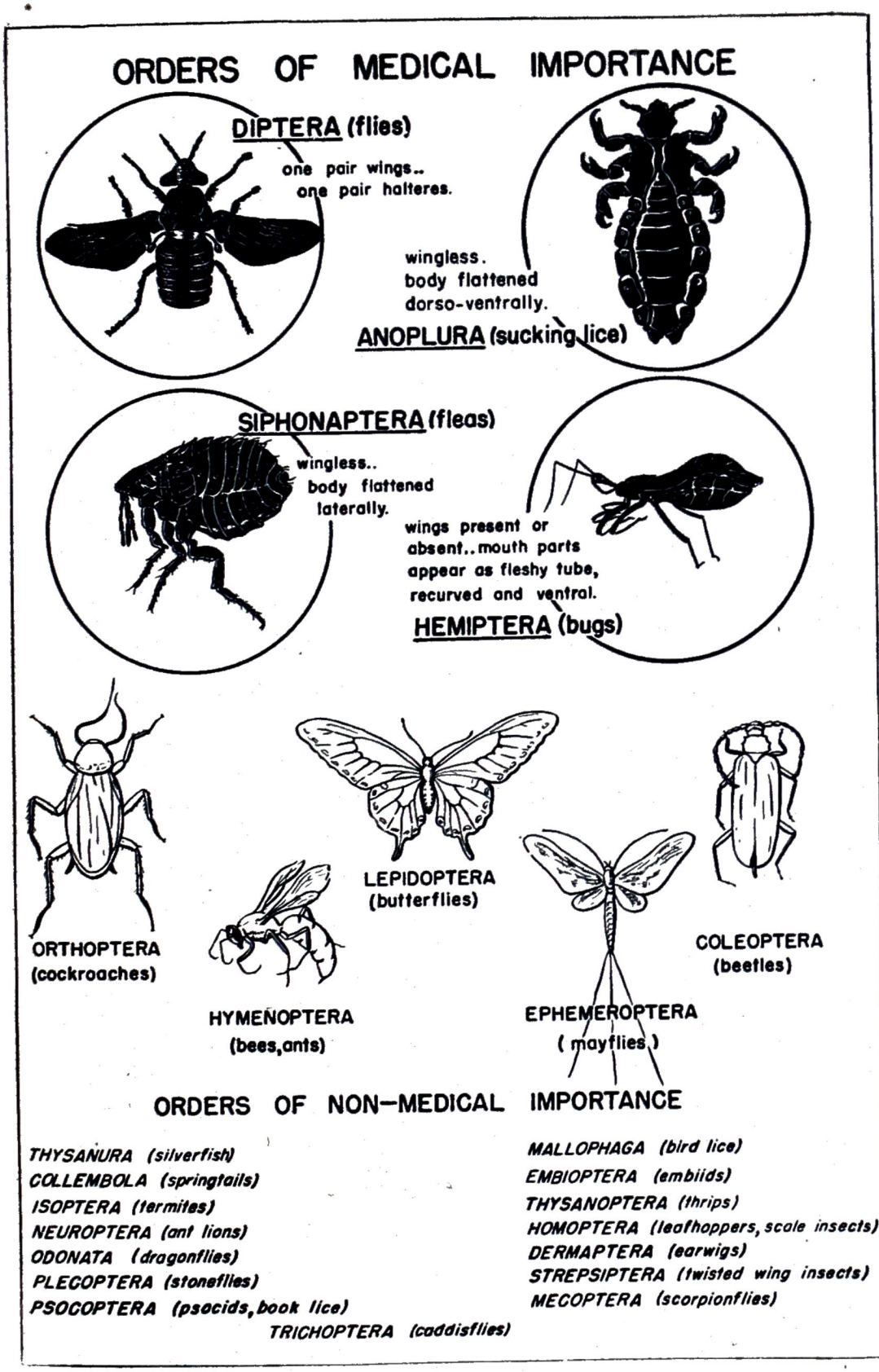
Cockroaches are omnivorous and have been under suspicion for many years mechanical carriers of certain human diseases. They have filthy habits, feeding o human excreta as well as on nearly all the foods consumed by man. The causati organisms of tuberculosis, leprosy, amebiasis, bacillary dysentery, and cholera ha been found to pass unharmed through their intestinal tracts. Contamination food may be accomplished either by contact or by fecal deposits. The cockroa may also serve as intermediate host of certain rare parasitic worms.

Biology and Morphology. Cockroaches are characterized by having a discli pronotum, a flattened body, long filamentous antennae, and strong legs adapted f running. The adults usually have two pairs of wings, the outer pair appear leathery. The eggs are assembled within the body of the female and are enclose in a hard capsule known as an *oötheca.* This structure is carried partly extrudi from the abdomen of the female. After several weeks it is deposited in some da corner or crevice. On hatching, the young are small, white, and very soft. Th metamorphosis is incomplete, for the young resemble the adults except for siz presence of wings, and development of sexual organs. Cockroaches are nocturn in habit and conceal themselves for protection from light and natural enemies.

At least five species have become domesticated and are generally distributed common household pests.

Key to Some Common Adult Cockroaches

1. Fore pair of wings well-developed, extending to or beyond the tip of abdomen . . .
   Fore pair of wings represented by small oval pads in the female, extending one-half the length of the abdomen in the male; color black or brown (oriental cockroach) ..... *Blatta orien*
2. Body about 12 mm. in length . . .
   Body 25 mm. or more in length . . .
3. Pronotum with two dark, longitudinal stripes; wings straw-colored (Croton bug, German cockroach, water bug) ..... *Blattella german*
   Pronotum without longitudinal dark stripes; wings marked with two light-yellow cross bands (tropical cockroach) ..... *Supella supellecti*



Orders of the class Insecta.

4. Wings uniformly reddish-brown, with a heavy yellow line on the outer edge of the basal half (Australian cockroach) .... *Periplaneta australa*
Wings uniformly reddish-brown, without such markings (American cockroach) ..... *Periplaneta americana*

CONTROL. Thorough cleanliness and protection of food supplies are important measures in roach control. In loosely constructed buildings where a mild climate prevails, reinfestation is common and control must be periodic. *Sodium fluoride,* although poisonous to man, is the best-known roach remedy. It should be thoroughly dusted or blown into hiding places where roaches run most frequently. This agent acts as a stomach poison, being ingested when the insect cleans its legs and antennae. Application should be repeated at intervals of one to two weeks, or until the roaches disappear. Borax powder and phosphorous pastes may also be used, although they are not so effective as sodium fluoride.

Kitchens and dining rooms may be treated with DDT. The 5 per cent emulsion, the 5 per cent solution in kerosene, or the 10 per cent dust may be sprayed or dusted into the runways and likely hiding places of young and adults. Pyrethrum sprayed about the room acts primarily as a stupefying agent on the cockroaches; after its use the insects should be swept up and destroyed before they crawl away for recovery.

Beetles (Order Coleoptera)

Beetles feeding on fecal material may serve as intermediate hosts of certain helminth parasites of man and animals—*Gongylonema pulchrum, Moniliformis moniliformis, Macracanthorhynchus hirudinaceus,* and *Hymenolepis diminuta.* The blister beetles (family Meloidae) carry a toxic substance diffusely scattered throughout the body which may blister the skin of man through simple contact with the living insect or from touching the crushed beetle. Cantharidin, a local irritant occasionally used in medicine, is prepared from certain species. Swarts and Wanamaker (1946) reported several cases of bullous lesions on the legs and necks of soldiers produced as a result of contact with a small common species of the genus *Epicauta.* Canthariasis of the digestive tract, urinary system and skin have been reported. Sharpe (1947) reported an unusual case of intestinal canthariasis produced by the larvae of the beetle *Ptinus tectus.* This species is a common pest of dry food products and the eggs were ingested with the food, hatching in the alkaline portion of the gut.

Butterflies, Moths (Order Lepidoptera)

Caterpillars of certain adults of Lepidoptera possess special hairs with poison-gland cells located at their bases. The fluids contained in these cells irritate the skin and produce an extensive rash and dermatitis upon contact. Hairs from the larvae of the browntail moth cause "browntail" rash; other well-known larvae with nettling hairs are those of the flannel, io, and buck moths and the saddleback caterpillar. Berkowitz (1945) reported numerous cases of urticaria among troop in New Guinea. *Ochrogaster contraria* is the common caterpillar in Austral the hairs of which have been reported by Flecker and McSweeny (1944) to p

an irritative dermatitis. *Megalopyge opercularis,* popularly known as the puss illar, is a common species occurring in southern United States.

Bees, Ants (Order Hymenoptera)

The venom of bees is injected through the sting located at the end of the abdomen. If the stinging apparatus has been left in the wound it should be removed to prevent the discharge of additional venom from the poison sac. As a rule, the effects of a sting are entirely local, but general symptoms—fever, dizziness, dyspnea, and urticarial lesions—have been reported. The introduction of venom into the conjunctiva may give rise to more serious reactions, the tissues becoming greatly inflamed and edematous.

It has been recently suggested that bees are not uncommonly associated with allergic reactions in persons sensitive to pollen or other substances which bees may bring into close proximity with human beings. The term "bee allergy" has been applied to this condition.

Certain species of wasps have been reported to act as mechanical carriers of the eggs of *Ascaris, Ancylostoma,* and *Trichuris* through the agency of their wings, legs, and body.

The bites and stings of ants are of little significance in temperate regions, but the large, formidable species in the Tropics may not only cause local irritation but may produce general symptoms of nervous system involvement. The large ants of Central America and northern South America, particularly the "tucandeira" (*Paraponera clavata*), are especially feared by the natives because of very painful lesions which follow their stings. In parts of India and Africa, tropical foraging ants of the genus *Monomorium* produce lesions by the bites of their mandibles.

Mayflies, Lakeflies (Order Ephemeroptera)

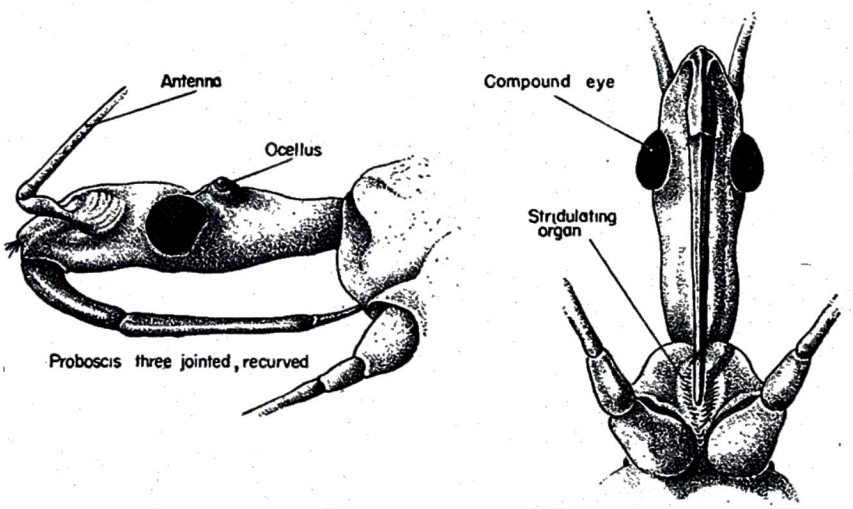
Members of this order are of medical interest in certain areas of the United States because of the allergic conditions which they produce. Along the shores of Lake Erie a common species of *Hexagenia* occurs in midsummer in such numbers that the cast skins are to be found everywhere. Persons breathing fragments of these skins may become highly sensitized and suffer severe asthmatic paroxysms.

True Bugs (Order Hemiptera)

The members of this order are characterized by the prominent beak, or proboscis, bent back under the head and thorax when in repose. It appears as a single fleshy tube arising from the lower front portion of the head. The adult bugs possess two pairs of wings; these are rudimentary in some genera. Metamorphosis is incomplete. The majority of species feed on a wide variety of plants and many are adapted for aquatic life. Only a few of the bugs are blood-suckers, and these occur in two families:

Family Cimicidae (bedbugs)
Family Reduviidae (conenose bugs)

Bedbugs (Family Cimicidae). Bedbugs have long been suspected to be v of human diseases, but to date there is no conclusive evidence that they are portant in the transmission of any disease in nature. The bite of a bedbug generally not felt immediately, but the salivary secretions may cause itch burning, and swelling; in some cases, secondary infections are started by scratchin the site of the bites.



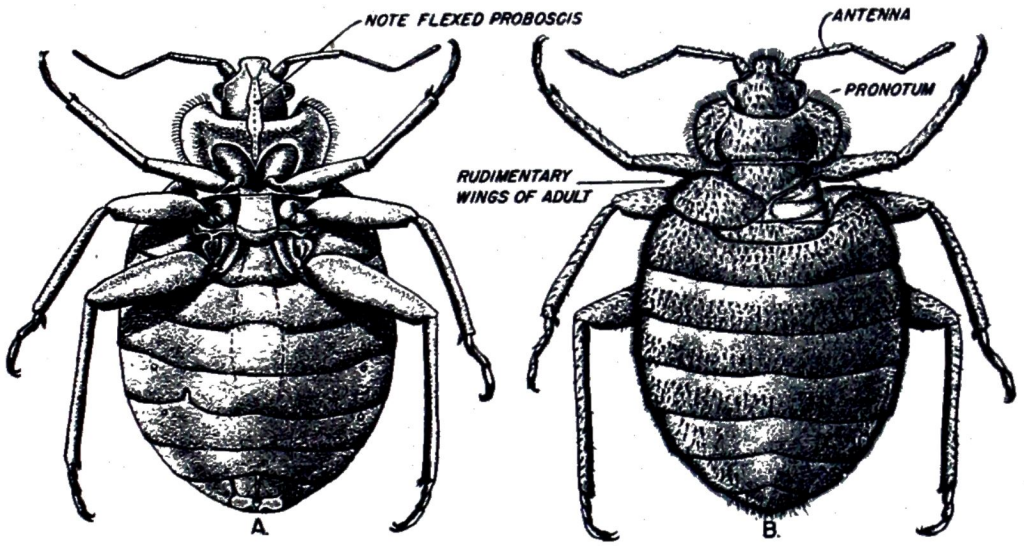
Head and proboscis of a bloodsucking hemipteron. Note stridulating organ on the prosternum, characteristic of the Reduviidae.

Biology and Morphology. Members of this family have a flattened body, are usually mahogany in color, and possess a four-segmented proboscis (three apparent). The antennae are four-jointed. Wings are rudimentary and appear only as mere pads on the body. The adult is about 5 mm. long and 3 mm. broad and is especially adapted by its flattened body for entering cracks and crevices to hide during the day. The rather broad head is set deeply into the prothorax between the large lobes formed by the pronotum. The female deposits about 50 eggs at a time and in about 10 days the young emerge. Four generations may develop in a year; the average period of life is probably three to six months. *Cimex lectularius* is the cosmopolitan bedbug; *C. hemipterus* is the common species found in the Tropics, especially in Asia.

Control. DDT is the most desirable of all available insecticides for the control of bedbugs. A 5 per cent kerosene spray, or the 10 per cent powder applied to mattresses and other likely hiding places will give a residual effect lasting for six months or more. Fumigation with hydrocyanic acid gas is effective but requir trained personnel. One pound of sodium cyanide is usually sufficient for 1000 cubi feet of air space.

Conenose Bugs, Assassin Bugs (Family Reduviidae). Most of the species this family are predaceous, feeding on other insects; some species are plant feed A few are mainly dependent on wild animals for a blood meal, and certain speci have become adapted to human habitations and are of medical importance the intermediate hosts of *Trypanosoma cruzi* which causes Chagas' disease. common method of transmission of the disease is through the agency of

id bugs, especially *Panstrongylus megistus*. In northern Argentina and y the more common transmitting species appears to be the "unchuca" *oma infestans*). However, the parasite is capable of developing in a number of other species of *Triatoma* and allied genera, as *Rhodnius, Eratyrus,* and *Eutriatoma*. Some 26 species of the blood-sucking reduviids (sometimes treated as



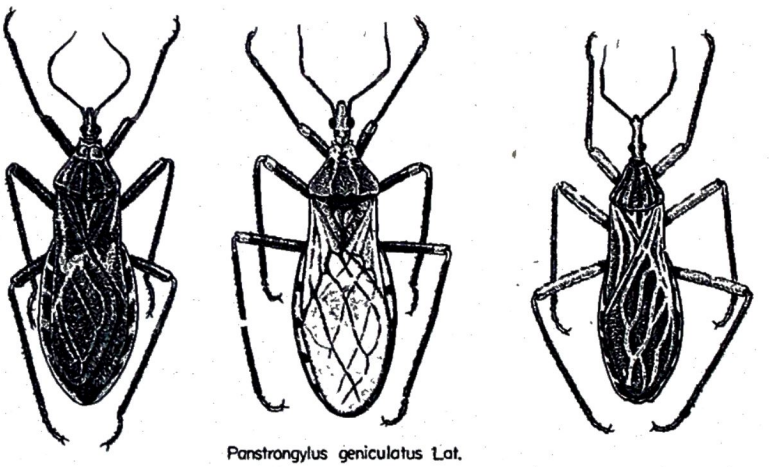
Cimex lectularius, the bedbug: (A) Ventral view. (B) Dorsal view.

a separate family Triatomidae) have so far been found naturally infected with *T. cruzi* and are capable of transmitting infection (Torrealba, 1946). In California, Kofoid found *Triatoma protracta* to be infected, while Reichenow (1934), in Guatemala, found the transmitting agent to be *T. dimidiata,* and Clarke and Dunn (1932), in Panama, have shown that *Panstrongylus geniculatus* is the usual transmitting arthropod. *Eratyrus cuspidatus* was also found naturally infected. Shuck (1945) reports *Triatoma longipes* and *T. rubida* as being naturally infected in Arizona. While bugs infected with *T. cruzi* have been recovered in the United States, no naturally infected human cases have been reported. The reduviid deposits infective feces as it feeds and these are rubbed or scratched into the excoriated skin at the site of the bite. Many species are said to produce painless bites; others inflict painful bites when disturbed. *Triatoma sanguisuga* has recently been reported by Kelselman and Grundman (1940) in Kansas as naturally infected with the western strain of equine encephalomyelitis.

Biology and Morphology. Members of the family Reduviidae are characterized by the three-segmented proboscis which arises from the anterior portion of an elongate head. When viewed laterally, it appears as a shallow loop with the tip resting just forward and between the prothoracic legs in a prosternal furrow. Important genera can be recognized by the position and insertion of the antennae.

The eggs are deposited in dusty corners and crevices of houses or in nests and burrows of the hosts; nests of the wood rat (*Neotoma*) are favorite places to collect many species. Reduviids tend to be nocturnal in feeding habits; both sexes bite man.

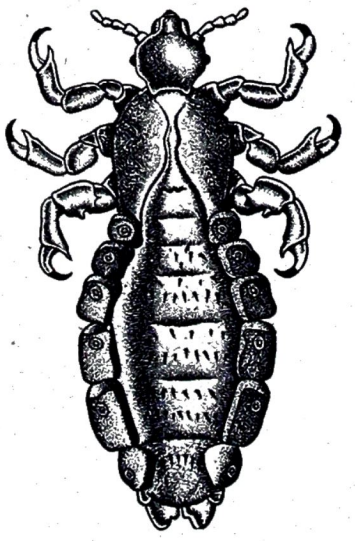
CONTROL. No effective control measures are known for these bugs, and tion is very difficult because of their habits. Mosquito nets and screened qua may offer some protection against adults and the larger nymphs.



Three medically important reduviids.

Sucking Lice (Order Anoplura)

The body louse (and probably the head louse) is known as the vector of epidemic typhus and trench fever. It has been shown to transmit relapsing fever in Europe, India, China, northern Africa, and North America. Transmission is accomplished when the crushed louse or its feces is scratched into the bite or excoriated skin; the bite alone is not sufficient. A characteristic scarring or bronzing of the skin (vagabond's disease) often occurs, due to toxic substances secreted during feeding. This melanoderma is especially marked where large numbers of lice have fed. Crab lice are not generally incriminated as vectors of disease although Chung (1944) points out that the crab-louse may act as a transmitter of typhus under certain conditions in which case they serve merely as reservoirs of the infected blood.



Pediculus humanus var. *corporis*, the body louse.

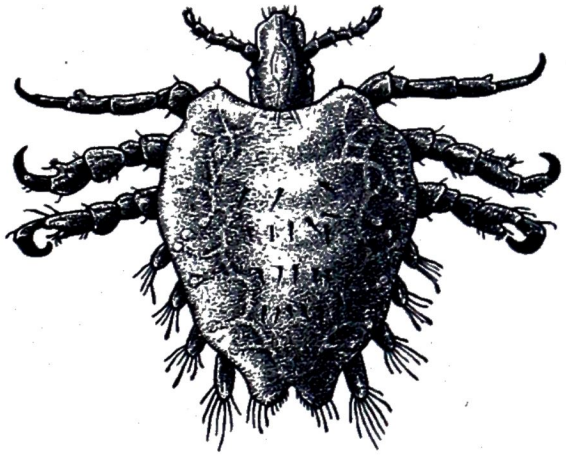
Sucking lice are small, dorsoventrally flattened, wingless insects which undergo an incomplete metamorphosis. Their legs possess one-jointed claws which are well adapted for clinging to hairs. The insects included in this order are exclusively blood-sucking ectoparasites. About 200 species are known, and of these two infest man.

