INSECTS, TICKS AND HUMAN DISEASES

by

C. H. CURRAN *and* FRANK E. LUTZ

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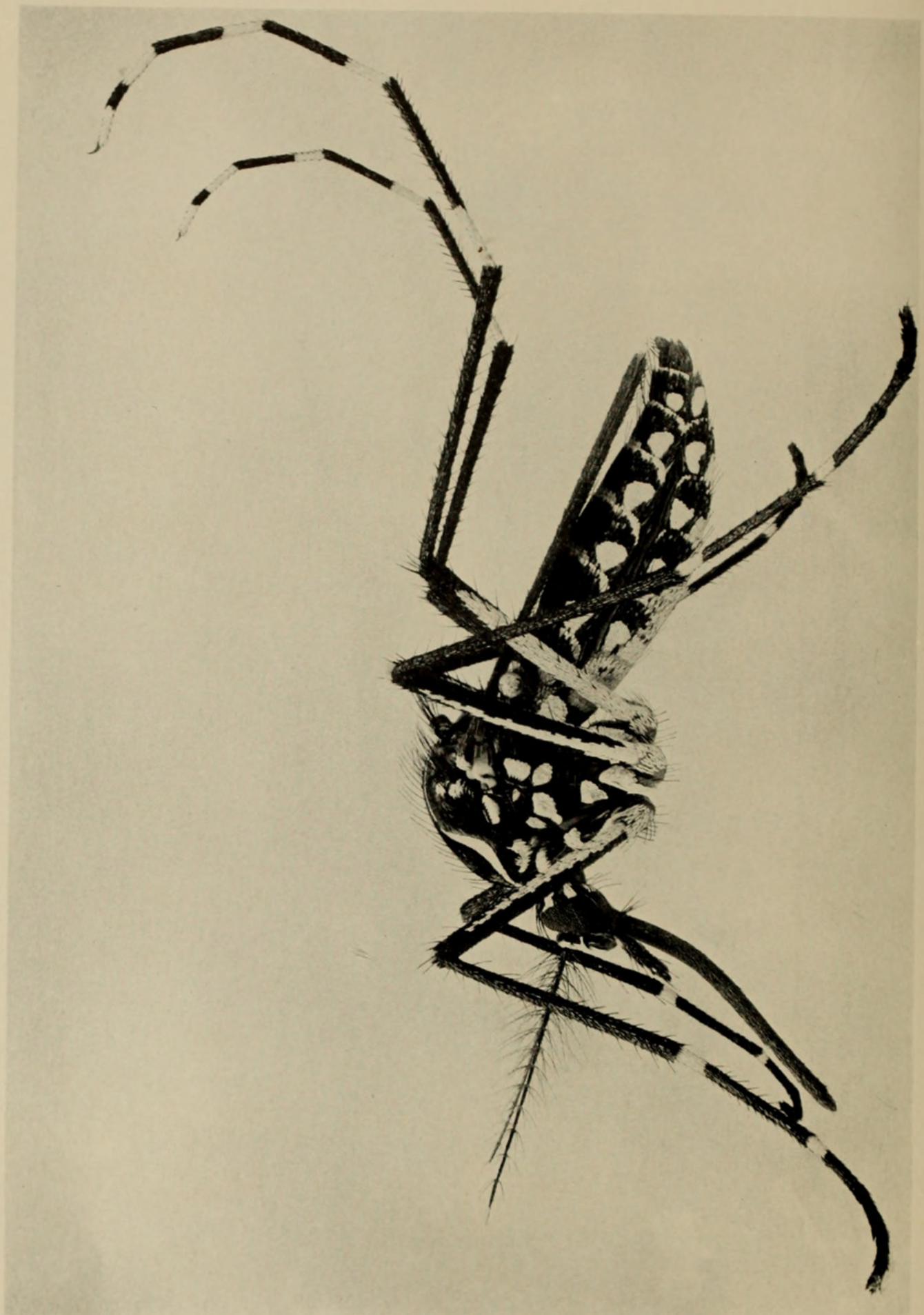

INSECTS, TICKS AND HUMAN DISEASES

A Brief Statement of Facts
Vitally Important to Man

by

C. H. CURRAN *and* FRANK E. LUTZ

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C. H. Curran and Frank E. Lutz

One of the varied and exceedingly important relations between man and insects is the transmission of serious human diseases by a relatively few kinds of insects. In some cases the transfer is purely mechanical; in other cases the insect is an essential part of the development of the disease. During war, when men gather in large numbers or enter regions containing diseases to which they are not immune, the seriousness of the spread of diseases by insects is greatly increased.

The Diptera are by far the most important disease-carriers among the winged insects. Unlike most other insects, Diptera never have more than one pair of wings. They are the flies, mosquitoes, and midges. Fleas and lice, all wingless, are the other insects that are outstanding in this connection. Ticks, which are not insects, are also very important carriers of disease.

DIPTERA

The mosquitoes may be known by the long, piercing, sucking mouth (proboscis), and the presence of scale-like hairs on the wings. They are moderately fragile and have long slender legs.

The midges are generally more delicate than mosquitoes. They lack the scales on the wings and even those that bite (some very small ones) have rather short mouthparts. Some of the larger midges are often mistaken for mosquitoes; but, since they do not "hum" and are not attracted to people, they are soon recognized as harmless.

"Flies" is a general term applied to the more robust members of the Diptera, regardless of size. The term is perhaps best exemplified by the house fly, green- and blue-bottle flies, and other flies in houses, and by the deer and horse flies that attack people in the woods. There are many thousands of different kinds of flies but only a relatively small number of them bite.

MOSQUITOES

The mosquitoes are divided into three main groups but only two, the Anopheline and Culicine, are important. There are disease carriers in both groups. The Anopheline group is well known because some of its members transmit malaria. The mosquitoes that carry yellow fever belong to the Culicine group. Other diseases are transmitted by members of each group.

Anopheles mosquitoes are readily distinguished from other adult mosquitoes because they have the scutellum almost evenly convex apically; the abdomen is usually without scales or they are few in number. When an *Anopheles* is at rest the body is held at an angle of about 45°. The wings of most species are spotted. The eggs

are laid singly or in loose masses and have characteristic floats. The larvae are surface feeders and rest with their bodies parallel with the surface of the water.

Culex, Aedes and other Culicines have the scutellum concave toward the sides so that it is trilobed; the abdomen is wholly covered with scales. When these mosquitoes rest or bite their body is parallel to the surface. The wings of only a few of the species are spotted. The eggs may be laid singly, in loose masses, or in compact "rafts" but they do not have individual floats. The larvae rest at an angle to the surface of the water.

MALARIA

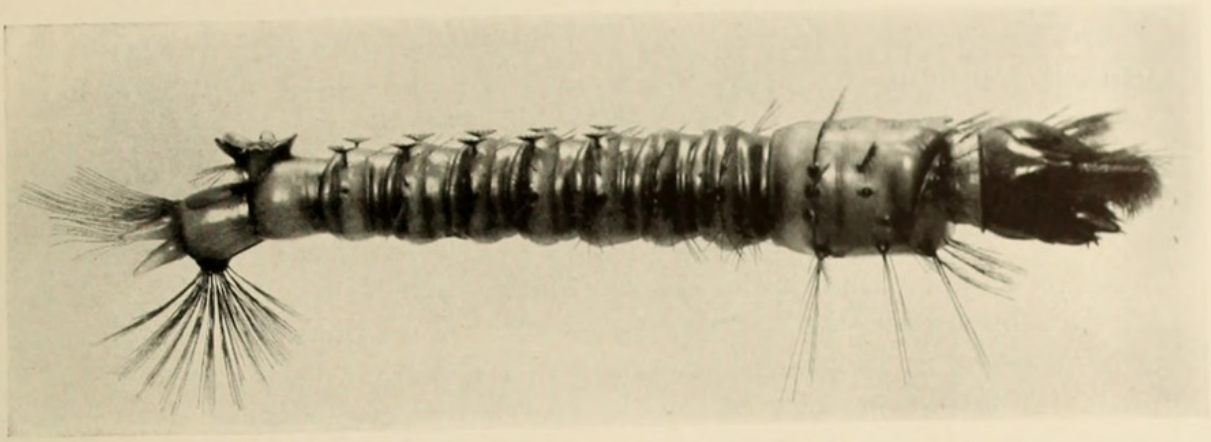
It has been authoritatively stated that malaria is "a disease of world-wide incidence and the cause of a higher sickness and death-rate than any other disease" (Encyclopaedia Britannica). In addition to deaths directly due to malaria, the disease weakens its victims, destroying their efficiency and making them more susceptible to other diseases.

A malarial parasite in man was first identified in 1880 by Charles Louis Alphonse Laveran, a French military physician then serving in Algeria. He received the Nobel prize for medicine in 1907. The parasites are one-celled animals of the genus *Plasmodium*, distantly related to amoebae. Their lives in the human body are relatively simple. An individual parasite enters a red blood cell and feeds on the cell's contents. When fully grown the parasite divides into a number of parts, each part being a new individual parasite. These youngsters break out of the blood cell in which they were formed and, for the most part, each of them enters another red blood cell to repeat the "asexual cycle." However, some of them, instead of being sexless, are either male or female. These sexual individuals float about in the blood stream and eventually die unless one of certain kinds of mosquitoes sucks them into its stomach.

The part played by certain mosquitoes in the transmission and, indeed, in the propagation of malaria was made clear in the last three or four years of the nineteenth century by the work of MacCallum (an American working on malaria in birds), Manson, Ross, Grassi, Bignami, Sambon, Low and others. It is briefly as follows.

Not all of even those mosquitoes that suck human blood are involved in the malarial cycle that includes man. There are apparently some exceptions to the usual statement that it must be a species of the genus *Anopheles* but, on the other hand, not all of the species of *Anopheles* are involved.

When a mosquito sucks blood from a malarial patient the mosquito is almost certain to draw into its stomach some of the sexual forms of the malarial parasite. Then, if the mosquito is one of those kinds that are susceptible to malarial infection, male and female forms of the parasite unite and the resulting organism bores through the lining of the mosquito's stomach and remains for a while as a cyst in the muscles of the stomach. Numerous spore-like bodies (sporozoites) develop



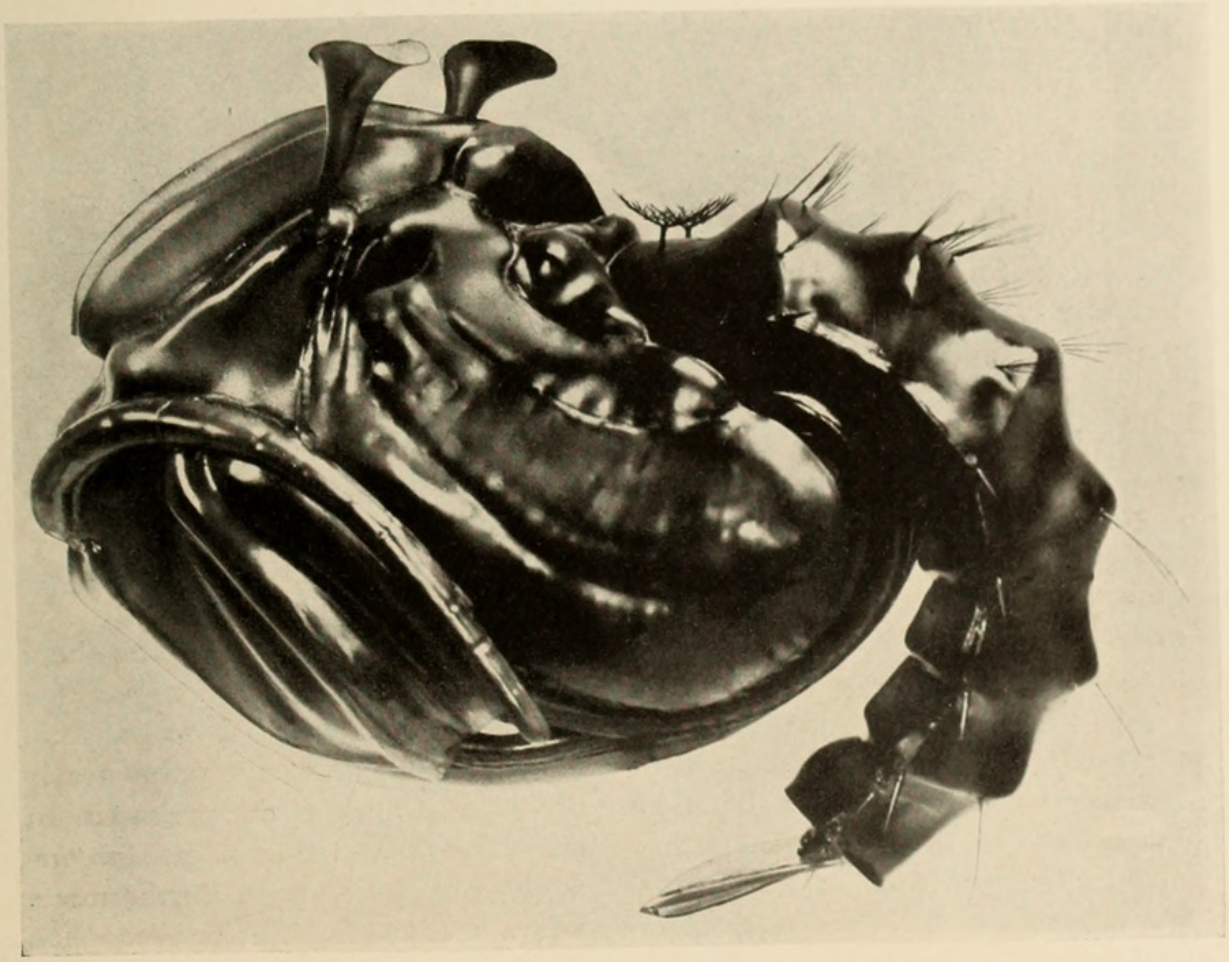


PLATE 1. — MODELS OF (ABOVE) A LARVA AND (BELOW) A PUPA OF A MALARIA MOSQUITO, *Anopheles*.