Body Louse (Pediculus Humanus var. Corporis). Eggs of the body louse are laid among the folds of the clothing at the rate of 8 to 12 daily; as many as 300 eggs are laid by one femal Young and adults live among the folds and seams of clothing, being rarely fo on the skin except when feeding or when extremely abundant. The preferred cation for feeding is in the region of the neck. Blood is sought frequently thro

day and night, and deprivation of food causes death of the adult in about ys and of the newly hatched nymph in about two days.

Louse (Pediculus Humanus var. Capitis). The eggs of the head louse deposited on the hairs of the head; the young mature in about 10 days. This iety of *P. humanus* differs but little in structure and in no essential manner in life history from *P. humanus* var. *corporis;* typical forms of the head louse are usually smaller and darker, with the antennae somewhat thicker.

Crab Louse (Phthirus Pubis). This species is popularly known as the crab or pubic louse. The first pair of legs is slender and is terminated by a straight claw. Legs of the second and third pairs are supplied with large, hooklike claws. The crab lice usually infest the pubic and perineal regions; in heavy infestations, they may be found on the eyebrows or hair of the armpits. The eggs hatch in about seven days, and the life cycle extends between 20 and 25 days.



Phthirus pubis, the crab louse.

Control of Sucking Lice. The new synthetic compound, DDT, is more highly effective and longer lasting than any other previously known insecticide and will no doubt be used exclusively in the control of the vectors of epidemic typhus and louse-borne relapsing fever; 10 per cent dust applied to the inner surface of clothing worn next to the skin will give protection until the clothes are washed. Methyl bromide, effective against nits, may be used as a fumigant for clothing and bedding. Steam is also efficient, causing but little shrinkage of woolen goods; an improvised apparatus for steam sterilization is easily assembled. Permanent delousing stations with pressure sterilizers are used, but they are being supplanted by DDT. Clothing and hair should be inspected regularly. Frequent bathing and changes of clothing will assist in control. Wheeler (1946) discusses the remarkable success achieved in Naples and southern Italy in 1943–44 as a result of mass dusting operations for the control of louse-borne typhus.

Fleas (Order Siphonaptera)

Fleas affect the health of man by acting as vectors of plague and endemic typhus urine typhus) and as intermediate hosts of the dog tapeworm, *Dipylidium*

burrows. Calcium cyanide, which gives off hydrocyanic acid gas, is a dust and be used by placing 1 tablespoon down each burrow and closing the entrance mediately. Large-scale fumigation, as carried out for ships, should be done onl experienced personnel. Stewart and Mackie (1938) have found that liquid me bromide is very effective in destroying rodents in their burrows. In areas w fumigation is not feasible, active trapping with spring traps and poisoning thro the use of the agents listed below may be recommended:

Kind of Poison	*Amount*	*Bait*
Barium carbonate	4.00 oz.	1 lb.
Red squill	16.00 oz.	9 lbs.
Thallium sulfate	0.25 oz. (½ level teasp.)	1 lb.
Strychnine alkaloid	0.1 oz. (2 level teasp.)	1 lb.
Arsenic trioxide	0.5 oz. (3 level teasp.)	1 lb.

Bread has proved to be a very successful bait when used with any of the above poisons. The selected poison is mixed with the broken or ground bread in the proportion mentioned and water added until the mixture will form a ball when compressed in the hand. Portions may be wrapped in wax paper to form "torpedoes" and placed in areas known to be frequented by rats. Coconuts, bananas, sweet potatoes, meat, melons, or peanut butter may also be used as fresh baits.

In controlling the ship-shore-ship rodent movements, rat guards or shields should be maintained on all connecting lines. Light clusters should illuminate bow and stern lines at night; all landing stages, gangways, and cargo nets should be removed from the wharves and between ships during darkness, in so far as is possible.

Mosquitoes, Flies, Gnats (Order Diptera)

The order Diptera comprises one of the largest single groups of insects, containing over 75,000 species. Structurally, these invertebrate animals are the most highly specialized of the class Insecta. All forms that are properly termed "flies" belong to this group. However, the word "fly" forms a part of the compound name of certain insects, such as butterfly, mayfly, or dragonfly, which are not members of the order Diptera. Nearly all species of the Diptera have sucking mouth parts, and a few possess structures capable of piercing the skin of man. These skin-piercing forms are the most important disease vectors and must be regarded as potential transmitters of any pathogenic microörganism. With few exceptions, flies with nonpiercing mouth parts cannot be held responsible for introducing infection into the body except through previously injured surfaces; however, they may be highly efficient in the mechanical transfer of parasites.

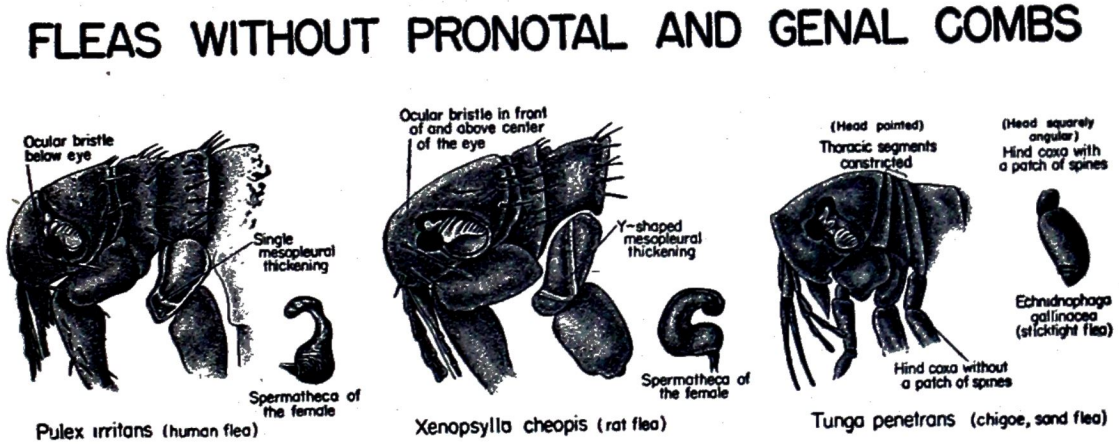
Classification. The characteristic feature of the Diptera is the presence of only one pair of functional wings; the second pair is reduced to knoblike structures known as *halteres*. With few exceptions, flies undergo a complete metamorphosis: egg, several larval stages, pupa, and adult.

Because of the enormous size of this order and the additions and correc

be controlled by eradication of the rodent host through fumigation. Ten per DDT powder may be applied to the beds of dogs and cats and to runways and used by rats. It may be used beneath rugs, on floors, or soil that is visited flea-infested animals; one-half pound will treat 1000 square feet. The 5 per cent DT-kerosene spray is most effective.

Rodent Control. It has been noted that a high death rate among rodents as a result of a plague epizoötic often precedes an outbreak of human plague. When rats or mice are reduced in numbers, there is more likelihood that the rodent fleas will seek the body of man for food; consequently, it is well to employ measures that will destroy both rodents and fleas simultaneously.

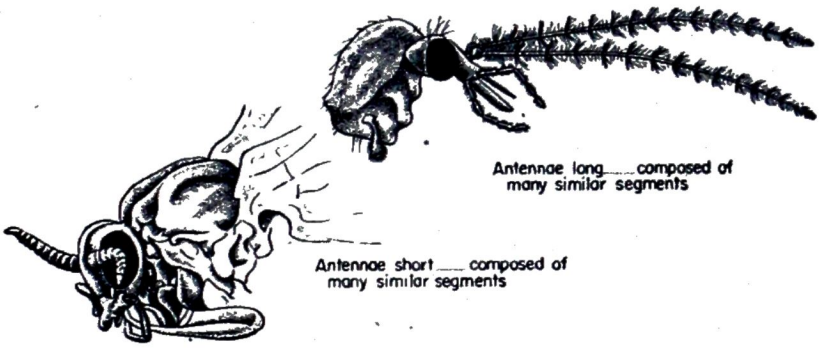
Exhaust gases from automobiles or other gasoline engines (carbon monoxide), calcium cyanide, or carbon bisulfide may be used in destroying rats in their



Identification characters of some medically important fleas occurring in the United States.

which are constantly being made, classification and identification have always been difficult and unsatisfactory to the laboratory worker. A practical method of classification is used at the U. S. Naval Medical School where, for convenience, members of the order Diptera are placed in one of three suborders—*Nematocera, Brachycera,* or *Athericera*—according to the shape and structure of the antennae. This classification is based upon visible anatomic features; since adult specimens are generally submitted for identification, the antennae provide adequate clues to the medically important groups.

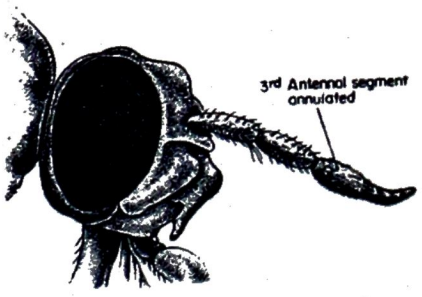
Suborder Nematocera (Orthorrhapha, in part)—Mosquitoes, Many Mosquito-like Gnats, Black Flies, Midges, Sand Flies. The antennae of adults are



Antennal characters of the suborder Nematocera.

composed of 6 to 20 similar segments, the two basal ones usually differentiated from the rest. The palpi are nearly always filiform and four- or five-jointed. The larvae have a well-developed head with chewing mouth parts. Disease vectors belonging to this suborder have *mouth parts which are capable of piercing the skin of man. Only the females bite;* the males obtain their nourishment from plant juices. Transmission of disease usually *requires a lapse of time, during which the vector is noninfective.*

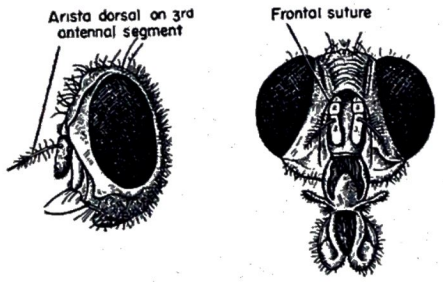
Suborder Brachycera (Orthorrhapha, concluded)—Horse Fly, Deer Fly, etc. The antennae are variable, generally the two basal segments are differentiated from the third which is frequently subdivided into a number of false segments or annulations; arista, when present, is rarely dorsal, usually terminal; in living specimens, the antennae extend in front of the head, bayonet fashion. The larvae have an distinct head and retractile, vertically biting mouth parts (mandibles). The medically important members of this suborder have *piercing mouth parts. The females alone can bite;* the males feed on plant juices. Disease transmission may be *direct or may require a lapse of time during which the insect vector is noninfective.*



Antennal characters of the suborder Brachycera.

Suborder Athericera (Cyclorrhapha)—Tsetse Fly, House Fly, Green Bottle ly, etc. The antennae are three-segmented. The spinelike *arista* is subject to ide variation in regard to position and structure, but is usually located dorsally

on the base of the third segment. A frontal lunule is present in nearly all medic important forms, and a frontal suture is usually present. The larvae are withou distinct head and the mouth parts are reduced to simple hooks. The pupae enclosed in the last larval skin to form a white yellowish to mahogany-brown puparium. T majority of disease vectors, in both sexes, hav *mouth parts which are incapable of penetrating the skin.* Transmission is *typically mechanical, requiring a prompt feeding on the second host for infection to take place.* Two main factors are involved in this type of transmission: (1) *contact with a contaminative source, such as an open sore, feces, garbage, or sputum and* (2) *subsequent contact with the broken skin, conjunctivae, food, or drink.* A few genera in this suborder have *piercing mouth parts; both the males and females bite* (*Glossina, Stomoxys,* etc.). Disease organisms undergo a biologic transformation in the medically important forms.



Antennal characters of the suborder Athericera.

Mosquitoes, Mosquito-like Gnats, Sand Flies, Black Flies, Midges (Suborder Nematocera)

This group is the most primitive of the three; it includes species which are important in the transmission of malaria, dengue, sand-fly fever, and many other diseases. Four families are recognized to be of medical importance:

Family Psychodidae (sand flies, moth flies)
Family Ceratopogonidae (no-see-ums, punkies, biting midges, sand flies)
Family Simuliidae (buffalo gnats, black flies, turkey gnats)
Family Culicidae (mosquitoes, mosquito-like gnats)

Sand Flies, Moth Flies (Family Psychodidae). Sand flies are the vectors of visceral and cutaneous leishmaniases. The species incriminated for *Leishmania donovani* (kala-azar) are *Phlebotomus argentipes* in India; *P. chinensis* and *P. sergenti* in China; and *P. major, P. sergenti,* and possibly *P. papatasii* in the Mediterranean region. *Phlebotomus papatasii* and *P. sergenti* are believed to transmit *L. tropica* (oriental sore) in the Old World, and *P. intermedius* to carry *L. braziliensis* (espundia) in South America. It is believed that both visceral and cutaneous leishmaniases are transmitted by the bite of the insect; crushing the fly may be important in the transmission of the cutaneous type.

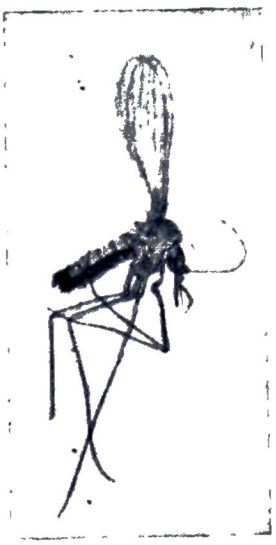
Phlebotomus papatasii is a proved vector of sand-fly or pappataci fever throughout the Mediterranean region, the Balkans and Asia eastward to India. *Phlebotomus verrucarum* and *P. noguchii* are transmitters of *Bartonella bacilliformis,* the cau of verruga peruana in Peru; the distribution of the disease is restricted to canyons along the western slope of the Andes where those species occur.

MacPherson (1941) reports that men of the Australian forces suffered seve in North Palestine from a disease referred to as "harara" and describes it as

gic reaction due to the bites of *Phlebotomus* at the height of sensitization. exposed skin becomes covered with hard wheals up to 1 cm. in diameter. se may subside or may be replaced by blisters which may become infected; in some cases the regional lymph nodes become enlarged and tender.

Biology and Classification. The more common members of this family belong to the genus *Psychoda* and are harmless, nonbiting flies. They appear in large numbers in and around breeding areas, such as sewage disposal plants and cesspools, and not uncommonly about wash basins. The adults are small and mothlike owing to their dense hairy covering. The wings rest in a rooflike manner over the body. Members of the closely related genus *Phlebotomus* are blood-suckers and produce painful bites. Like members of the genus *Psychoda,* the body and wings are covered with hairs. The antennae are long and hairy and consist of about 16 segments. The palpi are four-jointed and are longer than the head. Unlike *Psychoda,* the wings are raised over the abdomen at an angle of 45 degrees when the adult is at rest.

Sand flies (*Phlebotomus*) hide in damp places during the day. Only the females suck blood, emerging primarily at night to feed. They fly only short distances and rarely rise more than a few feet above ground. In open country where breeding places are associated with widely scattered rodent burrows, Hertig (1945) reported flight ranges up to 1500 yards as not uncommon. A few days after feeding the females deposit ova (40 to 60 per insect), by preference in crevices of damp, shaded rocks, stone fences, ruins of buildings, or caves within 100 or 200 feet of their feeding places. Occasionally, they may feed a second time and deposit a second batch of ova, but their life span is short—7 to 14 days. The entire life cycle covers one to two months.



Adult *Phlebotomus,* the sand fly.

Control. Sand flies of the genus *Phlebotomus* are not easily controlled, for their breeding places are difficult to demonstrate. Repellents have been used with some degree of satisfaction in certain areas. Bites may be prevented by avoiding infested areas at night. DDT has been shown to be effective; the 5 per cent solution in kerosene should be sprayed on inner walls from floor to ceiling, reaching well into the corners, and on the framework of doors, windows, and screens, both inside and out. It should be applied at the rate of 1 to 1½ gallons per thousand square feet. Screens should be painted with the solution. Hertig (1945) reported that 5 per cent DDT in diesel oil distributed by airplane gave remarkable control of adults in the Mediterranean region.

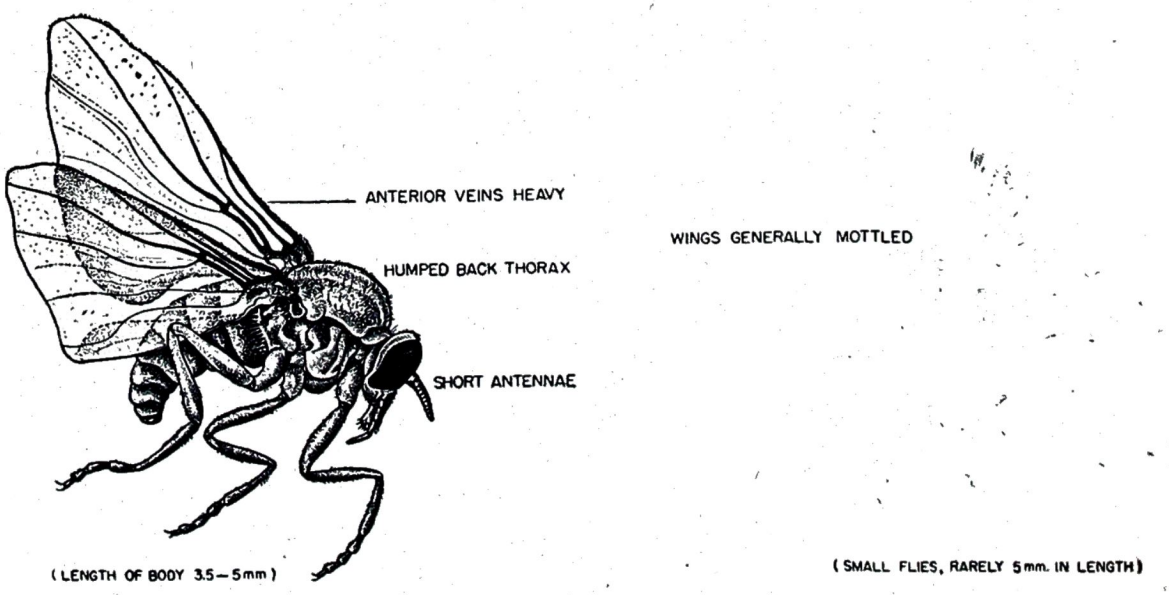
Black Flies, Buffalo Gnats (Family Simuliidae). Members of this family are extremely annoying and attack man readily in the immediate vicinity of their breeding areas, particularly during the day. In less heavily overgrown wooded areas the adults have been observed to migrate several miles. The bites are usually painless but may produce painful swellings. In northeastern parts of the United

States and in eastern Canada, black flies are the pests that probably interfere with the pleasures of outdoor life; they are a scourge to livestock and other mals in the southern states. In addition to discomfort resulting from their b certain species are vectors of the filarial worm *Onchocerca volvulus,* the causa organism of onchocerciasis, or blinding filarial disease. *Simulium damnosum S. neavi* are known transmitters in tropic Africa; *Eusimulium avidum, E. oc ceum,* and *E. mooseri* in Central America.

Biology and Classification. Dyar and Shannon have divided the family int four genera: *Parasimulium, Prosimulium, Eusimulium,* and *Simulium;* there about 200 known species. The adults are rather small, hump-backed flies, usually dark in color, which probably accounts for their common names of black flies and buffalo gnats. The antennae are short, as long as or a little longer than the head. The wings are large and broad with the anterior veins thickened; the remaining veins are poorly developed.

The characteristic larvae and pupae are found attached to slightly submerged wicker-work fish traps, rocks or vegetation in rapidly flowing, clear streams. Most American species breed in swiftly flowing mountain streams and a patchy distribution is evidently due to these limited breeding habits.

Control. Black flies are rather difficult to control, and emphasis should be placed on individual protective measures. Complete clothing and head nets will limit bites over the face and body while traveling in heavily infested areas. Insect repellents will give satisfactory protection for several hours, if applied evenly over exposed surfaces. Aquatic stages may be partially eliminated by clearing rocks and logs from the streams, but such procedures are economically unfeasible for extensive control. Sudden changes in water level were shown by Wanson and Henrard (1945) to be an effective method of control of *S. damnosum* in the Belgian Congo, whereas a gradual rise or fall in water level will permit the larvae to migrate to other suitable environments. Fairchild (1945) reports success in the use



(*Left*) Adult simuliid, the black fly. (*Right*) Adult *Culicoides,* a biting midge (commonly kno as "punkies," "no-see ums," or "sand flies").

emulsion in flowing streams, applied at the rate of 1 quart of DDT to ,000 parts of water.

iting Midges, Sand Flies, No-see-ums, Punkies (Family Ceratopogonidae). se flies appear chiefly in the evening and early morning and occur locally in numbers sufficient to make life almost unbearable. The bites of some species are very painful and extremely irritating, causing nodular swellings that itch persistently for several days or weeks. The common name "sand fly" is applied to members of this family as well as to the genus *Phlebotomus* in the family Psychodidae. Use of this common name may cause confusion, and a correct identification of the offending form is necessary before control measures can be instituted. Members of the genus *Culicoides* serve as the intermediate host of the filarial worm, *Acanthocheilonema perstans; C. furens* was shown by Buckley to be the intermediate host of *Mansonella ozzardi* on St. Vincent Island.

Biology and Morphology. These small, slender flies may be distinguished by the peculiar venation of the wings; the first two veins are very heavy, the others rather indistinct. Scales are absent and the wings are frequently covered with microscopic, erect hairs variously marked with iridescent areas in many species. The proboscis, like that of the simuliids, is very short. The antennae are 14-segmented. Eggs are laid in a variety of places, mainly in water or water-saturated sand and soil; larvae are commonly collected in tree holes. Throughout the Pacific Islands, large numbers of larvae and pupae have been found in water held in the numerous coral pockets above high-tide level. The slender brown pupae superficially resemble those of the mosquitoes, but unlike the latter they float almost motionless in a vertical position. The entire life cycle requires from 6 to 12 months. This family includes about 22 genera.

Control. Species of the genera *Culicoides* and *Leptoconops* have been controlled by selective residual treatment with DDT sprays or dusts. Their breeding places are usually limited and must be accurately determined before area treatment is begun. Bed nets and screens treated with DDT will poison many of these small gnats as they make their way through the meshes, but it may not kill them in time to afford complete protection from bites. Mosquito repellents are of value in protecting the hands, face, and ankles.

Mosquitoes, Mosquito-like Gnats (Family Culicidae). Mosquitoes have long been notorious as pests of man and animals, but this role is overshadowed by their importance as vectors of organisms pathogenic to man. From a medical viewpoint they are the most important of all blood-sucking diptera, being known transmitters of malaria, dengue, yellow fever, filariasis, and the various encephalitides.

Classification. Members of the family Culicidae are small, slender flies. The typical antenna is composed of 14 to 15 segments. The wings are long and narrow, and folded over the abdomen when at rest. The venation is characteristic: six longitudinal veins are nearly always present; the second, fourth, and fifth veins forked; the third vein is unbranched and arises from the anterior cross-vein at out the middle of the wing. The wing veins possess hairs or true scales, and the

hind margin is fringed with scales or simple hairs. The immature stages are al aquatic.

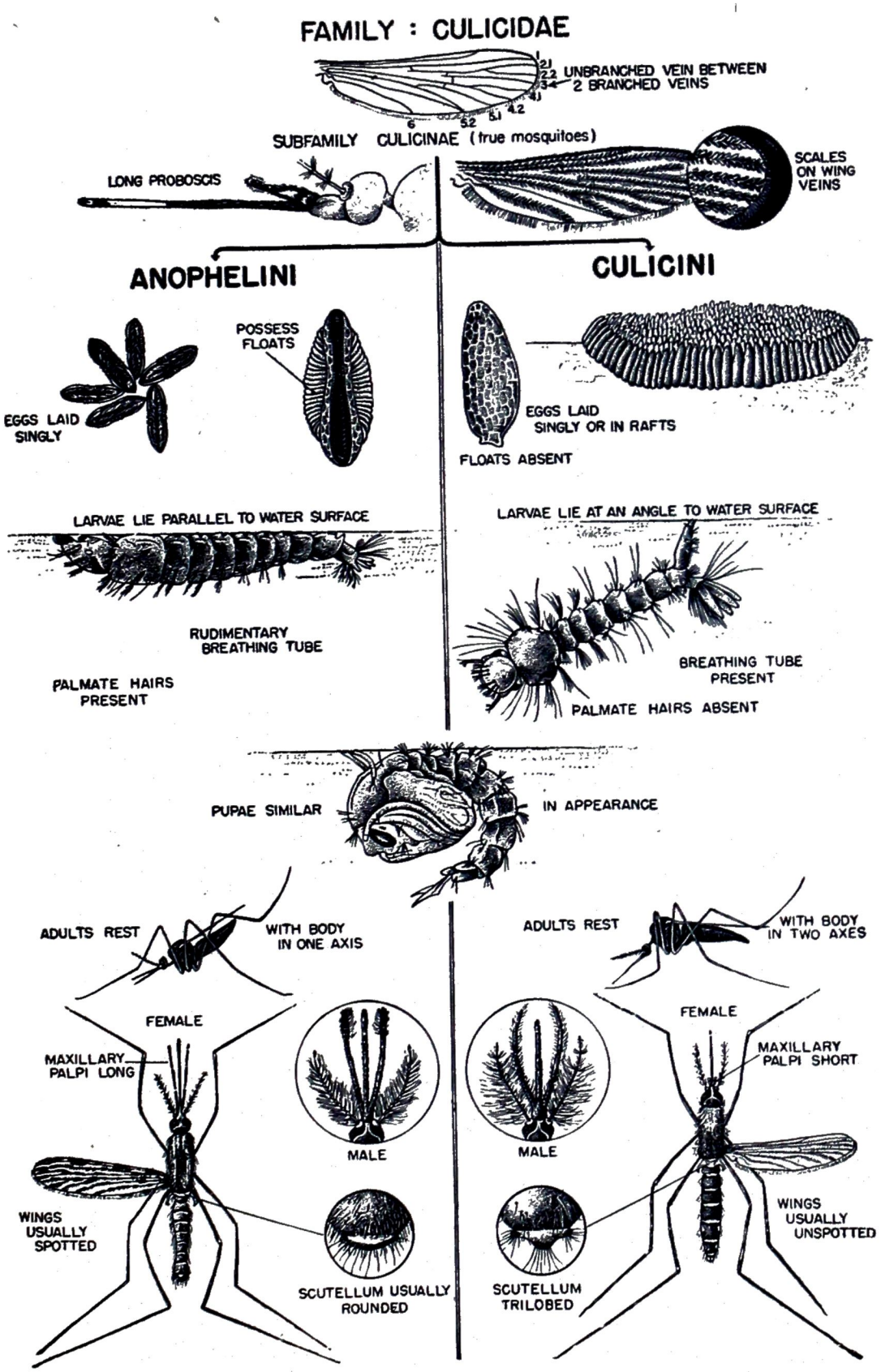
Edwards divides the family into three subfamilies: *Dixinae, Chaoborinae, Culicinae.* Only the latter is of medical importance. The subfamily Culicinae c tains about 1600 species, embodying the true mosquitoes, which are easily differ tiated from all other mosquito-like gnats by: (1) a long proboscis (as long as the head and thorax) and (2) scales located on the wing veins, along the posterior margin of the wings, and on the legs and body. The mouth parts of the females are adapted for piercing the skin and sucking blood (although some species do not bite man or animals). Males subsist primarily on plant juices and nectars.

For practical purposes, the subfamily may be divided into two tribes, the *Anophelini* and the *Culicini.* The tribe Anophelini is further divided into three genera, of which one, *Anopheles,* is of paramount importance. (The other two genera are restricted to definite geographic areas and are unimportant as vectors of malaria: *Chagasia* to South America and *Bironella* to the Australasian region). The tribe Culicini includes the great majority of the known species of mosquitoes; it is divided into a large number of genera and subgenera, with species often separated with difficulty.

It is to be expected that within this large group of insects considerable variation would exist in the life histories of the species, and it is not possible to select any one species as typical of the subfamily. In general, all mosquitoes in their immature stages are aquatic and undergo a complete metamorphosis: egg, larva, pupa, and adult. The larvae, or "wigglers," pass through four larval stages. With the fourth molt the pupa, or "tumbler," appears. This is a nonfeeding stage during which the adult structures are organized. Usually the pupal stage is quite short, the adults emerging in 24 to 48 hours.

The various species differ greatly in rate of development, feeding habits, resting sites of adults, mode of hibernation, and choice of breeding areas. Knowledge of this "species individuality" is of great importance in disease control, for it enables the entomologist to concentrate specific control measures against the particular, offending species—*species sanitation.*

Genus Aedes. Several species of *Aedes* are particularly well known because of their ability to transmit important tropic diseases. *Aedes aegypti,* a cosmopolitan species, is the important vector of urban yellow fever and dengue; *A. albopictus* is an oriental species known to transmit dengue in the Philippines and elsewhere in the Far East. The latter has recently been introduced into the Hawaiian Islands and is responsible for the transmission of dengue in that area (Usinger, 1944). *Aedes scutellaris* is typically Australasian in distribution, although recently one species of the *"scutellaris"* group was described from the Philippines (Stone and Farner, 1945). A member of this group has been proved to be the vector of dengue in New Guinea. Mackerras (1946) demonstrated that the outbreak of "jungle" dengue fever which occurred in New Guinea was transmitted by *Aedes hebrideus.* There are epidemiologic indications that island races of *A. hebrid* as well as other members of this *scutellaris* group vary in their ability to tr

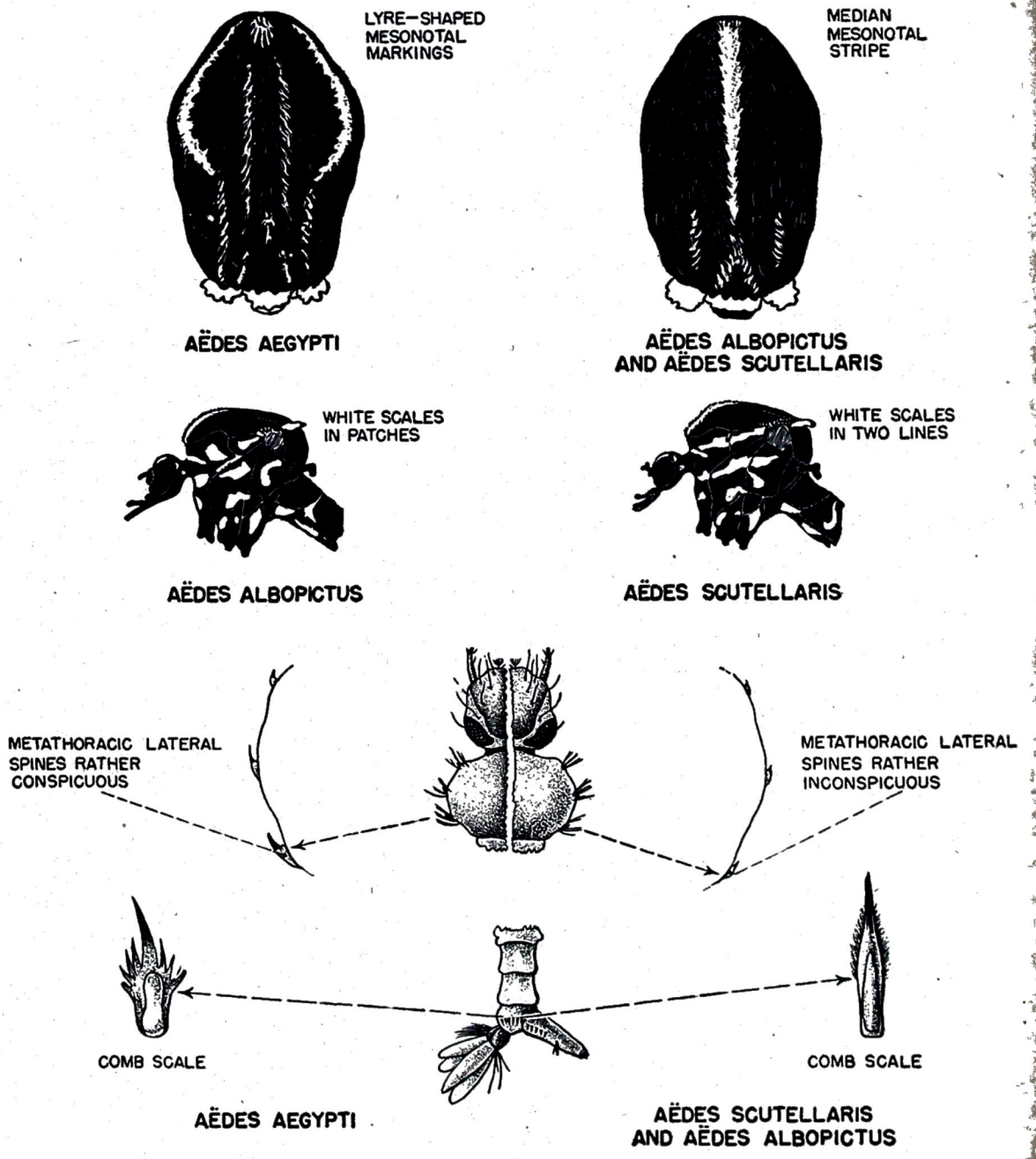


Tribal differences of the subfamily Culicinae (true mosquitoes).

dengue. *Aedes pseudoscutellaris* is the principal vector of filariasis and de in the Samoan-Fijian area. Several species of *Aedes* are involved in the tr mission of equine encephalomyelitis.

The three important species can be separated by the thoracic markings of adult; the mesonotum is marked by a lyre-shaped, silvery pattern in *Aedes aegy* but has only a median silver stripe in both *A. albopictus* and species of the *scute laris* group. All members of the latter have conspicuous white scales arranged i two parallel longitudinal rows in addition to several scattered spots; the closel related *A. albopictus* has white scales in scattered spots but never arranged in rows.

The larvae of all three species are very similar; those of *Aedes aegypti* are characterized by the conspicuous thornlike process at the base of the lateral metathoracic hair tufts and by the prominent secondary spines on the comb scales.



Diagnostic characters for distinguishing some medically important *Aedes.*

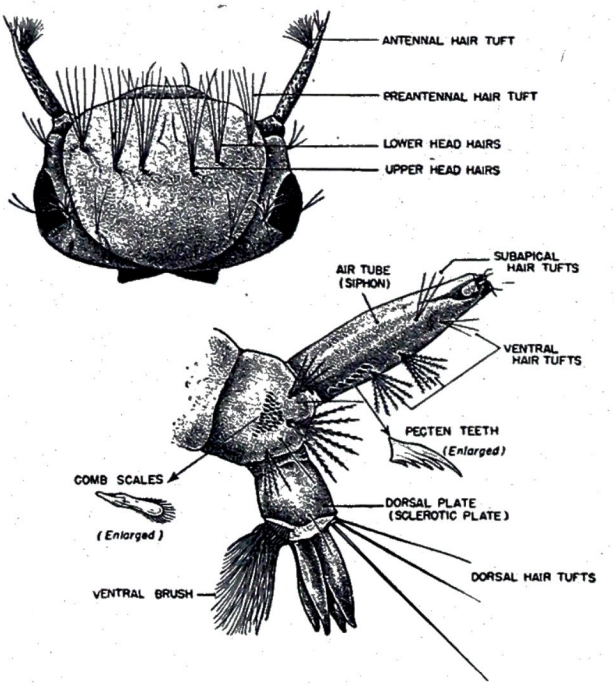
e of the extreme variability in the larval characters of *albopictus* and *scutel-s*, separation of the various species is rather difficult. It is best to make rear- and confirm tentative identifications by examination of male genitalia and adult characters.

The adults of most *Aedes* are avid biters, feeding throughout the day and ecially in the early morning or late afternoon. Many of them are relatively weak fliers, although some salt-marsh species are known to migrate 20 to 40 miles from their breeding grounds. Bonnet and Worcester (1946) in studying the dispersal flights of *Aedes albopictus* in Hawaii found the ordinary range of flight activity to be 200 yards or less. Similar observations have been made on *A. aegypti* and members of the *scutellaris* group. Eggs are generally deposited on the ground along the margins or dried bottoms of pools, ponds, marshes, and swamps, or above the water level on the sides of various types of containers, such as tin cans, coconut husks, tree holes, cut bamboo stalks, leaf axils, or other natural cavities. These catchments may dry out completely and the eggs will remain dormant for weeks or months. When the water levels are raised the eggs become flooded and hatch almost immediately. Those of some of the northern species will not hatch during the season deposited, but remain submerged to incubate and emerge in one great brood the following spring.

GEOGRAPHIC DISTRIBUTION OF *Aedes aegypti*, *A. albopictus*, AND SPECIES OF THE SCUTELLARIS GROUP

Aedes aegypti (yellow fever and dengue)	World-wide in tropic and subtropic climates
Aedes albopictus (dengue)	Oriental region; also in Celebes, Dutch East Indies, northern Australia (?), New Guinea (?), Hawaiian Islands (introduced)
Aedes scutellaris and closely related species (some or all may carry dengue)	Australasian region
A. hebrideus	Solomon Islands, New Guinea, Palau Islands, Dutch East Indies, Moluccas, Philippines, New Hebrides
A. pseudoscutellaris (bancroftian filariasis)	Samoa, Fiji, Ellice Islands, Marquesas Islands, Society Islands
A. tongae	Friendly Islands, Sikiana (Solomons)
A. andrewsi	Christmas Island
A. horrescens	Fiji
A. pernotatus	New Hebrides
A. guamensis	Marianas
A. hensilli	Carolines
A. alorensis	Lesser Sundas
A. paullusi	Sangir Island, Philippines
A. quasiscutellaris	Solomon Islands
A. marshallensis	Marshall Islands, Gilbert Islands
A. riversi	Okinawa, Ryukyu Islands

CONTROL. Control of these species is best accomplished by eliminating breeding places. Since nearly all of the disease-bearing *Aedes* are domestic their breeding habits, it is important to make weekly inspections of habit and camps. Tin cans, bottles, jars, pails, old tires, sagging eave troughs, rain b rels, fire buckets, and cisterns are likely sites. *Aedes aegypti* is not comm found in tree holes, differing from members of the *scutellaris* group and *A. albopi* in this respect. When artificial containers cannot be eliminated, they should screened or covered to exclude mosquitoes and inspected once each week to dete the presence of larvae. In open wells, water barrels, or cisterns, a light volatile oil, such as kerosene or nonleaded gasoline, will kill larvae quickly; these compounds readily evaporate, leaving the water suitable for drinking or washing purposes.



Anatomy of a culicine larva (*Culex quinquefasciatus* illustrated).

GENUS CULEX. *Culex quinquefasciatus* (syn. *C. fatigans*) is the common, brown, house mosquito and is an important pest in the warm temperate, tropic, and subtropic regions of the world. The adult is one of the important vectors of *Wuchereria bancrofti*. *Culex pipiens* is a vector of filariasis in Egypt, China, and Japan; it is a common house mosquito in the United States and has been shown to be a capable vector of *W. bancrofti* by Newton and Pratt (1946). *Culex tarsalis* has been found naturally infected with the western strain of equine encephalomyelitis and with human encephalitis in the United States. *Culex tritaeniorhynchus* is a known vector of Japanese B encephalitis.

There are about 300 species of mosquitoes in the genus *Culex*, and, like *Aedes*, they represent a very common group in most collections. The genus has b broken up into numerous subgenera, and frequently it is impossible to ide the females of the subgenera with any degree of certainty. Species of *Culex* rather dull-colored, and the mesonotal ornamentation, as found in many of

nt *Aedes* (subgenus *Stegomyia*), is lacking. The larvae of *C. quinquefasciatus* breed by preference in artificial containers; those of *C. pipiens,* also a ticated species, are found in rain barrels, cisterns, and polluted grassy pools swamps.

CONTROL. Domestic species of *Culex* may be controlled by removing or overturning all water-holding containers; breeding in cisterns and wells can be reduced by screening, spraying with kerosene, or introducing surface-feeding fish.

GENUS ANOPHELES. Probably no other group of insects has received so much attention as the anophelines, for they alone are responsible for the transmission of malaria, the most important of all arthropod-borne human diseases. In some parts of the world, certain anophelines are also important vectors of filariasis (*Wuchereria bancrofti* and *W. malayi*). The recent work of Byrd and St. Amant (1945) indicates that *Anopheles farauti* is the important vector of *W. bancrofti* in the area of the New Hebrides and Solomon Islands in addition to being the primary malaria vector in that region.

Not all anophelines are natural vectors of malaria; Hackett and Russell (1938) state that of the 175 odd species which may be considered as potential vectors, the great majority are rendered harmless in nature because their biting habits do not bring them into frequent and, especially, repeated contact with man.