within this cyst and, after leaving it, move through the mosquito to its salivary glands. Six to fourteen days, the time depending on temperature and the kind of malaria, are required for the parasite to accomplish these changes and to move from the mosquito's stomach to its salivary glands. Until this is done the mosquito is not infective; but, after the sporozoites reach the mosquito's salivary glands, they, or at least some of them, will enter the human blood stream when the mosquito pierces a person's skin to feed. These sporozoites then change into the asexual forms living in human red blood cells; and the unfortunate human has malaria.

It will be noted that mosquitoes are more than mere carriers of malaria; they are parasitized by the malarial organism just as truly as humans are. Were it not for man, mosquitoes would not have malaria; and, were it not for mosquitoes that are subject to malarial infection, man would not have malaria. Malaria can not be naturally transmitted from one person to another except by way of certain kinds of mosquito; and bites of these kinds of mosquito will not give the bitten person malaria unless the mosquito itself has malaria.

For some unknown reason all or most of the sexual individuals in the red blood cells of a malarial patient break out of the cells at approximately the same time. It is then that the patient has the characteristic chill and fever, possibly because of poison released into the blood stream when the infected cells break. The time between attacks is characteristic of the kind of malarial parasite that is present. There are three chief kinds. *Plasmodium malariae* is the relatively rare quartan kind causing chills and fever that start every fourth day. *Plasmodium vivax* is the wide-spread and common tertian kind causing chills and fever that start every third day. *Plasmodium falciparum* is "aestivo-autumnal" or quotidian kind causing chills and fever that start every second day. The latter is also called "pernicious fever;" and the very dangerous "black-water fever" may be an extreme form of it.

A mosquito which has once had malaria may pass it on to numerous humans before it dies. James and Shute found that *Anopheles maculipennis* kept under laboratory conditions was infective for two and a half months after feeding on a malarial patient. One such mosquito could do a great deal of damage.

The mouth-parts of adult male mosquitoes are not well adapted for piercing and, so far as is known, no male mosquito ever "bites" humans. The antennae of adult male mosquitoes are decidedly feather-like; those of adult females are thread-like.

On each side of the proboscis there is a palpus, a segmented appendage that looks somewhat like an antenna. *Anopheles* females have palpi nearly or quite as long as the proboscis. In the United States most of the *Anopheles* have spotted wings. Furthermore, when resting, a female *Anopheles* usually stands with proboscis and body in a straight line at an angle to (not parallel with) the surface on which it is. If you see such a mos-

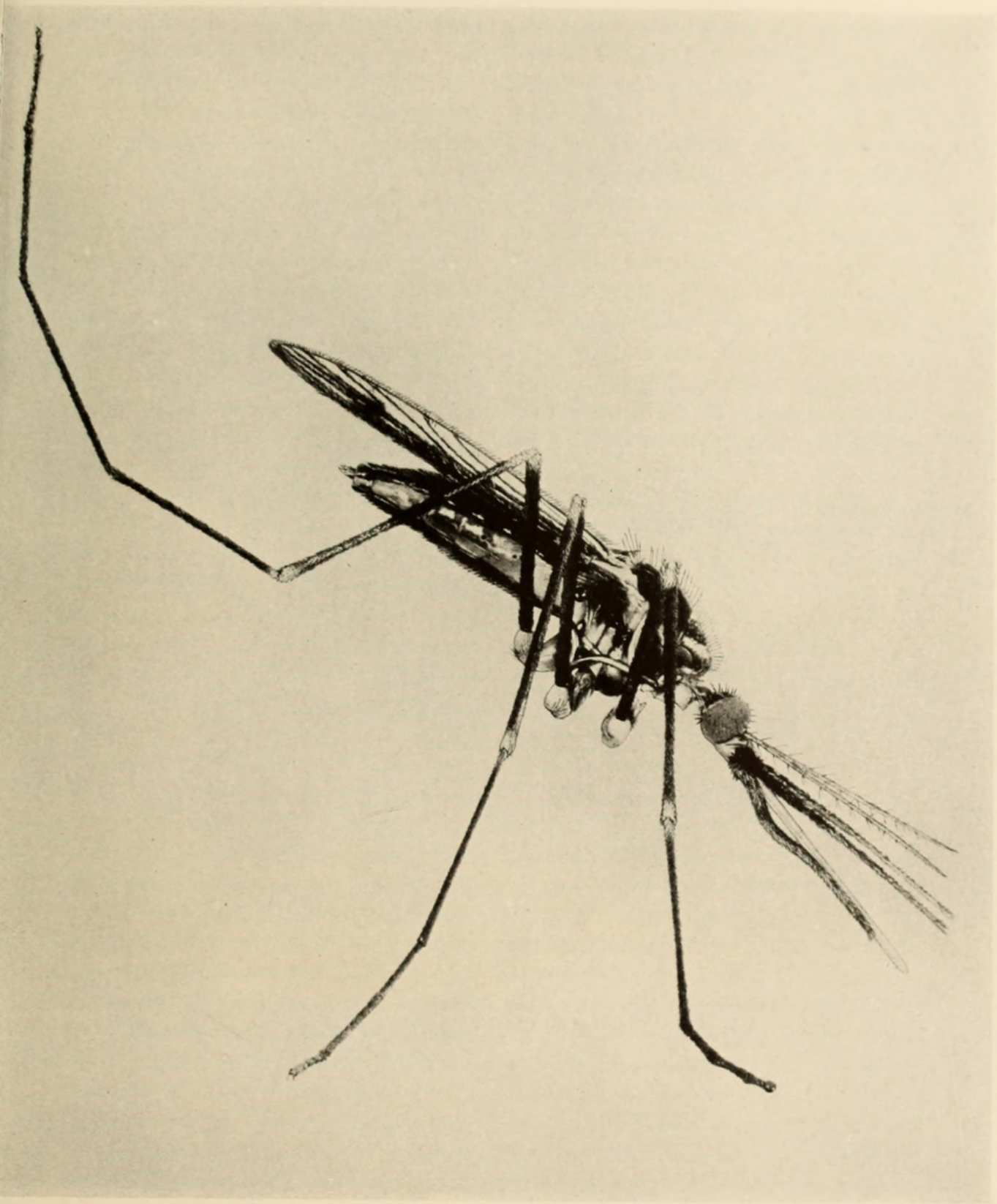


PLATE 2. — A MODEL OF A FEMALE MALARIA MOSQUITO, *Anopheles*.

quito, you may not be seeing a malaria-carrier but it is well to be suspicious of it and to act accordingly.

Contrary to common belief, a mosquito need not have a meal of blood before it can lay eggs. Many suck only plant juices, if, indeed, they feed at all. Even the blood-suckers often attack man less than they do other animals. An examination of the stomach contents of a large number of *Anopheles quadrimaculatus* in Louisiana showed that the stomach of only 4.3% of the individuals contained human blood and 95.7% of the individuals contained the blood of domestic animals. However, *A. quadrimaculatus* is one of the important carriers of human malaria. At least some species of mosquito may have races characterized by food preference, one of the races preferring human blood, another cow blood, and so on.

When mosquitoes pierce the skin to suck blood they usually inject a bit of fluid that is very irritating to some people but that may not greatly affect others. Apparently it is possible to acquire at least a partial immunity to this irritation; and possibly it is true that mosquitoes do not bite some people as freely as they bite others.

The duration of the life of adult female mosquitoes varies from a few weeks to six months or more, depending on the species and other factors. Males are relatively short-lived. Some species hibernate in the adult stage.

The immature stages of all mosquitoes are aquatic. The eggs are usually laid on the surface of water but in some cases they are laid on the damp ground of a depression where there will be a pool when rain comes. Some species, such as the common "rain-barrel mosquito," *Culex pipiens,* lays the eggs in compact masses and each mass may contain up to several hundred eggs. Most species, including those of *Anopheles,* lay their eggs singly or in loose clusters. An egg of *Anopheles* may be recognized by its having a "float" on each side.

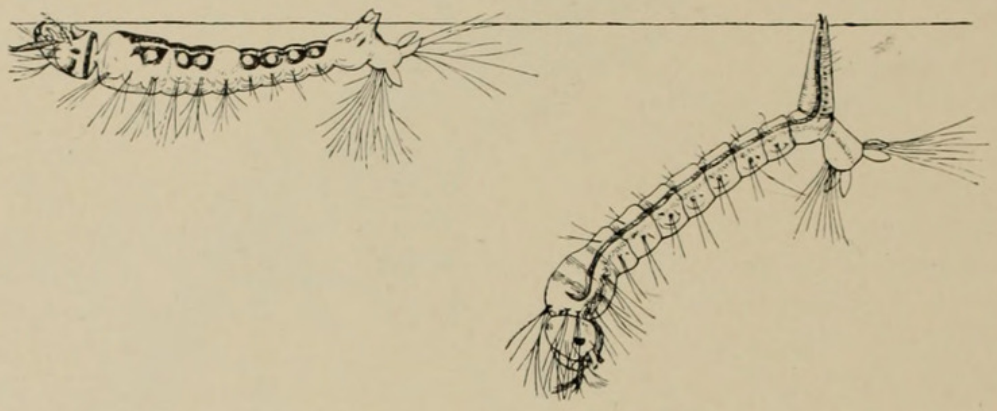


FIGURE 1. — RESTING POSITIONS OF LARVAE OF (LEFT) ANOPHELINE AND (RIGHT) CULICINE MOSQUITOES.

The larvae of mosquitoes move through the water with a lashing, twisting motion that has earned for them the name "wrigglers." Each has a "breathing tube" at the hind end of the body. When in need of air, the larva comes to the surface of the

water and pushes the tip of this tube into the air. Tracheae carry air to all parts of the larva's body. The breathing tube of *Anopheles* is relatively short and the *Anopheles* larvae when resting at the surface of the water are parallel to the surface. *Anopheles* larvae feed chiefly at the surface, eating microscopic bits of organic matter. The larvae of most other mosquitoes rest at an angle to the surface and largely feed on organic matter on the bottom of the water.

It is not unusual for larval life to be completed in a week or ten days, although some species spend the winter as larvae. Mosquito pupae are active but they do not feed. Their shape somewhat suggests a seed. The slender abdomen, folded against the thorax, serves as a paddle when the pupa moves. Instead of having a breathing tube at the end of the abdomen the pupa has a pair of trumpet-shaped tubes on top of the thorax. Pupal life is usually very short, in some cases only a day or two.

Since mosquitoes breed in water and, hence, are common in swampy districts, malaria is most common in such districts. Also, since adult *Anopheles* are most active at night, people who are frequently outdoors at night are most likely to get malaria. The old idea that malaria is caused by night air of the swamps was a natural error. Now that we know the facts, we know that infection can be prevented by avoiding the bites of malarial mosquitoes. The best method of doing this is to get rid of the mosquitoes.

Of course, the most thorough-going method of getting rid of mosquitoes is to get rid of all water in which they might breed. This is not usually entirely feasible.

Some species breed in the water in artificial containers such as cisterns, rain barrels, and empty tin cans. Cistern and rain barrels can be fitted with mosquito-proof covers. Discarded cans and the like should be buried or otherwise made incapable of holding water. Some species breed in water in the hollows of partially decayed trees; but these are rarely troublesome. If they are, drainage holes can be cut in the trees or the hollows can be filled with cement or even dirt.