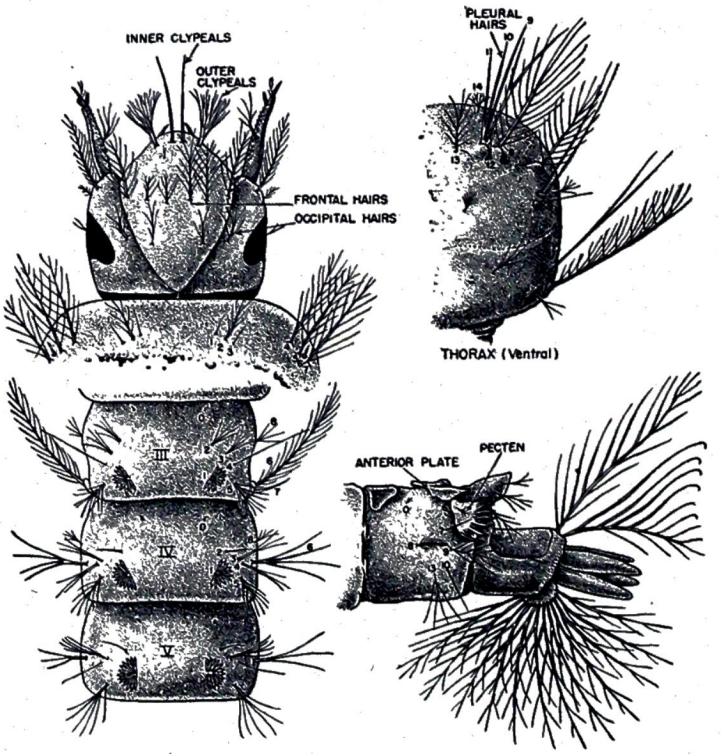
Among the factors that may be important in determining whether a given anopheline is an efficient vector of malaria or filariasis are: the type of breeding place or places and their distance from human habitations; the usual length of flight and the tendency of the adult mosquitoes to enter houses; the occurrence, abundance, and seasonal prevalence of the anophelines; their inclination to bite and their time of feeding; the susceptibility of the mosquito to infection and the choice of hosts (man or animals) as determined by precipitin tests; and the sporozoite or filarial index.

The great majority of the species conform to the commonly recognized pattern of "spotted-wing mosquitoes." Unlike the culicines, the females have maxillary palpi about as long as the proboscis, an important criterion in separating the two tribes. The scutellum is evenly rounded or crescent-shaped; the abdomen does not have scales on the first abdominal tergite (or at least the sternites are bare); and the legs are long and slender. The larvae have rudimentary breathing tubes and lie parallel to the under surface of the water. Palmate hairs are usually present, at least on the abdomen.

The life histories show much variation within the genus; it is generally felt that the time required for development is longer than that for most other genera. The life cycle of the anopheline mosquitoes under favorable conditions usually varies from 14 to 21 days, although some species may hibernate in the egg, larval, or adult stage. In the Tropics where breeding is relatively continuous throughout the year, the number of days required for completion of the aquatic stages may be materially reduced so that the life cycle may not take over 10 days. Most of the species probably prefer the comparatively pure, quiet, fresh water of pools, ponds, marshes, streams, and swamps; some prefer polluted water;

others may breed in the axils of water-holding plants; still others select sw flowing streams with or without marginal vegetation; a few are able to breed brackish water.

The classification of mosquitoes is steadily undergoing changes which follo the progress of the science of medical entomology. The scope of the present dis cussion does not permit the inclusion of large keys necessary to identify anopheline mosquitoes of the world. The following pictorial keys to the larv and adult anophelines will separate the several species occurring in the United States (see pp. 696, 697).



Anatomy of an anopheline larva (*Anopheles quadrimaculatus* illustrated). (Redrawn after Ross and Roberts.)

CONTROL. In planning mosquito control as an antimalarial measure, it is important to recognize the different species of *Anopheles* that are efficient vectors in the area concerned. As already stated, only a few species are active vectors of the disease; in the United States and Europe only two or three species are of primary importance. Different races of *A. maculipennis* are the most important in Europe, as are *A. quadrimaculatus* and a variety of *maculipennis* in the United States. In India, Russell (1939) reports that about 13 species are still under suspicion.

There are three important methods in the prevention of malaria, all of which were combined in the earlier campaigns against this disease in the Canal Zon in Panama and more recently in the extensive control throughout the Pac Islands: (1) Protection of the individual from bites of mosquitoes. (2) Destru tion of adult mosquitoes and their breeding areas. (3) Chemical prophyla (Harper, Lisansky, Sasse, 1947). Of these three, only (1) and (2) apply to mosquito vector and will be briefly summarized.

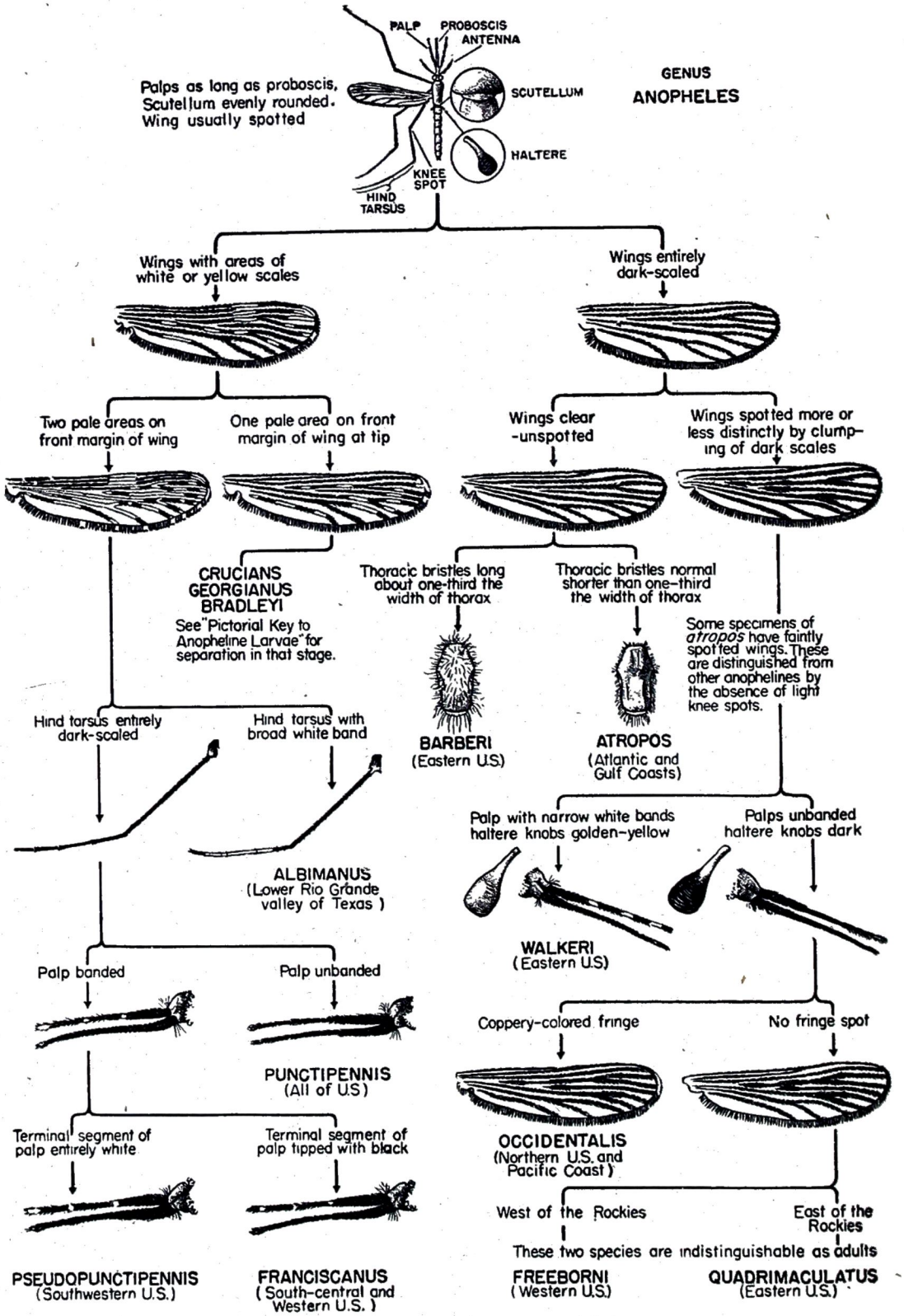
ion of the Individual from Bites of Mosquitoes. These measures primarily de using bed nets, insect repellents, and proper screening (18-mesh); remov- adult resting places; wearing proper clothing; avoiding malarious areas; and wing other personal protective measures to preclude the passage of the aria parasite from man to mosquito and from mosquito to man, thus inter- ting the transmission cycle. Education regarding the dangers of malaria and e method of infection also has been of considerable importance in this respect; ell (1941) has discussed some of the social obstacles to malaria control.

Destruction of Adult Mosquitoes and Their Breeding Areas. The basis of rmanent prophylaxis against malaria in a given region must depend upon the struction of the particular species of *Anopheles* which is involved in the spread the disease in the region concerned. Control measures should be directed ward the larvae, pupae, and the fully developed insects. Against the adults, spray- g with the various available insecticides will result in an appreciable reduc- in transmission of the disease. The possibility of airplanes and ships intro- cing malaria into a country, by carrying infected anophelines from an endemic ter, should not be overlooked. In all probability, *A. gambiae* crossed the an from Dakar, either by aircraft or fast destroyer, and was introduced into uth America. This efficient vector resulted in transmission of malaria to over per cent of the population in Ceara and Rio Grande Do Norte. According to e Rockefeller Foundation, mortality in certain districts amounted to 10 per t; a subsequent report states that there were more than 5000 fatal cases. Such dental introductions can be avoided if all vehicles from endemic centers are ted with pyrethrum sprays, both on arrival and on departure.

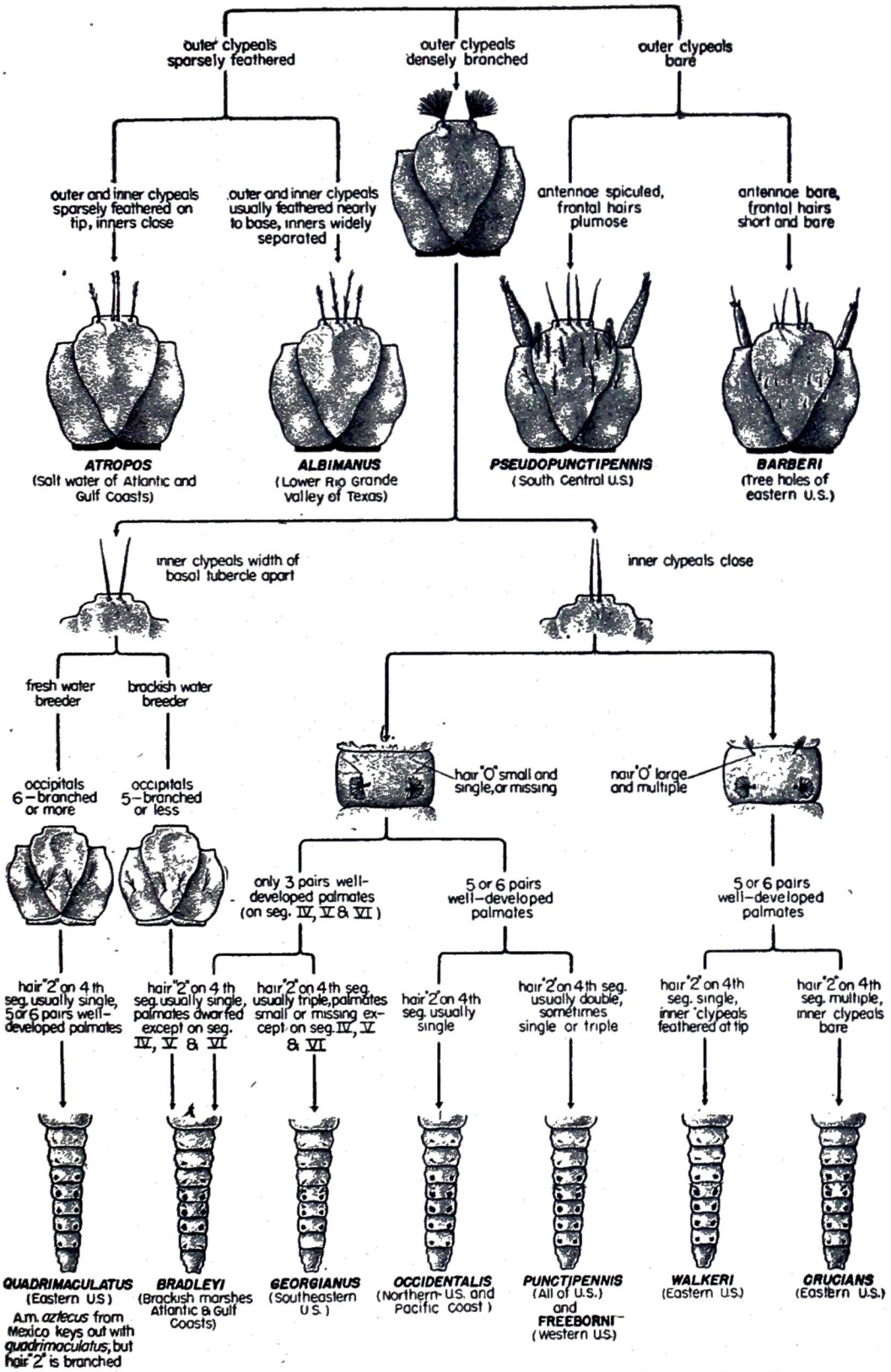
Against the larvae, permanent control measures are preferred to temporary ones. elimination of mosquito-breeding areas may be accomplished by filling, ining, or stream-clearing. In different parts of the world, extensive sanitary neering projects for permanent drainage have been carried out with con- erable success, but such procedures are not feasible in many localities and little ss has been obtained in others.

ccording to Watson (1940), on many estates in India much malaria is en- ly attributable to man's interfering with nature by clearing away jungles and ams and exposing them to sunlight. By so doing, the harmless species have driven out and the breeding of dangerous ones permitted, as *Anopheles imus* in the north, *A. fluviatilis* or *A. culicifacies* at different elevations in the . The elimination of "man-made" breeding areas of *A. farauti* (syn. *moluc- sis*) in the New Hebrides-Solomon Islands region was one of the major prob- s in the control of this vector of malaria among military forces during World II (Perry, 1946). Nearly 75 per cent of the breeding of this species was cted to such artificial catchments as road ruts, improperly constructed road- ditches, and similar areas.

rainage should never be attempted without consultation of capable medical ologists, field malariologists, and sanitary engineers. Faust (1937) points out within recent years relief drainage, carried on without the supervision of



Pictorial key to the adult female anophelines of the United States. (Redrawn after Daggy, courtesy U. S. Public Health Service.)



Pictorial key to the larval anophelines of the United States. (Redrawn after Knutson, courtesy, U. S. Public Health Service.)

sanitary engineers or entomologists, has increased the breeding places of *Anop quadrimaculatus* in the southern United States, with consequent outbreaks of disease in previously nonmalarious areas. Especial attention has been devoted the Division of Malaria Control of the Tennessee Valley Authority to the prepar tion of reservoirs before the impoundage, effort being made to present a cl water surface after filling. With the successful employment of fluctuation water level as an antilarval measure, various accessory control procedures ha been utilized more extensively. It has been shown that marginal drainage, shor line improvement (drift removal), and herbicide work are essential to secure maximum results from variation of water fluctuations.

When filling, drainage, or clearing is not practicable, the spraying of water surfaces with chemical larvicides is generally practiced. Paris green, diesel oil ⅍2, kerosene, or DDT are useful in controlling anopheline larvae. The methods of application and amounts to be used vary under different conditions; in most instances, directions for use are supplied with the organic larvicides. In airplane distribution of dusts or sprays, many problems are encountered.

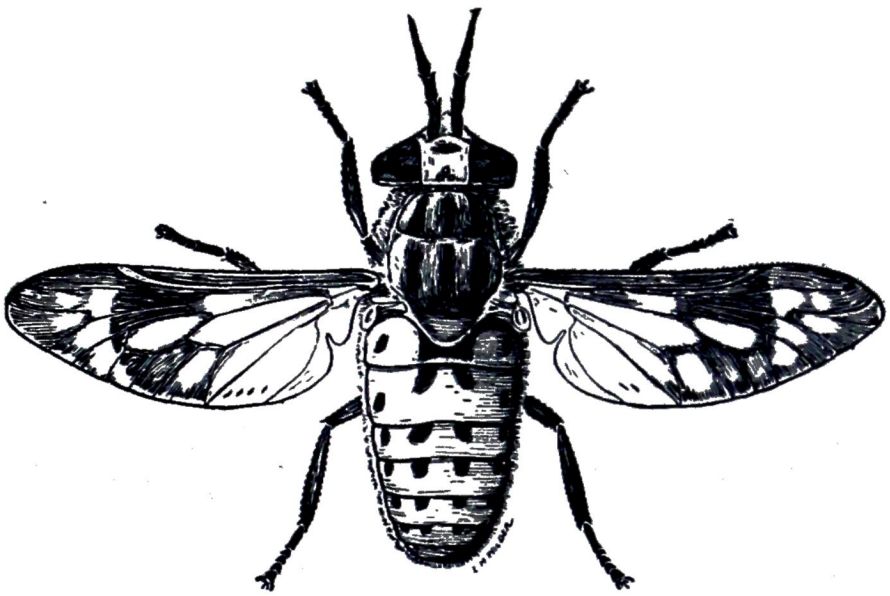
More details in regard to the description of species of anophelines and their control as vectors of malaria are beyond the scope of this text. Information compiled from antimalarial campaigns, particularly on the experience gained by malaria control and survey organizations of the Armed Forces, is well recorded by Russell, West, and Manwell (1946). The important features of practical malariology, integrating the newer developments with older information, are therein presented, and an excellent account of the basic elements of each phase of the subject is clearly defined. Publications dealing with the use of DDT as an insecticide are available through the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

Horse Flies, Deer Flies (Suborder Brachycera)

Of the recognized 17 families in this suborder, only one, the *Tabanidae,* is of medical importance. There have been occasional reports of some species in the family Rhagionidae biting man, but the habit is an exception rather than the rule. Many species of tabanids may act as mechanical vectors of disease, the organisms not developing or multiplying within the body of the flies. *Chrysops discalis,* the western deer fly, was shown by Francis and Mayne (1921) to convey *Pasteurella tularensis* in this way to man and animals. Tabanids have been suspected as vectors of espundia (*Leishmania brasilensis*) in the forested regions of Brazil and Paraguay. *Chrysops dimidiata* and *C. silacea* serve as the intermediate hosts of *Loa loa* in tropic Africa.

Biology and Morphology. Members of the family Tabanidae are usually large or medium-sized flies with robust bodies and large eyes. The antennae are porrect and variable in structure, always three-segmented; the third joint is often annulated. In most of the genera the antennae are short, although in members of the genus *Chrysops* they are longer than the head.

The eggs are deposited in masses on water plants and grasses overhan



Chrysops discalis, the deer fly or green-head.

marshy areas. The carnivorous larvae are usually aquatic and are to be found in the muddy bottoms of swamps, ponds, and streams. Adult males live upon plant juices. In some of the genera—*Tabanus, Haematopota, Pangonia,* and *Chrysops*—the females are well-known for their blood-sucking habits.

TABANUS. There are over a thousand species in this genus. The three-segmented antennae are shorter than the head; ocelli are absent; the wings are usually clear, but spots and bands may be present; spurs are absent at the ends of the hind tibiae.

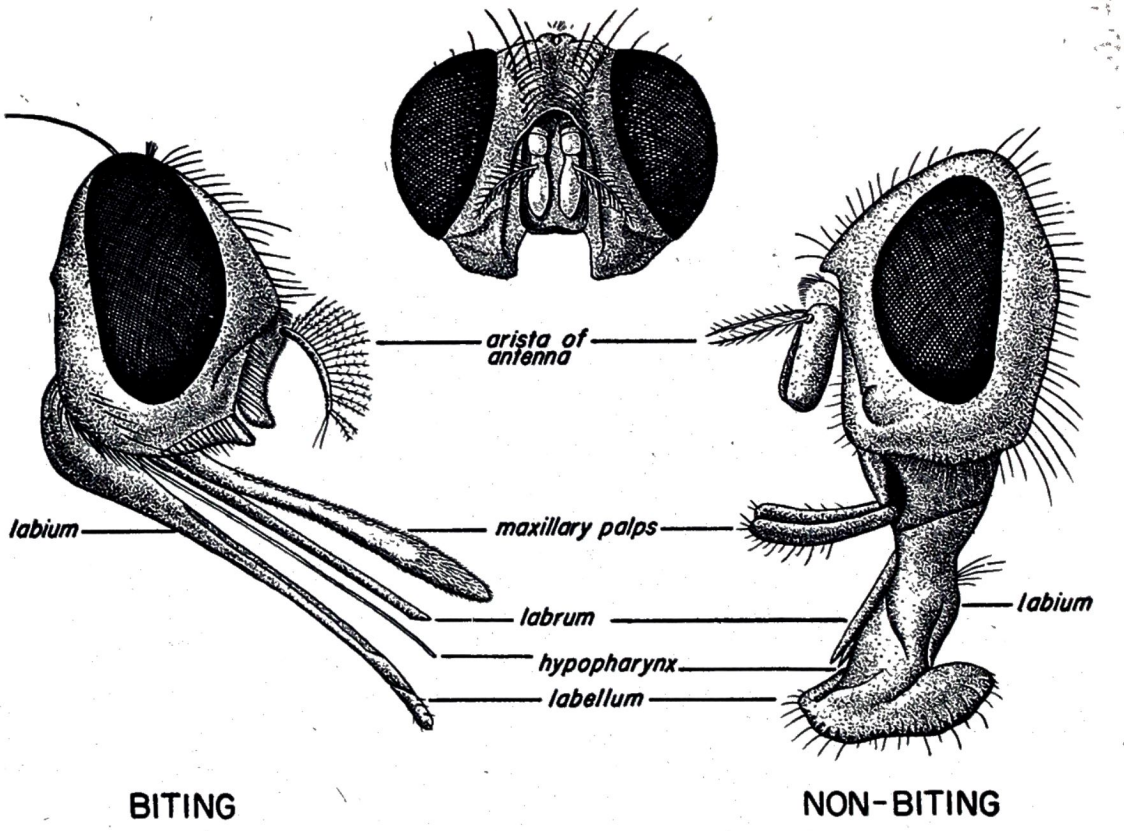
CHRYSOPS. The conspicuous markings on the wings, the long antennae, and marked ocelli (three in number) are characteristic of this genus. The second segment of the antenna is as long as the first; the third segment has four annulations. The hind tibia has small spines at the tip.

CONTROL. Effective control is difficult; drainage of swamps where tabanids are breeding has limited value. Repellents are not too effective. A hymenopterous insect which attacks the egg masses has been introduced into some sections of the United States and is giving promising results.

TSETSE FLY, HOUSE FLY, GREEN BOTTLE FLY (SUBORDER ATHERICERA)

The members of this suborder comprise a large number of medium to small flies. They may be separated from members of the previous two suborders by their antennae which are rather short and never have more than three segments. The distal one bears an *arista* on its base. Dipterologists have broken this suborder into several families; for practicality and convenience the suborder is here divided into two categories according to mouth-part structure, and the terms *biting* and *nonbiting* flies are used to separate the medically important groups.

The *biting* forms have a rigid chitinized structure, the *labium,* which forms the piercing organ. This beaklike proboscis normally projects forward when not use. The labium of the *nonbiting* forms consists of a rather flabby mem-



Mouthpart structure of biting and non-biting flies (suborder Athericera).

branous structure suspended from the lower part of the head which may be pulled up or extended at will. The broad, flattened, pincushion-like *labella* at the tip of the proboscis are not capable of piercing the skin. Spines and teeth on the labellar lobes enable a few species to scrape or even puncture the skin of man or animals.

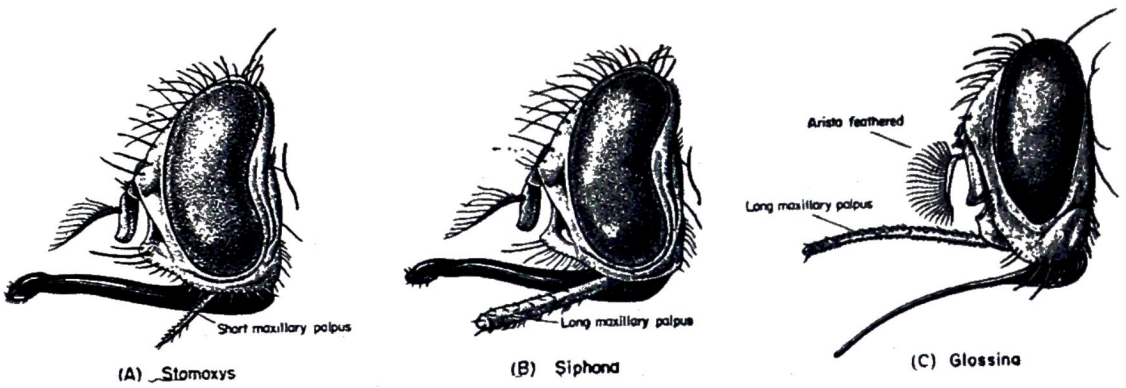
BITING FLIES

Stable Fly, Dog Fly. Members of the genus *Stomoxys* closely resemble the house fly and are erroneously referred to as "biting house flies." *Stomoxys* has frequently been used in experimental transmission of disease, but there is no conclusive evidence that it is a vector in nature. Larvae are found breeding in decaying piles of hay, straw, lawn clippings, and in cast-up seaweed along beaches. They are known to breed in animal wastes but never in human excrement. Macgregor (1945) has reported a case of accidental intestinal myiasis caused by ingesting food contaminated with eggs of this species.

Horn Fly (Genus *Siphona*). This is a serious pest of cattle and occasionally attacks man. It closely resembles the house fly, but is only about half as large.

Tsetse Fly (Genus *Glossina*). This genus is limited to tropic Africa and includes about 25 species. These flies are peculiar in that the female is viviparous, producing a single, very large, fully developed, yellowish-brown, motile larva. The larvae are deposited in shady, sandy soil. Pupation takes place almost immediately.

Glossina palpalis is the principal vector of West African sleeping sickness (due



Heads of three important biting flies (suborder Athericera).

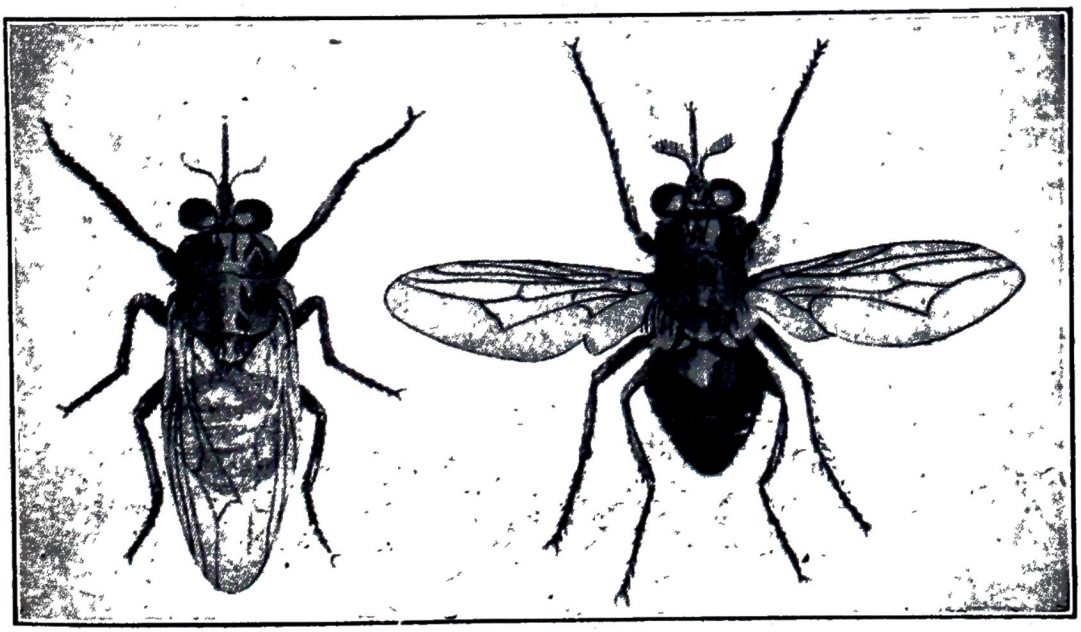
to the parasite *Trypanosoma gambiense*); *G. morsitans* is the transmitter of the East African form of the disease (due to *T. rhodesiense*) in Rhodesia, the Sudan, and the Belgian Congo. *Glossina tachinoides,* which Lester (1936) reported to be more frequently infected with *T. gambiense* in nature than *G. palpalis,* is found in a belt along the southern border of the Sahara from the Atlantic to Arabia.

CONTROL. The control of tsetse flies is difficult considering the long flight range of adults and the habits of the female in depositing larvae. Known fly belts should be avoided; screened quarters and the wearing of white clothing are the best prophylactic measures.

NONBITING FLIES

The dividing line between families of this group is not always clearly defined; some genera have been shifted from family to family, while others are still awaiting permanent assignment to their correct group. It is impossible to discuss the species in detail; only the more common and important genera will be considered.

The house fly and many of its relatives are common agents in the mechanical transmission of certain infections which are often grouped under the term "fly-



Glossina palpalis in natural resting position and with wings outstretched. (MacNeal, after Doflein.)

borne diseases." The spongelike mouth parts, the numerous body spines, and sticky pads on the feet of these flies have been found to carry a large number different pathogens. Some of these disease organisms may pass unaltered throu the digestive tract and remain viable in the feces or "fly specks." The method feeding has an important bearing on the house fly's ability to transmit disease organisms. The secretions regurgitated during this act may harbor typhoid and cholera bacilli, or contain the pathogens causing amebic or bacillary dysentery which are thus transferred to food and milk. In the same manner, the spirochetes of yaws may be transferred by flies feeding on the ulcer and then depositing the organisms on scratches or skin abrasions of healthy individuals; likewise, the causative agent of trachoma may be spread by flies feeding on soiled bandages or on infective matter in the eyes of patients. Members of the genus *Hippelates* (the eye gnat) are attracted to man to feed on lacrimal secretions, open sores, cuts, and ulcers. Herms (1926) reported them as being very common in the Coachella Valley in California where they were important transmitters of organisms causing various types of conjunctivitis.

It should be emphasized that these filth flies may easily carry the pathogens found in excrement, sputum, open sores, or putrefying matter to food, milk, healthy mucous membranes, or to uncontaminated wounds.

The larvae of many of the genera may accidentally become internal parasites of man, producing a condition called *myiasis*. Clinically, the types of myiasis may be classified according to the part of the body invaded. Thus, when the invasion involves the intestinal tract, it is referred to as "intestinal myiasis"; when it involves the skin, "cutaneous myiasis." Other types are urinary, ophthalmic, auricular, and nasal myiases.

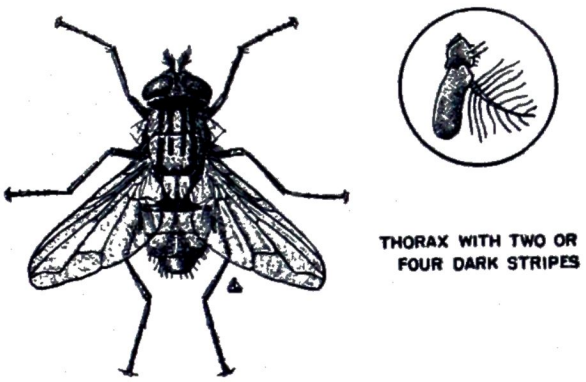
Musca Domestica. The common house fly is the most familiar representative of the order Diptera. The eggs are laid in masses of 75 to 150. A single female is able to lay as many as 21 batches in a single month after emergence.

Control. House-fly control is mainly directed toward the suppression of fly breeding, but also includes measures against adults, as well as protective devices designed to exclude flies and prevent them from contaminating food.

Manure, particularly that of horses and hogs, constitutes one of the principal breeding places, and its proper disposal is of great importance. It can be sprayed with a DDT-water emulsion in concentrations as low as 0.1 per cent to kill any fly larvae which may develop. Fly breeding in human excreta is particularly dangerous; wherever possible, toilets should be carefully fly-proofed. In temporary camps the use of trench latrines and prompt covering of feces are extremely important in reducing breeding. Applications of DDT to the feces for larval control is neither economical nor effective. Sodium arsenite is a powerful and cheap poison and 1 gallon of the concentrate, mixed with 40 to 80 gallons of water, will give excellent control for flies and fly maggots. Paradichlorobenzene, if available, is effective only if used in deep pits which are well sealed.

Neglected garbage furnishes excellent breeding material. Refuse cans should be available, kept tightly covered, and thoroughly cleaned when empty. Garbage

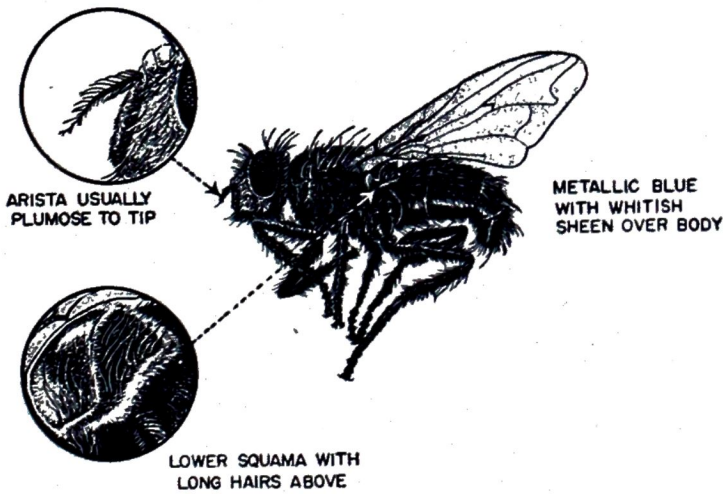
buried, or disposed of at sea some distance off shore. Screens, flytraps, poisons, flypapers, and flyswatters are all important measures against . Baited traps should be placed near galleys, mess halls, garbage racks, and



Musca domestica, the common house fly. (Courtesy, Dr. S. P. James, U. S. National Museum.)

trines. The use of DDT as a residual spray is probably more effective against ılt flies than against any other group of insects. A 5 per cent solution in kero- or water emulsion should be applied just short of dripping to the surface re flies tend to concentrate. Screens should be hand painted with this solu-

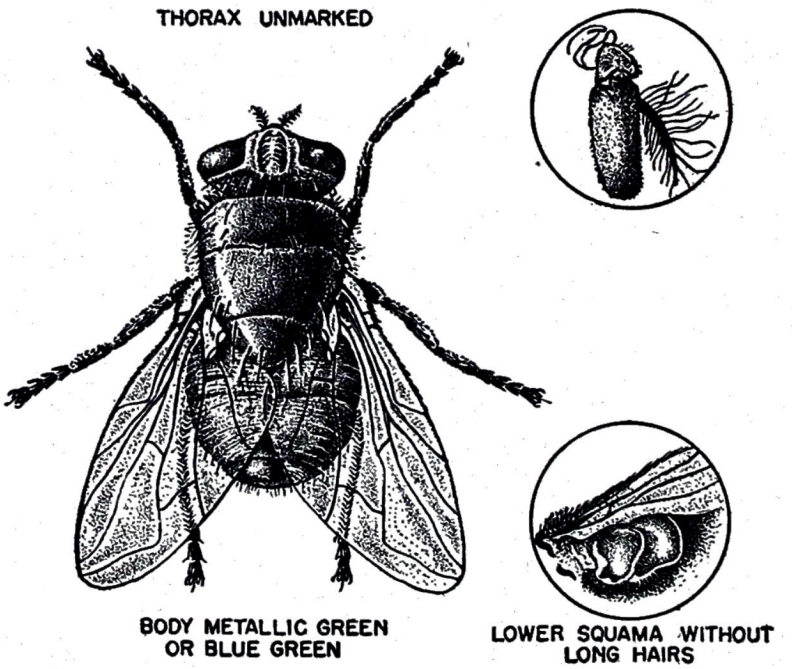
iphora. Members of this genus are rather large, about 10 to 15 mm. long, are frequently called "blow flies" or "blue bottle flies"; they have red eyes; body is blue in color and exhibits a slight metallic luster. *Calliphora erythro-*



Calliphora erythrocephala, the blue bottle fly.

hala (red cheeks with black hairs) and *C. vomitoria* (black cheeks with red s) are two widely distributed species which are common in most parts of the ld. These forms normally deposit ova on exposed food or decaying animal vegetable matter of any kind, as well as in open wounds or ulcers of animals occasionally, of man.

Lucilia. Members of this genus are small, about the size of the house fly. T are world-wide in distribution with habits somewhat like *Calliphora.* The ad are usually metallic green in color, often being called "green bottle" flies. *Luci sericata,* distinguished by its yellow palpi, is a frequent cause of intestinal myiasi *L. caesar* is less actively parasitic. The larvae of both species (and also of *Phormi regina,* the wool maggot or black blow fly) have been used extensively in the treatment of osteomyelitis, although all are capable of injuring healthy tissue. Stewart (1934) has particularly shown that *L. sericata,* which has been widely used as a surgical maggot because it appeared to be exclusively saprophagous, will attack and invade healthy living tissue.

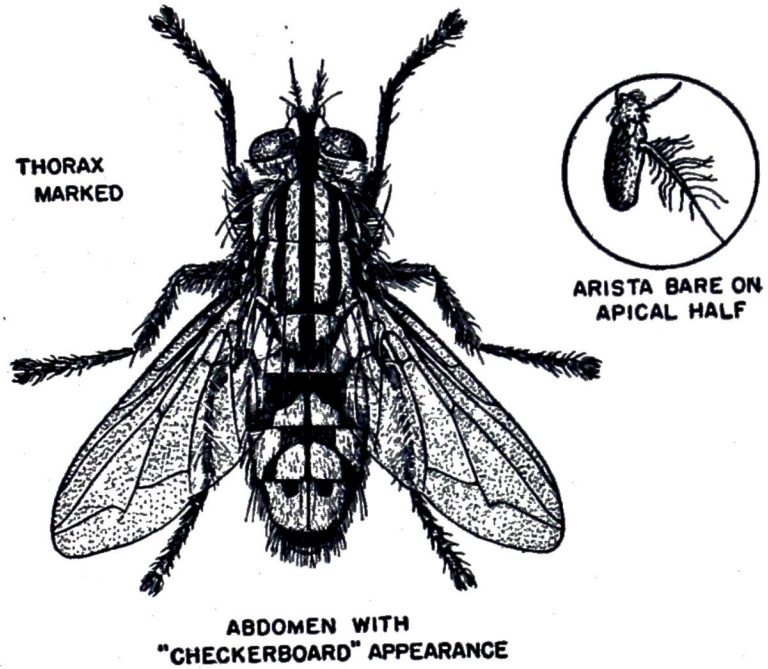


Lucilia sericata, the green bottle fly.

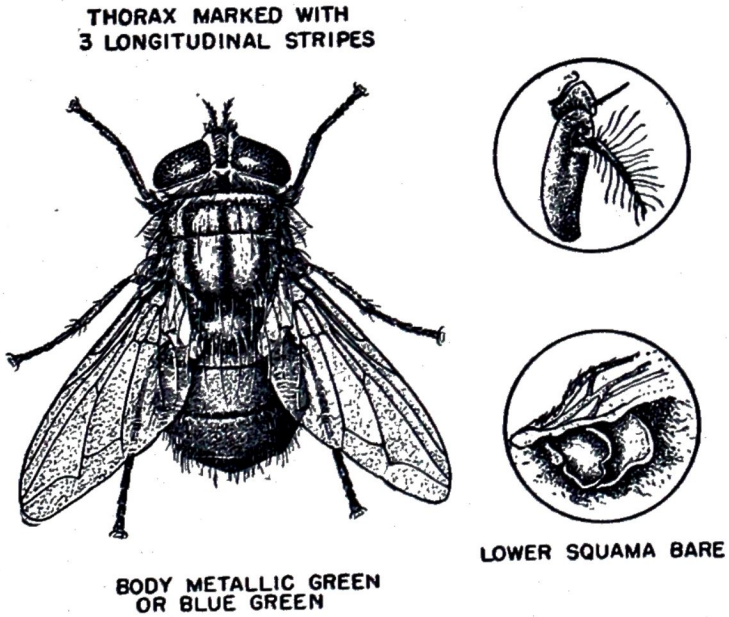
Sarcophaga. Species belonging to this genus are usually distinguished by their rather large size. The thorax is striped and the abdomen commonly marked with dark areas in a "checker-board" fashion. The adults, commonly called "flesh flies," are frequently observed about garbage and decaying animal matter. The larvae have been recorded living as parasites in sores and in the nasal cavities and intestinal tracts of man and animals. The genus is peculiar in that some species are viviparous. The larvae have powerful, curved mouth hooks; the stigmal plates are set in a deep cavity at the posterior end of the body.

Cochliomyia. The adults of this genus superficially resemble the green bottle flies (*Lucilia*) but may be recognized by the three longitudinal dark stripes on the thorax. Two species, *C. americana* and *C. macellaria,* are of particular interest, for the larvae are known to be important producers of several types of myias *Cochliomyia americana* is found in the southwest United States and through the American tropics. *Cochliomyia macellaria* is frequently found in associati with *C. americana,* but it appears to be a secondary invader. Eggs of *C. mace*

often deposited in carcasses of animals; the larvae normally confine their ac- to necrotic tissues.