Depressions containing small pools, even temporary ones, should be filled or drained. The proper drainage of swamps usually requires the cooperation of trained entomologists and engineers. Improperly constructed or clogged drainage ditches may themselves become breeding areas, particularly for *Anopheles*.

Mosquito larvae and pupae are eaten by a large number of aquatic insects, including even the larvae of some mosquitoes (*Psorophora* and *Megarhinus*). They have still other natural enemies but the most efficient natural enemies of mosquito eggs, larvae, and pupae are certain fish. Goldfish are very useful in the control of mosquitoes breeding in fountain basins and ponds kept for ornamental purposes. Top minnows, such as *Gambusia*, are recommended for anti-mosquito work, especially in the control of *Anopheles* and other mosquitoes having top-feeding larvae. Most small fish eat mosquito eggs,

larvae and pupae. In order to get the most help from fish the banks of the ditch, pond or stream should be kept clear of weeds and the edges should be sharp and free from overhangs.

If water in which mosquitoes would breed can not be eliminated and breeding can not be controlled by fish, then oil or poison must be used. Practically every kind of mosquito larva must get air by pushing the end of its breathing tube through the surface of the water and into the atmosphere. If there is a sufficient film of oil on the water, the larvae come in contact with it when they come to the surface to breath. The oil has a toxic action and it is also possible that the delicate openings into the tracheae may be clogged with the oil. Ordinary kerosene can be used for this purpose but it is expensive and evaporates rather quickly. Light fuel oils are more generally used, and sometimes pyrethrum and other insecticides are added. Oiling is of little value on running water.

Paris green, a stomach poison, has been used with success against some mosquitoes. One part of Paris green mixed with 100 parts of fine dust (ordinary dry earth) and scattered on the surface of pools or ponds at the rate of 2 ounces of the mixture to 100 square feet of surface will kill most of the *Anopheles* and other surface-feeding larvae. It is said that so little Paris green does not injure cattle that may drink the water. To kill bottom-feeding mosquito larvae the poison may be mixed with wet sand so that it will sink when scattered on the breeding areas. Not all lots of Paris green are equally effective. Samples should be tested before much is used.

Incidentally, before using either oil or other material, it would be well to ask the federal Bureau of Entomology (U. S. Department of Agriculture) or your State Entomologist for more detailed and up-to-date information than is given here.

There is no efficient method of large-scale destruction of adult mosquitoes. The advertised "traps" that electrocute insects that come to lights often do much more harm than good because they kill so many insects that are beneficial to man and so few that injure him.

The mosquitoes in a closed room may be stupefied by fumigating with burning pyrethrum powder but they must then be swept up and killed. More deadly fumigation would scarcely be attempted except in extreme cases. Thoroughly screening the house so that mosquitoes can not get into the room is a much better plan. Screen with 18 meshes to an inch is better than the more common 16-mesh kind.

The important fact that in these days of high-speed, long-distance transportation the whole world must be watched for danger from disease-carrying insects is well illustrated by the invasion of Brazil by *Anopheles gambiae* from Dakar. The essential facts are contained in the following extracts from the "Reviews" for 1938, 1939, 1940 and 1941 of the Rockefeller Foundation by its president, Raymond B. Fosdick.

1938

"If Orson Welles, in his now famous broadcast of October 30, 1938, had announced not that the Martians had landed in New Jersey, but that a mosquito called *Anopheles gambiae*, a native of Africa, had arrived on the American continent, there would have been no public alarm. Indeed it is doubtful if there would have been any public interest. But *Anopheles gambiae* is potentially a much more dangerous invader than the Martians would have been. H. G. Wells's Martians, it will be remembered, were unable to adjust themselves to life on this planet and quickly died. *Anopheles gambiae*, striking from Equatorial Africa, has invaded South America and is making itself very much at home in Brazil.

"Who is this new invader of the Western Hemisphere and how did it get here? *Anopheles* mosquitoes are malaria carriers; the *Anopheles gambiae* is the most dangerous member of a dangerous family. Although the species has hitherto been reported from Algeria and Morocco, and from Southern Arabia as well, its principal home is the African tropical belt, extending from the southern border of the Sahara Desert south to the Zambesi River. It is the scourge of Central Africa, a carrier of a serious and often fatal type of malaria, sometimes complicated by the so-called 'blackwater' fever. Until 1930 this species of mosquito was not known on this side of the Atlantic. In that year, however, or shortly before, it crossed the ocean, apparently by airplane or on one of the fast French destroyers which at that time were working in connection with the French air lines between Dakar in West Africa and Natal in Brazil. The species was first discovered in 1930 within the city limits of Natal by Dr. Raymond C. Shannon, a member of the Foundation's staff, during a routine mosquito survey in connection with the yellow fever service. The seriousness of its presence was immediately recognized, but it was hoped that the invasion might be localized by natural conditions unfriendly to the invader.

"These hopes were disappointed. In 1930 and 1931 there occurred in the vicinity of the breeding area in Natal an outbreak of malaria of a severity unprecedented in the annals of the city. The yellow fever service was compelled to undertake gambiae control in order to maintain an efficient staff for its own work. By 1931, following prevailing winds, gambiae mosquitoes had traveled up the coast 115 miles. Two years of severe dry seasons seemed to check the invasion, and then, with the recurrence of normal rainfall, the onward flight started again.

"In recent years, severe epidemics of gambiae-carried malaria have occurred in localities over two hundred miles west and north of Natal. In the Jaguaribe Valley of the State of Ceará alone there were over fifty thousand cases of malaria in 1938. Over 90 per cent of the population was affected, with mortality in certain districts estimated at 10 per cent. So disabling and widespread was the epidemic that, in some parts, crops were not planted and salt production was greatly reduced because of lack of labor. It is estimated that as a result of the ravages of this mosquito nearly every person in these affected areas will be on government relief in 1939.

"George E. Vincent, formerly President of the Foundation, in his report for 1928 wrote, 'It has been said that a good malaria fighter must "learn to think like a mosquito." He must ask: Which of many kinds of anopheline mosquitoes shall I try to imagine myself? How far is it possible to fly? When and where is food to be had? Which blood is to be preferred, human or animal? How can one get into a screened house? Where shall one rest after a good meal? Where is the best place to deposit eggs? Is the water of the right kind and temperature? Is it stagnant or flowing? Is there vegetable growth to protect eggs and larvae from fish?' Fortunately, through the work of the Foundation's staff and others in Africa, much is known about the gambiae. It breeds prolifically and rapidly, requiring only seven or eight days to develop from egg to adult, a fact that makes breeding possible in very temporary water collections. It has variable breeding habits, but seems to prefer stagnant, sunlit water. It has a high infection rate. During the outbreak in the city of Natal in 1930, 62.8 per cent of 172 specimens of gambiae caught and dissected were found to be infected with malaria, a rate higher than anything hitherto known in the Americas. The gambiae seems to prefer human to animal blood; of over a thou-

sand specimens tested in 1931, 82.3 per cent contained human blood. It is a domesticated insect; it usually bites indoors, not outdoors. Fairly reliable flight records show a distance of over three miles.

"Late in 1938 representatives of the Brazilian health service and of the Foundation staff investigated the infected area in North Brazil. They visited São Gonçalo and Baixa Verde, both of which have had heavy outbreaks of malaria following the introduction of gambiae to the region; and the lakes about Assú. They also went up the Jaguaribe River through Jaguaribe Mirim, Ouro Branco and Icó, to Lavras. This visit confirmed the seriousness of the situation. Once the gambiae gets into a river valley it spreads up the valley unless blocked at some point by natural or artificial barriers.

"With the assistance of The Rockefeller Foundation an anti-gambiae service is now being organized. Except for the distribution of quinine by field personnel working in infested districts, this service will not have the responsibility for medical care of the sick in dispensaries or otherwise. Inasmuch as there is insufficient time to develop a separate agency, it will be organized as a part of the existing local yellow fever service. This affiliation will make possible the utilization of the wide experience of the yellow fever service in the infested area and will provide a group of trained men accustomed to working under discipline. It is hoped by this method to confine the gambiae to the relatively arid areas which it now occupies, and possibly even to exterminate it there. If the gambiae should break through to the well-watered Parnahyba and Sao Francisco River Valleys, it is feared that it would be impossible to prevent its spread to a large part of South, Central and perhaps even North America. The Parnahyba Valley is 500 miles from Natal; the gambiae mosquitoes are already nearly half way there.

"In 1938 the International Health Division of the Foundation set aside $100,000 for expenditure in 1939 on the problem of the gambiae in Brazil. The Government of Brazil has also earmarked substantial sums. Funds will be released for control measures as soon as the plans of attack are drawn."

1939

"Many public health workers throughout the Americas are awaiting with anxiety the outcome of the campaign that has been organized against this mosquito. These workers realize that one of the most serious health problems facing their own countries is involved in the possibility of gambiae continuing its invasion and sooner or later reaching their territories. The tragic result of such a spread cannot be over-stated. A distinquished malariologist, Dr. M. A. Barber, has recently said: 'This invasion of gambiae threatens the Americas with a catastrophe in comparison with which ordinary pestilence, conflagration and even war are but small and temporary calamities. Gambiae literally enters into the very veins of a country and may remain to plague it for centuries. Even the penetration of yellow fever into the Orient might be a lesser evil, because its vector is domestic and more easily controlled.' . . .

"The actual field service of the campaign against the gambiae is being carried on by the personnel of the Foundation in collaboration with the Brazilian government. The Foundation has assumed the responsibility of direction and administration. Early in 1939 the Malaria Service of the Northeast (of Brazil) was created by government decree and began the task of organizing a field force to prevent further extension of the gambiae, to minimize the effects of its activity in the area already infested and to reduce its range.

"The first results in 1939 were frankly disappointing. The organization of the Malaria Service of the Northeast coincided with the beginning of the rainy season, when the gambiae advances by leaps and bounds, and this, together with the lack of personnel trained in methods of mosquito control, prevented any early apparent results of the campaign. As was anticipated, widespread epidemics of malaria occurred, and during the first few months of the Service some 114,000 persons were treated for the disease. During these early months the only visible consequence of activity was the reduction of mortality from malaria through medication of acute cases.

"By the beginning of July, however, a staff of over two thousand doctors, technicians, scouts, inspectors, guards and laborers, trained

in methods of control, was available, and even though the rainy season was unusually prolonged, appreciable results were obtained, not only in minimizing the further spread of gambiae in the frontier districts, but also in reducing the incidence of the mosquito in certain heavily infested sections to a point where careful surveys repeatedly failed to reveal the presence of either larvae or adults.

"In this campaign both climate and physical geography promise to be indispensable allies. The rainy season is restricted to 4 months out of 12, i.e., from February through May, and gambiae is a mosquito which breeds mainly in residual rain-water pools, shallow, open to the sun and without vegetation. It does not lay its eggs in permanent or deep water, in running, salty or shaded water or in water supporting aquatic vegetation. On the other hand, it takes advantage of every little depression in the ground, such as wheel tracks or hoofprints, no matter how shallow or small, which can present a water surface for eight or nine days. During the rainy season, with its almost daily showers, gambiae becomes a formidable antagonist. But for eight months in the year, the heat of the tropical sun, the strong continuous trade winds, and the low humidity combine to dry up all shallow surface waters and to make life precarious and of short duration for the gambiae. Potential breeding places are reduced to disconnected pools in the beds of the larger rivers, none of which maintains a flow in summer. Most of the higher rolling country back from the coast is practically non-infectible by gambiae. Its arid, stony soil supports a scrub vegetation composed of a resistant, thorny bush mingled with cactus. The region is without water for larvae, and without shelter for gambiae adults. The sparse population of the interior is therefore closely bound to the river systems and so also is the gambiae mosquito throughout the summer.

"The plans of the campaign against gambiae sound like the plans of an army on defense. The frontiers of the infested region are defined by fumigation posts on all the outgoing roads. These are the forts of this new kind of Maginot Line. A 10-mile zone beyond the gambiae's farthest limit of advance is to be kept non-infectible, which from the mosquito's point of view is the 'scorched earth' policy. Within this zone, as well as within the area already infected, all breeding places of the mosquito must be eliminated or treated with Paris green or other larvicide. The whole region is being mapped from the air so that no pools, ponds or other collections of water will be overlooked. The adult mosquitoes are being sought and killed in the houses with insecticide sprays to diminish the chances of their laying eggs and thus perpetuating the species in the region. Every automobile and train that leaves the infested area is being stopped, inspected and fumigated. A maritime service has been organized at points along the coast to disinfect every boat or plane bound for clean ports. It is war in a very real and grim sense, and, unlike other types of war, its purpose is the preservation of human life.

" . . . by December, 1939, gambiae had been pushed back to its central strongholds in the main river valleys and on the narrow coastal shelf. If the mosquito can be held within its present limits during the wet season of 1940, we can begin to think of the possibility of its eventual eradication from the entire region. This, of course, would mean extermination of the last surviving pair. It must be admitted that eradication is a rash word in terms of prophecy. As in all campaigns, accidents may determine the issue. Thus in one case the gambiae mosquito was transported many miles into previously uninfested territory through the medium of an old automobile which used an improvised wagon road through the jungle and thus avoided the fumigation post on the main thoroughfare. In another case it was a small fishing boat that carried the mosquito up the coast, thus driving a wedge in the defense line against the spread of the disease. If the war is won, victory will come through continued vigilance. The wet season of 1940 will test the efficacy of the present measures and will be critical as far as the gambiae campaign is concerned."

1940

"A year ago we reported that the gambiae had been pushed back to its central strongholds in the main river valleys and on the narrow coastal shelf of Northeastern Brazil — an area of perhaps twelve thousand square

miles. Around this area a line of fumigation posts was erected to keep the mosquito from breaking through into new territory, and a concerted advance was begun to narrow still further the boundaries of its domain. The weapons employed were Paris green for potential breeding places and spray insecticides for the fumigation of all buildings.

"This intensive campaign in 1940 had dramatic results. During the critical wet season the gambiae was pushed back on all sides, so that by the beginning of the dry season it had been practically restricted to the lower Jaguaribe Valley. This made possible the concentration in this area of a large number of workers for the final onslaught beginning in July. It can now be reported that no larvae or adults of gambiae have been found in the lower Jaguaribe Valley since the first week in September. A small additional focus lying some sixty kilometers beyond the known infested area was discovered in October, but it yielded readily to attack and was apparently clean by the middle of November. No evidence of gambiae in Brazil was found during the last forty-seven days of 1940.

"Further relevant evidence lies in the fact that in areas of earlier infestation where control measures have been progressively discontinued gambiae have not been found, even during the rainy season when the Brazilian type of anophelines flourish. In the Icó field laboratory alone, routine microscopic examination of some two million anopheline larvae, collected during the last eight months of 1940 in areas where control measures had been suspended, failed to reveal any evidence of surviving gambiae infestation. Considering the fact that the gambiae mosquito is a domestic insect with marked preference for certain types of readily observed breeding places, the failure to find either larvae or adults in an area in which no control measures are being applied seems highly significant.

"Those directing the campaign no longer consider it rash to speak of the eradication of gambiae from Brazil, although it must be remembered that the struggle will not be won until the last fertilized female gambiae on this side of the Atlantic is destroyed. In any case, no matter how many isolated foci may yet be uncovered, the critical phase of this immediate campaign seems to be over. Certain mopping-up operations remain to be done as the search is continued for infested areas. The number and extent of these areas should become rapidly apparent with the onset of the rainy season early in 1941."

1941

"A year ago we reported that it no longer seemed rash to speak of the eradication of gambiae from Brazil, although some mopping-up operations might be necessary if any areas became infested at the onset of the rainy season in 1941. It is a satisfaction to report that no such infested areas were discovered during the entire year. Except for a short period of two months in a small area in which infestation was first found in October 1940, no control measures were carried out during the year in the gambiae region, and a free opportunity was thus afforded for any remaining members of the species to increase their numbers at will. Thorough search by well-trained and selected personnel throughout the entire area of previous infestation, and even far beyond the old limits, failed to reveal the presence of a single gambiae.

"This particular battle would seem to have been won — at great labor and cost, and after enormous suffering. But the gambiae mosquitoes have apparently not given up their intention of establishing themselves in the Western Hemisphere. Airplanes are crossing the Southern Atlantic with increasing frequency, and commercial planes, of course, are now carefully fumigated, both after they leave Africa and again before their passengers are discharged in Brazil. A dead female gambiae was discovered after fumigation in a plane arriving in Brazil in October 1941, and two more in January 1942. The original infestation, with all its subsequent miseries, could readily have been started by a single fertilized female. Truly the price of liberty, as far as this malaria-carrying mosquito is concerned, is eternal vigilance."

YELLOW FEVER

Yellow fever, now known to be carried by mosquitoes, was for years one of the most dreaded diseases of the

American Tropics and western Africa. It occasionally extended its ravages into the United States. There were outbreaks in Boston in the seventeenth century and in New York as late as 1856, to mention only two northern localities that have been afflicted with it. New Orleans is in constant danger from it. Asiatic and Pacific regions have, as yet, been free of yellow fever; but, once introduced there, it might spread like a great conflagration.

Unlike malaria, yellow fever acts quickly. A patient either dies soon or recovers. If he recovers, he is usually immune to the disease for at least some years. The fact that during the attack the skin becomes yellow gave the disease its name.

It was formerly believed that yellow fever was spread by contact with a yellow fever patient, his excrements, his vomit, or even with any object that he had touched. As early as the middle of the last century, workers began to suspect that the disease is carried by mosquitoes. Starting about 1881, Dr. Carlos Finlay of Cuba, upheld the suggestion that mosquitoes are the carriers. Working by observation and experiment he had all but proved his case when in 1900 the U. S. Army in Cuba organized a commission to study the infectious diseases there.

The United States commission consisted of Dr. Walter Reed (its head), Dr. James Carroll, Dr. Jesse W. Lazear, and Dr. Aristides Agramonte. They soon abundantly proved that yellow fever is transmitted by a mosquito that was then called *Stegomyia fasciata*, now known as *Aedes aegypti*. They also demonstrated that it is not spread by contact with a yellow fever patient, his excrements or vomit. Volunteers, protected from mosquitoes, lived with yellow fever patients and even slept in beds soiled by the patients without acquiring the disease. Other volunteers, living in clean surroundings apart from yellow fever patients, allowed themselves to be bitten by infected *Aedes aegypti*. These volunteers developed the disease provided the mosquito had some days before sucked the blood of a yellow fever patient.

Dr. Lazear was accidentally bitten by such a mosquito while working in a hospital ward and died of the fever.

There has been much discussion concerning the identity of the organism that causes yellow fever. Whatever it is, it is exceedingly small, so small that it passes through the pores of bacterial filters with the "filterable viruses." Riley and Johannsen (1938, "Medical Entomology") say: "Noguchi in a series of papers presented seemingly definite evidence that the disease was due to a spirochaete which he named *Leptospira icteroides,* but his work met with much criticism, and he himself, before his tragic death in West Africa, came to recognize that he had probably been dealing with a mixed infection or an incorrectly diagnosed case of infectious jaundice and its organism *L. icterohaemorrhagie.*"

Although it is now known that mosquitoes of other species, even of other genera, can and do transmit yellow fever, *Aedes aegypti* is directly responsible for most of the trouble in cities.

It is a "domestic" species, breeding in cisterns, water buckets, flower vases and similar containers. Development from egg to adult takes about two weeks at ordinary tropical temperatures. The adult may live for at least five months.

The success of fighting yellow fever in densely populated areas by fighting *Aedes aegypti* was shown by the results in Cuba, in the 1905 outbreak in New Orleans, and in the building of the Panama Canal. However, a new phase of the battle against yellow fever developed. Its history may be told by again quoting extracts from the "Reviews" of the Rockefeller Foundation.

1937

"In the *Review* of a year ago, mention was made of the fact that the epidemiological strategy of the battle with yellow fever had been badly upset by the discovery of the existence of the disease in jungle districts where there were no *Aedes aegypti* mosquitoes. It had previously been assumed that this mosquito was the only carrier and that man was the only natural host. The new picture of yellow fever, therefore, proved to be far darker than had been supposed. It is now known that vast areas of the hinterland of both South America and Africa are endemic centers of the disease. By what vector it travels, other than the *Aedes aegypti* mosquito, or what other hosts there are except man, is not known."

1938

" . . . Clinically, pathologically and immunologically, it has so far been impossible to differentiate jungle yellow fever from the classical aegypti-transmitted variety. Strains of virus isolated from jungle cases differ no more from strains isolated from urban cases than do these latter from each other. Jungle strains can be transmitted in the laboratory by *Aedes aegypti* just as the urban strains can be transmitted by various species of jungle mosquitoes found in Africa and by others found in South America.

" . . . Were it not for the existence of the jungle infection, yellow fever might have disappeared permanently from the Americas in 1934. . . .

"While vaccination promises to be of great aid in preventing the transfer of yellow fever by the human host from one locality to another, it cannot of course eliminate the virus in the jungle nor block its dissemination through contiguous forests in the tropics. Lurking somewhere in these forests are unknown vectors and other hosts than man; and a great deal of work remains to be done before they can be accurately identified."

1939

" . . . Blood tests of wild monkeys show that they are involved in epidemics, but other animals may also play a part. The capture and analysis of thousands of forest mosquitoes during an epidemic showed that three species had yellow fever virus in them, and that two of them could transmit the disease to monkeys by biting. This so-called 'jungle' yellow fever constitutes what may be a permanent reservoir of infection, and vast areas of the South American hinterland are undoubtedly endemic centers of the disease.

"Consequently The Rockefeller Foundation in recent years has shifted its emphasis from temporary anti-aegypti mosquito campaigns in a few of the larger centers to a broader program which includes three principal points:

"1. The permanent prevention of aegypti-transmitted yellow fever through more rigid control measures in urban areas.

"2. The early discovery of such outbreaks of yellow fever as may occur.

"3. The prevention of jungle yellow fever, in so far as possible, through mass vaccination of exposed populations."

1940

" . . . The work of the Foundation in Colombia, South America, in 1940, has thrown new light on this puzzling situation. . . .

" . . . the presence of yellow fever virus was demonstrated in two species of mosquitoes — the *sabethine* [*Sabethes* or *Sabethoides?*] and the *haemagogus* [*Haemagogus*]. In spite of repeated attempts to isolate the virus from many classes of insects, no virus was found in any form of insect life other than mosquitoes.

"The next step was to determine the susceptibility of jungle animals to yellow fever virus. For this purpose over two thousand wild animals were captured. It was found that while the yellow fever virus did not kill any of the animals tested and generally did not produce signs of illness, many species had virus circulating in the blood stream while the animals were running about — a condition especially favorable to the spread of the virus. The tests showed several broad groups of animals, comprising many species, to be susceptible. The chief groups are as follows:

Primates: man and monkeys.
Marsupials: the opossums, all species.
Edentates: anteaters, sloths, armadillos.
Rodents: agouti, paca, capybara, some species of mice.

. . .

"As a result of the several avenues of investigation followed in Colombia, the following tentative generalizations appear to be justified:

"1. Yellow fever is primarily a disease of jungle animals. The classical form involving transmission from man to man by the *Aedes aegypti* mosquito is more of a secondary cycle depending largely upon conditions of population concentration and mosquito breeding created by man himself.

"2. Transmission of jungle yellow fever appears to be by jungle mosquitoes from animal to animal.

"3. There is no animal reservoir of virus in the usual sense. Virus continues to circulate in the blood of susceptible animals for three or four days only, and does not subsequently reappear. Mosquitoes, however, once infected tend to harbor the virus for the remainder of their lives, which may be several months under favorable conditions. . . .

"The discovery that yellow fever can be transmitted in the jungle by carriers other than the *Aedes aegypti* mosquito does not minimize the significant part which the aegypti mosquito plays in the distribution of the disease among human beings. It is not too much to assert that if in urban areas this insect were brought under control as it has been in Brazil, the world could avoid the threat which in these days of fast transit might so easily develop into a cataclysm in East Africa, in India and even in the Orient, to say nothing of parts of the Americas, should the virus of yellow fever break through the barriers of quarantine, vaccination and medical vigilance."

1941

"Continued investigation of jungle yellow fever in Colombia brought added evidence that, in certain areas at least, a *Haemagogus* mosquito is the chief villain in the tragedy. One of the puzzling aspects of this problem has been the complete disappearance of this mosquito at certain periods, especially during the dry season, while at the same time the disease has continued among both animals and men. How could the disease be accounted for in those seasons when the vector supposedly responsible was not to be found? This problem was resolved by the discovery that *Haemagogus* is characteristically an inhabitant of the tree tops and may be found there when it is absent in catches made at ground level. The investigators were forced to develop techniques new to yellow fever work, and as one of them expressed it, it became necessary 'to associate with the monkeys in the interlacing branches high above the jungle floor.'

"With this knowledge available, it was possible to capture haemagogus mosquitoes throughout the entire dry season of 1941, and yellow fever virus was found repeatedly in the mosquitoes caught in the tree tops. An adequate mechanism was thus demonstrated for the carry-over of yellow fever virus from one rainy season to the next, and an explanation was afforded of the known frequency of jungle yellow fever among men engaged in felling trees."