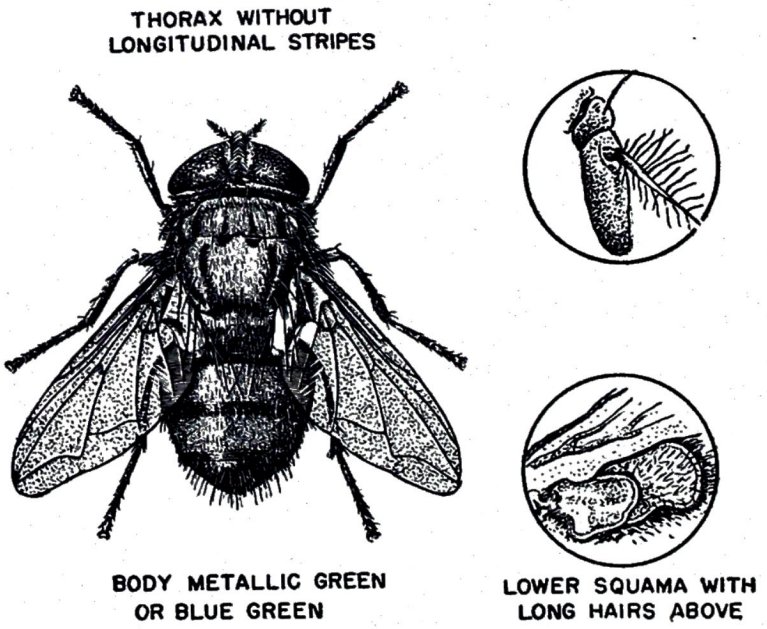
Sarcophaga haemorrhoidalis, the flesh fly. (Courtesy, Dr. S. P. James, U. S. National Museum.)



Cochliomyia americana, the primary screw-worm fly. (Courtesy, Dr. S. P. James, U. S. National Museum.)

Musca Sorbens. Throughout the Central and South Pacific Islands this fly has become the most objectionable pest in and about camp areas. It breeds primarily cow dung and horse manure and occasionally in human excrement. It is readily acted to open sores and wounds and in Mesopotamia it is known to be an rtant transmitter of various types of conjunctivitis.

Chrysomyia. These flies resemble *Cochliomyia* but may be generally sep by their different geographic distribution. The genus is confined to Africa, isl of the Pacific (including the Philippines), Australia, and certain sections of As They are medium-sized flies of a light metallic green or blue-green color. T larvae are frequently reported as parasites of sheep and are known to cause a disfiguring myiasis of man. The adults are readily attracted to bleeding surfaces and will oviposit in the ears and nostrils of persons having offensive discharges.



Chrysomyia bezziana, the Old-World screw-worm fly. (Courtesy, Dr. S. P. James, U. S. National Museum.)

Wohlfahrtia Magnifica. The larva of this species is a common cause of cutaneous myiasis in the Old World. Its habits are like those of *Cochliomyia americana.* The larvae are deposited on the skin or about the eyes and, at least in young children, they may penetrate the unbroken surface. Several cases of myiasis due to *W. vigil* have been reported in North America.

Dermatobia Hominis. This is a large, thick-set fly about 15 mm. long, with prominent head and eyes, small antennae, and a marked narrowing at the junction of the grayish thorax and metallic-blue abdomen. The species is widespread in tropic America, living in damp forested regions. When ready to oviposit, the flies capture *Psorophora* mosquitoes as they emerge from the pupa (and occasionally other biting or nonbiting Diptera or even ticks) and deposit 15 to 25 eggs on the ventral side of the abdomen, gluing them to it in such a position that the point of emergence of the larva is directed away from the mosquito. When the mosquito contacts either man or other warm-blooded animals in the process of biting, the larva is stimulated to emerge; it then burrows through the puncture wound into the subcutaneous tissue by means of its powerful mouth hooks. Here it develops into a club- or flask-shaped structure (ver macaque), later becoming more cylindrical (called "torcel" in Venezuela, and "berne" in Brazil). It girdled by several rows of prominent spines. As the larva grows, a tumor

g develops with a central orifice toward which the posterior (pointed) ity of the larva projects and through which it takes air into its spiracles. a period of 7 to 15 weeks, it leaves the tissues and burrows into moist soil to pupate. Harrell and Moesley (1942) point out that the larvae may at times burrow deeply into vital tissues.

Auchmeromyia Luteola. The larva of this species is the blood-sucking "Congo floor maggot." It is about 16 mm. long and has a dirty-white, thick, leathery, wrinkled skin; otherwise, it resembles the larva of *Musca domestica.* The adult fly deposits her eggs by preference in the dry dust of cracks on the floor of native huts. The larvae hatch in a few days and seek blood within a few hours, crawling out at night to feed on sleeping natives. They are said to survive for a month without food. This is the only known instance of a blood-sucking larva which attacks man. (Other species of blood-sucking larvae infest the nests of birds and the burrows of certain mammals). Attacks of these maggots may be avoided at night by sleeping on a cot a few inches above the floor.

Cordylobia Anthropophaga. The larva is known as the "African skin maggot," or "ver du Cayor." The ova are deposited in dry sand, occasionally on clothing, but not directly on the skin. After three or four days the larva emerges and by means of its mouth hooks attaches itself to the skin of the first animal with which it comes in contact, most often a rat or a dog, but quite frequently a child. The larva bores its way painlessly into the skin and produces a lesion like a boil which has a central opening through which the larva breathes. It resembles the ver macaque, is somewhat barrel-shaped, and beset with small spines. Twelve to 14 days after penetration it leaves the body of the host and pupates in the soil.

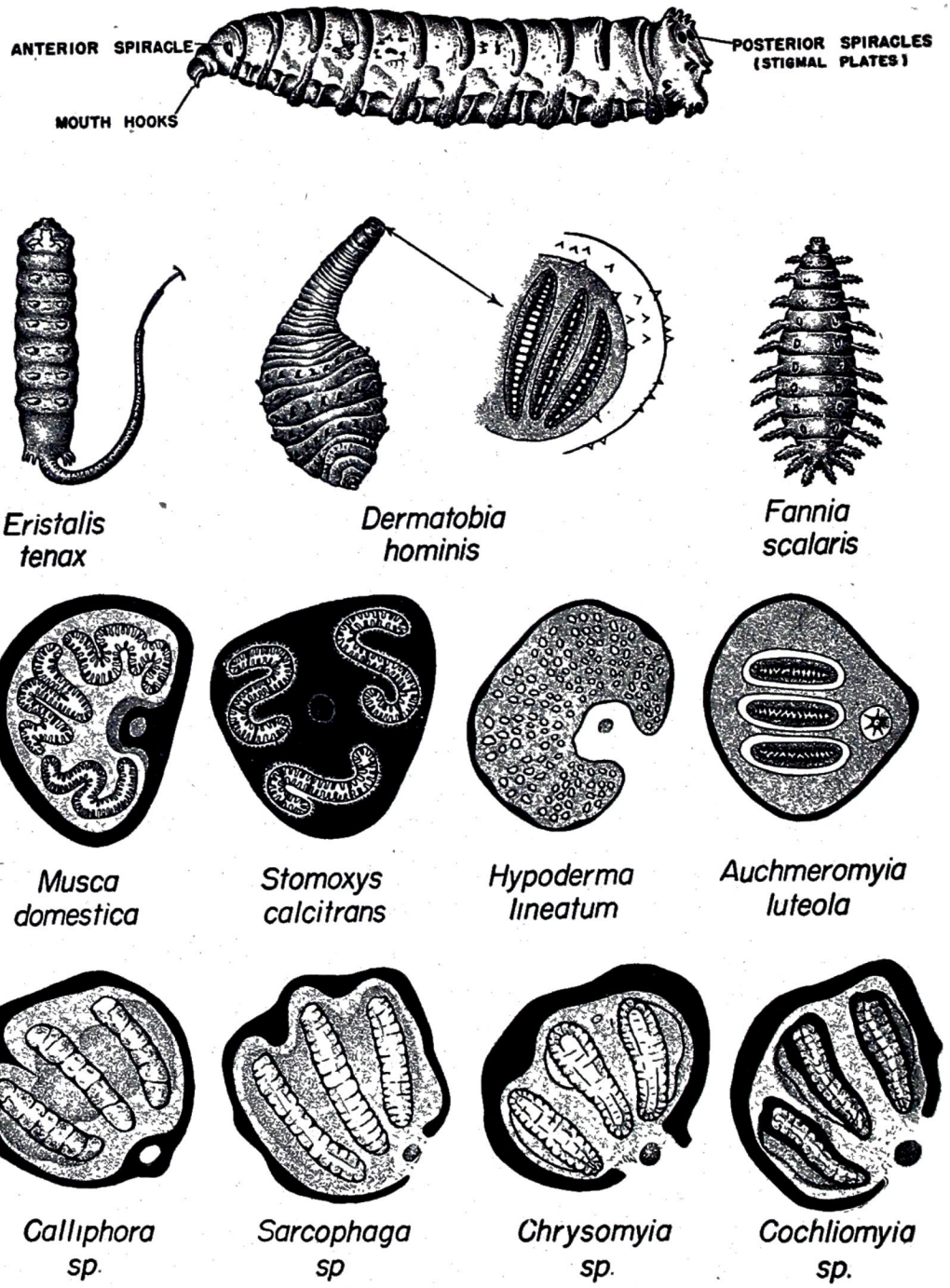
Gastrophilus Intestinalis. This species is commonly known as the "horse bot." A number of cases of human infection have been reported; however, man appears to be an unsuitable host. When the larvae reach the skin they tend to migrate aimlessly and give rise to a "creeping eruption" similar to that caused by the larvae of the dog hookworm. Like *Dermatobia,* mouth parts are vestigial in the adult stage.

Eristalis Tenax. The larva of this species has been reported to cause intestinal myiasis. It is popularly known as the "rat-tailed" larva because of its long breathing tube. Schwartzwelder (1942) reports 22 cases of human infection; all but one involved the gastrointestinal tract. Immature forms are found in polluted waters.

Piophilia Casei. The small black, rather antlike fly, commonly known as the "cheese skipper," has been reported by Simmons to be a common cause of intestinal myiasis. Cheese, bacon, ham, smoked meats, and fish are especially favored by the larvae. Man becomes accidentally infected upon eating these foods.

Determination of Dipterous Larvae

Certain points in the anatomy of dipterous larvae must be considered in determining genus, family, or even species. Maggots, the larvae of flies, are footless, wormlike, and more or less cylindrical. The broad extremity is usually the sterior end and the tapered one the anterior or head end. The terminal seg-



Body structure and stigmal plates of some myiasis-producing fly larvae.

ment bears two chitinized plates; these are the posterior stigmal plates; their shape, sculpturing, and position are characters used in specific determination. Detailed preparation is not necessary for an examination of the plates and spiracles. It is sufficient merely to remove a thin slice at the posterior end and to examine the exterior surface under the low-power objective of the microscope.

Collection and Preservation of Arthropods

Specific identification of medically important arthropods is often very helpful or even essential in determining which measures should be used in their control. Methods of collecting and preparing such specimens for identification are described in the pages immediately following.

e specimens should not be sent through the mails. In shipping specimens mounted slides or contained in vials of alcohol, special care must be taken in packing to prevent ge. In the Tropics, particular care should be taken to store insects in dry containers. and insect pests will soon destroy a collection if proper care is not taken. Salve tins or pill boxes, packed with adults, as indicated below, should be enclosed in mailing tubes or other sturdy containers for shipping. If mounted adults are sent, the pins must be forced firmly into place and the mounting box must be enclosed in excelsior within another sturdy shipping box. All shipped material should be labeled "Fragile" and accompanied by complete data as to locality, date, elevation, collector's name, and other pertinent information as to habits, habitat, abundance, and distribution. As far as possible, reared specimens should be accompanied by associated larval and pupal skins.

Mosquitoes. Adult mosquitoes are usually collected at catching stations, in bait or light traps, or from various daytime resting places. A chloroform tube is commonly used in their capture. Such a tube can be easily prepared by placing a half inch of cut rubber bands or other rubber scraps in the bottom of a large shell vial or test tube, saturating the rubber with chloroform, covering with a plug of crumpled paper or cotton, and topping with a circle of stiff paper. Various types of suction apparatus are used for taking specimens alive or in large numbers.

Minuten nadeln may be used to pin freshly killed adults. The adult mosquitoes may also be glued to paper points, using Duco Household Cement, orange shellac, or some other adhesive. Dried specimens should be relaxed before being mounted; care should be taken not to rub the specimens or break off the more fragile body parts.

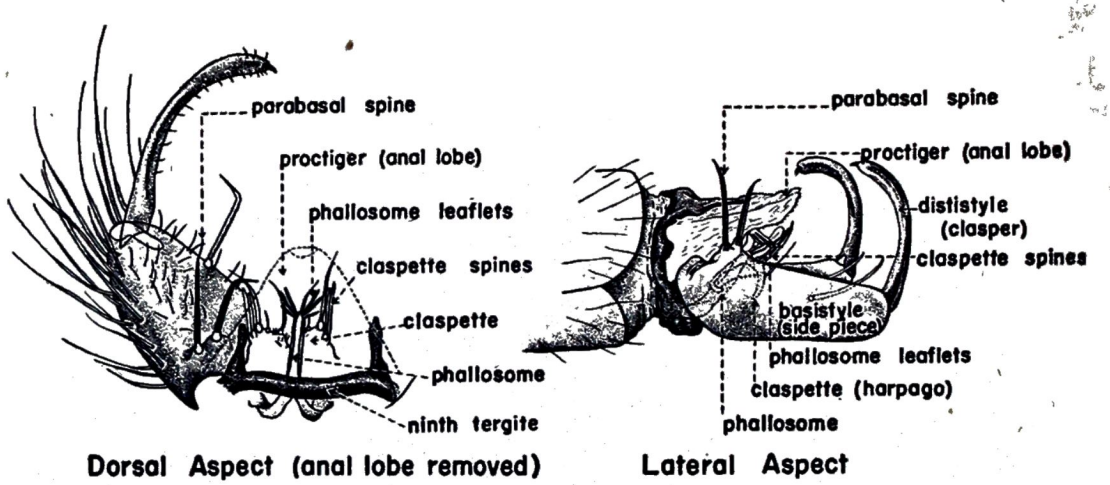
Unmounted adults can be placed between layers of glazed cotton, cellucotton, or cleansing tissue in pill boxes or salve tins of appropriate size. Plain cotton is objectionable because the specimens become entangled in the fibers and breakage results when they are removed for mounting. The cellucotton expands and contracts, depending upon the humidity; therefore, care should be taken to cut the sections of this material large enough to fit snugly to allow for shrinkage when drying. If naphthalene or paradichlorobenzene is added to prevent the development of mold or the attack of insect pests, it should be used sparingly in fine crystals in the bottom of the pill box (preferably in the outside container) and should not be allowed to come in contact with specimens.

Terminalia. A study of male terminalia is often necessary for specific identification. The terminalia must be cleared and mounted on slides for microscopic examination. Many methods of preparation are known; a simple one is given below.

1. Clip the tip of the abdomen with fine scissors and wet in a dish of 70 to 95 per cent alcohol.
2. Transfer with a pipet or a bent needle to a dish of 10 to 20 per cent potassium hydroxide for 5 to 20 minutes—longer if the specimen is to be stained.
3. Transfer to a slide and remove the excess potassium hydroxide by blotting from the margin of the drop.
4. Add a small amount of glacial acetic acid to neutralize the potassium hydroxide and partly dehydrate; blot off the excess.
5. Add a drop of chloral-gum media, described under larval mounts; orient the specimen and place small bits of glass or paper around it to prevent crushing by the coverslip.

If balsam or clarite mounting media are desired, the specimens should be cleared by adding a drop of clove oil or xylol between steps 4 and 5, and the clarite or balsam substituted for chloral-gum in step 5.

In the genus *Anopheles* the proctiger tends to obscure the details of the phallosome and claspettes; it is desirable to dissect these from the proctiger and ninth segment. This should be done under a dissecting microscope just before adding the mounting medium. For a special technic on dissecting and staining *Anopheles* terminalia, see Komp, Public Health Reports, Vol. 57, no. 36, p. 1327.



Anopheles male terminalia. (Lateral aspect redrawn after Ross and Roberts.)

Eggs. Fertile anopheline eggs can often be obtained by confining females in a small cage over a dish of water, or in a small vial with a few milliliters of water in the bottom. The eggs can be easily recovered by filtering, and the sheets of moist filter paper with the eggs can be packed between layers of damp cotton in a container sealed with paraffin. Eggs packed in this way will remain viable for several days and can be transported to a central laboratory for rearing. A sample batch of eggs on a narrow strip of moist filter paper can be preserved in formaldehyde fumes in a tube tightly corked and sealed with paraffin. A cotton plug saturated with 10 per cent formalin should be placed in the bottom and another dry plug should be placed about 1 cm. above it, so that the eggs are not directly wetted with formalin. The novocain tube is very satisfactory for this method of egg preservation.

Larvae. Mosquito larvae are usually found floating at the surface of the water where they can be collected by skimming the water with a cup or dipper. The larvae are removed with a wide-mouthed dropper or spoon, placed in collecting jars, and returned to the laboratory for rearing, identification, or preservation. They can be reared on scrapings of dog biscuit, pablum, yeast, or crushed toast crumbs, care being taken to change the water frequently. For quick identification the examination of a freshly killed larva in a drop of water on a slide is often sufficient. Details are much more readily seen when the specimen is cleared and permanently mounted on a slide. For careful study all mosquito larvae should be prepared in this way.

Before mounting or preserving mosquito larvae in alcohol, the specimens should be killed in a manner that avoids shrinkage and distortion. Single larval specimens in a drop of water can be killed by dipping them in hot (not boiling) water for 15 to 20 seconds. For storing, specimens should be passed through 50 per cent, then 70 per cent alcohol, and placed in vials with cotton plugs to prevent movement and breakage. Very convenient containers can be made from empty novocain tubes discarded by dentists.

Mounting media. A number of different media and technics may be used for mounting mosquito larvae and other small arthropods for microscopic study.

Chloral-gum Media. The use of Berlese's formula, or one of its several modifications, is advantageous since no dehydration of the specimen in alcohol is necessary. This reduces handling of larvae to a minimum and lessens the likelihood of mechanical injury. Some difficulty, however, has been experienced with the permanency of these mounts. Small fragments of glass or narrow strips of paper, previously saturated in the medium, can be placed on either side of the specimen to prevent crushing by the coverslip. The last few segments of a culicine larva should be nicked with a needle, but not completely severed, to allow the breathing tube to appear in full lateral view. The slide should be kept in a horizontal position for several weeks until the medium hardens. The edges

coverslip should then be ringed with some sealing agent such as clarite, isobutyl late, cellulose cement, black asphaltum sealing material, or Duco Household t.

's modification of the chloral-gum formula is commonly used. It can be prepared follows:

Gum arabic (gum acacia)	8 Gm.
Distilled water	10 ml.
Chloral hydrate	75 Gm.
Glycerin	5 ml.
Glacial acetic acid	3 ml.

The gum arabic is dissolved in water, the action hastened by keeping the water warm, and the other ingredients are added in the order given. The thick solution can then be strained through several thicknesses of clean muslin, if necessary. Other modifications have been recommended, but the above formula seems the simplest to prepare and its ingredients are available in most laboratories.

Polyvinyl Alcohol-Phenol-Lactic Acid Medium. The following medium provides another rapid method for mounting mosquito larvae and other small arthropods without clearing and dehydration in alcohol:

Polyvinyl alcohol stock solution	53.5 ml.
Phenol	25.0 ml.
Lactic acid	21.5 ml.

stock solution is prepared by dissolving the powdered alcohol (Dupont-Grade RH-) in water until the solution becomes as viscous as thick molasses. This stock solu- becomes clear on standing, or clearing can be hastened by heating over a water Specimens can be mounted in this medium as described for chloral-gum, and the erslips ringed for more permanent slides.

Canada Balsam, Clarite, and Isobutyl Methacrylate. For mounting specimens in media h have xylol as a solvent it is necessary first to dehydrate in 50, 70, and 95 per cent ol. The specimens should then be cleared in clove oil, carbolxylol (three parts l and one part melted phenol crystals), or absolute alcohol followed by xylol. The ens should remain in the various changes 5 to 20 minutes. After clearing, they may mounted in balsam, clarite, or isobutyl methacrylate. With balsam and clarite, dening of the media may take several days. Isobutyl methacrylate, on the other hand, s very quickly and slides can be used in a few hours; ringing or sealing is unnecessary. slides should be fully labeled with locality, date, and collector.