DENGUE

This disease is also called breakbone fever because of the intense pains accompanying it. Fortunately it does not have a high fatality rate, although it is responsible for much suffering and loss of work. It occurs in the tropics and also in the southern parts of Asia, Europe and the United

States. It is carried by at least some of the mosquitoes of the genus *Aedes*, including *A. aegypti*, the urban yellow fever mosquito, and in the Philippines by *A. albopictus*. The disease organism is a filterable virus.

ENCEPHALITIS

Under this heading are included a number of closely related virus diseases that cause enormous losses to livestock each year and may cause outbreaks among the human population. Western equine encephalitis has been known from Kansas and the West for more than fifty years as a disease of horses. St. Louis encephalitis also attacks horses. Eastern encephalitis is a disease of birds. Dr. Wm. A. Davis has shown that various species of *Aedes* are capable of transmitting these diseases and it is possible that certain species of *Culex* may transmit the St. Louis type. These diseases cause deterioration of the brain, the space it occupied being replaced by water. "Sleeping sickness" is the result. When humans contract the western forms of the disease, chances of recovery are rather good, but the eastern form is almost always fatal. Human outbreaks are sporadic and many years may elapse between them.

FILARIASIS

Wuchereria, also called *Filaria*, is a genus of parasitic nematode worms. *Wuchereria bancrofti* is one of the more important species. Its mature stages occur in the lymphatics of man. Embryos ("larvae," microfilariae) live in various of the visceral organs by day or when the patient is active; but at night or when the patient is resting they swarm, often in large numbers, in the peripheral blood stream. If a mosquito such as *Culex quinquefasciatus* sucks blood containing these embryos, the embryos make their way through the walls of the mosquito's body, where they grow and change their form. If at that time the mosquito bites a human, the worms that have reached the mosquito's labium ("lower lip") crawl out and make their way into the human. Their presence in man, especially in the lymphatic system, causes various disorders including enormous swellings of the legs, a condition that is called elephantiasis.

It is worth noting that Sir P. Manson's work on *Filaria* in 1878 was the first demonstration of a parasite being transferred from mosquitoes to man.

FLIES

Among the many species of two-winged insects (Diptera) that are popularly called "flies," *Musca domestica* is the one most often found in man's dwellings. It is *the* house fly. Because it frequently breeds in the excrement of man and other vertebrates, it has been called the filth fly; and because, under certain conditions, it plays an important part in the spread of typhoid and other intestinal diseases, it has been called the typhoid fly. With the pronounced decrease in the number of stables and cow-barns in towns and cities, and with the highly desirable increase of sanitary sewage disposal, the importance of this fly in normal times in North America and in much of Europe has greatly decreased. However, the house fly is a

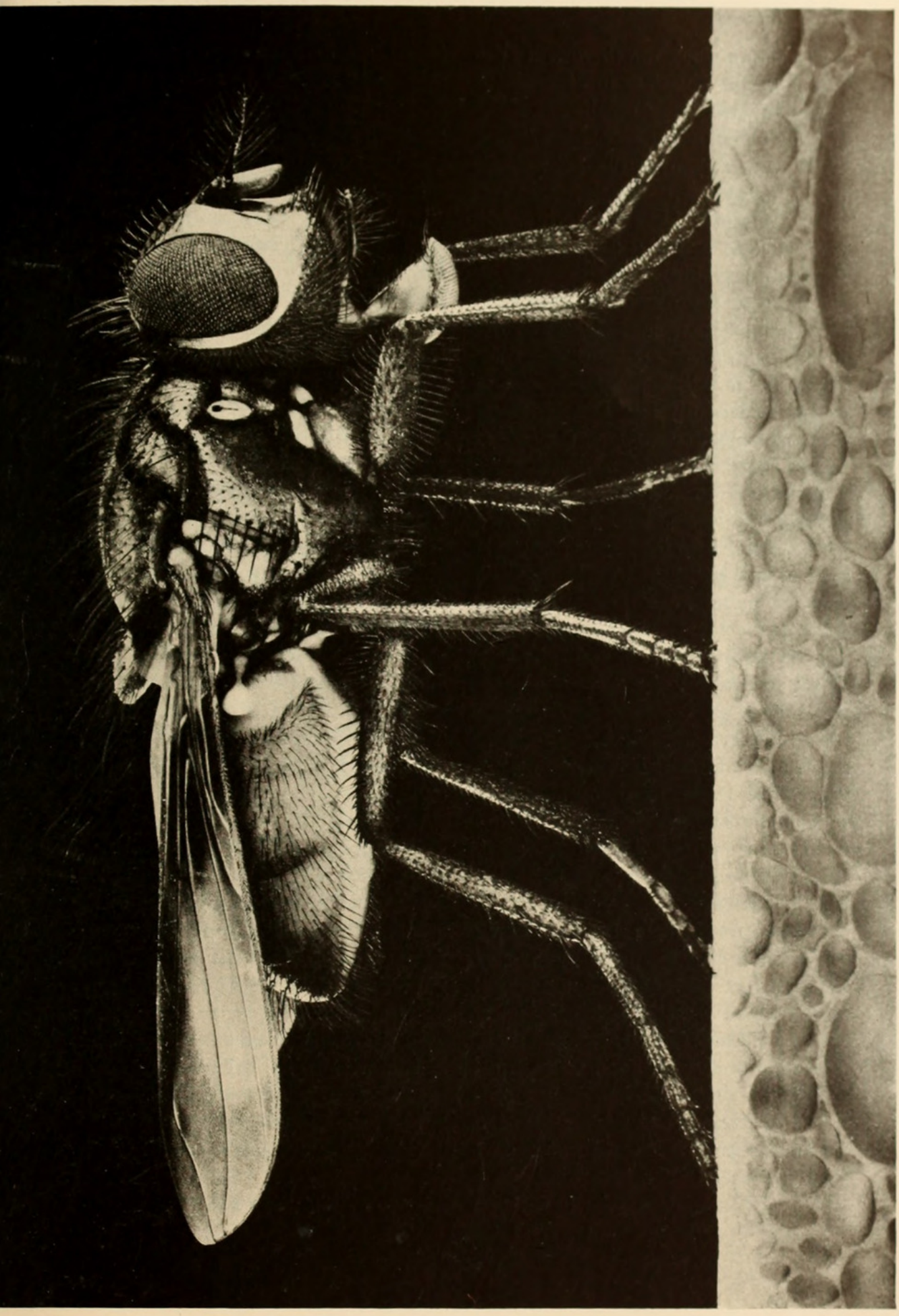


PLATE 3. — A MODEL OF THE HOUSE FLY, *Musca domestica*.

real menace wherever there is a relatively dense population of humans living in unsanitary conditions.

Musca domestica never "bites." The biting house fly, also called the stable fly, is *Stomoxys calcitrans*. It somewhat resembles *Musca* but, in addition to more technical distinctions, its beak is sharp-pointed in contrast with the flat-tipped proboscis of *Musca*.

Although horse manure, especially if it be mixed with straw, is the most favorable breeding place for *Musca*, it will successfully breed in any mass of fermenting organic matter. Each female may lay 1000 or more eggs. They hatch in a few hours if the weather be warm. Under conditions favorable to them the larvae (maggots) become full-grown in less than a week and the pupal stage lasts only about four days. Thus, development from egg to adult may be completed in about ten days. Using figures such as these, plus assumptions that no flies die and that favorable breeding conditions are unlimited, calculations are frequently made to determine how many descendants a single pair of flies would have in one season. Such calculations merely show how false the assumptions are.

Musca spreads disease in a mechanical way. An adult fly crawling on, for example, the excrement of a typhoid patient or of a "typhoid carrier" may get typhoid germs on its feet and then, crawling on human food, may leave such germs on the food by simple contact. Or, it may feed on typhoid-laden excrement and later regurgitate its food, germs and all, on our food. Since adults of *Musca domestica* have been found 13 miles from the place where they were marked and released, it is evident that they may be a large factor in the spread of typhoid and other intestinal diseases, including cholera. Adult flies may mechanically spread other diseases such as tuberculosis, anthrax, yaws (a tropical skin disease), trachoma, and possibly leprosy and poliomyelitis ("infantile paralysis"). As to poliomyelitis, *Stomoxys calcitrans* has been more frequently cited as a probable carrier but the question as to which, if either, is an important factor in the transmission of this disease is not yet settled.

As is the case with other injurious insects, the best control of *Musca* and *Stomoxys* is by preventing breeding and this usually requires community action. The proper treatment of manure piles and latrines is not easy. The best advice that can be given here is to secure detailed directions from your State Entomologist and from the Bureau of Entomology of the United States Department of Agriculture.

"Swatting" flies in the house and incidentally smearing their possibly disease-laden fluids on the walls and furniture is not very sanitary. "Sticky fly-paper" is much better. The various sprays may do little more than stupefy flies, after which they should be swept up and killed by burning or otherwise. Since these sprays may contain kerosene or some other inflammable substance such sprays should not be used near an open flame.

Glossina is a genus of blood-sucking flies occurring in Africa and Arabia. They are popularly called tsetse flies.

Unlike most "biting" insects, the males as well as the females suck blood. These flies somewhat resemble large house flies but they are more elongate and have longer wings which give them a parallel-sided appearance when at rest. The mouth parts somewhat resemble those of *Stomoxys calcitrans*. Another characteristic of these flies is that the larvae live in the mother's body. The larvae feed on maternal secretions until they are ready to pupate, at which time they leave their mother's body.

The thing that makes this genus important is that its members are carriers and intermediate hosts of protozoa of the genus *Trypanosoma*. *Trypanosoma brucei* is the organism causing nagana, a very serious disease of cattle and horses. *Trypanosoma gambiensis* is the cause of African sleeping sickness, an even more serious disease of man. The former is carried by *Glossina morsitans* and the latter by *Glossina palpalis* and *G. tachinoides*.

If these flies bite a person having *Trypanosoma gambiensis* in his blood and not more than a few hours later they bite a healthy person they will, by simple mechanical transfer, inoculate the second person. Possibly other biting flies and even mosquitoes do the same. This infectiveness disappears in a few hours but the parasites penetrate the intestinal walls of *Glossina,* and, after a complicated metamorphosis analogous to the transformation of the malarial parasites in a mosquito's body, are ready to enter human blood again.

A satisfactory control of *Glossina* has not yet been developed. Clearing the riverside forests where they live and burning the grass in open places is of local value. Screening of patients to prevent the flies from reaching them seems to have little effect. Possibly wild mammals are reservoirs of infection.

Flebotomus is a genus of minute, biting "sand flies." Although not common in the United States, they are widely distributed and often abundant in the tropics. In addition to the irritation caused by their bites, they are either suspected to be or proved to be carriers of such human diseases as three-day (papataci) fever, kala azar, tropical ulcer, Carrion's disease (Oroya fever or verruga peruviana) and leishmaniasis.

Many of the members of the family Ceratopogonidae, particularly the species of *Ceratopogon* and *Culicoides,* bite human beings. They were formerly included in the Chironomidae but the true midges do not bite although they resemble mosquitoes and are often mistaken for them. Two of the common names applied to the biting midges are punkies and no-see-ums. Their bite is very irritating and they are so small that it is difficult to see them in time to kill them before they bite. Their larvae are aquatic or live in decaying vegetation or between tide zones. It is not known that any of our native species carry disease but several species in the Cameroons are intermediate hosts of a filarial worm in its transfer from man to man.

In some places, species of Simuliidae, the "black flies," are a major pest.

They are active by day and attack both animals and man. Sometimes certain species occur in enormous numbers and bite severely. Since their larvae live in running water, artificial control is practically impossible. Our northern species probably do not spread disease, although certain tropical species of *Simulium* are known to be intermediate hosts of nematode worms living in nodules of the skin of man, causing the disease called onchocerciasis. If the nematode settles in eyes, blindness frequently results. Fortunately, this disease is at present limited to Mexico, Central America and tropical Africa.

The family Tabanidae contains many species variously known as horse flies, gad flies, deer flies and so on. Some species are quite large and none are really small. Only the females bite. It is known that at least one species, *Chrysops discalis,* may transmit tularaemia in a purely mechanical way. West African species *(Chrysops dimidiata* and *C. silacea)* are intermediate hosts of a filarial worm (*Filaria diurna*) causing the disease loa loa.

REPELLANTS FOR PROTECTION AGAINST BITING DIPTERA

Many lotions or ointments have been used to repel mosquitoes, midges and biting flies but none are completely satisfactory, even for a short time. Oil of citronella is an old standby; but many people do not like the odor and prefer the insect bites. "Staway" is a newly developed product that is practically odorless. It possibly affects rayons and should not be used in contact with these fabrics.

The following formula, developed and extensively tested by the Canadian Entomological Branch, is said to give excellent results.

Oil of thyme . . . . . ½ fluid ounce
Concentrated extract
of pyrethrum . . . . . 1 fluid ounce
Castor oil . . . . . 2 to 3 fluid ounces

In addition to the above almost any fly spray, and particularly those containing both rotenone and pyrethrum, will give considerable protection. Ordinary kerosene or coal oil will repel pests for some time but the effects are not lasting.

FLEAS

Fleas are notorious chiefly for their bite but some of them carry disease, particularly plague. Typhus also may be carried by fleas but it is more often associated with lice. The eggs of fleas are usually laid on the ground or drop to the ground from the animal on which they have been deposited. The larvae feed on organic debris, often in the cracks of floors or in the nests of the hosts. Pupation takes place there. Adult fleas may live more than two years. The fleas that consistently bite humans in the United States are the dog and cat fleas (*Ctenocephalides canis* and *felis)* and, of course, the human flea (*Pulex irritans*). Other fleas bite man occasionally but do not persist in their attacks.

BUBONIC PLAGUE

Justinian, who ruled the Eastern Roman Empire in the sixth century, is chiefly remembered for the laws that he instituted in the lands over which he ruled; but, despite the great good that he accomplished in bring-

ing justice to the conquered lands, the people suffered greatly from disease. It was during his rule that there was the first recorded great epidemic of bubonic plague. It started in Egypt in the year 542 and spread as far north as Constantinople. It lasted for more than fifty years and resulted in the death of an estimated 100,000,000 people.

The next great outbreak killed about one-fourth (25,000,000) of the population of Europe during the fourteenth century. About two hundred years later an epidemic of plague swept over Great Britain, where more than half of the population died from the disease, there being more than 70,000 deaths in London alone during the years of "The Black Death" (1664-1666). It has been suggested that some of the ancient epidemics of "plague" were typhus, not bubonic plague. The only large, recent epidemic of plague occurred in Manchuria in 1910-1911, resulting in the deaths of more than 60,000 persons; but every year there are numerous isolated cases or small epidemics in various parts of the world.

Bubonic plague seems to be primarily a disease of rats, squirrels, and other rodents. It is a bacterium, *Pasteurella pestis*. Simond showed in 1898 that it is spread from rodent to rodent by fleas. The form of the disease that occurs in rodents other than "domestic" rats and mice is called sylvatic plague. There are three different forms of the disease in man and recovery is frequent only from the form in which the disease is confined to swellings ("buboes") of the femoral and axillary glands. In a second form the bacteria develop in the blood stream, causing secondary pneumonia, which is transmitted from man to man as a result of inhaling droplets ejected by the coughing of a diseased person. A third form, the septicaemic or "fulminating," may develop rapidly from either the bubonic or the pneumonic plague. Death is almost certain to result from either of the last two.

Man may, at least occasionally, contract bubonic plague by contact with rodents that have the sylvatic form or that have recently died as a result of it. Possibly man may also contract the disease as the result of scratching into his skin excrement from some kinds of the fleas that have fed on diseased squirrels or other diseased rodents living in the open country. However, it seems unlikely that epidemics ever start in that way. The blood sucked by a flea and the bubonic bacteria that may be sucked up with the blood in most cases pass through the flea's intestine. The undigested portion of the blood and the bacteria are voided as feces but most kinds of fleas do not regurgitate from the mouth while feeding. This is not true of *Xenopsylla cheopis*, the flea that is often abundant on rats living in human habitations, especially in cities. If this flea feeds on the blood of a rat infected with the bubonic bacterium, a jelly-like mass may form in the flea's alimentary tract in front of the mid-intestine. This mass blocks the alimentary tract so that blood sucked by the flea can not pass into the intestine and be digested. As a consequence, the flea gets very hungry

and is continually trying to feed. Also, while the flea is feeding, the blood that it has just sucked, together with some of the blood from a former feeding, is regurgitated. If this flea with its alimentary tract thoroughly infected with bubonic bacteria regurgitates while feeding on a human, it will infect that person with the plague. When these three things come together—rats infected with the plague, the flea *Xenopsylla cheopis*, and large numbers of human beings—an epidemic of bubonic plague is almost certain to break out. If one of the three is absent, such an epidemic is unlikely and probably impossible. The best safeguard for us is to get rid of rats and other rodents around human habitations.

While rat fleas play the most important part in the dissemination of plague they are not the only carriers of the disease. In 1941, Wheeler, Douglas and Evans demonstrated that the sticktight flea *(Echidnophaga gallinacea)* also carries the disease. The sticktight flea is chiefly a pest of chickens but it also attacks other birds, cats, dogs, rodents, and occasionally man. Birds are not known to suffer from plague but the "sticktight" is found commonly on the burrowing owl and, since this bird is known to be associated with rodents in their burrows, it may play an important part in spreading the disease through the transportation of infected fleas.

THE CHIGOE FLEA

The names Chigoe, chigger (see mites), chique, jigger and sand flea are applied to a flea *(Tunga penetrans)* that has the very unpleasant habit of fastening itself to the human body and burrowing into the flesh. Its favorite places are along the side of or under the toe- or finger-nails, or between the toes; but they may attack any part of the body. It is a very small flea that, because of this habit, causes a great deal of misery to humans but it is not a disease carrier.

It is the female flea that does the damage. She attaches herself and, after feeding, bores under the skin, causing a painful sore or pustule. The eggs are laid while the female is embedded and may remain in the wound or drop to the ground. If they hatch in the wound, the larvae drop to the ground, where they develop in the same way as other fleas.

The Chigoe is found in subtropical and tropical America and Africa. When it infests buildings it may be destroyed by thorough spraying, dusting with poison, or fumigation. Those that have entered human flesh may be cut out and the wound cleaned and dressed; or the insects may be killed by the application of turpentine or other remedies, discharge taking place as a result of ulceration.

THE TRUE BUGS

A great many of the bugs (Hemiptera and Homoptera) will "bite" man occasionally but very few of them are human pests, the best-known being the bedbug. Many small bugs that normally feed on plants, such as leafhoppers and aphids, will quite often take a nip, but these are not bloodsuckers and no after-effects result. Some of the larger bugs that prey

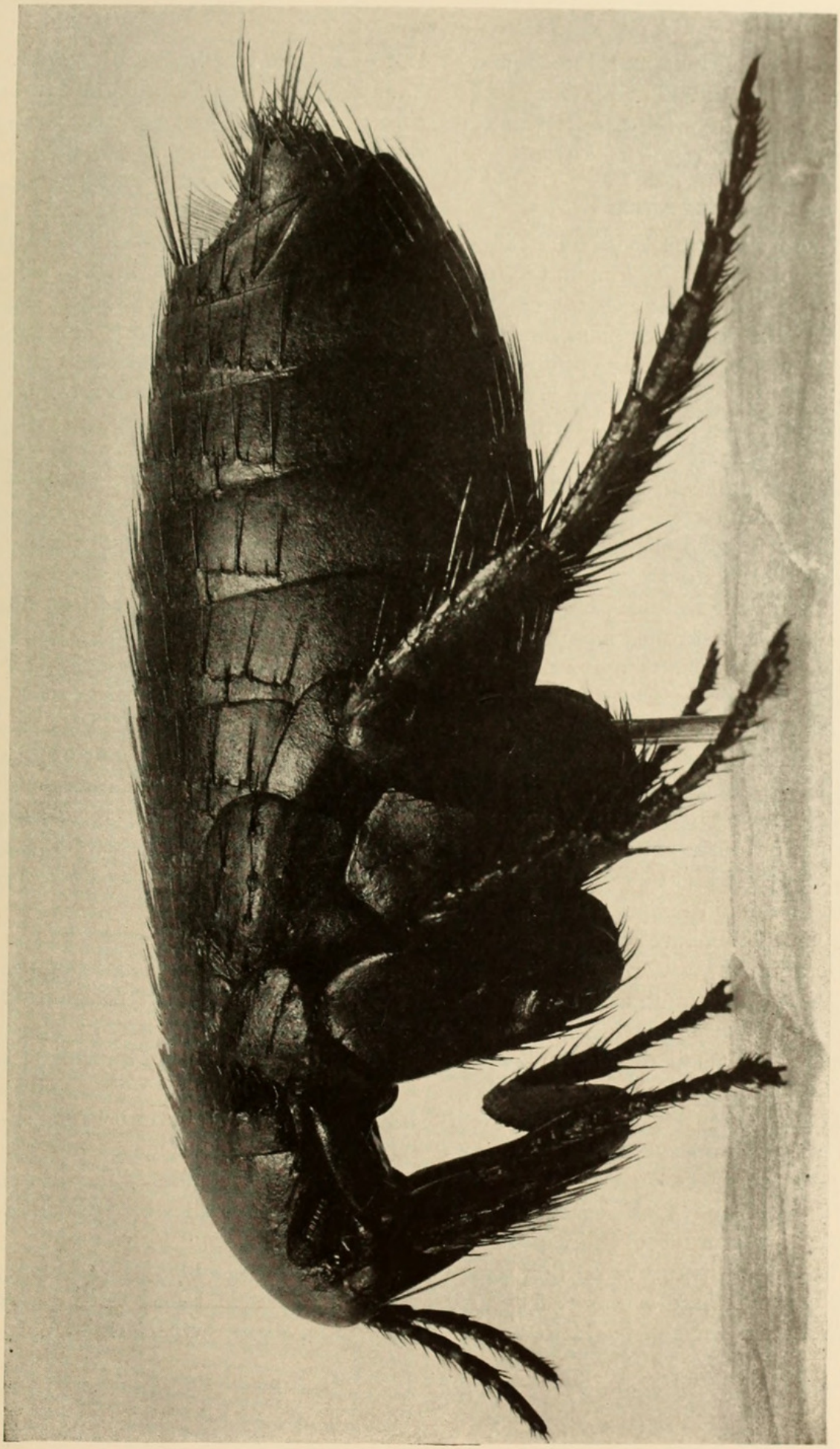


PLATE 4. — A MODEL OF THE RAT FLEA, *Xenopsylla cheopis*.

upon other insects may bite humans if handled carelessly. Only one group, the assassin bugs, is definitely associated with the spread of disease.

THE BEDBUG

There are three kinds of bedbugs that consistently attack man, the common one being *Cimex lectularius*. It is world-wide in its distribution. The other two are tropical or subtropical. (In addition to these, there are a few kinds that attack bats and birds and so closely resemble the ones attacking man that only an expert can distinguish them.)

There is no positive evidence that bedbugs carry disease in nature, but it has been demonstrated that they may do so under controlled laboratory conditions. The general opinion is that, while they are capable of carrying and spreading certain diseases, they do not do so normally and cannot be regarded as carriers.

Bedbugs require about two months to mature during warm weather and apparently do not breed during the cool months in temperate zones. Consequently, there are only two or three generations a year. The fact that bugs of all ages are found at the same time is due to the egg-laying habit, each female laying ten to fifty of her two to five hundred eggs every few days.

During the day bedbugs conceal themselves under folds in bed mattresses and in cracks and crevices in beds, walls and floors, coming out at night for a meal of human blood. When a light is turned on they scurry for cover. If food is scarce, they may travel from one apartment to another and even from one house to another. They are usually carried into the house on clothing or in travelling bags. Railroad coaches, street cars, busses, hotels, cloak rooms and friends' homes may be sources from which the bugs come.

Bedbugs may be controlled by thoroughly spraying crevices in the beds and rooms with odorless kerosene or coal oil. (Be careful of fire.) The efficiency of the spray is greatly increased by the addition of pyrethrum and rotenone.

CHAGAS' DISEASE

Chagas' disease is caused by a protozoan, *Trypanosoma cruzi*, and is transmitted from man to man by species of *Triatoma*, *Mestor* and *Rhodnius*, all members of the Assassin Bug family. These bugs are also known as kissing bugs and cone-noses, the latter because of the shape of the head. They comprise a group that has apparently changed from a predaceous, insectivorous habit to one of sucking vertebrate blood. Some related species that do not persistently suck blood may do so at times.

The trypanosome undergoes changes when swallowed by the bug; but the disease is apparently not transmitted by the bite of the insect. The insect usually defecates while or immediately after feeding. The trypanosomes in the insect's intestine are carried in the insect's excrement and may enter the body of man as a result of the person scratching or licking the sore caused by the bite of the bug.

Chagas' disease was originally recognized in Brazil in 1909, where it was quite prevalent, especially among

young children. It is frequently fatal. It has since been found in other tropical American countries and as far north as the southern United States.