Other Nematocerous Diptera. Specimens of the smaller diptera of medical importance ratopogonidae, Psychodidae, and Simuliidae—are best preserved in 70 per cent hol in the field. *Phlebotomus* adults can be mounted later on slides for careful study, t if *Culicoides* are mounted in this way it is often difficult to make out the characteristic lor markings on the wings. Simuliid adults can also be preserved in alcohol and later d for mounting. In all three of these groups, specimens may also be preserved dry, as cribed for mosquito adults, and later mounted in various ways for more detailed y.

tes. Specimens may be preserved in alcohol and subsequently mounted on slides. For rary mounts, they may be pipetted onto a glass slide and covered with a drop of l acetic acid and gently heated over an alcohol lamp. This results in perfect clearing extension of the specimen so that the finest details of both dorsal and ventral sur- s can be seen.

or permanent mounts, specimens are transferred to a drop of glacial acetic acid, ed and heated very gently until bubbling begins. The coverglass is then lifted off,

the specimen transferred to another slide and mounted in chloral gum or other sui media. To prevent crystalization the acetic acid in the chloral gum technic should replaced by the less volatile and more viscous glacial lactic acid.

Ticks. These arachnids can be picked from their host animals or they can be collect by "flagging"—drawing a rough flannel cloth over the grass and shrubbery in an infest area, and then removing any ticks that attach to the "flag." They may be preserved in per cent alcohol or cleared and mounted on slides. If slides are to be made the ticks be fixed in an extended position by pressing them gently between two glass slides whil they are killed by dipping them in hot water. They can be stored in 70 per cent alcohol, cleared in potassium hydroxide, dehydrated in alcohol, and mounted in balsam, clarite, or isobutyl methacrylate, as described for fleas.

Fleas. These insects may best be collected from small animals by etherizing the host in a bell-jar or other large container and picking up the stupefied fleas that attempt to escape. If the host is killed, it should be dropped immediately into a tight cloth bag to prevent the escape of the fleas that leave the animal as soon as the body temperature begins to drop. Dogs or cats may be dusted with ground pyrethrum or derris root, and the fleas picked up from papers spread on the floor under the animal. Specimens may be preserved in 70 per cent alcohol or mounted on slides for specific identification by the following procedure:

1. Drop living fleas or preserved specimens into 10 per cent potassium hydroxide and allow them to remain there for a day or two until cleared sufficiently.
2. Transfer the specimens to water in a watch glass containing a few drops of hydrochloric acid; allow them to remain one-half hour.
3. Dehydrate in 50 per cent alcohol.
4. Place in 95 per cent alcohol for one-half hour.
5. Clear in beechwood creosote for one hour, or run through several changes of absolute alcohol and clear in clove oil or xylol.
6. Mount on slides in balsam, isobutyl methacrylate, or clarite.
7. Label fully, including host animal, locality, date, and collector's name.

Miscellaneous Arthropods. Spiders, scorpions, centipedes, millipedes, lice, bedbugs, maggots, nymphs, and other soft-bodied insects may be preserved in 70 per cent alcohol; the corks of the vials should be paraffined to prevent loss through evaporation. If a small amount of glycerin is added, the specimens will not become dry and shrunken upon loss of alcohol. The vials should be kept upright so that the corks will remain dry and stay in good condition for a long period of time. The larger, hard-bodied adult insects may be pinned and labeled carefully and stored in Schmitt or cigar boxes. Care should be taken to keep specimens dry. A small amount of naphthalene flakes or paradichlorobenzene should be added to storage boxes to prevent mold and damage by insect pests.

Fixing Fluid. The following formula provides an excellent fixing fluid for the study of insect anatomy. It is a clearing and relaxing fluid and works equally well for cleaning slides, coverslips, and other small glassware. The insects to be studied can be placed in the material for 30 minutes or less, depending upon the specimen.

Alcohol	265 ml.
Ethyl acetate	95 ml.
Benzol	35 ml.
Water	245 ml.

The ingredients are mixed in the order named.

Technic for Determining Source of Mosquito Blood Meals

1. Collections of engorged female mosquitoes are made and the insects transferred alive to the laboratory.
2. The mosquitoes are killed and identification is made as to species.

a pair of forceps a mosquito is secured near the anterior end of the abdomen lower part of the abdomen is squeezed so that the blood will spread and be ed over a small piece of filter paper.

tinent data as to collecting place, resting site, date, time, name of collector, con- under which collections were made, nearest likely blood source, possible blood in the area, prevalence of mosquitoes, etc., are recorded and the specimen of on the filter paper is stored in a cool, dry place until the precipitin tests can be

The blood is extracted by soaking the filter paper in physiological salt solution for hour or more. If the process takes over two hours, extraction should be done in an x.

The supernatant fluid from the above is then carefully layered onto human anti- . (See medicolegal tests for blood.) Antisera other than that of man may be used ding upon the likely occurring hosts of the mosquitoes in the area under observa-

CHAPTER 28

Poisonous Snakes and Lizards*

Snakes

Snakes belong to the class Reptilia and the order Squamata, suborder Ophidia. The two families to which poisonous snakes belong are the Colubridae (colubrine snakes) and Viperidae (viperine snakes).

Although the toxicity of the venom and the amount normally present are matters of great importance in estimating the lethal powers of species of poisonous snakes, the principal feature to be considered is the ability of the fangs to introduce venom into the tissues of the animal bitten. For example, in the Opisthoglypha there are fangs attached to the maxilla but these are placed posteriorly to the solid teeth in front, so that, since the venom cannot be inoculated, these snakes are from a practical point of view nonpoisonous. Then, too, snakes in which the fangs are so situated have only a small poison gland and their venom is of low toxicity. In dangerous snakes the poison fangs are placed anteriorly, attached to the maxilla, which, in the poisonous Colubridae, is long and lies horizontal and, in the Viperidae, is short and lies vertical.

The nonvenomous snakes are in the Aglypha series and have solid teeth. There has been a question as to toxicity of the saliva of some aglyphs, but this is probably an allergic manifestation. With the Protereoglypha, where the dangerous snakes belong, there are grooved or canalized poison fangs, attached anteriorly to the maxilla.

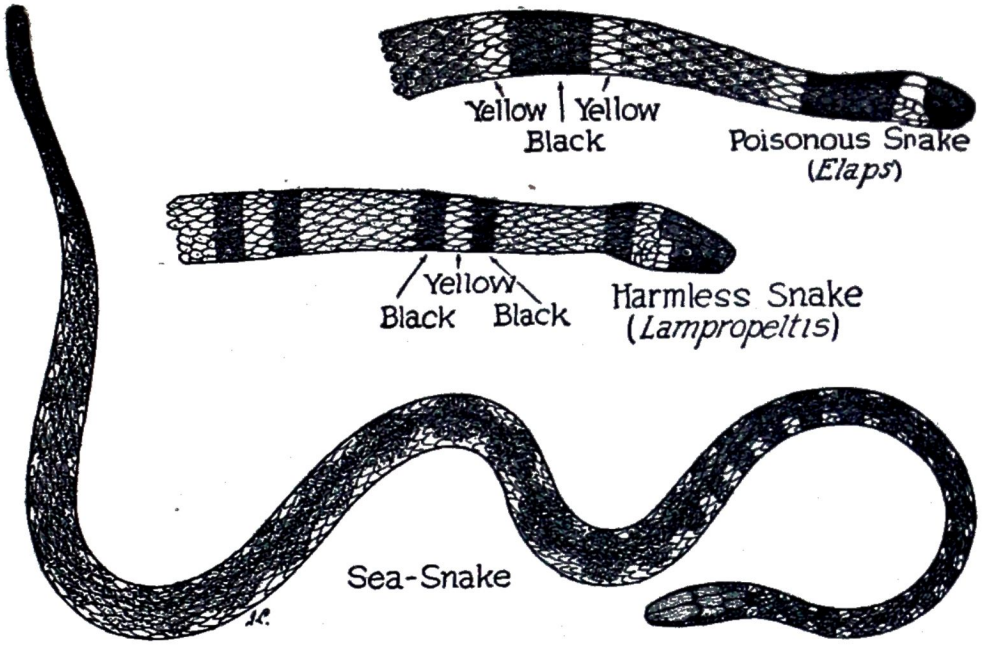
Colubridae. The three series noted above belong to this very large family. The poisonous species belong either to the Hydrophinae (sea snakes), which have an eel-shaped tail and a rather flattened body, or to the Elapinae (land snakes), which have a round tail. As a rule, sea snakes live in salt water near the shore, but such snakes have been reported from fresh water lakes in the Philippines. They are of importance in the Tropics and are a source of danger to fishermen. While their venom is extremely toxic, and their fangs situated anteriorly, the danger from them is minimized by their small heads and relatively inefficient bite. The Elapinae have short, strong fangs anteriorly located, and behind them small grooved (not canalized) teeth. The poison gland, which is the homologue of the parotid, has a duct located in the upper lip and terminating in a papilla. The poison duct does not enter the fang lumen but empties into muscular folds which surround the base of the fang, hence breaking off of a fang does not necessarily injure the duct. There is a succession of teeth in snakes, so that a new fang grows out if the original one is extracted.

Many of our harmless snakes such as the garter snake and black snake belong to the Colubridae.

The cobras belong to the subfamily Elapinae and are best known by a necklike expansion or hood. The only poisonous colubrine snakes in the United States are the bead snake (*Micrurus fulvius*), often called the Florida coral snake, and the Sonoran coral (*Micruroides euryxanthus*). Both of these snakes were formerly included in the genus *Elaps*.

The bead snake is black with about 17 broad crimson bands bordered with yellow. Although small, it is very venomous. The upper jaw has anteriorly grooved fangs, which

*Revised by Paul W. Clough, M.D.



The poisonous coral snakes of the United States, *Micrurus fulvius* and *Micruroides euryxanthus* (formerly *Elaps*), have transverse rings of black, vermillion and yellow. Differentiating these snakes from harmless ones which resemble them there are black rings bordered by two yellow ones, while with the harmless snakes a yellow ring is bordered by two black ones. The sea snake (*Enhydrina* species) has a rudderlike tail which is here shown twisted to one side.

appendages are not present in the nonpoisonous coral snakes, these latter having teeth in the upper jaw so that the wound shows four rows of punctures instead of two rows and one larger puncture on each side to mark the entrance of the fangs.

In Asia there are many important poisonous colubrine snakes, the cobra (*Naja tripudians*), the King cobra (*Naja bungarus*) and the kraits (*Bungarus candidus*).

All of the Australian poisonous snakes are colubrines.

SNAKES OF THE UNITED STATES (STILES)

(*A*) Pupil of eye vertical; pit present; single row of ventral scales posterior to the vent; adults with head more or less triangular, constriction behind head more or less prominent ..... Pit vipers (all poisonous)

(*B*) Pupil of eye circular; pit absent; double row of ventral scales posterior to the vent

(*a*) Color: yellow, black, yellow, red, in bands ..... Coral snake (poisonous)

(*b*) Color: black, yellow, black, red, in bands ..... False corals (not poisonous)

(*c*) Color: all others ..... Not poisonous

Viperidae. The viperine snakes are characterized by a broad head, narrow neck, short and stumpy tail, and a short upper jaw which, with the fangs, is directed obliquely backward. The rattlesnake (*Crotalus*), the copperhead (*Ancistrodon contortrix*), and the water moccasin (*A. piscivorus*) are widely distributed in the United States.

There are many harmless snakes which more or less resemble these "pit vipers," as the rattlers, moccasins, and copperheads are called. This term refers to a deep hole or pit found on the side of the head between the nostril and the eye. It is a blind sac. The much dreaded "fer-de-lance" (*Bothrops lanceolata*) is a crotaline snake.

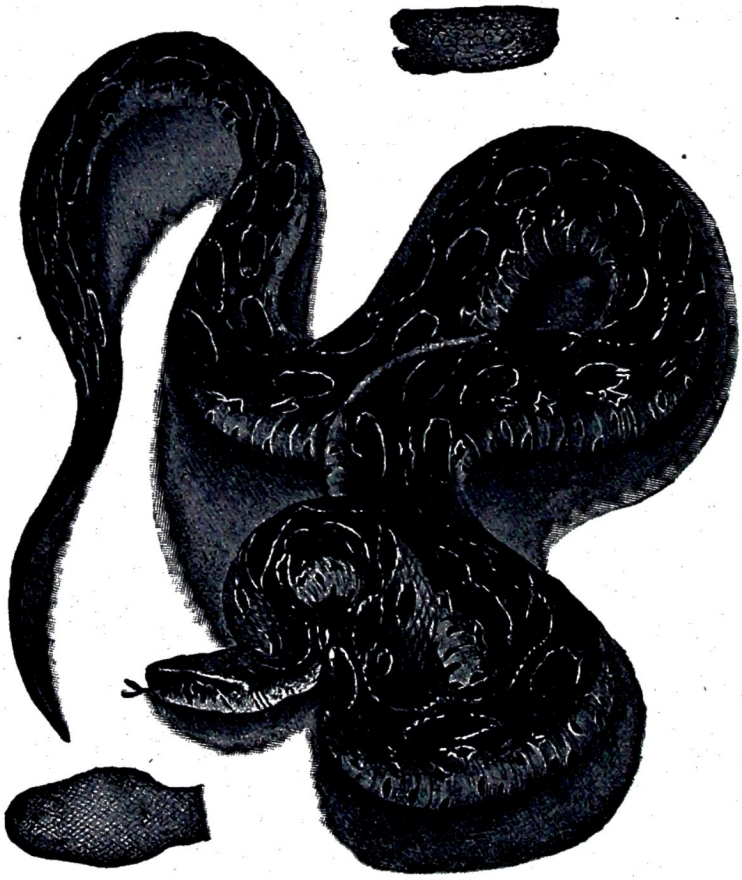
Some divide the Viperidae into the Crotalinae, which possess the pit, and the Viperinae which do not have this structure. Russell's viper (*Daboia russelli*) is the best known of the Viperinae and is one of the most important poisonous snakes of India.

e poison fangs are grooved or perforated and connected with the poison glands

which resemble salivary glands and may be almost an inch in length in large snakes. tongue is slender and forked and is a tactile organ.

The jaws are remarkable for their great extensibility, not only vertically, but lat permitted by the ligamentous connections of the two halves of the mandible or lo jaw.

As the fangs are directed backward it is necessary for the snake when striking to ope the jaws widely and bend back the neck. The fangs are then brought forward erected by the sphenopterygoid muscles. Barnes has pointed out that in vipers venom gland lies between the fibers of the maxillary and sphenopterygoid muscles



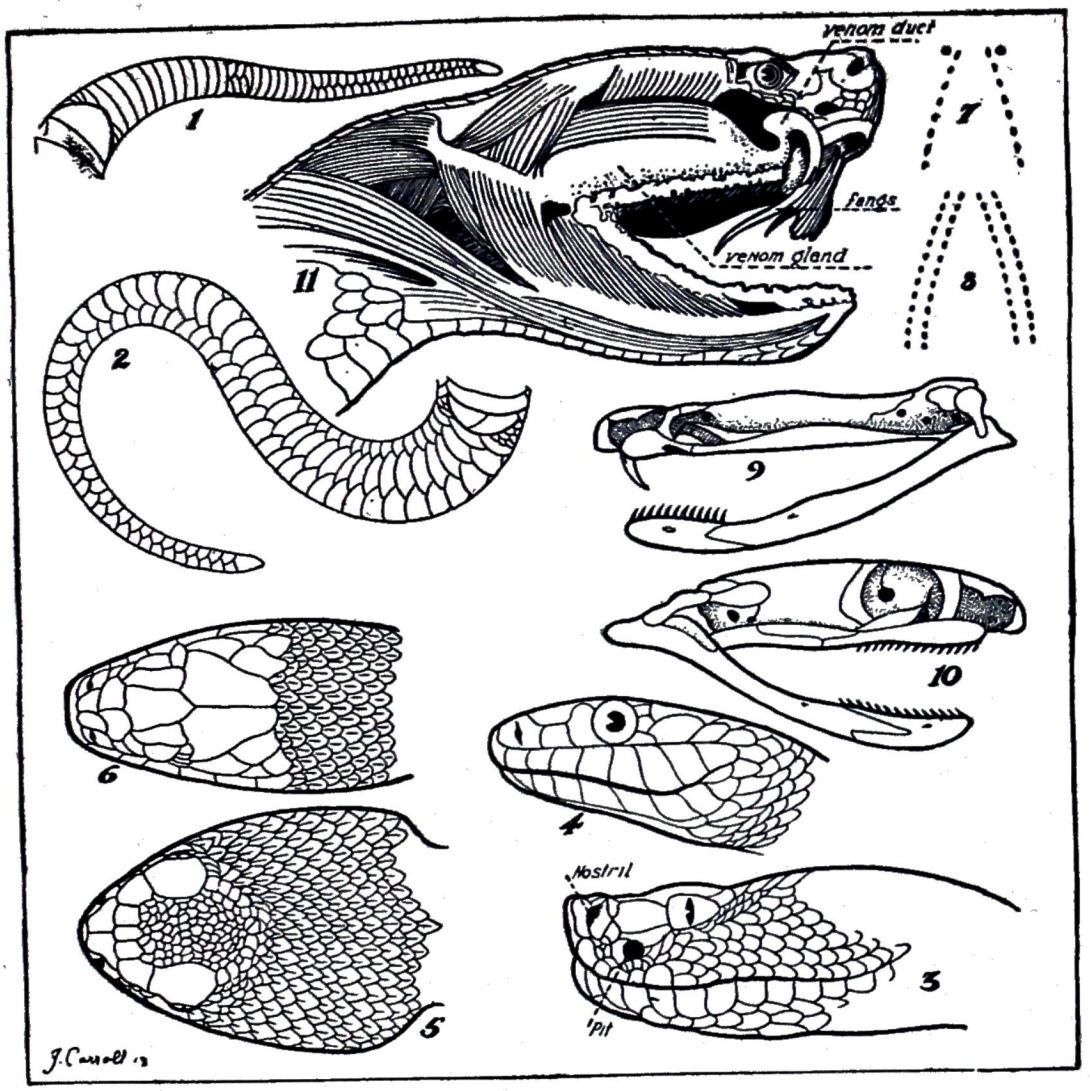
Daboia russelli. (After Mense.)

that the contraction of the latter in erecting the fang would also squeeze the venom gland and eject the venom. The snake bite is a combination of bite and blow. The functional fangs of colubrine snakes, however, are not mobile.

In addition to the possession of the pit these vipers have a more or less triangular head and in particular a single row of large scales on the under surface posterior to the vent (anus), while the harmless snakes show an elongated oval head and two rows of large ventral scales posterior to the vent.

Snake Venom. In examining the wound made by a snake the two punctures of the fangs indicate the bite of a poisonous snake. If these fang-puncture points are far apart it shows that a large snake, and probably one capable of injecting a greater amount of venom, has given the bite.

When a snake strikes the fangs move from the horizontal to the erect position, the mouth being widely open. When the fangs enter the jaws close and pressure is exerted on the poison glands so that the venom pours out.

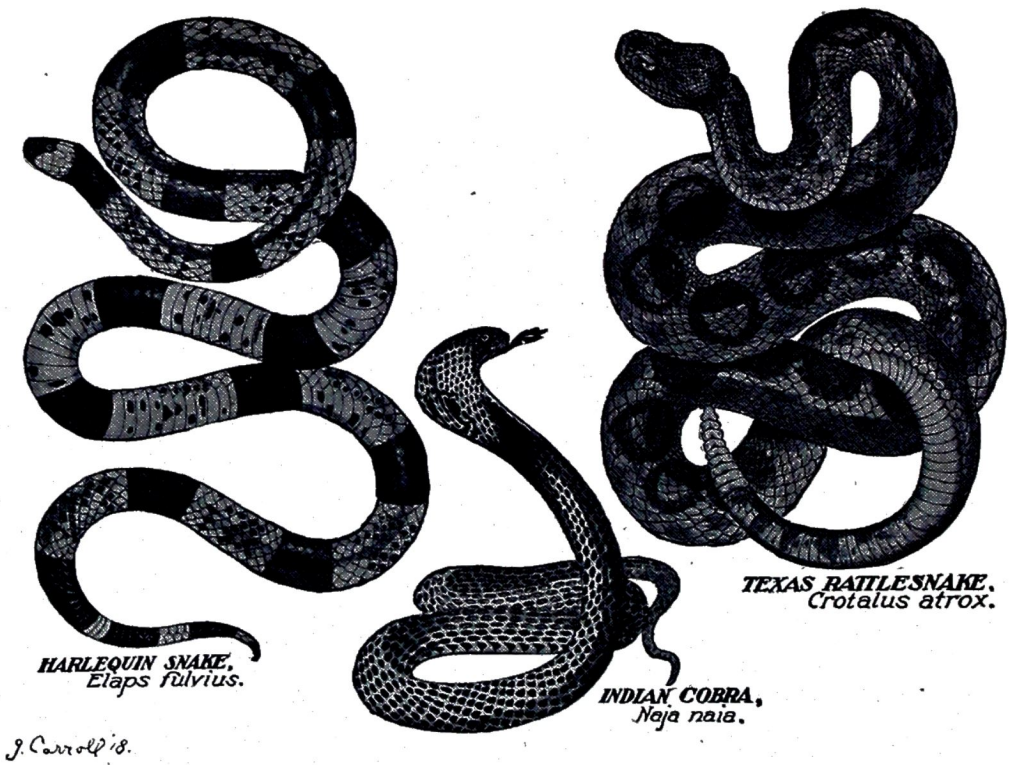


(1) Single row of scales posterior to vent (poisonous snake—water moccasin). (2) Double row of scales of harmless snake (*Natrix*). (3) Side view of head of pit viper. (4) Side view of head of harmless snake. (5) Dorsal view of pit viper. (6) Dorsal view of harmless snake. (7, 9) Bite puncture and skull of *Micrurus*. (8, 10) Same of harmless snake. (11) Poison apparatus of rattlesnake.

The idea that a snake exhausts its venom when striking is not true. Colubrine snakes may bite shortly after the first attack, and inject each time a lethal dose of venom. Fresh venom varies from an almost colorless fluid to one with a brownish or greenish color. It is viscid and quickly decomposes from the varied bacterial flora it contains. A number of years ago the injection of rattlesnake venom was used in the treatment of epilepsy but dangerous and even fatal reactions resulted from the pathogenic anaerobes at times present in the venom of snakes. Dried venom is quite stable in the dark, and retains its toxicity for years.

The amount of venom varies with the size and condition of the snake, an adult cobra yielding about 1 ml. Acton and Knowles give the following table expressed in milligrams of desiccated venom.

Common cobra (mean yield)	317.0	mg.
Common krait (mean yield)	8.17	mg.
Banded krait (mean yield)	64.4	mg.
Russell's viper (mean yield)	108.0	mg.



Important poisonous snakes. (*Elaps fulvius* is now included in the genus *Micrurus*.)

They estimate the minimum lethal dose for man as 15 mg. with cobra venom and mg. with the venom of Russell's viper (*Daboia*). The venom of the kraits is more pote that of the very common Indian krait, *Bungarus candidus,* being given as 1 mg.

The cobra, after having bitten, remains attached for a short time while the *Dabo* strikes with the greatest rapidity and immediately releases itself.

Cobra and krait bites (colubrine snakes) produce more or less simil symptoms such as paralysis of articulation with nausea and vomiting and lat paralysis of the respiratory apparatus. There is only an insignificant reaction the point of bite.

The venom is mainly neurotoxic, causing death by paralysis of cardiac and respira centers. Cobra venom is also very hemolytic. This hemolysin is activated by the no complement of the serum of the animal poisoned, the hemolysin as contained in venom not being toxic when alone. Lecithin also has the property of activating the hemo lytic substance in venom.

In rattlesnake bites (viperine snakes) there is marked pain at the site of wound with much swelling and hemorrhagic infiltration. The swelling petechial mottling spread up the limb from the point of entrance of the ve Cold sweats, nausea, cardiac depression, and syncope are common. An except to this general rule is *Crotalus terrificus,* whose venom is strongly neurot affecting vision and respiration. The local effects are slight.

Rattlesnake venom is active chiefly on account of its hemorrhagin, or rather endot lysin, which destroys the endothelial lining of blood vessels.

The hemolytic (hemotoxic) effects of the venom of the West Indian and Central merican vipers are most marked—hemorrhages from the conjunctivae and stomach ccurring along with reflex vomiting. There is marked damage to the blood vessel walls, eath occurring in coma in about eight hours in the absence of antivenin. Even with ıch treatment transfusion may be necessary. Of the American pit vipers, the rattlesnake enom is the most toxic and that of the water moccasin least so, but the necrotizing ower of the latter is more marked.

Venoms may also contain proteolytic ferments which may account for the softening of ıuscles in snake-bite cases. The toxic effect of the venom takes place without an appreciaıle incubation period, hence different from true toxins.

The most venomous snakes seem to be the sea snakes (*Enhydrina*). This venom is alnost entirely neurotoxic.

The tiger snake of Australia is almost equally venomous and the krait (*B. candidus*) ext. The rattlesnake is about one-fifth as venomous as the krait.

Certain venoms greatly increase the coagulability of the blood so that intravascular hromboses may occur. It is chiefly with the venoms of *Daboia* and *Bungarus* that such hromboses are likely to occur and this accounts for the almost instantaneous death which ıt times results from bites of such snakes, when the toxin is injected directly into a vein.

Treatment of Snake-bite Poisoning. The nonspecific treatment of snake-bite poisoning which has usually been recommended is: (1) Application of a tight ligature above the site of the bite for 20 to 30 minutes. The ligature, which should preferably be a rubber band, is to be applied about a single-bone extremity, not about one with two supporting bones. (2) It is recommended that a piece of rubber gauze be cut and placed on the site of the bite. Suction by mouth should then be kept up steadily for at least one-half hour if no antivenin is available. If antivenin is at hand, it should be administered at a distance from the site of the bite, and the suction continued. Incision increases the chance of secondary infection.

Bannermann has shown that a dog bitten by a cobra cannot be saved by free incision and the rubbing in of permanganate crystals. It may, however, be saved by the immediate injection of 10 ml. of a 5 per cent solution of permanganate, but not if two minutes have elapsed. Bites from the *Daboia* are fatal, however the permanganate be applied. Bannermann, therefore, does not consider the permanganate treatment of any practical value. Rogers thinks that Bannermann's experiments with dogs do not give a true idea of the value of permanganate because he has had success in experimenting with cats and because he believes it has saved human lives. Chromic acid injections (1 per cent) have also been recommended. Acton and Knowles consider potassium permanganate as unreliable and recommend subcutaneous injections of a 5 per cent solution of gold chloride. These local injections may be helpful if used before the venom has been absorbed but they have no effect on venom taken up by the circulation. Intravenous injection of permanganate is not only without effect but is dangerous. Amaral states that the ligature will not prevent the venom from spreading and may accentuate the proteolytic and cytolytic action. In his opinion permanganate solutions in active concentrations have a deleterious action on tissues. *The use of potassium permanganate is now generally regarded as contraindicated.*

Internally alcohol does not seem to be of any value; in fact, many of the deaths have been attributed to excessive ingestion of whiskey. Strychnine in large, almost poisonous, doses was highly recommended in Australia, but the statistics seem to make the value of this remedy doubtful.

In an article on snake bite, N. Hamilton Fairley (1934) states that early free excision combined with mechanical suction is the only method of local treatment likely to be successful in body bites. Immediate application of a ligature and free excision (3 by 3 cm.), down to the muscles, was the only effective local treatment in sheep bitten by tiger snakes. He refers to the work of Crimmins (1927), advocating ligature and incision combined

with suction by a breast pump, and that of Jackson and Githens (1931), in which i of the wound bite, combined with suction by a Bier's apparatus and irrigation with is recommended. Fairley regards these methods as useful accessories to ligature, inc and excision. As regards the use of permanganate, Raymond Ditmars (Cecil's Med states "Nothing could be more foreign to the treatment of snake bite than such prac For local treatment he advocates deep incision and forced suction. *Cauterization s never be used.*

Allen (1939) thinks the earliest possible excision of a large area of tissue may be b ficial. In still more desperate cases amputation is a more positive remedy. He thinks the tourniquet may be serviceable, with or without refrigeration, as a preliminary to layed amputation. He believes the use of an *occlusive* tourniquet is harmful, and d not recommend incisions.

Herbert Clark (1942), who has had more than 30 years' experience in Central Ame emphasizes the necessity for *immediate* treatment. The snake should be killed identification. He advocates the use of a tourniquet sufficiently tight to stop venous not arterial flow. This should be loosened for a few seconds every 10 minutes. Extracti of the venom by suction should be started at once. Suction may be applied by the mo over a thin sheet of rubber laid over the bite. This should be continued vigorously five minutes, the site should then be washed, antivenin given, and suction repeated. cisions are not advised as they increase the raw surfaces and hasten absorption. venin should be given subcutaneously, and the tourniquet should be kept in position an hour after the administration. Alcohol is contraindicated, and potassium permangan cannot reach the venom beneath the skin.

ANTIVENINS. The active agents of snake venoms may be either of the nature of h rhagins, neurotoxins, or fibrin ferments. In colubrine snakes the neurotoxin vastly pr dominates whereas with the viperines it is the hemorrhagin. Certain Australian sn contain all three toxins in about equal proportion, whereas with the rattlesnakes America it is almost entirely the hemorrhagin which causes the poisoning. The *Micru* (*Elaps*) of Florida is a colubrine snake and its venom is neurotoxic in nature.

The cause of death in colubrine snake bites is chiefly from paralysis of the respirato centers whereas with the pit vipers it is chiefly from hemorrhages in the vital orga Antitoxins have been prepared against both viperine and colubrine venoms and these specific; thus a colubrine antivenin will not be of value against a viperine bite. Antive should be administered either intravenously or intramuscularly. The amounts reco mended for injection to neutralize a fatal dose of snake poison vary from 100 to 300 of the antivenin serum. There is no accurate method of standardization.

In Central America antibothropic serum can be given in all cases with a good cha of effectiveness, since 80 to 85 per cent of the bites are due to species of *Bothrops.*

When Calmette (1894) first produced antivenin the idea prevailed that it useful for any snake venom, a view soon found to be untenable. There are no institutes in many parts of the world where antivenins are made to combat local venoms; thus in the U. S., there is the Antivenine Institute of Amer which produces an antivenin for rattlesnake, copperhead, and water-mocca venom. These venoms are chiefly hemorrhagic. Previously, the toxicity of so venoms made the immunization of horses precarious, but methods of detoxi tion are now being used which are more successful. Both monovalent and po valent sera are produced. Often, when it is impossible to determine the sp of the offending snake, a polyvalent serum is indicated. Antivenins are gi either intramuscularly or intravenously. With highly poisonous venoms venous therapy is indicated. Fairley emphasizes that dosage is in inverse p

on to y weight, so that children may require several times the amount of erum sufficient for a heavier adult. This is because of the natural neutralizing ower of the blood stream. A large individual, having more blood partially to eutralize venom than a smaller person or a child, requires less antivenin. Owing to arying strengths of antivenins (concentration methods) one should depend for osage on the instructions accompanying the product. Besides the local and specific treatment for snake bite one should put the patient at rest physically and nentally, as psychic shock is an important matter with some snake-bite patients. Fairley also recommends black coffee or caffein. Strychnine and alcohol, and in particular morphine, should be avoided.

Lizards

Lizards are nonpoisonous with the exception of the two Gila monsters (*Heloderma suspectum* and *H. horridum*). The first is found in Arizona and New Mexico (Gila river valley), the second in southwestern Mexico. They are about two feet long, heavily built, and covered with small tubercles. The name monster is most applicable. The poison fangs are in the lower jaw, and the bite of these apparently sluggish creatures may cause death. When aroused, they are very vicious and it is as difficult to open the closed jaws as in the case of a bulldog. They deposit parchment-like eggs in the sand of the desert.

; or in one species and not in another of the same genus. There do not a to be marked individual differences in the same species under the same conditio to age, time of year and sexual maturity. The development of the toxin is believed be the result of the exaggeration of a normal metabolic function and not a pathol phenomenon. The toxicity is most marked when sexual processes are most active, that during the breeding season. For example, the eggs of our pickerel are venomous.

Fish Which Poison by Their Sting or Bite. According to Barbour (1 many spiny fishes secrete an irritant poisonous slime which may be gener distributed over the surface of the body, or more frequently is located in glan situated at the base of highly specialized spines which serve to inject the poiso The sting rays, *Trygon* or *Dasybatis,* are typical among Elasmobranchs. *Scorpa Chilomycteris,* and the freshwater cat fishes such as *Ameiurus* are examples am the Teleosts. In some of these the poison is very virulent, in others only sligh irritant.

Fish of the genus *Muraena* have specialized teeth associated with a poison s which secretes a venom which is introduced into the wound made by the bite.

There are various rays which are well known all over the world as capable of inflic wounds. In the sting rays (Trygonidae) the tail is armed on the upper side with a bar spine which in some species is connected with a poison apparatus. Some of these sting r when wounding a person who may step on them while wading in the water may at same time inoculate tetanus bacilli which are particularly dangerous because of character of the deep-punctured wounds. In the electric rays (Torpedinidae) the do surface is electrically positive and the ventral one negative. To receive a shock one communicate with the *Torpedo* species at two distinct points. Some of these electric are capable of temporarily paralyzing the arm of a man.

Two of the best known poisonous fish are *Trachinus draco* and *Scorpa scropha.* The flesh of these fish is wholesome as food. *T. draco* is like a trout appearance and has blue and brown stripes. It has a grooved spine passing thro each of its gill covers which is connected with a poison gland. There is als poison apparatus connected with the dorsal fin. *S. scropha* is an ugly, red fish large head and prominent fins. The French fishermen call it "le diable." The po apparatus is connected with the first three rays of the dorsal fin.

Persons in bathing who strike against these fins are more apt to be wounded than fishermen who handle the fish with caution. After being wounded a person expe stabbing pains in the affected part. A sensation of suffocation follows and the victim become delirious. At times collapse and death result. At the site of the wound at there is an erythematous area which later becomes black and may become gangr As the poison rapidly enters the general circulation, treatment similar to the local ment of a snake bite is called for. These fish seem to be more dangerous durin spawning period.

S. plumieri, the lion or scorpion fish, has been reported by Bayley (1940) to fr the shoals of the fine bathing beaches in Barbados, where it hides in weed-c crevices of the coral. Bathers may be injured by striking its sharp spines or by s on the fish. The poison injected by the spines often gives rise to very severe symp violent pain comparable to renal colic, sweating, pallor, dyspnea, tachycardia, v diarrhea, and often later a rash.

The only two important animal parasites with which the eating of fish is concted are: (1) *Diphyllobothrium latum* and (2) *Clonorchis sinensis*. The broad ussian tapeworm is a rather common parasite of man in the Baltic provinces and comes from eating insufficiently salted pike and other fish infected with this larval tapeworm. The liver-fluke disease of China and Japan is caused by eating various raw or insufficiently cooked fresh-water fish. These fish are the secondary intermediate hosts, the primary ones being mollusks. A very small fluke of Japan, *Metagonimus yokogawai*, is transmitted by the ingestion of certain goldfish.

Mollusks and Disease

The importance of disease transmission by snails has been taken up under the helminthic infections caused by flukes.

Oysters. There are more than 100 species of true oysters (*Ostrea*), exclusive of various allied forms, such as the pearl oyster or the window-pane oyster. Oysters belong to the class Lamellibranchia and the two most important edible species are *O. edulis*, the European oyster, and *O. virginica*, the Americo-Canadian one. The question often arises as to the edibility of oysters which are green in color. This color is considered desirable in certain European countries, and is produced in France by feeding the oysters a diatom, *Navicula ostrearia*. The green pigment is present in the gills and palps. Such greening may be natural. Sometimes there is a green color in the body of the oyster due to copper.

It is probable that the only ground for considering a sound oyster as capable of causing food poisoning is from its effect on individuals with an idiosyncrasy to shellfish—and such idiosyncrasy seems not uncommon.

Typhoid Fever and Oysters. There have been numerous outbreaks of typhoid fever in both the United States and England for which the eating of contaminated oysters was responsible. Oysters may be contaminated when growing in sewage-contaminated beds, but in the studies of typhoid infection from eating raw oysters the blame has been placed on polluted water used for floating oysters. If the water in which the oysters are placed for storage (floating) is pure, such a process makes the oyster safer. At present, floating in chlorinated sea water is of particular sanitary advantage. Outbreaks of typhoid fever, as for instance that of the New York epidemic of 1924–1925, when more than 100 deaths from typhoid fever were recorded, have led to official regulation. In uncontaminated salt water, studies have shown that the oyster gets rid of the typhoid organism in from two to three weeks.

Mussels. These also belong to the class Lamellibranchia. Mussels are widely distributed, and in Europe form an important article of food (the edible mussel, *Mytilus edulis*). They seem to thrive better in saline waters which have a somewhat lesser salt tent than sea water. Fresh-water mussels have an economic value in the use of their for button-making. Besides ill effects related to idiosyncrasy, we may have poisoning ing to paralysis or even death. In California (1927), there were reported 102 cases ussel poisoning with six deaths. The symptoms developed in 10 to 20 minutes after tion. The toxin seems to be thermostable and is absent except during the spawning on (June through September).

Poisonous Coelenterates

The phylum Coelenterata includes animals of very simple structure, only sponges and protozoa having a more lowly type. It is customary to distinguish morphologic types of coelenterates, the polyp and the medusa.

Polyps. The best example of a polyp is a sea anemone.

Quite interesting in the study of immunity is the constant association of an anemo with certain hermit crabs. The anemone covers the soft tail-end of the crab, thus pr tecting the crab from attacks by its enemies. The mouths of the two animals are in c juxtaposition so that the food of the crab is shared with the anemone. This crab acqu an immunity to the poison of the anemone, probably as the result of frequent ingesti of fragments of anemone. Other crabs are very sensitive to the anemone poison, sufferin paralysis and death. The poison of certain anemones may even harm other anemones.

A condition known as "la maladie des plongeurs" occurs among the spon fishermen of the Mediterranean. This is due to stinging by anemones and characterized by marked itching, burning, and erythema. In some cases the s of the affected area becomes necrotic and sloughs off leaving an ulcer.

Levin and Behrman (1941) in the West Indies have described a dermatitis caused the coral polyp of the genus *Actinia*. Species of the genus *Alstinion* and *Hellenopolyp* may cause nausea and vomiting in addition to local lesions. Applications of vinegar a olive oil have been recommended for the local symptoms.

Jellyfish (Medusa). This umbrella-like coelenterate has tentacles which ha down from the margin of the organism.

As a rule jellyfish are harmless but certain species produce unpleasant or even serio effects by their sting. Lesions following contact with unspecified "jellyfish" have b reported by Allen (1920) and Stewart (1922). The local rash in Allen's case was lowed by profuse weeping eczema, by aphonia, and by laryngitis lasting for four we Aoki (1922, 1923) portrays the severe effects, besides urticaria, of stinging by *Olindioi formosa*—shock, acute cardiac distress, dyspnea, muscle pains, and as a possible seq emaciation.

In the Mediterranean a jellyfish *Rhizostoma pulini* produces edema and urti carial eruptions as the result of its sting. In many parts of the Tropics jellyfish are found which give rise to quite serious symptoms. In the Philippines there are certain species of jellyfish which cause serious illness, although as a rule one experiences no discomfort from coming in contact with many other species while swimming in the waters of that part of the world.

According to Light, the species of *Dactylometra,* called "fosforo" by the natives, is the most dangerous one there encountered. It has long ribbon-like oral lappets and 24 slender white, marginal tentacles. In this the sting is inflicted by nematocyst batteries in the long, ribbon-like oral palps. *Lobonema,* called by the natives "lanterna," is of large white or white and purple in color, and stings by the long filaments which arise the mouth arms. Stitt has treated a number of patients stung by jellyfish in the Philip the symptoms ranged from a mild erythema to marked congestion of the respi tract and other general symptoms.

Old has described these symptoms very accurately and notes the following:

The symptoms appear in from 10 to 60 minutes with marked hysterical manifestations, incessant cough, and coryzal signs. Light believes that the cases described by Old were due to stinging by *Dactylometra.*

Wade describes his own experience with a jellyfish sting while swimming in Manila Bay. The tentacles became wrapped about the upper arm and stinging was instantaneous as the tentacles did not cling. The poison did not reach the conjunctiva or other mucous membranes. There was at once a sensation of burning in the area of contact, but it was 15 minutes before other symptoms appeared. There was pain in the loins and also in the scrotum. This was followed by a curious restlessness and weakness, then a sense of constriction in the throat, with chest discomfort and then coryza and lacrimation. The symptoms abated and within an hour there only remained weakness and soreness of the bronchi. A vesicular dermatitis appeared on the arm and the traces of the sting had not disappeared after two or three weeks. Other cases have been reported associated with feeble heart action and semiconscious states. There is always to be considered the possibility of one's drowning when in the emotional or semiconscious state. Wade describes a death in a robust Filipino who was stung on the leg. His companions were only a few yards away, but by the time they had reached him he had collapsed and was gasping and livid, and was dead a few moments later. It was at first thought he had been bitten by a sea snake but there was no mark on the leg, except conspicuous purplish discoloration. On autopsy, status lymphaticus with persistent thymus, acute congestion of the viscera, and edema of the lungs were demonstrated.

The Portuguese man-of-war (*Physalia*) has long locomotive tentacles which stretch out 30 to 50 feet as the animal is blown along by its pearly purple-crested bladder-like float or sail. The thread cells are capable of inflicting rather painful stings when handled without a knowledge of the effect of coming in contact with these thread cells.

Along the coast of eastern Florida great swarms of a small, very dark brown *Medusa* occasionally appear near the shore (*Linuche unguiculata,* formerly better known as *Linerges*). They are so abundant that very severe stinging occasionally occurs. The symptoms are similar to those described above.