In addition to spreading the disease, the insects may cause severe illness as a direct result of their bites. They apparently inject a specific poison that causes a burning sensation, intense itching and much swelling. In addition to the original focal swelling, red blotches may develop on various parts of the body. The effects may last for weeks, although they usually disappear within a few days. Bites from some of the species may cause nausea, palpitation of the heart, rapid breathing and other symptoms which are also evident in Chagas' disease but uninfected bites are not fatal.

A northern species of Assassin Bug that sometimes bites humans is the Masked Bedbug Hunter, the young of which are usually covered with dust. They feed on bedbugs but, as they feed also on other household insects, their presence does not necessarily mean that bedbugs are in the house.

LICE

True lice, not plant lice, are wingless insects of the order Anoplura, also called Siphunculata. They are probably related to the true bugs. All of them live on and suck the blood of mammals. The Head Louse of man (*Pediculus humanus* or *capitis*) may be the same species as his Body Louse (*Pediculus corporis* or *vestimenti*). The latter is also called Cootie and Grayback. The Crab Louse of man is *Phthirius pubis*.

The control of lice attacking man may be accomplished by personal cleanliness; fumigation of living quarters, bedding and all clothing by chloropicrin ("tear gas") or some other effective fumigant; sterilization of clothing and bedding by steam or air at 140° for twenty minutes, or by ironing them slowly with a hot iron; use of mercuric chloride for destroying pubic lice; and use of kerosene for the killing of head lice. Since some louse-borne diseases can be transmitted by crushing infected lice between the fingers, this means of control is dangerous.

TYPHUS FEVER

Other names that have been applied to the disease that is now generally known as typhus fever are ship fever, jail fever, war fever, Brill's disease, tabardillo, murine disease and spotted fever. It should not be confused with typhoid fever. The disease organism is a bacterium, *Rickettsia prowazeki*. One of the symptoms of typhus is a blotching of the skin; but since similar spottings are caused by other diseases, the name "spotted fever" for typhus is confusing. The name "murine disease" alludes to the part that rats and mice have in the spread of typhus.

Rats and mice are subject to typhus. Apparently fleas, especially *Xenopsylla cheopis*, transmit the disease from rodent to rodent and also from rodent to man. Lice of the genus *Pediculus* are apparently the principal — possibly the only — carriers of typhus from man to man. The disease enters the human system either when an infected louse bites the person or when the feces of an infected louse or the crushed body of an infected louse is rubbed on a scratch

or other break in the skin of the person. After a louse has bitten a typhus patient a period of seven to eleven days must elapse before the crushed body of the louse can transmit the disease but it may be transmitted by the louse's feces after as few as three days. Development of the disease in humans requires ten or twelve days.

The disease is milder in children and an attack results in immunity, which may explain the apparently low incidence of the disease among peoples who are normally infested with lice. Outbreaks of typhus are common among soldiers and in concentration camps because the crowded and often unsanitary conditions in camps favor the increase of lice. The control of rats and of lice means the control of typhus. The recent development of a vaccine for innoculating against typhus may greatly reduce the danger of the spread of the disease.

TRENCH FEVER

Trench fever is carried by lice in the same way as is typhus fever but there is a great difference in its symptoms. There is no spotting of the skin; the disease may last for two or three months; and no immunity is produced. The onset of the fever after infection by crushed lice occurs in from five to twenty days; but if the infection occurs from the louse's excrement the fever develops in eight days. It is not known how much time must elapse after feeding upon a victim of trench fever before crushed lice can produce the disease in man but the feces are capable of doing so after five days.

Trench fever is not a dangerous disease, but it may be responsible for great loss of manpower. Those suffering from it often are very slow in regaining their strength and may be absent from duty for three or four months. It was only during the first world war, that the disease became well known and was studied by both British and American commissions established for that purpose. Almost all that we know about the disease is the result of the investigations of these commissions. It is impossible to determine the number of cases that occurred during the first world war because thousands of cases of influenza were diagnosed as P.U.O. (pyrexia of unknown origin) before it was discovered that two diseases were concerned. The name trench fever did not come into use until the disease itself became common.

EPIDEMIC RELAPSING FEVER

This type of relapsing fever is spread solely by lice, chiefly as a result of scratching by an individual who has crushed lice. The spirochaete causing the disease develops in the liquids and organs within the body-wall of the louse but is unable to survive long in the intestine. The disease is not common but is liable to appear in epidemic form. It is easily controlled by the elimination of lice.

TICKS AND THEIR RELATIVES

Insects never have more than three pairs of jointed legs; and the head of an insect is not immovably joined to the thorax. Scorpions, spiders, mites and ticks have four pairs of jointed legs (at least when adult) and the head is immovably joined to the thorax. Scorpions have a segmented abdomen. Spiders and mites, including ticks, have

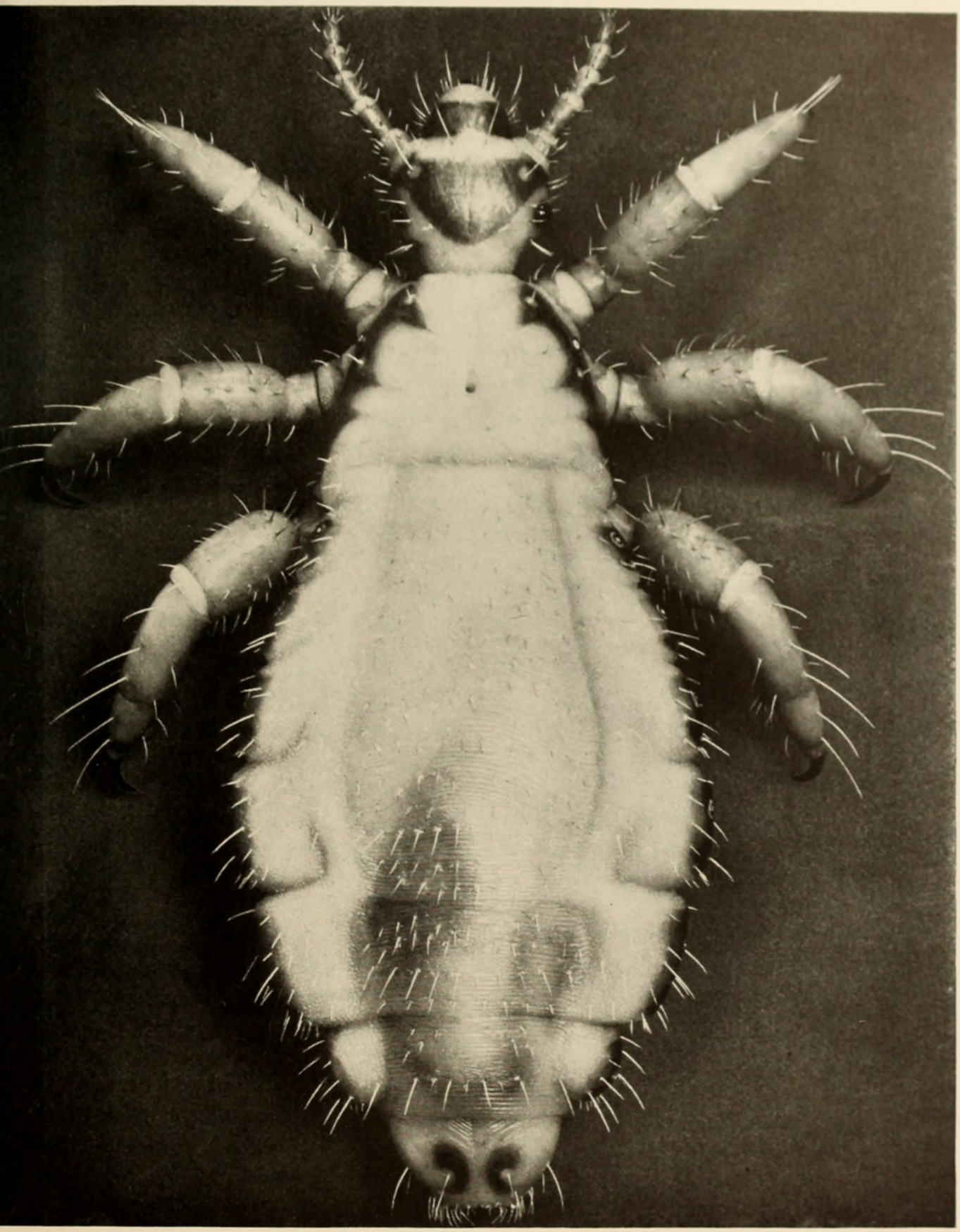


PLATE 5. — A MODEL OF THE BODY LOUSE, *Pediculus corporis*.

the abdomen unsegmented. Spiders have a definite constriction in front of the abdomen; ticks and other mites have the abdomen more broadly joined to the rest of the body. Ticks are classed as a superfamily (Ixodoidea) of the order (Acarina) of mites. The distinctions between ticks and the other mites are rather too technical to be given here.

TICKS

Ticks are parasitic on vertebrate animals, including man, and may prove to be among the most important carriers of diseases to man and domestic animals.

The life history of the various kinds of ticks follows the same general pattern but there is a very great difference in the time required to reach maturity. Some kinds complete their life cycle in less than a year, while others require up to four years. A single female may lay as many as 18,000 eggs; three or four thousand is a common number. Newly hatched ticks may live for about four months without feeding, and nymphs and adults may starve for more than a year. The six-legged larvae or "seed-ticks" hatch from eggs on the ground and attach themselves to some animal. Some kinds remain on the animal until mature but most of them, after feeding for from a few hours to a week or more, drop to the ground to molt. After molting they again attach themselves for feeding or they may hibernate. In all, there may be from three to eight molts (depending on the species) before the adult stage is reached. Attachment occurs primarily for the purpose of feeding; however, some kinds also mate on the host.

Ticks present a very different appearance before and after they have become engorged with blood. Before feeding, the tick is round or ovoid in outline and quite flat or a little convex above and concave below. Its legs are conspicuous. When it has become engorged it may be five or six times as long, the body is rounded, and the legs are relatively small. As the blood is digested the body becomes smaller.

"The best way to remove a tick, and this should be done without delay, is to take hold of it with the fingers and pull it off slowly with a firm straight pull without jerking" (Herms). If care is not used, the head may break off and remain in the wound.

ROCKY MOUNTAIN SPOTTED FEVER

Tick fever, black fever, blue disease and black measles are other names of this disease. It has been known in the Bitter Root Valley of Montana since 1872 but, despite its name, it is not restricted to the western mountain areas. In the East it is most prevalent in Maryland, Virginia, and North Carolina. Parker states that it is present in at least 39 states; and since 1931 it has been reported from 26 of the eastern and central states. The virulence of this fever varies greatly in different parts of the country. In southern Idaho the mortality is only 1% to 3% of the victims, in California about 16%, and in eastern Montana very much higher. The outbreak of a rash on the wrists, ankles and sometimes on the back, later spreading to all parts of the body, is one symptom and explains the descriptive name "black measles."

Proof that Rocky Mountain spotted

fever is carried by ticks was furnished by McCalla and Brenton in 1905, although Wilson and Chowning had advanced the theory three years earlier. Wolbach discovered the disease organism *(Rickettsia rickettsi)* in 1919 and named it in honor of Dr. Ricketts, whose work in connection with Rocky Mountain spotted fever and typhus was outstanding. Dr. Ricketts died from an infection during his researches on typhus in Mexico.

Rocky Mountain spotted fever occurs in rabbits and other rodents and is transmitted from rabbit to rabbit by the rabbit tick *(Haemaphysalis leporis-palustris)*. This tick does not bite man and therefore does not transmit the disease to humans. The ticks that do transmit the disease both from rodent to rodent and from rodent to man are (more or less in the order of their importance) the Rocky Mountain spotted fever tick *(Dermacentor andersoni)*, the American dog tick *(D. variabilis)*, the Pacific Coast tick *(D. occidentalis)*, and the brown dog tick *(Rhipicephalus sanguineus)*.

Ticks may become infected with *Rickettsia* during their first meal or during any future meal. Once infected, they are capable of transmitting the disease during their entire lifetime; and the females can even transmit the disease to their offspring through the eggs. Because the immature stages of ticks feed particularly on rodents, cats, dogs, etc., almost the whole source of human infection is the bites of adult ticks.

The disease passes the winter in ticks that are either in the adult or nymphal stage. Parker states that the bite of an infective, over-wintered tick in the early spring may not produce recognizable infections but may produce an immunizing attack of the disease. Later in the season bites become more dangerous, the disease becoming more severe as the result of warm weather. However, since the adults of *D. andersoni* dislike hot weather, they usually seek cover under grass by the first of July, after which time there is very little danger of being bitten by this species. In sections of the country where other species of ticks capable of transmitting the disease are active during the summer months, the danger of infection is present at all times.

Fortunately, an infected tick does not transmit the infection until it has fed on its "host" for from about two to ten or more hours. Consequently the danger of infection is slight if attached ticks are removed within a few hours. One usually becomes aware of a tick crawling on the body or trying to insert its mouthparts, but ticks may very often become attached without the knowledge of the victim and they may remain for a considerable time before they are detected. It is therefore advisable for those in tick-infested areas to examine themselves thoroughly on returning from the fields or woods. Oddly enough, it is usually men who acquire Rocky Mountain spotted fever in the West, where *D. andersoni* occurs; but it is usually women in the East where the dog tick is the vector.

General control measures against the Rocky Mountain spotted fever tick have not been satisfactory and the safe thing is to keep out of tick-infested areas during the dangerous part of

the year or to wear clothing that will make it difficult for the ticks to reach the body. A vaccine has been developed by the U. S. Public Health Service for protection against the fever. It gives protection for at least one season but it is less effective as the season progresses and the virulence of the *Rickettsia* increases.

TICK PARALYSIS

Tick paralysis is rather prevalent and there are numerous cases each year. It is rarely fatal to humans. As far as is known, it is caused only by the Rocky Mountain spotted fever tick and its occurrence therefore coincides with the distribution of *D. andersoni*. The exact cause of the paralysis is not known but it is believed to be due to a salivary secretion that is injected by the tick into the body of the person upon whom it is feeding.

Children seem to be particularly susceptible to tick paralysis. In one of the early cases reported in Oregon by Temple in 1912, the patient after retiring the preceding night in healthy condition was unable to stand in the morning, and by the third day the paralysis was so complete that the child was unable to speak or eat. The removal of two engorged ticks resulted in complete recovery within a week. After removal of the ticks the patient usually recovers fully within a day or two.

In most cases of the disease the engorged ticks have been discovered on the nape of the neck or along the spine, these being the favorite places of attachment for this species of tick. Recovery may take place naturally when the ticks drop off; but, on the other hand, death may result if a number are present and the paralysis is prolonged.

COLORADO TICK FEVER

This fever occurs in many parts of the Rocky Mountain region and results from the bite of the Rocky Mountain spotted fever tick *(Dermacentor andersoni)*. It is painful and debilitating, but not fatal. The disease organism is not known.

RELAPSING FEVER

Relapsing fever has been known in Africa for about a hundred years; but it was not until 1904 that Ross and Milne definitely showed that the disease is tick-borne. As early as 1857 David Livingston reported upon the evil effects following the bite of a tick that was later named *Ornithodoros moubata* by Murray (1877). It is said that the natives of Central Africa have long dreaded the bites of ticks.

The disease organisms of relapsing fever are various species of the bacterial genus *Spirochaeta*. Possibly they are merely forms of one species, *S. duttoni* or *S. recurrentis*. It occurs on all of the principal continents and, wherever found, is transmitted by ticks of the genus *Ornithodoros*. In the United States it is confined to the Southwest and to altitudes above 3000 feet in our western mountains, the regions occupied by *Ornithodoros turicata* and *O. hermsi* respectively. The natural "reservoirs" of relapsing fever in the United States are squirrels and other rodents.

When infected blood is taken into the body of a tick the Spirochaetae bore their way through the walls of the digestive tract and into apparently

all parts of the tick. Those that reach ovaries innoculate the eggs of the tick and the infection is passed on to the next generation. Some reach the tick's salivary glands and others the coxal glands (glands at the bases of the tick's legs). Those that reach the salivary glands are injected by the tick into the wound caused by its subsequent feeding. Probably those that reach the coxal glands may enter the human body through a break in the skin. There is a case on record in which a man contracted the disease directly from a squirrel by accidentally smearing his fingers with its blood.

TULARAEMIA

This is primarily a disease of rabbits but it has been found in other wild animals, including coyotes, sheep and quail. It severely attacks man also. The disease organism is a bacterium, *Pasteurella tularensis.* It is widely distributed in the United States. The rabbit tick, *Haemaphysalis leporis-palustris,* is largely responsible for its distribution from rabbit to rabbit, although the rabbit louse, *Haemodipsus ventricosus,* also is a vector. Probably transmission of the disease occurs whenever blood from an infected animal is transferred to a susceptible one, including man. When the disease was first recognized in 1919 it was called deer fly fever because it was found to follow the bite of a species of deer fly, *Chrysops discalis.* People who shoot rabbits or prepare them for cooking are in danger of becoming infected by the blood of diseased ones coming in contact with a scratch or other break in the person's skin.

OTHER MITES

Many kinds of mites other than ticks may occasionally bite human beings, but only a few kinds consistently attack man. Although not carrying a disease, some of them may be considered to be themselves a disease.

SCABIES

This disease, also called mange and itch, is a very small, almost colorless mite, *Sarcoptes scabiei,* that bores under the skin, particularly where it is delicate, making tunnels that may exceed an inch in length. Since the life cycle is completed in about two weeks and each female lays fifteen or twenty eggs, a single female gaining entrance under the skin is soon responsible for an extensive sore, the skin becoming irritated by poisons given off by the mites. Scratching results in bleeding and often increases the irritation. In addition, scratching may spread the mites to other parts of the body.

This mite occurs also on swine, horses, cattle, dogs, and probably on other mammals. Outbreaks on man can often be traced to some individual who has been in contact with mangy domestic animals. In peace time its presence on man is usually of local distribution, although whole families or school districts may be affected. During war, when people may be crowded together unduly, it may become very prevalent and movements of infested people may carry it into districts that were formerly free from it.

The treatment now recommended in England, where extensive tests have been conducted because of the great menace of infestation during war con-

ditions, is 18% of sulphur incorporated in a bland soap and applied to the body in a lather that is allowed to dry. About three applications in four days often results in a complete cure. The British distribute the medication in what they call "sulphur lather tablets." Although these tablets are not currently available in the United States, the treatment was originally developed here by Dr. R. A. Nolan.

CHIGGERS

Harvest mites, red bugs, or chiggers are often the cause of much suffering by those who find it necessary to be in the fields during the summer and autumn. These mites should not be confused with the Chigoe flea, sometimes called chigger.

The chiggers attacking man are the larvae of mites belonging to the family Trombidiidae and especially to the genera *Trombicula* and *Eutrombicula*. The adults are large mites, sometimes being as much as half an inch long, and vary in color from light to dark red. The nymphs and adults are believed to feed on decaying vegetation in the soil, but the larvae are predaceous upon various kinds of animals, including snakes. The eggs are laid in the soil. The young larvae make their way to the surface and crawl up on grasses, weeds, or other low foliage, where they lie in wait for a victim.

When the chigger has become attached by means of its sharp mouthparts it remains for two to three days. Within a few hours the area surrounding the mite becomes reddened, quickly swells, and later develops into a water blister. Even before the swelling occurs there may be intense itching. Scratching increases the irritation. On man the mites usually attach themselves in places where the clothing fits tightly, such as beneath a belt or garters, but they may be located on any place on the body. When present in large numbers there may be a slight fever but the chief unpleasantness results from the intense irritiation and the resulting lack of sleep.

Chiggers occur throughout the temperate and tropical regions, less abundantly in the north. There is no control, but some protection may be obtained by changing clothes immediately after returning from the field and taking a hot bath with plenty of strong soap lather. Tall weeds and grass harbor large numbers of the mites and these areas should be avoided if possible. Sprinkling flowers of sulphur or pyrethrum on the body under the clothing is said to give some protection. The internal use of sulphur, which is exuded in perspiration, also has been recommended.

The itching caused by the mites may be alleviated by the use of a paste made with bicarbonate of soda or by dabbing the itching spots with rubbing alcohol or ether. "Lather-less" shaving creams are recommended both as a preventive and to lessen the itching.

RAT MITES

Rat mites *(Liponyssus)* are extremely small creatures that act in the same way as chiggers. They are to be found in buildings and are often the cause of considerable discomfort to man. While the swellings produced are much smaller than those caused by chiggers,

they are equally as irritating for several hours. The mites attack both rats and mice and frequently become abundant in their nests. The control of these rodents will eliminate the mites but it may be several weeks after the destruction of the rodents before the mites disappear.

SPIDERS AND SCORPIONS

The universal fear of spiders and scorpions has little basis in fact, for these creatures play a relatively minor role among the arthropod pests of man. Unlike some of the mites which are true parasites, these animals are accidental attackers. Occasionally they injure man directly by injecting venom into his body. Although much still remains to be learned about the exact virulence of some of the incriminated arachnids it is certain that the great majority of spiders and many scorpions are harmless. Their venom has been specialized to kill insects and other invertebrates for food and is, with several notable exceptions, relatively impotent when introduced into the bodies of warm-blooded animals. As far as is known, these arachnids do not transmit diseases of man.

THE VENOMOUS SPIDERS

The average spider bite produces a painful sensation comparable to that of some of the biting flies, and there follow slight local reactions at the site of the punctures. Only a few species from among many thousands secrete a venom which, differing qualitatively, is capable of producing serious neurotoxic symptoms and rarely even causes death.

Most of the largest and seemingly most formidable of all spiders, the tarantulas or bird-spiders, are considered to be relatively innocuous. A few of the American species have been singled out as being possible exceptions but as yet too little is known about their actual virulence. Species of a related family found in Australia, *Atrax robustus* and *formidabilis* of the Diplu-ridae, seemingly possess a venom that is highly neurotoxic and is capable of causing systematic distress comparable to that of the notorious "black widow" spider.

A considerable number of true spiders have been accused of being venomous through prejudice or circumstantial evidence, but few have been demonstrated by modern investigators to be truly dangerous. The famed European tarantula *(Lycosa tarentula)* is now known to be a relatively harmeless creature.

The most notorious of all the venomous spiders are the species of *Latrodectus*. Found in temperate and tropical regions throughout most of the world, the various species have been justly regarded by many different peoples as being especially dangerous. The "Malmignatte" of southern Europe, the "Katipo" of New Zealand and the "Black Widow" of the United States are shining black spiders, strongly marked with red. Other species, such as the "Knobbie Spiders" of South Africa, are less brightly colored, but the venter is always marked by an X-shaped paler maculation, the "hourglass."

Probably the best known species of the genus is the black widow *(Latrodectus mactans)*, found throughout a

large part of North and South America. This spider spends most of its life in a coarse, irregular web located in burrows, crevices, or recesses under rocks or trash. The disturbed and littered areas around man's homes and outbuildings are favorable situations, and not infrequently these spiders are found in the buildings themselves. Bites occur when man accidentally brushes against or squeezes a spider and the creature instinctively bites and injects venom until it is free to run away. Following the injection of venom, come sharp to excruciating muscular pains accompanied by nausea, profuse perspiration, difficulty in breathing, and other symptoms. In the average case the severe symptoms abate within a few hours and normality is attained within a few days. Relatively few people die, as is indicated by Dr. E. Bogen, a foremost authority on the medical status of the bite, who stated that "I am unable to find more than twenty deaths in the past four hundred years due to the Black Widow."

Treatment of black widow bite consists for the most part of measures to relieve the pain (sedatives, hot baths, intravenous injection of epsom salts) during the severe stage. Do not use alcoholic drinks or stimulants. A specific anti-venom has been used successfully.

Ordinary insecticides are not recommended for the eradication of venomous spiders. Within limited areas of infestation, such as around and in outbuildings and homes, a systematic search for the spiders and their destruction individually is preferable to general fumigation.

THE VENOMOUS SCORPIONS

The poison gland of the scorpion is located in the specialized last segment of the post-abdomen, and the venom passes through a curved spine or sting. Most species are able to break the skin of man and cause a more or less painful injury, but in general the effect may be described as negligible. However, as in the case of spiders, a very few scorpions have a venom which differs in quality from that of most of their kin, one which sometimes causes severe symptoms or death. Also, as in spiders, the dangerous scorpions are of relatively small size.

A number of virulent scorpions occur in northern Africa, of which *Prionurus australis* and *Buthus occitanus* are perhaps the most important. An effective scorpion anti-venom has been developed. In the Americas there are several species which have come to be regarded as dangerous. The best-known species is the Durango scorpion of Mexico *(Centruroides suffusus)*, which is reputed to cause more deaths each year than the black widow spider. Most of the deaths occur in children under ten years of age. The symptoms include numbness following the sting, then itching of the nose and throat, excessive production of saliva, a gradual collapse and waves of convulsions, following which comes gradual recovery or possibly death. Treatment for the sting includes sedatives, hot baths, and the use of a serum. A similar species of scorpion *(Centruroides sculpturatus)* occurs in Arizona and is reported to have caused twenty-five deaths from 1929 to 1938, chiefly in children.